A303 Amesbury to Berwick Down

TR010025

Volume 6

6.1 Environmental Statement

Chapter 9: Noise and Vibration

APFP Regulation 5(2)(a)

Planning Act 2008

Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009

October 2018

9 Noise and Vibration

9.1 Introduction and competent expert evidence

9.1.1 This chapter assesses the potential noise and vibration impacts of the construction and operation of the Scheme, following the methodology set out in Design Manual for Roads and Bridges Volume 11, Section 3, Part 7 HD 213/11 – Revision 1 (Ref 9.1) (hereafter referred to as "DMRB"), and the associated Interim Advice Note (“IAN”) 185-15 (Ref 9.2). This chapter details the methodology followed for the assessment, summarises the regulatory and policy framework related to noise and vibration and describes the existing environment in the area surrounding the Scheme. Following this, the design, mitigation and residual effects of the Scheme are discussed, along with the limitations of the assessment.

9.1.2 This chapter of the ES has been undertaken by competent experts with relevant and appropriate experience. The technical lead for the noise and vibration assessment is Suzanne Scott and her professional qualifications and experience are summarised in Appendix 1.1. Details of relevant noise and vibration terminology are provided in Appendix 9.1.

9.2 Legislative and policy framework

9.2.1 As discussed in Chapter 1, the primary basis for deciding whether or not to grant a Development Consent Order (DCO) is the National Policy Statement for National Networks (NPSNN) which, at sections 4 and 5, sets out policies to guide how DCO applications will be decided and how the impacts of national networks infrastructure should be considered. Table 9.1 identifies the NPSNN policies relevant to the noise and vibration assessment and where in the ES chapter information is provided to address the policy.

Table 9.1: Relevant NPSNN policies for noise and vibration assessment

Relevant NPSNN paragraph reference	Requirement of the National Policy Statement for National Networks (NPSNN)	Where in the ES Chapter is information provided to address this policy.
5.189	Where a development is subject to EIA and significant noise impacts are likely to arise from the proposed development, the applicant should include the following in the noise assessment, which should form part of the environment statement: • a description of the noise sources including likely usage in terms of number of movements, fleet mix and diurnal pattern. For any associated fixed structures, such as ventilation fans for tunnels, information about the noise sources including the identification of any distinctive tonal, impulsive or low frequency characteristics of the noise.	Existing noise sources discussed in section 9.6 Baseline conditions. Proposed fixed plant discussed in section 9.3 Assessment methodology. Noise sensitive receptors discussed in section 9.5 Study area. Predictions of how the noise environment will change during

Relevant NPSNN paragraph reference	Requirement of the National Policy Statement for National Networks (NPSNN)	Where in the ES Chapter is information provided to address this policy.
	• identification of noise sensitive premises and noise sensitive areas that may be affected. • the characteristics of the existing noise environment. • a prediction on how the noise environment will change with the proposed development: • in the shorter term such as during the construction period; • in the longer term during the operating life of the infrastructure; • at particular times of the day, evening and night as appropriate. • an assessment of the effect of predicted changes in the noise environment on any noise sensitive premises and noise sensitive areas. • measures to be employed in mitigating the effects of noise. Applicants should consider using best available techniques to reduce noise impacts. • the nature and extent of the noise assessment should be proportionate to the likely noise impact.	construction and operation are provided in section 9.9 Assessment of effects. Mitigation measures are identified in section 9.8 Design, mitigation and enhancement measures
5.190	The potential noise impact elsewhere that is directly associated with the development, such as changes in road and rail traffic movements elsewhere on the national networks, should be considered as appropriate.	The impacts of the Scheme, including on the wider road network are discussed in section 9.9 Assessment of effects
5.191	Operational noise, with respect to human receptors, should be assessed using the principles of the relevant British Standards and other guidance. The prediction of road traffic noise should be based on the method described in Calculation of Road Traffic Noise. …. For the prediction, assessment and management of construction noise, reference should be made to any relevant British Standards and other guidance which also give examples of mitigation strategies.	The assessment methodology is discussed in section 9.3 Assessment methodology, including CRTN and relevant British Standards
5.192	The applicant should consult Natural England with regard to assessment of noise on designated nature conservation sites, protected landscapes, protected species or other wildlife. The results of any noise surveys and predictions may inform the ecological assessment. The seasonality of potentially affected species in nearby sites may also need to be taken into account.	The assessment of noise on biodiversity is discussed in Chapter 8 Biodiversity. Changes in traffic noise levels at Parsonage Down are reported in section 9.9 Assessment of effects
5.195	The Secretary of State should not grant development consent unless satisfied that the proposals will meet, the following aims, within the	A discussion of how the Scheme complies with these three aims

Relevant NPSNN paragraph reference	Requirement of the National Policy Statement for National Networks (NPSNN)	Where in the ES Chapter is information provided to address this policy.
	context of Government policy on sustainable development: • avoid significant adverse impacts on health and quality of life from noise as a result of the new development; • mitigate and minimise other adverse impacts on health and quality of life from noise from the new development; and • contribute to improvements to health and quality of life through the effective management and control of noise, where possible.	is provided in section 9.9 Assessment of effects.
5.199	For most national network projects, the relevant Noise Insulation Regulations will apply. These place a duty on and provide powers to the relevant authority to offer noise mitigation through improved sound insulation to dwellings, with associated ventilation to deal with both construction and operational noise. An indication of the likely eligibility for such compensation should be included in the assessment. In extreme cases, the applicant may consider it appropriate to provide noise mitigation through the compulsory acquisition of affected properties in order to gain consent for what might otherwise be unacceptable development. Where mitigation is proposed to be dealt with through compulsory acquisition, such properties would have to be included within the development consent order land in relation to which compulsory acquisition powers are being sought.	The results of an initial assessment under the Noise Insulation Regulations is reported in section 9.9 Assessment of effects
5.200	Applicants should consider opportunities to address the noise issues associated with the Important Areas as identified through the noise action planning process.	A discussion of the impacts on noise important areas is provided in section 9.9 Assessment of effects

9.2.2 In accordance with the NPPF, the NPSNN policies relating to the applicant's assessment are the primary source of policy guidance regarding this assessment. The NPPF was revised in 2018, but the requirements which relate to this assessment have not substantively changed, and the NPSNN remains the primary source of policy guidance.

9.2.3 Other relevant policies have been considered as part of the noise and vibration assessment where these have informed the identification of receptors; the assessment methodology; the potential for significant environmental effects; and required mitigation. These policies include those as detailed below:

Policy

a) National Planning Policy Framework (NPPF) – paragraph 180.

b) Noise Policy Statement for England Explanatory Note (NPSE) (Ref 9.3).

c) Planning Practice Guidance on Noise (PPG-N) (Ref 9.4).

d) Wiltshire Council Core Strategy Policy 57 (Ref 9.5).

9.2.4 The NPPF closely aligns with the aims set out in paragraph 5.195 of the NPSNN to avoid significant adverse impacts and to mitigate and reduce other adverse impacts. It also states that planning decisions should aim to 'identify and protect tranquil areas which have remained relatively undisturbed by noise and are prized for their recreational and amenity value for this reason'.

9.2.5 The Explanatory Note within the NPSE introduces the following concepts to aid in the establishment of significant effects:

a) No Observed Effect Level (NOEL): the level below which no effect can be detected. Below this level no detectable effect on health and quality of life due to noise can be established;

b) Lowest Observable Adverse Effect Level (LOAEL): the level above which adverse effects on health and quality of life can be detected; and

c) Significant Observed Adverse Effect Level (SOAEL): the level above which significant adverse effects on health and quality of life occur.

9.2.6 The NPSE recognises that 'it is not possible to have a single objective noise-based measure that is mandatory and applicable to all sources of noise in all situations'. The levels are likely to be different for different noise sources, for different receptors and at different times of the day. The assessment methodology in Section 9.3 outlines the LOAEL and SOAEL used for each potential impact. The setting of these levels has been informed by the additional guidance in the web-based PPG-N on the concepts of NOEL, LOAEL and SOAEL.

9.2.7 Wiltshire Council Core Strategy Policy 57 section vii refers to 'having regard to the compatibility of adjoining buildings and uses, the impact on the amenities of existing occupants, and ensuring appropriate levels of amenity are achievable within the development itself, including the consideration of … and pollution (such as ….noise)'. The aim of the noise and vibration assessment is to consider the impact of the Scheme on sensitive receptors.

9.3 Assessment methodology

Scoping

9.3.1 Where assessment has been undertaken in accordance with the Scoping Opinion point, a response and the relevant ES section is provided; where an

alternative approach has been agreed with the relevant stakeholders, an explanation is provided. The Scoping Opinion as received is provided in Appendix 4.1.

Table 9.2: Scoping Opinion and response

Scoping Opinion	Where addressed within the ES
Planning Inspectorate	
The ES should ensure that the worst case scenario is assessed and as such, the Inspectorate considers that the diversion and high load routes should be included in the assessment as at present there is no information provided to suggest the frequency or durations of use. There is also no quantification of the level of use of the 'high load' route so as to demonstrate the noise impacts of the Proposed Development need not be considered. The ES should also explain the anticipated maintenance schedule for all routes and how this is to be delivered as part of the DCO.	The tunnel closure diversion and high-load route are scoped out of the noise assessment based on the infrequent usage as detailed in Chapter 2 (The Scheme) section 2.3. This was discussed with the Inspectorate on 30th January 2018. Long term maintenance detailed in section 2.4
The Inspectorate notes that the Applicant wishes to scope out the assessment of operational ground borne vibration as such vibration only occurs on unmaintained road surfaces. The Inspectorate agrees that this matter can be scoped out of the ES in relation to the realigned and tunnelled sections of the A303. However, the Inspectorate does not agree that significant effects with regard to operational vibration effects along the diversion and high load routes can be ruled out on the basis of the information provided. Therefore, these matters should be assessed as part of the ES	The tunnel closure diversion and high-load route are scoped out of the noise assessment based on the infrequent usage as detailed in Chapter 2 (The Scheme) section 2.3. This was discussed with the Inspectorate on 30th January 2018.
The Scoping Report states the study area will "*focus on the closest identified receptors*" however it does not explain how such receptors will be determined. There is no clear evidence as to how the locations of sensitive receptors and extent of likely impacts have been taken into account in determining the study area. The ES should clearly explain the methodology along with the identification of the receptors and study areas, ensuring that a robust assessment of likely significant effects is carried out. The Applicant should seek to obtain agreement of the methodology with the LPA as stated in DMRB. The ES should clearly define receptors selected as being 'representative' of larger groups.	This text related to construction impacts only. Details of the study area for construction impacts are provided in section 9.5. Agreement with Wiltshire Council on the approach reported in section 9.3
The Scoping Report sets out that a selection of locations will be used to determine the baseline levels of noise. The Applicant should agree these locations with the relevant local authority. The ES should explain and depict the locations of baseline noise monitoring locations. The Scoping Report makes no indication of the timeframe over which baseline surveys will take place or at what times of the year. The approach to establishing the baseline noise environment should be discussed and agreed with the relevant local authority. This should include the locations of the monitoring points, the time periods covered	Figure 9.1 illustrates the monitoring locations. Section 9.6 reports the methodology and results with further details in Appendix 9.4. Agreement with Wiltshire Council on

Scoping Opinion	Where addressed within the ES
and other relevant factors such as weather conditions which should also be explained in the ES.	the locations and methodology reported in section 9.3
The noise assessment is required, as set out in the NPSNN, to take into account out in the NPSNN, to take into account ecological receptors as well as human. As such, consideration should be given to findings of the biodiversity and ecological surveys in terms of identifying sensitive receptors. NE should be consulted in relation to the assessment on designated nature conservation sites, protected landscapes, protected species or other wildlife. Inter-relationships with other aspects should be considered - for example, noise impacts on the setting of heritage assets.	The biodiversity assessment considers the potential for noise impacts on biodiversity receptors as detailed in Chapter 8 (Biodiversity). Likewise, the potential for noise impacts on the setting of heritage assets is presented in Chapter 6 (Cultural Heritage). The inter-relationship between topics are reported in Chapter 15 Cumulative Effects.
The Scoping Report does not reference the working hours which are proposed, particularly in relation to the TBM. The ES should set out the working hours that have been assessed as part of each component of the Proposed Development and they should be consistent with what is permitted in/by the DCO should it be granted.	Details of working hours are provided in section 9.9 and Chapter 2 (The Scheme) section 2.4
The Scoping Report at present does not reference monitoring of noise levels during construction or operation to ensure the appropriateness of mitigation. The need for and scope of monitoring during construction and operation of the Proposed Development should be presented in the ES.	Survey proposals are detailed in section 9.8
The Scoping Report confirms that the assessment will consider vibration effects on properties within 40m of the preferred route. The Inspectorate considers that the assessment should extent to all roads that are affected by the Proposed Development and likely to result in significant effects. In particular this should account for the diversion and high load routes.	Section 9.3 details the methodology for operational traffic vibration impacts, properties within 40m of the Scheme, existing A303 and affected routes are included in the assessment. The tunnel closure diversion and high-load route are scoped out of the noise assessment based on the infrequent usage as detailed in Chapter 2 (The Scheme) section 2.3. This was discussed with the Inspectorate on 30th January 2018

Scoping Opinion	Where addressed within the ES
Environment Agency	
Timing of works that could impact on fish populations is a key constraint, particularly with respect to the proposed bridge works and while this is an issue that would also be dealt with through our normal Environmental Permitting process, the potential for noise to disturb fish movement has not been identified in Section 6.5 (Noise and Vibration). We recommend that the potential impact from noise and vibration on fish movement and other species, as may be experienced from bridge piling works, is included in the consideration of construction impacts and mitigation measures.	The potential impact on fish is considered in Chapter 8 (Biodiversity), section 8.9
Wiltshire Council	
6.5.4 – Please note that prior consent under the Control of Pollution Act has been discussed for use on this project	The option for the contractor to use the prior consent process is included in the OEMP (Appendix 2.2)
6.5.6 – The noise from the construction compound should be covered by any assessments carried out and subsequent control measures	Construction compound activities are included in the assessment, results reported in section 9.9
6.5.9 – The following planning guidance and legislation have been taken into account as part of identifying the assessment methodology, receptor selection / sensitivity, potential significant environmental effects; and mitigation: a) National Policy Statement for National Networks (Ref 3); b) National Planning Policy Framework (Ref 8); c) Noise Policy Statement for England (Ref 135); and d) Web-based resource “Planning Practice Guidance on Noise” (PPG-N) (Ref 136) e) Wiltshire Core Strategy, Core Policy 57 (see criterion vii)	Confirmed, details of relevant legislative and policy framework provided in section 9.2
6.5.17 – Details of the three Noise Important Areas in Amesbury have been requested	Confirmed, locations provided and marked on Figure 9.1
6.5.19 – Any additional haul roads should be included in the assessment of construction effects	Haul road activities are included in the assessment, results reported in Section 9.9
6.5.49 – Details of all noise and vibration monitoring points have been requested	Monitoring locations and methodology agreed with Wiltshire Council, locations illustrated on Figure 9.1.
6.5.60 – Any properties requiring noise insulation works should be identified	Results of preliminary noise insulation assessment included in section 9.9
6.5.64 – The wide seasonal variation in traffic flows should be identified in any average figures which may be produced	The approach to considering ‘busy’

Scoping Opinion	Where addressed within the ES
	periods is detailed in sections 9.3, and the results discussed in section 9.9
6.5.70 – Details of the [significance] methodology are yet to be specified, and should be subject to further discussions prior to approval	The methodology section of the chapter, including the approach to defining significance, was provided to Wiltshire for comment. Confirmed in subsequent discussions Wiltshire in agreement with the methodology

Consultation

9.3.2 Initial discussions were held with representatives from Wiltshire Council Public Health and Public Protection Department in November 2017 to discuss and agree the approach to the noise and vibration assessment as presented in the Scoping Report. This discussion included agreement on the assessment methodology and baseline monitoring procedures. In addition, information was gathered relating to:

a) local noise sources other than road traffic (i.e. MOD activities including firing noise from Salisbury Plain and low flying helicopters and planes from Boscombe Down);

b) future developments in the area, which will feed into the traffic modelling work;

c) any receptors requiring particular attention (nothing identified);

d) local concerns that Wiltshire Council is aware of (no existing noise/vibration concerns relating to the A303 identified);

e) specific requirements relating to construction (working hours / noise and vibration limits and their preference to adopt the Control of Pollution Act (COPA) Section 61 approach). In addition Wiltshire Council identified the potential issue of 24 hour generators at construction compounds and expressed a preference for permanent power supplies; and

f) local knowledge of, and current mitigation proposals (if any) for, Noise Important Areas on the A345 north/south of Amesbury, for which Wiltshire Council is responsible (no current mitigation proposals).

9.3.3 Subsequent to the initial discussion, a plan showing the study area for the noise and vibration assessment and a plan showing the proposed noise and vibration monitoring locations were provided to Wiltshire Council Public Health and Public Protection Department for comment.

9.3.4 Meetings were held with Wiltshire Council Public Health and Public Protection Department on 2nd July 2018 and 7th August 2018 to provide further updates on the progress with the noise and vibration assessment and to discuss the impacts of the Scheme. The assessment methodology and baseline monitoring results sections of the draft chapter (including Appendix 9.4 Noise Monitoring) were provided for comment in advance of the 7th August 2018 meeting. The construction noise, construction vibration, construction traffic, operational traffic and operational plant noise results were discussed at the 7th August 2018 meeting. Based on the predicted magnitude of the vibration annoyance impacts at Stonehenge Cottages, at the closest approach of the tunnelling works, Wiltshire Council identified temporary re-housing as a potential mitigation measure at this location. No other specific concerns were raised. A further telecon was held on 6th September 2018 to provide an update on the completed assessment, and confirmed Wiltshire Councils agreement to various aspects of the final assessment including the baseline monitoring locations and monitoring methodology, the selection of receptors and study areas and the overall methodology adopted for the assessment. Wiltshire Council re-iterated on this call their strong preference for the use of the Section 61 prior consent process during construction.

9.3.5 Public consultation comments received and their associated responses are provided within the Consultation Report, a copy of which is included with the application.

Construction noise

9.3.6 A quantitative assessment of construction noise impacts has been undertaken. Estimates of reasonable worst case construction noise levels have been made for a selection of 19 of the closest identified potentially sensitive receptors to the works. These selected receptors are also representative of neighbouring properties in their vicinity. By choosing a selection of the closest identified potentially sensitive receptors the reported impacts are, therefore, typical of the worst affected receptors and all potentially significant effects are identified. At receptors further away from the works the impact would be reduced.

9.3.7 Reasonable worst case construction noise levels have been estimated on a quarterly basis throughout the works in accordance with the methodology in BS 5228: 2009+A1: 2014 ‘Code of Practice for Noise and Vibration Control on Construction and Open Sites’ (Ref 9.6). At this stage, before contractors have been appointed to construct the Scheme, precise information on the construction works is not available. However, a contractor has been appointed to provide reasonable assumptions on the likely works. Therefore, the estimated construction noise levels are based on information which includes the number and type of plant likely to be required for each activity, typical ‘on’ times for each

item of plant, working areas, working times and durations. Further details on the activities and plant throughout the construction works are provided in Appendix 9.2.

9.3.8 BS 5228 contains a number of example methodologies for identifying significant construction noise effects based on fixed thresholds or noise level changes. For the purposes of this assessment the 'ABC' method has been adopted. This approach is based on setting the threshold for the onset of potentially significant adverse effects (i.e. the SOAEL, as defined in Section 9.2) depending on the existing ambient noise level. Receptors with low existing ambient noise levels (Category A) have a lower threshold than those with high existing ambient noise levels (Category C). Higher thresholds are set for normal daytime construction working hours, compared to the more sensitive evening/weekend and night time periods. As a conservative approach, the threshold for the onset of any adverse effect (i.e. the LOAEL, as defined in Section 9.2) is set at a construction noise level equal to the existing ambient noise level. Construction noise levels between the LOAEL and the SOAEL have the potential to result in adverse effects but would not normally be classed as significant adverse effects. However, noise mitigation measures are still considered/applied in such locations to seek to keep all effects to a minimum. Table 9.3, which is adapted from Table E.1 in BS 5228, sets out the construction noise SOAEL and LOAEL used for this assessment.

Table 9.3: Construction noise SOAEL and LOAEL for all receptors

Time of Day	SOAEL $L_{Aeq,T}$ dB (façade)			LOAEL $L_{Aeq,T}$ dB (façade)
	A[1]	B[2]	C[3]	
Daytime (07:00 – 19:00) and Saturdays (07:00 – 13:00)	65	70	75	Existing ambient
Evenings (19:00 – 23:00 weekdays) and Weekends (13:00 – 23:00 Saturdays and 07:00 – 23:00 Sundays)	55	60	65	Existing ambient
Night-time (23:00 – 07:00)	45	50	55	Existing ambient

[1] Category A: threshold values to use when ambient noise levels (when rounded to the nearest 5 dB) are less than these values

[2] Category B: threshold values to use when ambient noise levels (when rounded to the nearest 5 dB) are the same as the category A values

[3] Category C: threshold values to use when ambient noise levels (when rounded to the nearest 5 dB) are higher than the category A values

NOTE: if the ambient noise level exceeds the Category C threshold values then the SOAEL and LOAEL are defined as equal to the existing ambient

9.3.9 To determine the SOAEL and LOAEL ambient noise levels at the relevant façade of each of the selected receptors have been determined based on predicted 2017 baseline traffic noise levels.

9.3.10 Construction traffic noise impacts along existing roads have been estimated based on the Calculation of Road Traffic Noise (CRTN) methodology (Ref 9.7) Basic Noise Level (BNL) at a reference distance of 10 metres from the nearside

carriageway, both with and without the construction traffic, for each road link in the traffic model. Construction traffic data has been provided for two phases of the works, phase 1 (2021-2023) and phase 2 (2024-2026). The main works in Phase 1 are Winterbourne Stoke bypass, Longbarrow Interchange and Countess Roundabout flyover. The main work in Phase 2 is construction of the tunnel. The Winterbourne Stoke bypass, Longbarrow Interchange and Countess Roundabout flyover are assumed to be operational in Phase 2.

Construction vibration

9.3.11 Construction vibration impacts have been assessed for all construction activities which are a potentially significant source of vibration proposed in close proximity of any identified potentially sensitive receptors. These works are tunnelling, using a Tunnel Boring Machine (TBM) and road construction (pavement) works using vibratory rollers/compactors.

9.3.12 Piling during the construction works does not have the potential to cause significant vibration effects, as the proposed method of pilling is continuous flight auger (CFA) or cast in-situ piles, including the concrete casing for the piles. Levels of vibration associated with these techniques are minimal and therefore this has not been considered further.

9.3.13 Vibration levels have been estimated in accordance with the relevant methodologies in BS 5228. It is standard practice to consider vibration impacts from construction works up to a maximum distance of 100m from the works, as no impact would be anticipated beyond this. This approach has been adopted for this assessment, with the exception of the inclusion of Stonehenge, which is a minimum of approximately 200m horizontally from the closest tunnel bore, due to the level of interest in the potential impact of the Scheme on the stones.

9.3.14 The transmission of ground-borne vibration is highly dependent on the nature of the intervening ground between the source and receptor and the activities being undertaken. BS 5228 provides data on measured levels of vibration for various construction works. Impacts are considered for both damage to buildings and annoyance to occupiers.

9.3.15 Table 9.4 details Peak Particle Velocity (PPV) vibration levels and provides a semantic scale for the description of construction vibration effects on human receptors, based on guidance contained in BS 5228.

Table 9.4: Construction vibration criteria for human receptors (annoyance)

Peak Particle Velocity Level	Description
$10mms^{-1}$	Vibration is likely to be intolerable for any more than a very brief exposure to this level.
$1.0mms^{-1}$	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.
$0.3mms^{-1}$	Vibration might be just perceptible in residential environments.

Peak Particle Velocity Level	Description
0.14mms^{-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.

9.3.16 For human receptors the LOAEL is defined as a PPV of 0.3mms^{-1} (millimetres per second), this being the point at which construction vibration is likely to become perceptible. The SOAEL is defined as a PPV of 1.0mms^{-1}, this being the level at which construction vibration can be tolerated with prior warning.

9.3.17 In addition to human annoyance, building structures may be damaged by high levels of vibration. The levels of vibration that may cause building damage are far in excess of those that may cause annoyance. Consequently, if vibration levels within buildings are controlled to those relating to annoyance (i.e. 1.0mms^{-1}), then it is highly unlikely that buildings would be damaged by construction vibration.

9.3.18 BS 7385-2: 1993 'Evaluation and measurement for vibration in buildings – Part 2: Guide to damage levels from groundborne vibration' (Ref 9.8) provides guidance on vibration levels likely to result in cosmetic damage and is referenced in BS 5228. Guide values for transient vibration, above which cosmetic damage could occur, are given in Table 9.5.

Table 9.5: Transient vibration guide values for cosmetic damage

Type of building	Peak Component Particle Velocity in Frequency Range of Predominant Pulse	
	4Hz to 15Hz	15Hz and above
Reinforced or framed structures Industrial and heavy commercial buildings	50mms^{-1} at 4Hz and above	
Unreinforced or light framed structures Residential or light commercial buildings	15mms^{-1} at 4Hz increasing to 20mms^{-1} at 15Hz	20mms^{-1} at15Hz increasing to 50mms^{-1} at 40Hz and above
NOTE 1: Values referred to are at the base of the building. NOTE 2: For un-reinforced or light framed structures and residential or light commercial buildings, a maximum displacement of 0.6 mm (zero to peak) is not to be exceeded.		

9.3.19 BS 7385-2 states that for transient vibration, such as from individual impacts, the probability of building damage tends towards zero at levels less than 12.5mms^{-1} PPV. For continuous vibration, such as from vibratory rollers or tunnel boring, the threshold is around half this value.

9.3.20 It is also noted that these values refer to the likelihood of cosmetic damage. ISO 4866:2010 'Mechanical vibration and shock. Vibration of fixed structures. Guidelines for the measurement of vibrations and evaluation of their effects on structures' (Ref 9.9) defines three different categories of building damage:

a) cosmetic – formation of hairline cracks in plaster or drywall surfaces and in mortar joints of brick/concrete block constructions;

b) minor – formation of large cracks or loosening and falling of plaster or drywall surfaces or cracks through brick/block; and

c) major – damage to structural elements, cracks in support columns, loosening of joints, splaying of masonry cracks.

9.3.21 BS 7385-2 states that minor damage occurs at a vibration level twice that of cosmetic damage and major damage occurs at a vibration level twice that of minor damage. Therefore, this guidance can be used to define the potential impact identified in Table 9.6 for continuous vibration.

Table 9.6: Construction vibration criteria for assessing building damage

Damage Risk	Continuous Vibration Level PPV mms^{-1}
Major	30
Minor	15
Cosmetic	6
Negligible	<6

Construction – significance of effect

9.3.22 The main factor in identifying construction noise and vibration annoyance significant effects is the magnitude of the impact relative to the SOAEL. In general, construction noise or vibration levels above the SOAEL would be considered significant, and levels below the SOAEL not significant. However, in line with best practice this initial decision on the significance of an effect is then combined with professional judgement which takes into account a range of other factors including:

a) the duration of the impact. Based on the guidance in BS 5228 construction noise or vibration levels above the SOAEL for less than 10 days (or 10 evenings/weekends or nights) in any 15, or less than 40 days (or 40 evenings/weekends or nights) in any 6 month period would not normally be considered significant. At this stage, before contractors have been appointed to construct the Scheme, detailed information on the exact timing and duration of individual activities is not known, therefore a conservative judgement has been made of the likelihood of the duration criteria being exceeded based on the available information;

b) the timing of the impact, night time impacts being more likely to be considered significant than daytime impacts;

c) the location of the impact at the receptor, for example, a receptor may contain areas which are more or less sensitive than others, e.g. in a school, office spaces or kitchens would be considered less sensitive than classrooms; and

d) the nature, times of use and design of the receptor, e.g. a receptor which is not used at night would not be considered sensitive to night time construction works.

9.3.23 The magnitude of the impact of construction traffic on public roads is assigned based on the anticipated change in traffic noise level, in accordance with the same criteria as used for short term operational road traffic noise impacts, as detailed in Table 9.8. The significance of the effect of construction traffic is considered in the same way as operational traffic noise as detailed in the Operational traffic – significance of effect section below.

Operational traffic noise

9.3.24 The general principle of DMRB is to allocate an assessment method according to risk - this process uses three levels of assessment: Scoping, Simple and Detailed. The assessment level used for this Scheme is the most comprehensive Detailed assessment, as the Scheme is considered to have the potential to result in potentially significant changes in traffic noise.

9.3.25 Noise from a flow of road traffic is generated by both the vehicle engines and the interaction of tyres with the road surface. The traffic noise level at a receptor, such as an observer at the roadside or residents within a property, is influenced by a number of factors including traffic flow, speed, composition (percentage of heavy duty vehicles (HDV)), gradient, type of road surface, distance from the road and the presence of any obstructions between the road and the receptor.

9.3.26 Noise from a stream of traffic is not constant, but to assess the noise impact a single figure estimate of the overall noise level is necessary. The index adopted by the Government in CRTN to assess traffic noise is $L_{A10,18h}$. This value is determined by taking the highest 10% of noise readings in each of the 18 one-hour periods between 06:00 and 00:00, and then calculating the arithmetic mean. As recorded in DMRB, a reasonably good correlation has been shown to exist between this index and the perception of traffic noise by residents over a wide range of noise exposures.

9.3.27 CRTN provides the standard methodology for predicting the $L_{A10,18h}$ road traffic noise level. Noise levels are predicted at a point measured 1m horizontally from the external façade of buildings.

9.3.28 The CRTN methodology applies a ‘low flow’ correction between 18 hour flows of 1,000 and 4,000. The low flow correction procedure amplifies the impact of changes in traffic flows which are already low, in particular at receptors very close to the road. The 1,000 18 hour flow cut off is the lower limit of the CRTN prediction methodology.

9.3.29 Although the main focus of the assessment is on daytime impacts, DMRB also requires an assessment of night-time traffic noise levels using the parameter $L_{night,\ outside}$, which is the traffic noise level over the period 23:00 to 07:00. However, this parameter is not calculated by the standard CRTN methodology.

DMRB refers to three methods for calculating night-time traffic noise levels developed by the Transport Research Laboratory (TRL) (Ref 9.10). The most widely used is 'Method 3' which factors the $L_{night,outside}$ from the $L_{A10,18h}$, based on the typical diurnal pattern of traffic flows in the UK. This method was used in the noise assessment work completed for the various options at the previous stages. However, for the detailed assessment of the Scheme a more detailed method has been used.

9.3.30 One of the aims of the Scheme is to alleviate congestion during the day. At night, congestion is not a problem, and therefore the changes in traffic noise levels due to the implementation of the Scheme are generally smaller at night than during the day. To more accurately represent the change to night-time traffic noise levels a method based directly on night-time traffic conditions, rather than simply factoring the daytime traffic noise levels has been adopted.

9.3.31 A hybrid of the DMRB 'Method 1' (based on individual hourly flows) and 'Method 2' (based on 8 hour night time flows) has been used to assess potential night-time traffic noise impacts. The 8 hour night-time traffic flow from the traffic model has been used to determine a typical 1 hour flow during each hour of the night and the Method 1 prediction method applied.

9.3.32 DMRB also requires consideration of the likely annoyance to residents caused by traffic noise, in both the short and long term. Individuals vary widely in their response to the same level of traffic noise. However, the average or community response from a large number of people to the same level of traffic noise is fairly stable and, therefore, a community average degree of annoyance caused by traffic noise can be related to the long-term steady state noise level. In addition, DMRB notes that people are more sensitive to abrupt changes in traffic noise, for example, following the opening of a new road, than would be predicted from the steady state relationship between traffic noise and annoyance (as described above). These effects last for a number of years. However, in the longer term, the perceived noise annoyance tends towards the steady-state level due to familiarisation.

9.3.33 The objective of the assessment, as set out in DMRB, is to gain an overall appreciation of the noise and vibration climate, both with (Do-Something (DS)) and without (Do-Minimum (DM)) the Scheme, to identify where noise impacts occur and to determine where mitigation to reduce these impacts may be appropriate. These conditions are assessed for the baseline year (the year of opening) and the future assessment year (15 years after opening).

9.3.34 DMRB outlines the steps to be carried out at the Detailed assessment stage, which have been followed for this assessment:

a) Identify the study area (see Section 9.5) and predict 18-hour (06:00 - 00:00) and night-time (23:00 - 07:00) traffic noise levels at all residential properties within the 600m calculation area for all assessment scenarios.

b) Carry out the following comparisons for each property in order to identify the number of properties where residents may experience an increase or decrease in traffic noise levels and annoyance:

   i. The Do-Minimum scenario in the baseline year against the Do-Minimum scenario in the future assessment year (long-term);

   ii. The Do-Minimum scenario in the baseline year against the Do-Something scenario in the baseline year (short-term); and

   iii. The Do-Minimum scenario in the baseline year against the Do-Something scenario in the future assessment year (long-term).

c) For night-time traffic noise levels, undertake comparisons for the two long-term comparisons and for properties where the $L_{night,\ outside}$ level is 55 dB(A) or more in the relevant scenarios;

d) Assess the impact on sensitive receptors, other than residential properties, within the 600m calculation area. This is based on 18 hour (06:00 - 00:00) traffic noise levels and considers the same three comparisons as outlined in (b) above for residential properties;

e) Complete a qualitative assessment of sensitive receptors which are within the 1km boundary, but outside the 600m calculation area; and

f) For affected routes which are outside the 1km boundary, complete an assessment by estimating the CRTN Basic Noise Level (BNL) on these roads (the traffic noise level at 10m) with and without the Scheme. Count the number of dwellings and other sensitive receptors within 50m of these routes.

9.3.35 Different façades of the same property can experience different changes in traffic noise level depending on their orientation to the noise source. DMRB requires that each of the above comparisons of traffic noise levels is based on the façade which experiences the least beneficial change i.e. the largest increase, or, if all façades undergo a decrease, the smallest decrease. Additionally, DMRB requires that the above comparisons of annoyance use the highest levels of annoyance in the first 15 years. For properties which experience an increase in noise due to the Scheme, the greatest annoyance is likely to be immediately after the Scheme opens to traffic. For properties which experience a decrease in noise (and also in the Do-Minimum comparison), the greatest annoyance is the steady-state level of annoyance in the long term.

9.3.36 A preliminary indication of any properties likely to qualify under the Noise Insulation Regulations is provided in the assessment. A full assessment would be completed once the detailed design is finalised and in accordance with the timescales set out in the Regulations.

9.3.37 The operational assessment is based on annual average 18 hour traffic conditions. During weekends in the summer months (and other holiday periods such as Easter and bank holiday weekends) the area can be busier. This results in longer delays and lower speeds on some sections of the A303, in particular past Stonehenge and increased traffic on alternative routes such as the B3086 to the north. Therefore, a sensitivity analysis of the likely impacts of the Scheme during these 'busy' periods has been completed, based on 18 hour traffic data representative of these busy periods.

9.3.38 Predicted daytime and night-time traffic noise levels have been generated using noise modelling software. The model is based on traffic data generated by a traffic model of the Scheme and surrounding area. The traffic flow and % HDV data are taken directly from the model. However, the traffic speeds are subject to a process called 'speed banding' which assigns one of four speeds to all non-motorway roads, as set out in IAN 185/15. The model also includes the ground topography, ground type and buildings to form a 3D representation of the study area. Further details of the noise model data sources and assumptions are provided in Appendix 9.3.

9.3.39 The SOAEL and the LOAEL for road traffic noise used in this assessment are detailed in Table 9.7.

Table 9.7: Traffic noise SOAEL and LOAEL for all receptors

Time period	SOAEL	LOAEL
Daytime	68 dB $L_{A10,18h}$ (façade) 63 dB $L_{Aeq,16h}$ (free-field)	55 dB $L_{A10,18h}$ (façade) 50 dB $L_{Aeq,16h}$ (free-field)
Night	55 dB $L_{night,outside}$ (free-field)	40 dB $L_{night,outside}$ (free-field)

9.3.40 For daytime, the SOAEL is set at 68 dB $L_{A10,18h}$ (façade), which is consistent with the daytime trigger level in the Noise Insulation Regulations. For consistency with the Noise Insulation Regulations, levels of 67.5 dB are rounded up to 68 dB. The daytime LOAEL is set at 50 dB$L_{Aeq,16h}$ (free field), based on the guidance provided in the WHO Guidelines for Community Noise regarding the onset of moderate community annoyance (Ref 9.11).

9.3.41 For night-time, the SOAEL is set at 55 dB $L_{night,outside}$ (free field). This aligns with the interim night-time outdoor target level provided in the WHO Night Noise Guidelines for Europe (Ref 9.12). The LOAEL is set at 40 dB $L_{night,outside}$ (free field), which is defined as the LOAEL for night time noise in the WHO Night Noise Guidelines for Europe.

9.3.42 The road traffic noise SOAEL and LOAEL are used to consider how the Scheme complies with the three policy aims in paragraph 5.195 of the NPSNN, within the context of Government policy on sustainable development:

a) to avoid significant adverse impacts i.e. reduce traffic noise levels at receptors in the study area to below the SOAEL;

b) to mitigate and minimise other adverse impacts i.e. reduce traffic noise levels at receptors in the study area which are between the LOAEL and the SOAEL; and

c) to contribute to improvements where possible, i.e. reduce traffic noise levels at all receptors in the study area where possible.

9.3.43 The assessment sets out what mitigation measures have been incorporated into the Scheme to meet the three aims, and also any measures which were not considered reasonable or practical to include.

Operational traffic vibration

9.3.44 Vibration from traffic can be transmitted through the air or through the ground. Airborne vibration is produced by the engines and exhausts of road vehicles, with dominant frequencies typically in the range of 50 - 100Hz. Ground borne vibration is produced by the interaction of the vehicle tyres and the road surface with dominant frequencies typically in the range of 8 - 20Hz. The passage of vehicles over irregularities in the road surface can also be a source of ground borne vibration.

9.3.45 Traffic vibration can potentially affect buildings and disturb occupiers. DMRB reports that extensive research on a wide range of buildings has found no evidence of traffic induced ground borne vibration being a source of significant damage to buildings and no evidence that exposure to airborne vibration has caused even minor damage.

9.3.46 Airborne vibration is noticed by occupiers more often than ground borne vibration, as it may result in detectable vibrations in building elements such as windows and doors.

9.3.47 DMRB states that perceptible vibration only occurs in rare cases and identifies that the normal use of a building, such as closing doors and operating domestic appliances, can generate similar levels of vibration to that from traffic in most circumstances.

9.3.48 It is a requirement of new highway constructions that the highway surface be smooth and free from any discontinuities. Paragraph A5.25 of DMRB highlights that in relation to ground borne vibration ‘no evidence has been found to support the theory that traffic induced vibrations are a source of significant damage to buildings’. Paragraph A5.26 of DMRB also states: ‘Such vibrations are unlikely to be important when considering disturbance from new roads and an assessment will only be necessary in exceptional circumstances’. Hence, no significant effects from traffic induced ground borne vibration due to the passage of vehicles over irregularities on the Scheme, in terms of either disturbance or damage to buildings (or other structures) are anticipated and no further assessment has been completed.

9.3.49 To assess the magnitude of the impact of traffic induced airborne vibration on residents, a parameter is needed which reflects a person’s subjective rating of

vibration disturbance. DMRB recommends the use of the $L_{A10,18h}$. The relationship between the $L_{A10,18h}$ and annoyance due to vibration is similar to that for annoyance due to steady state traffic noise, except that the percentage of people bothered by vibration is lower. For a given level of noise exposure, the percentage of people bothered very much or quite a lot by vibration is 10% lower than the corresponding figure for annoyance due to traffic noise. Below 58dB(A) the percentage of people bothered by traffic induced vibration is assumed to be zero.

9.3.50 The potential for vibration impacts is limited to the immediate vicinity of a road, and the relationship between annoyance due to vibration and traffic noise level in DMRB is based on properties located within 40m of a road. Therefore, at each property within 40m of the Scheme, the existing A303 replaced by the Scheme or other affected routes, and at which traffic noise levels are predicted to be 58dB, $L_{A10,18h}$ or more, the percentage of people likely to be bothered very much or quite a lot by vibration has been calculated.

Operational traffic – significance of effect

9.3.51 An initial identification of significant effects is carried out based on the magnitude of change in traffic noise levels due to the Scheme. DMRB provides two example classifications for the magnitude of the traffic noise impact of a proposed road scheme, as shown in Table 9.8. These relate to both short-term changes and long-term changes in noise levels. The short term classification detailed in Table 9.8 is the main driver of the initial identification of significant effects.

Table 9.8: Magnitude of traffic noise impacts

Short term change		Long term change	
Noise level change (rounded to 0.1dB) $L_{A10,18h}$ dB	**Magnitude of impact**	**Noise level change (rounded to 0.1dB) $L_{A10,18h}$ dB**	**Magnitude of impact**
0	No change	0	No change
0.1 – 0.9	Negligible	0.1 – 2.9	Negligible
1.0 – 2.9	Minor	3.0 – 4.9	Minor
3.0 – 4.9	Moderate	5.0 – 9.9	Moderate
5.0+	Major	10.0+	Major

9.3.52 In general, a negligible or minor magnitude of impact is not normally considered significant and a moderate or major magnitude of impact is normally considered significant. However, in line with best practice this initial decision on the significance of an effect is then combined with professional judgement which takes into account a range of other factors including:

a) the absolute noise levels e.g. if traffic noise levels are already very high (above the SOAEL) then a smaller noise level change than outlined in Table 9.8 may be considered significant. Conversely if traffic noise levels

are very low (below the LOAEL) then a larger noise level change may be required to be considered significant;

b) where the magnitude of change in the short term lies relative to the boundaries between the bands outlined in Table 9.8, e.g. in some circumstances a change of e.g. 2.9 dB, which just falls into the minor category, may be considered significant;

c) if the magnitude of change in the long term is different than the short term, e.g. if the short term change is minor (not significant) but the long term change is moderate (significant) then a significant effect may be identified;

d) the circumstances of the receptor, e.g. a receptor may contain areas which are more or less sensitive than others, e.g. office spaces or kitchens in a school, would be considered less sensitive than classrooms. Alternatively, if a receptor is particularly vulnerable, such as a school for hearing impaired children;

e) the acoustic character of an area, e.g. if a scheme introduces road noise into an area where road noise is not currently a major source;

f) the likely perception of a traffic noise change e.g. does the noise change combine with other changes, such as an increase in the visibility of a road, which may increase the perceived impact; and

g) the proportion of a designated site that is affected, e.g. comparing the proportion of a designated site within the noise study area, such as the WHS, that is above the LOAEL or SOAEL in each assessment scenario.

Operational plant noise

9.3.53 A service building related to the operation of the tunnel is proposed at each tunnel portal (see Chapter 2 The Scheme section 2.3). Both service buildings contain various items of internal plant, plus potentially a range of associated external plant. At the detailed design stage the potential to remove the need for external plant would be investigated further. Some of the internal plant would operate continuously, such as transformers and Air Handling Units, and others only intermittently, such as a back-up generator in case of a power failure. Significant effects due to the breakout of noise through the structure of the building have been scoped out of the assessment based on the small scale nature of the proposed plant, with the exception of the inlet/outlet in the walls of the building associated with the Air Handling Unit and a number of internal fans. In addition, 17 small condensers are currently proposed outside the building of which a maximum of 9 would operate continuously. At this stage, specific details of the acoustic specification of the plant are not known, however, an assessment of the potential impact has been completed. This has been based on details of the number, type and noise levels of the proposed plant which is considered to be representative of the plant which would be installed. A worst case approach in terms of the number of plant operating at any one time has been taken. The potential for significant adverse effects has been identified

based on comparison of the plant noise levels with background noise levels in the vicinity, in accordance with the approach in BS 4142:2014 'Methods for rating and assessing industrial and commercial sound' (Ref 9.13).

9.3.54 Nine sets of two fans would be installed in the roof of the tunnel at each end of each bore (see Chapter 2 The Scheme section 2.3). Each fan would incorporate a silencer to reduce noise levels. The first set of fans in each bore would be approximately 100m from the entrance to the tunnel, with additional sets at 100m intervals. The main purpose of the fans is to extract smoke out of the tunnel in the event of a fire. However, a maximum of 14 fans in each bore may also operate if exhaust emissions build up in the tunnel to an unacceptable level. To reach this level a high volume of traffic would need to be moving through the tunnel very slowly (less than 20km/hr). This situation is not anticipated to occur on a regular basis as the aim of the Scheme is to alleviate congestion on the A303, and is very unlikely to occur at night. However, for completeness an assessment of the potential impact has been carried out. This is based on example fan data, which is likely to be conservative. A worst case approach has been taken with regards to the location of the fans in operation. The potential for significant adverse effects has been identified based on comparison of the fan noise levels with background noise levels in the vicinity, in accordance with the approach in BS 4142.

9.4 Assessment assumptions and limitations

9.4.1 OS Address Base data detailing building usage and OS building height data have generally been used as provided. However, the heights of residential buildings have been standardised, and a limited check for errors (such as buildings with 0m height) has been completed using information available online, and adjustments made accordingly.

9.4.2 The potential for operational ground borne vibration impacts is related to the presence of irregularities in the road surface, which are not an issue with new road surfaces and are resolved by routine maintenance of existing roads. Therefore, in accordance with the guidance in DMRB, operational ground borne vibration impacts are scoped out of the assessment.

9.4.3 All non-Highways England roads in the study area are assumed to be surfaced with standard hot rolled asphalt in all scenarios. Based on the advice in DMRB a road surface correction of -1 dB is applied at speeds below 75 km/hr and -0.5 dB at and above 75 km/hr. Information on current road surfacing in the area held by Highways England indicates that the A303 and A36 (i.e. the roads maintained by Highways England within the noise modelling area) are predominantly surfaced with thin surfacing which results in lower levels of noise generation than a standard hot rolled asphalt surface. Based on the advice in DMRB, a road surface correction of -1 dB is applied at speeds below 75 km/hr and -3.5 dB at and above 75 km/hr.

9.4.4 No existing noise barriers have been identified within the noise modelling area.

9.5 Study area

9.5.1 Potentially sensitive receptors within the study area have been determined from the OS address base dataset, OS mapping and discussions with Wiltshire Council (as detailed in section 9.3). DMRB defines residential properties, educational buildings, medical buildings, community facilities (such as places of worship) designated sites (such as the WHS and Parsonage Down SSSI), scheduled monuments and public footpaths as potentially sensitive to noise and/or vibration.

9.5.2 The study area for the quantitative assessment of construction phase noise and vibration impacts focuses on the closest identified potentially sensitive receptors to the various works. Receptors have been chosen based on their potential sensitivity, as defined in DMRB and discussed above, and their proximity to the various works. The selected receptors are also representative of neighbouring properties in their vicinity. By choosing a selection of the closest identified potentially sensitive receptors the reported impacts are, therefore, typical of the worst affected receptors and all potentially significant effects are identified. At receptors further away from the works the impact would be reduced. Wiltshire Council has confirmed they are content with the construction phase study area and receptors.

9.5.3 The study area for the assessment of operational phase noise impacts has been defined as outlined below, following the guidance set out within DMRB. Wiltshire Council has confirmed they are content with the operational phase study area and receptors.

9.5.4 The study area comprises the Scheme, the existing A303 replaced by the Scheme and all surrounding existing roads that are predicted to be subject to a change in traffic noise level as a result of the Scheme of:

a) 1dB or more in the short term (Do-Minimum (DM) opening year to Do-Something (DS) opening year); or

b) 3dB or more in the long term (DM opening year to DS 15 years after opening), subject to a minimum change of 1dB between the DM and DS 15 years after opening.

9.5.5 These roads are defined as ’affected routes’ and are identified by analysis of the traffic data. The identification of affected routes considered all roads with 18 hour (06:00-00:00) weekday traffic flows above the 1,000 lower cut off of the CRTN prediction methodology in all scenarios.

9.5.6 The study area for the detailed quantitative assessment of noise impacts comprises a 600m calculation area corridor either side of the Scheme carriageway, 600m either side of the existing A303 carriageway replaced by the Scheme, and 600m either side of all affected routes within a 1km maximum study area around the Scheme and existing A303 replaced by the Scheme.

9.5.7 For residential properties and other sensitive receptors that are within the 1km maximum study area around the Scheme and the existing A303 replaced by the Scheme, but more than 600m from an affected route, the Scheme or existing A303 replaced by the Scheme, a qualitative assessment of the traffic noise impacts is completed.

9.5.8 For affected routes which are outside the 1km maximum study area around the Scheme and existing A303 replaced by the Scheme, an assessment has been undertaken by estimating the CRTN Basic Noise Level (BNL) for these routes with and without the Scheme. A count of the number of dwellings and other sensitive receptors within 50m of these routes has been undertaken.

9.5.9 The study area for the assessment of operational phase airborne vibration annoyance impacts is defined, in accordance with DMRB, as 40m from the above ground sections of the Scheme, the existing A303 replaced by the Scheme and identified affected routes within the 1km maximum study area.

9.5.10 The Scheme includes some minor works to existing roads outside the Scheme extents on the A303 i.e. at the Rollestone Corner junction north of the A303, and Allington Track, Amesbury Road and the A3028 Double Hedges east of the Scheme. For the purposes of defining the study area as set out above, all these works have been included in the study area definition.

9.5.11 The 1km and 600m study areas are illustrated in Figure 9.1. The identified affected routes are illustrated in Figure 9.2.

9.6 Baseline conditions

Current baseline

9.6.1 Under the Environmental Noise Directive (END) strategic noise mapping of major roads, railways, airports and agglomerations has been completed across England, including for the A303. Five ‘Noise Important Areas’ (those areas most exposed to noise) were identified in the Round 2 strategic noise mapping (carried out in 2012) in the vicinity of the Scheme. The two Noise Important Areas on the existing A303 in Winterbourne Stoke (reference 3527 and 3528) are the responsibility of Highways England and mitigation has been incorporated as part of the Scheme via the bypass of the village. The three Noise Important Areas in Amesbury are the responsibility of the local Highways Authority (reference 12681, 12682 and 12683), though the impacts on these areas have been considered as part of the assessment. The Noise Important Areas are illustrated in Figure 9.1.

9.6.2 Information on current road surfacing in the area held by Highways England indicates that the A303 and A36 (i.e. the roads maintained by Highways England within the study area) are predominantly surfaced with thin surfacing, which results in lower levels of noise generation than a standard hot rolled asphalt surface. All other roads in the study area are assumed to be standard hot rolled asphalt in the current baseline.

9.6.3 The study area is predominantly rural in nature. Road traffic noise from the existing A303 is a readily appreciable problem that affects the setting of the WHS. Other sources of road traffic noise include the A360, A345 and other local roads. The existing A303 also passes close to residential properties at Amesbury and Winterbourne Stoke, and the A345 runs through Amesbury and adjacent to Larkhill and Durrington.

9.6.4 The area is subject to occasional noise from light aircraft, commercial aircraft, military aircraft and other military activities.

9.6.5 A baseline noise survey at ten locations along the Scheme was completed in spring 2018. Wiltshire Council has confirmed they are content with the baseline monitoring locations and methodology, as reported in section 9.3. The purpose of the baseline noise survey was to assist with developing an understanding of the general noise climate along the route of the Scheme. For example, to identify if any other local noise sources (other than road traffic) are present and contribute significantly to the local noise climate.

9.6.6 The results of the baseline noise survey were also used as part of a verification exercise for the traffic noise prediction modelling. The traffic noise model has been used to predict traffic noise levels at the monitoring locations, with the predicted and measured levels being compared. The aim of this process is to demonstrate that the noise model is predicting a sensible range of results across the study area. An exact match would not be expected for a variety of reasons, for example, the noise predictions are based on typical weekday traffic conditions over a year, not the exact traffic conditions during the monitoring period; weather conditions including wind speed, wind direction and rain will affect the measurements (the prediction method is designed to be conservative in terms of the effect of wind direction); in addition the noise predictions only consider road traffic noise, whereas the measurements include all ambient noise sources.

9.6.7 Noise monitoring locations are shown on Figure 9.1. These locations were chosen to focus on some of the closest receptors to the Scheme.

9.6.8 The monitoring procedures conformed to BS 7445: 2003 ‘Description and Measurement of Environmental Noise’ (Ref 9.14). Unattended monitoring was carried out at locations M1-M9 using secure garden locations at residential properties. Attended monitoring was undertaken at Stonehenge (M10).

9.6.9 A summary of the noise monitoring results is provided in Table 9.9, which details the average weekday measured noise levels and a comparison with predicted annual average weekday traffic noise levels. Further details of the monitoring programme are provided in Appendix 9.4.

9.6.10 As would be expected, the highest measured and predicted noise levels are recorded at locations very close to the existing A303 i.e. M5 Stonehenge Cottages and M8 on the High Street in Winterbourne Stoke. At locations more remote and/or shielded from the A303 by intervening buildings, levels are much

lower, for example M7 Foredown House on the northern edge of Winterbourne Stoke.

9.6.11 At all locations except M10 Stonehenge the predicted $L_{A10,18h}$ traffic noise levels align with the average measured ambient levels. At Stonehenge, measured ambient noise levels were higher than the predicted traffic noise levels. At this location non-traffic noise sources were noted as a significant source, notably noise generated by visitors to the site.

Table 9.9: Baseline noise monitoring

Ref	Description	Measured $L_{A10,18h}$ dB free-field (average over monitoring period)	Predicted traffic noise $L_{A10,18h}$ dB free-field
M1	Beacon Close, Amesbury	56.6	57.0
M2	Lords Croft, Amesbury	53.0	54.6
M3	Countess Farm, Amesbury	56.9	59.1
M4	Bowles Hatches, Amesbury	58.6	57.8
M5	Stonehenge Cottages, A303	67.0	66.6
M6	Hill Farm Cottages, A303	53.4	54.3
M7	Foredown House, Winterbourne Stoke	52.9	50.8
M8	High Street, Winterbourne Stoke	76.5	74.1
M9	Scotland Lodge, Winterbourne Stoke	55.4	57.1
M10	Stonehenge	61.9	56.1

9.6.12 Overall, the comparisons of measured and predicted levels provide confidence that the noise model developed to quantify the noise impacts of the Scheme is robust.

Future baseline

Construction year baseline (2021)

9.6.13 Based on consideration of future anticipated developments in the area current (2017) baseline conditions are not expected to change substantially by 2021. As detailed in section 9.3 ambient noise levels used in the construction noise assessment are based on 2017 conditions.

Opening Year (2026) and future assessment year (2041) Do-Minimum

9.6.14 As for the current baseline scenario, based on information on current road surfacing in the area held by Highways England the A303 and A36 (i.e. the roads maintained by Highways England within the study area) are assumed to be surfaced with thin surfacing in both 2026 and 2041, which results in lower levels of noise generation than a standard hot rolled asphalt surface. All other

roads in the study area are assumed to be standard hot rolled asphalt in 2026 and 2041.

9.6.15 A summary of predicted Do-Minimum traffic noise levels and the change from the Scheme opening year to the future assessment year is provided in Table 9.10.

Table 9.10: Long-term change in predicted Do-Minimum traffic noise levels (DM 2026 to DM 2041)

Change in noise level		Daytime		Night-time
		Number of residential buildings	Number of other sensitive receptors	Number of residential buildings
Increase in noise level Daytime $L_{A10,18h}$ dB Night-time $L_{night,outside}$ dB	0.1 - 2.9	1777	21	249
	3.0 - 4.9	0	0	0
	5.0 - 9.9	0	0	0
	≥10	0	0	0
No change	0	0	0	3
Decrease in noise level Daytime $L_{A10,18h}$ dB Night-time $L_{night,outside}$ dB	0.1 - 2.9	0	0	0
	3.0 - 4.9	0	0	0
	5.0 - 9.9	0	0	0
	≥10	0	0	0

9.6.16 Table 9.11 provides a summary of the corresponding change in traffic noise annoyance at residential buildings from the Scheme opening year of 2026 to the future assessment year of 2041, as required by DMRB.

Table 9.11: Long-term change in Do-Minimum traffic noise annoyance (DM 2026 to DM 2041)

Change in % Annoyed		Daytime
		Number of Residential Buildings
Increase in annoyance level	<10%	1777
	10 <20%	0
	20 <30%	0
	30 <40%	0
	≥40%	0
No change	0	0

Change in % Annoyed		Daytime
		Number of Residential Buildings
Decrease in annoyance level	<10%	0
	10 <20%	0
	20 <30%	0
	30 <40%	0
	≥40%	0

9.6.17 An estimated total of 1,777 residential buildings are located within the 600m noise prediction study area, as shown on Figure 9.1. However, only 252 buildings meet the DMRB criterion of 55 dB $L_{night,outside}$ at one or more façades in one or more scenarios for inclusion in the night-time traffic noise assessment.

9.6.18 A total of 21 non-residential sensitive buildings are located within the 600m noise prediction study area, consisting of six educational buildings (schools and nurseries in Amesbury), three medical buildings (medical centres and an ambulance centre in Amesbury), six community facilities (social clubs, leisure centre and library in Amesbury, and the Stonehenge visitor centre) four places of worship (three in Amesbury and one in Winterbourne Stoke) and two hotels with no residential accommodation (Travelodge and Holiday Inn, Amesbury) as shown on Figure 9.1. Table 9.10 and Table 9.11 are based on the façade at each building which undergoes the least beneficial change in traffic noise level from the DM 2026 scenario to the DM 2041 scenario. The results are provided for the top floor of each building, for example, 1.5m for a one storey house, 4m for a two storey house. Further details of the noise model set-up and assumptions are provided in Appendix 9.3.

9.6.19 The traffic noise changes from DM 2026 to DM 2041 are presented as a noise difference contour plot in Figure 9.3. The map is based on free-field traffic noise levels at first floor level (4m above ground) using a 10m x 10m grid and is provided for illustration purposes. For information the map extends to the maximum 1km study area.

9.6.20 All the residential buildings and sensitive non-residential receptors experience a negligible (0.1 - 2.9 dB) increase in daytime traffic noise levels from 2026 to 2041 in the absence of the Scheme. This is due to the general growth in traffic over time. This results in a corresponding small increase in annoyance due to traffic noise at all residential buildings.

9.6.21 A summary of the change in annoyance due to airborne vibration from road traffic between the two Do-Minimum scenarios is provided in Table 9.12. A total of 202 residential buildings have been identified within 40m of the Scheme, existing A303 which is replaced by the Scheme, and the identified affected routes within the 1km study area.

9.6.22 Based on the façade with the worst case change in traffic noise levels from 2026 to 2041, noise levels at 48 of the 202 residential buildings are below the cut off of 58 dB $L_{A10,18h}$ in both 2026 and 2041, below which annoyance due to airborne vibration from road traffic is assumed to be zero. This therefore accounts for the 48 residential buildings identified in Table 9.12 as experiencing no change in annoyance due to airborne vibration. These buildings are located on affected routes within Amesbury with low traffic flows. All the remaining residential buildings experience a small increase in annoyance level due to the normal growth of traffic over time from 2026 to 2041.

Table 9.12: Long-term change in Do-Minimum traffic vibration annoyance (DM 2026 to DM 2041)

Change in % Annoyed		Daytime
		Number of residential buildings
Increase in annoyance level	<10%	154
	10 <20%	0
	20 <30%	0
	30 <40%	0
	≥40%	0
No change	0	48
Decrease in annoyance level	<10%	0
	10 <20%	0
	20 <30%	0
	30 <40%	0
	≥40%	0

9.6.23 Table 9.13 details the long term change in the Calculation of Road Traffic Noise (CRTN) Basic Noise Level (BNL) at the identified affected routes beyond the 1km maximum study area. The location of these roads is illustrated in Figure 9.2.

Table 9.13: Affected routes beyond 1km - change in traffic noise levels (DM 2026 to DM 2041)

Link Ref.	Description	No. receptors within 50m		BNL $L_{A10,18h}$ dB at 10m from the road		
		Residential	Non-residential	2026 DM	2041 DM	Change
62627_62643	A303/A36 junction, Deptford	0	0	64.3	63.8	-0.5
62625_62624	A303/A36 junction, Deptford	0	0	59.5	61.1	+1.6

Link Ref.	Description	No. receptors within 50m		BNL $L_{A10,18h}$ dB at 10m from the road		
		Residential	Non-residential	2026 DM	2041 DM	Change
62641_62636	A303/A36 junction, Deptford	2	0	59.2	60.8	+1.6
62636_62637	A303/A36 junction, Deptford	0	0	57.4	59.5	+2.1
62626_62636	A303/A36 junction, Deptford	0	0	63.4	64.6	+1.2
62626_62636	A303/A36 junction, Deptford	0	0	63.4	64.6	+1.2
62625_62633	A303/A36 junction, Deptford	0	0	61.4	62.4	+1.0
62626_62633	A303/A36 junction, Deptford	0	0	61.3	62.4	+1.1
9265_9412	Orchard End, Bulford	29	0	65.0	65.4	+0.4
9995_9996	Bulford Droveway, Bulford	2	0	63.4	63.6	+0.2
9284_65923	Bulford Road, Bulford	6	0	61.4	61.8	+0.4
75034_75035	The Packway, Larkhill	2	1	67.1	68.0	+0.9
9283_75034	The Packway, Larkhill	33	0	67.0	67.9	+0.9
9283_9426	The Packway, Larkhill	3	3	67.0	67.9	+0.9
9426_65870	The Packway, Larkhill	1	0	67.4	68.4	+1.0
65221C_65870	The Packway, Larkhill	0	0	66.8	67.9	+1.1
9285_75043	London Road, Shrewton	17	0	63.6	64.5	+0.9
9285_75042	London Road, Shrewton	29	0	63.6	64.5	+0.9
9360_9405	Elston Lane, Shrewton	24	0	58.7	60.0	+1.3
9360_9457	Elston Lane, Shrewton	12	0	58.7	60.0	+1.3
9404_75042	High Street, Shrewton	27	1	61.7	63.0	+1.3
9355_9404	High Street, Shrewton	13	1	61.9	62.9	+1.0
9355_9403	High Street, Shrewton	52	1	60.4	61.6	+1.2
9407_62753	A360 Maddington Street, Shrewton	33	1	67.1	68.0	+0.9
62756_62757	B390 Chitterne Road, Shrewton to Chitterne	0	0	60.7	62.4	+1.7
9335_62757	B390 Chitterne Road, Shrewton to Chitterne	4	0	67.9	68.9	+1.0
9335_9336	B390 Chitterne Road, Shrewton to Chitterne	0	0	67.8	68.8	+1.0
9336_9337	B390 Shrewton Road, Shrewton to Chitterne	0	0	67.8	68.8	+1.0

Link Ref.	Description	No. receptors within 50m		BNL $L_{A10,18h}$ dB at 10m from the road		
		Residential	Non-residential	2026 DM	2041 DM	Change
9337_75046	B390 Bidden Lane, Chitterne	36	0	65.1	66.2	+1.1
65265_75046	B390, Chitterne	6	0	66.2	67.2	+1.0
9252_65265	B390, Chitterne	17	0	65.9	66.9	+1.0
9252_75133	B390, Chitterne to A36 (Knook Camp)	1	0	65.9	66.9	+1.0
75053_75133	B390, Chitterne to A36 (Knook Camp)	3	0	68.9	69.8	+0.9
64913_75053	B390, Chitterne to A36 (Knook Camp)	13	0	66.3	67.3	+1.0
61445_64913	B390, Chitterne to A36 (Knook Camp)	0	0	64.3	65.4	+1.1

9.6.24 All except one of the identified affected routes are anticipated to experience a negligible increase in traffic noise levels from 2026 to 2041 in the absence of the Scheme. This is due to the normal growth of traffic over time. One link (62627_62643 at the A303/A36 junction) undergoes a negligible decrease from 2026 to 2041. Traffic flows on this link are low and although traffic flows do increase from 2026 to 2041 in line with the general growth in traffic over time, a slight reduction in the proportion of HGVs results in an overall negligible decrease.

9.7 Potential impacts

9.7.1 Mitigation measures which have been incorporated in the design and construction of the Scheme are set out in Section 9.8. Prior to implementation of such mitigation measures the Scheme has the potential to affect noise and vibration (positively or negatively), both during construction and once in operation, as described in the following sections.

Construction

9.7.2 The main construction activities that would take place are site clearance, earthworks, retaining wall construction and road construction (pavement) works, as well as the construction of bridges and the tunnel structure.

9.7.3 The construction of the Scheme has the potential to result in temporary noise impacts at the closest receptors to the works. The potential for temporary construction vibration impacts is dependent on the need for construction activities which are a potentially significant source of vibration, such as tunnelling and road construction (pavement) works using vibratory rollers / compactors.

9.7.4 The method of construction used for the tunnel would be a combination of techniques consisting of a Tunnel Boring Machine (TBM) and Slurry Treatment Plant (STP) for the soil recovery and separation process. Material excavated from the tunnel would be extracted at the western portal for both tunnel bores and transported to the STP within the Longbarrow compound by a pipe for treatment. Segments for the tunnel lining would be transported from the Segment Lining Production Plant (SLPP) at Longbarrow compound to the western tunnel portal by specialist Multi-Service Vehicles (MSV's) along the haul route. The exact method of construction used would be finalised once a contractor has been appointed.

9.7.5 Construction traffic can have a temporary impact on sensitive receptors located along existing roads used by these vehicles. The potential for such impacts is dependent on the volume and route of construction traffic. No planned diversions or night-time road closures are currently anticipated with the exception of very short periods to tie in the Scheme to the existing road. In addition, re-routing of existing traffic onto alternative roads during the construction works is also a potential source of temporary impacts.

Operation

9.7.6 The operation of the Scheme has the potential to result in both beneficial and adverse permanent traffic noise impacts. The Scheme moves the road closer to some receptors, and further away from others. The relocation of the road into a tunnel would significantly reduce operational traffic noise levels along the tunnelled section past Stonehenge.

9.7.7 The magnitude of the operational traffic noise impact at a receptor is dependent on a range of factors including the traffic flow, composition, speed, road surface, ground topography, the presence of intervening buildings/structures and the distance to the road. The alleviation of congestion on sections of the A303 in busy periods, resulting in an increase in traffic speeds and flows may result in increases in traffic noise levels during these periods.

9.7.8 Traffic noise reduction measures have been incorporated into the design of the Scheme by means of the vertical and horizontal alignment and through the proposed use of a thin surfacing system, which results in lower levels of noise generation than a standard hot rolled asphalt surface. The need for further measures, such as noise barriers, has been determined in conjunction with other environmental disciplines, to avoid secondary impacts (including, for example, upon landscape and visual and cultural heritage features).

9.7.9 No specific traffic noise assessments have been completed of the operation of the diversion route, for instances when the tunnel is closed, or the amended 'High Load' route. This is due to the very limited anticipated frequency of tunnel closure events and the very limited use of the High Load route as detailed in Chapter 2 section 2.3.

9.7.10 Plant associated with the operation of the tunnel, in particular the service buildings at each portal, is also a potential operational noise source.

9.8 Design, mitigation and enhancement measures

Construction

Embedded Mitigation

9.8.1 A Construction Environmental Management Plan (CEMP) would be prepared and implemented by the construction contractors. An Outline Environmental Management Plan (OEMP) has been prepared at this stage and included in the DCO application, see Appendix 2.2. The final CEMP would include relevant noise criteria, proposed surveys and a range of best practice measures associated with mitigating potential noise and vibration impacts - such measures include:

a) contractors to appoint a Community Relations Manager (CRM) responsible for leading engagement with affected communities;

b) selection of quiet and low vibration equipment and methodologies;

c) review of construction programme and methodology to consider low noise/low vibration methods (including non-vibratory compaction plant where required);

d) optimal location of equipment on site to minimise noise disturbance;

e) the provision of acoustic enclosures around static plant, where necessary;

f) use of less intrusive alarms, such as broadband vehicle reversing warnings;

g) compliance with standard working hours, as recommended by Wiltshire Council, as set out in section 2.4.8.

h) no start-up or shut down of vibratory plant e.g. rollers or compactors, within 50m of receptors.

9.8.2 The potential attenuation of noise from construction activities through the use of the localised use of temporary site hoardings or noise barriers has not been included in the assessment of construction noise in order to represent a worst-case scenario. BS 5228 advises that noise barriers can provide a reduction in noise levels of 5dB when the top of the plant is just visible over the noise barrier, and 10dB when the plant is completely screened from a receptor. The effectiveness of a noise barrier depends upon its length, effective height, position relative to the noise source and to the receptors, and the material from which it is constructed. Therefore the potential attenuation provided by any such barriers cannot be quantified at this stage.

9.8.3 Working hours would be restricted to Wiltshire Council's standard working hours of weekdays 07:30 – 18:00 and Saturday 07:30 - 13:00 at two locations. These are to the north of Winterbourne Stoke and north of Amesbury between Countess Roundabout and the eastern end of the Scheme, where the majority of sensitive receptors are located. This restriction would include the construction of the River Till bridge and the flyover at Countess Roundabout.

9.8.4 The core working hours for the rest of the Scheme are weekdays 07:00 – 19:00 and Saturday 07:00 – 13:00. Working during these slightly extended daytime hours would only be permitted outside of the two identified sensitive areas at Amesbury and Winterbourne Stoke.

9.8.5 Tunnelling works, once the TBM is launched, would be undertaken continuously 24 hours a day, 7 days a week. Work would take place inside the tunnel bores with some activities at the portals which are in deep cutting and screened from sensitive receptors. Works to support tunnelling activities outside of these areas, namely the Slurry Treatment Plant (STP) and Segment Lining Production Plant (SLPP) at Longbarrow Compound, and the delivery of segments, on the haul route between Longbarrow Compound and the western portal, have the potential to be undertaken on a 24 hour basis which would be determined by the contractor once appointed. The location of these works, including the compound, have been informed by the proximity of nearby receptors and are remote from nearby sensitive receptors.

9.8.6 There may be a requirement to undertake occasional works on evenings/ weekends/nights, such as to tie the Scheme into existing roads and bridge installations. This would be determined by the contractors once appointed and agreed with Wiltshire Council through the finalised CEMP (the current OEMP is provided in the DCO application).

9.8.7 During the Scheme construction phase appropriate mechanisms to communicate with local residents would be set up to highlight potential periods of disruption (e.g. web-based, newsletters, newspapers, radio announcements etc.). This would include the appointment of a Community Relations Manager (CRM) responsible for leading engagement with affected communities. An information web-page would be provided and kept up-to-date on the Highways England website to reflect construction and community liaison requirements. It is envisaged that the web-page would provide up-to-date information on the progress of the construction works, areas affected by construction, mitigation in place to reduce adverse effects, information regarding planned construction works (including any proposed works outside normal hours, diversion routes etc.) and works recently completed. The communication strategy would minimise the likelihood of complaints. Residents would be provided with a point of contact, the CRM, for any queries or complaints. In addition, the Highways England Customer Contact Centre (HECCC) would also be available to deal with queries from the public. This includes an information line staffed by Highways England 24/7. A complaint management system would be in place, in line with systems used by Highways England on other major infrastructure projects. Any noise and vibration complaints would be investigated and

appropriate action taken as required. The complainant would be provided with a response outlining the results of the investigation and any action taken.

Enhancement

9.8.8 Although not included in the assessment, where possible, material excavated from the Scheme and stockpiles would be placed so as to provide screening of noise from the works to nearby receptors during construction.

Surveys

9.8.9 Surveys would include physical measurements and observational checks/audits.

9.8.10 The contractors would undertake and report noise and vibration surveys as is necessary to ensure and demonstrate compliance with all noise and vibration commitments and the requirements of the final CEMP.

9.8.11 Regular onsite observation surveys and checks/audits would be undertaken to ensure that best practice Best Practicable Means (BPM) are being employed at all times. The site reviews would be logged and any remedial actions recorded. Such checks would include:

a) compliance with hours of working;

b) presence of mitigation measures e.g. engine doors closed, airlines not leaking and site hoarding in place;

c) compliance with agreed working methods; and

d) compliance with any specific requirements of the final CEMP.

9.8.12 The survey and compliance assurance process would be set out in the noise and vibration management plan(s), as part of the final CEMP.

9.8.13 As detailed in the OEMP proposals for all survey locations would be set out in the final CEMP. Vibration surveys would be undertaken at Stonehenge Cottages commencing when the TBM is approaching the cottages, as discussed in Section 9.9 of this chapter.

Operation

Embedded Mitigation

9.8.14 The Scheme would minimise operational noise and vibration impacts by:

a) selecting a route alignment which takes the road away from residential receptors in Winterbourne Stoke;

b) using a vertical alignment which uses a combination of natural landform and ‘false cuttings’ to integrate the Scheme into the landscape whilst at

the same time, enclosing traffic and reducing noise in adjacent areas. In particular 2m false cuttings to the north of Winterbourne Stoke.

c) setting the route within a tunnel and deep cutting within the WHS;

d) use of a noise absorbent finish at the entrance/exit of the tunnel and Green Bridge Four, further details are provided in Appendix 9.3;

e) maximising the use of earthworks at Countess flyover and minimising the extent of retaining walls;

f) the use of a thin surfacing system, which results in lower levels of noise generation than a standard hot rolled asphalt surface;

g) inclusion of 1.8m high absorptive noise barriers between the slip roads on both the north and south side of Countess flyover; and

h) inclusion of a 1.5m high solid parapet on the south side of the River Till viaduct.

Enhancement

9.8.15 The surface finish of the retaining walls at the approaches to the tunnel portals and at Countess flyover (above the earthworks) would be designed to reduce the reflection of noise.

9.9 Assessment of effects

Construction noise

9.9.1 Predicted noise levels during the construction phase have been calculated for each quarter between 2021 and 2026 which is when activities have the potential to result in noise impacts.

9.9.2 Predicted noise levels are for the core working hours for the Scheme (weekdays 07:00 – 19:00 and Saturday 07:00 – 13:00). However, as detailed in section 9.8, working hours would be restricted to the slightly shorter Wiltshire Council's standard working hours of weekdays 07:30 – 18:00 and Saturday 07:30 - 13:00 during works in the vicinity of Amesbury and Winterbourne Stoke.

9.9.3 Tunnelling works, once commenced, would be undertaken continuously 24 hours a day, 7 days a week. Work would take place inside the tunnel bores with some activities at the portals which are in deep cutting. Given the separation distance between the tunnel portal and the closest receptors, over 500m, the potential for night-time impacts from tunnelling works directly has not been considered further. Works to support tunnelling activities outside of these areas, namely the Slurry Treatment Plant (STP) and Segment Lining Production Plant (SLPP) at Longbarrow compound, and the delivery of segments on the haul route between Longbarrow compound and the western portal, have the potential to be undertaken on a 24 hour basis. Therefore, an assessment of

potential night time noise impacts from these activities has been carried out at the closest residential receptor, C17 (Hill Farm Cottages).

9.9.4 The predicted noise levels at each receptor for each quarter during the construction phase are shown in Appendix 9.2. Receptor locations are marked on Figure 9.1. The range of predicted construction noise levels in each quarter, and whether the LOAEL and/or SOAEL are predicted to be exceeded, is summarised in Table 9.14. The predicted noise levels shown are worst-case based on all plant working and represent the highest noise level from construction activities during each quarter. As detailed in section 9.3, to define the SOAEL and LOAEL ambient noise levels at the relevant façade of each of the selected receptors has been determined based on predicted 2017 baseline traffic noise levels.

Table 9.14: Summary of predicted construction noise levels

Receptor ID	Daytime Criteria dB $L_{Aeq,}$		Predicted Range of Construction Noise dB, L_{Aeq}		Exceeds SOAEL	Exceeds LOAEL
	SOAEL	LOAEL	Min	Max		
C1 - Ratfyn Farm Bungalows	65	60	45	54	No	No
C2 - Ratfyn Farm	65	56	48	63	No	**Yes**
C3 - Lindisfarne	70	64	50	60	No	No
C4 - Travelodge (SE façade)	70	65	52	77	**Yes**	**Yes**
C5 - Travelodge (NW façade)	65	60	61	67	**Yes**	**Yes**
C6 - 22 Countess Rd	65	55	53	67	**Yes**	**Yes**
C7 - 5 Tollgate Close	65	53	40	67	**Yes**	**Yes**
C8 - Countess Farm	65	62	46	69	**Yes**	**Yes**
C9 - 7 Lords Croft	65	59	50	70	**Yes**	**Yes**
C10 - Diana's House	70	65	47	73	**Yes**	**Yes**
C11 - Bowles Hatches	65	62	46	67	**Yes**	**Yes**
C12 - Park Farm Cottages	65	50	36	60	No	**Yes**
C13 - Stonehenge Cottages	65	56	38	59	No	**Yes**
C14 - Stonehenge	65	55	40	53	No	No
C15 - Stonehenge Visitors Centre	65	49	49	55	No	**Yes**
C16 - Rollestone Crossroads	70	63	N/A [1]	75	**Yes**	**Yes**
C17 - Hill Farm Cottages	65	56	47	65	No	**Yes**

Receptor ID	Daytime Criteria dB $L_{Aeq,}$		Predicted Range of Construction Noise dB, L_{Aeq}		Exceeds SOAEL	Exceeds LOAEL
	SOAEL	LOAEL	Min	Max		
C18 - Foredown House	65	49	41	72	**Yes**	**Yes**
C19 - Richmond Fellowship, Cherry Lodge	65	45	20	65	No	**Yes**

[1]*Works at C16 (Rollestone Crossroads) are expected to last for a period of less than one quarter and therefore predicted noise levels have only been calculated for one quarter period*

9.9.5 The main noise generating activities are programmed at the start of the construction period (2021 Q3 to 2023 Q3) and during these works the SOAEL is predicted to be exceeded at a number of receptors for short-durations. The predicted noise levels represent the highest that would be expected during each quarter period. The nature of the construction phase means that the worst-case situation predicted may exist only for a matter of days, or even hours. There would be regular periods within each quarter, even during the course of a single day, when the assumed plant would not be in operation, for example during breaks or changes in the working routine.

9.9.6 At receptors in the vicinity of works at Countess Roundabout (C4 - C11), the daytime SOAEL is predicted to be exceeded at times during construction of the bridge and flyover. The SOAEL is predicted to be exceeded by 2-7dB at these locations.

9.9.7 Construction noise levels at the Travelodge hotel to the north of Countess Roundabout (C4 and C5) are predicted to exceed the daytime SOAEL during construction of the bridge and flyover. As these are daytime noise levels, and no routine night-time works would take place at this location, the impact on the receptors (as a hotel) is not considered significant.

9.9.8 At the very closest receptors to Countess C8, C9 and C10, the SOAEL is predicted to be exceeded, for short durations, during consecutive quarters during the early years of the construction works. There is a risk of levels above the SOAEL occurring for more than 10 days in 15, or 40 days in 6 months, and therefore the adverse construction noise effect is classed as significant at these receptors.

9.9.9 At receptors C6, C7 and C11, which are further from the works, the SOAEL is estimated to be exceeded during only one or two quarters, therefore the risk of levels above the SOAEL occurring for more than 10 days in 15, or 40 days in 6 months is reduced and a significant adverse construction noise effect has not been identified.

9.9.10 The exact timing of works at Rollestone crossroads is not known at this stage, but is likely to take place at the start of the construction period during enabling

works. One receptor, C16, is located close to the junction works and therefore construction noise levels are predicted to exceed the SOAEL during the junction improvement works at this location. The duration of these works would be limited and the worst-case noise level predicted is unlikely to be exceeded for more than a few days. On this basis a significant adverse construction noise effect has not been identified.

9.9.11 At the closest receptor to the new River Till crossing (C18) the SOAEL is predicted to be exceeded during construction of the bridge and installation of the deck. The SOAEL is predicted to be exceeded, for short durations, during consecutive quarters during the early years of the construction works. There is a risk of levels above the SOAEL occurring for more than 10 days in 15, or 40 days in 6 months, and therefore the adverse construction noise effect is classed as significant at this receptor.

9.9.12 Activities to support tunnelling, namely the STP, SLPP and the delivery of segments, have the potential to be undertaken on a 24 hour basis. The need for works would be determined by the contractor once appointed. Therefore an assessment of night-time noise from these activities has been undertaken at the closest receptor to these works; Hill Farm Cottages (C17). The predicted night-time noise level is equal to the LOAEL of 50 dB L_{Aeq} at this location and therefore the impact is not considered to result in a significant adverse effect. The predicted night-time noise level and relevant LOAEL and SOAEL for this receptor are detailed in Appendix 9.2.

9.9.13 A summary of the identified significant noise effects during construction is provided in Table 9.25.

Construction vibration

9.9.14 The activities likely to generate potentially significant vibration levels during construction are tunnelling, and road construction (pavement) or other works using vibratory rollers or compactors. The method of pilling used during the construction phase would be continuous flight auger (CFA) or cast in-situ piles, including the concrete casing for the piles. Levels of vibration associated with this technique are minimal and therefore this has not been considered further.

9.9.15 Vibration levels have been calculated in accordance with the procedures set out in BS 5228-2 Table E.1. Source data for pavement works, namely vibratory rollers and compactors have been taken from TRL Report 429 ‘Groundborne vibration caused by mechanised construction works’ (Ref 9.15).

9.9.16 Predicted maximum PPV levels for receptors within 100m of tunnelling and/or pavement works are shown in Table 9.15. The exact depth of the tunnel would be determined at the detailed design stage; however, to ensure a worst case approach, the minimum depth within the design parameters has been used. The actual tunnel depth is therefore likely to be slightly greater than assumed in this assessment resulting in slightly lower vibration levels.

Table 9.15: Predicted maximum PPV levels from tunnelling and pavement works for receptors within 100m

Receptor	Maximum PPV mms^{-1}		
	Tunnelling	Pavement works – steady state operation	Pavement works – start up + rundown[3]
C6 - 22 Countess Road	-	0.13	0.25
C8 - Countess Farm	-	0.41	0.68
C10 - Diana's House	-	0.47	0.77
C11 - Bowles Hatches	-	0.24	0.43
C14 - Stonehenge[1]	0.16	-	-
C13 - Stonehenge Cottages[2]	2.00	-	-
C16 - Rollestone Crossroads	-	0.98	0.77

[1]Stonehenge is more than 100m from any construction activities but has been included as a receptor for tunnelling works due to the high level of interest in the impacts at the stones. The closest pavement works are over 1km away

[2]Pavememt works outside the tunnel over 100m from receptor

[3]Assumes minimum separation distance of 50m between receptor and plant during start up and rundown

9.9.17 For human receptors the LOAEL is defined as a PPV of 0.3mms^{-1}, this being the point at which construction vibration is likely to become perceptible. The SOAEL is defined as a PPV of 1.0mms^{-1}, this being the level at which construction vibration can be tolerated with prior warning.

9.9.18 The SOAEL is not exceeded at any receptors during start-up and run-down of vibratory plant, assuming a minimum 50m separation distance is used. The predicted maximum PPV is between the LOAEL and SOAEL at four receptors. These receptors are closest to pavement works at Countess Roundabout and Rollestone Cross junction. No significant adverse construction vibration effects are anticipated due to start up and shut down of vibratory plant.

9.9.19 The predicted maximum PPV is between the LOAEL and SOAEL at the two closest receptors to Countess Roundabout (C8 and C10) and the single receptor at Rollestone Cross (C16) during pavement works when plant is being operated in it's steady-state. No significant adverse construction vibration effects are anticipated due to the steady state operation of vibratory plant.

9.9.20 Stonehenge Cottages are located above the tunnel which would be at a minimum depth of approximately 32m at this point. The SOAEL is predicted to be exceeded at this location when the TBM is within 55m of this receptor. It is anticipated that tunnelling activities within this distance from the receptor would occur for approximately 14 days, comprising 7 days during the excavation of the eastbound tunnel and 7 days for the westbound tunnel. There would be a period of several months between the eastbound and westbound tunnelling works at this location and therefore the SOAEL threshold would not be exceeded for 10

or more days (or nights) in any 15, or for more than 40 days (or nights) in any six month period. On this basis a significant adverse effect has not been identified. However, as detailed in the OEMP vibration surveys would be undertaken at Stonehenge Cottages commencing when the TBM is approaching the cottages to verify the predictions.

9.9.21 During tunnelling the maximum PPV from construction works is significantly below the LOAEL for annoyance at Stonehenge. At levels below the LOAEL, vibration is not generally considered perceptible.

9.9.22 With regards to structural damage, even at the closest receptor (Stonehenge Cottages) the predicted construction vibration levels are considerably below the lowest criteria of $6mms^{-1}$ for the onset of cosmetic building damage.

9.9.23 The potential for combined effects from noise and vibration during construction works resulting in additional significant effects, is not considered likely. No significant adverse effects are predicted for both construction noise and vibration at individual receptors. A small number of receptors (C11 and C16) are predicted to exceed the SOAEL for construction noise for a short duration, and also experience vibration levels between the LOAEL and SOAEL for pavement works at the closest approach. Based on the magnitude of the predicted levels and the short duration of the likely impacts an additional significant combined effect is not predicted. Only one location is predicted to exceed the SOAEL for vibration, Stonehenge Cottages, but only for a limited period. Due to the large separation distance between surface construction works and this receptor (over 500m), a significant combined effect from construction noise and vibration is not considered likely.

Construction traffic

9.9.24 During construction, additional traffic would be generated by the construction works directly and re-routing of existing traffic around the works would also occur. Both of these can result in changes in traffic flows, and therefore traffic noise levels, along existing roads. The impacts in Phase 1 (2021-2023) are generally predicted to be slightly greater than Phase 2 (2024-2026) as the main elements of the Scheme (Winterbourne Stoke bypass, Longbarrow Interchange and Countess flyover) would be operational in Phase 2, resulting in less re-routing, as only the tunnel would remain to be constructed in Phase 2.

9.9.25 Moderate or major increases in traffic noise due to the addition of construction traffic or re-routing due to the works, resulting in significant adverse effects, have not been identified on any existing roads. Minor increases are anticipated on the B390 to the north of the Scheme between the A36 and Shrewton due to existing traffic re-routing away from the works. Minor increases are also identified on short sections of road to the north of Salisbury. Based on the magnitude of the anticipated change and the temporary nature of the impact these are not classed as significant effects.

9.9.26 Along the A303 itself speed limits of 30 to 50mph are proposed during construction at various times and locations, resulting in some localised reductions in traffic noise levels where the existing speed limit is higher.

9.9.27 The operational significant traffic noise effect at Church Street and High Street, Amesbury, identified in the next section, due to the closure of the existing Stonehenge Road access onto the A303 west of Amesbury, would occur throughout the construction works, as this permanent road closure would be implemented at the start of the works. Similarly, the operational significant traffic noise effect at Foredown House north of Winterbourne Stoke, identified in the next section, due to the operation of the Winterbourne Stoke bypass, would occur from the start of phase 2 of the construction works when the permanent operation of the bypass would begin.

Operation – environmental impact assessment

Operational Traffic Noise Changes

9.9.28 All the operational traffic noise comparisons are based on the façade at each building which undergoes the least beneficial change in traffic noise level. The results are provided for the top floor of each building, for example, 1.5m for a one storey house, 4m for a two storey house. Further details of the noise model set-up and assumptions are provided in Appendix 9.3.

9.9.29 All the noise difference contour plots (Figure 9.4 and Figure 9.5) are based on free-field traffic noise levels at first floor level (4m above ground) using a 10m x 10m grid and are provided for illustration purposes. For information the maps extend to cover the maximum 1km study area.

9.9.30 Table 9.16 summarises the short-term change in predicted traffic noise levels in 2026 between the Do-Minimum and Do-Something scenarios at both residential buildings and other sensitive receptors within the 600m study area. The short term traffic noise changes from Do-Minimum 2026 to Do-Something 2026 are presented as a noise difference contour plot in Figure 9.4.

Table 9.16: Short-term change in predicted Do-Something traffic noise levels (DM 2026 to DS 2026)

Change in noise level		Daytime	
		Number of residential buildings	Number of other sensitive receptors
Increase in noise level Daytime $L_{A10,18h}$ dB Night-time $L_{night,outside}$ dB	0.1 - 0.9	1499	13
	1.0 - 2.9	60	4
	3.0 - 4.9	17	2
	≥5	5	0
No change	0	55	0

Change in noise level		Daytime	
		Number of residential buildings	Number of other sensitive receptors
Decrease in noise level Daytime $L_{A10,18h}$ dB Night-time $L_{night,outside}$ dB	0.1 - 0.9	50	1
	1.0 - 2.9	41	1
	3.0 - 4.9	14	0
	≥5	36	0

9.9.31 An estimated total of 1,777 residential buildings are located within the 600m noise prediction study area, see Figure 9.1. However, only 252 buildings meet the DMRB criterion of 55 dB $L_{night,outside}$ at one or more façades in one or more scenarios for inclusion in the night-time traffic noise assessment.

9.9.32 A total of 21 non-residential sensitive buildings are located within the 600m noise prediction study area, consisting of six educational buildings (schools and nurseries in Amesbury), three medical buildings (medical centres and an ambulance centre in Amesbury), six community facilities (social clubs, leisure centre and library in Amesbury, and the Stonehenge visitor centre) four places of worship (three in Amesbury and one in Winterbourne Stoke) and two hotels with no residential accommodation (Travelodge and Holiday Inn, Amesbury) as shown on Figure 9.1.

9.9.33 In the opening year of 2026 five residential buildings are anticipated to experience a major (≥5 dB) increase in traffic noise. These are Foredown House on the northern edge of Winterbourne Stoke and four buildings on High Street in the centre of Amesbury. A further 17 residential buildings and two community facilities (Dunkirk Social Club and the Methodist Church) on Church Street/High Street are anticipated to experience a moderate increase (3.0 - 4.9 dB) at the closest facades to the road. These impacts at Foredown House and on Church Street and High Street are classed as a significant adverse effect.

9.9.34 The major increase in traffic noise at Foredown House is limited to the northern façade facing the bypass. The southern façade of the house facing the existing A303 experiences a major reduction in traffic noise. Absolute traffic noise levels at the building are low in the 50 to 55 dB $L_{A10,18h}$ range with and without the Scheme.

9.9.35 The impacts on Church Street/High Street in Amesbury are due to the closure of the existing access onto the A303 via Stonehenge Road, which occurs at the start of construction. This results in traffic from the South West in the Woodford Valley, which currently uses this access, rerouting via Church Street and High Street to the A345 to join the A303 at Countess Roundabout. Traffic originating on Stonehenge Road and Church Street, which currently accesses the A303 via Stonehenge Road, must also reroute to Countess. High Street is one way (northbound) and therefore traffic originating on High Street would continue to access the A303 via the A345 and Countess Roundabout as existing.

9.9.36 Traffic flows on Church Street/High Street are very low both with and without the Scheme. The greatest change is towards the north end of High Street where 18 hour weekday flows are just over 1000 in the 2026 Do-Minimum scenario rising to just under 1800 in the 2026 Do-Something scenario. The 'low flow' correction in the CRTN traffic noise prediction methodology amplifies the resulting magnitude of the noise change in such small flows, which combined with the slight increase in the percentage of HDVs and the very close proximity of the receptors to the road, results in a significant adverse effect.

9.9.37 The absolute traffic noise levels in this area are not unusual, in the 2026 Do-Minimum scenario traffic noise levels at the closest facades to the road are generally in the high 50 to low 60 $L_{A10,18h}$ dB range. Rising to the low 60 to mid 60 dB range in the 2026 Do-Something scenario.

9.9.38 There is the potential for other noise sources associated with a High Street type environment such as shoppers, deliveries, pubs etc. to contribute to the overall ambient noise level, which would reduce the impact of the change in traffic noise levels. Some of the buildings on Church Street/High Street identified in the OS address base dataset as residential contain a mixture of uses e.g. pubs, hotels and shops. As a worst case approach the residential use is assumed to correspond to the façade experiencing the moderate/major increase in traffic noise.

9.9.39 At 50 residential buildings located in Winterbourne Stoke, Stonehenge Cottages and the northern end of Stonehenge Road, a moderate or major reduction in traffic noise levels is anticipated in the opening year. This is due to the bypass to the north of Winterbourne Stoke, the tunnelled section of the A303 and the closure of the Stonehenge Road access. This impact is classed as a significant beneficial effect. A major reduction in operational traffic noise is anticipated at Stonehenge.

9.9.40 At all other residential and non-residential sensitive buildings the impact of the Scheme in the opening year is minor, negligible or no change. This effect is classed as not significant. The majority of these remaining receptors experience a negligible increase due to the tendency for the Scheme to result in a slight increase in traffic flows through Amesbury.

9.9.41 At Countess Junction, in the absence of noise barriers, an overall increase in traffic noise levels is anticipated. The inclusion of noise barriers on both sides of the mainline flyover between the slip roads reduces the magnitude of the increase to negligible at the majority of the closest receptors.

9.9.42 The implementation of the Scheme would mitigate the two Noise Important Areas on the existing A303 in Winterbourne Stoke due to the major reduction in traffic noise levels through the centre of the village with the bypass in operation. The three Noise Important Areas on the A345 in Amesbury would experience a negligible change in traffic noise levels with the Scheme in operation.

9.9.43 Table 9.17 summarises the long-term change between the 2026 Do-Minimum and 2041 Do-Something scenarios. The long term traffic noise changes from Do-Minimum 2026 to Do-Something 2041 are presented as a noise difference contour plot in Figure 9.5.

Table 9.17: Long-term change in predicted Do-Something traffic noise levels (DM 2026 to DS 2041)

Change in noise level		Daytime		Night-time
		Number of residential buildings	Number of other sensitive receptors	Number of residential buildings
Increase in noise level Daytime $L_{A10,18h}$ dB Night-time $L_{night,outside}$ dB	0.1 - 2.9	1622	17	217
	3.0 - 4.9	13	3	0
	5.0 - 9.9	13	0	0
	≥10	0	0	0
No change	0	2	0	0
Decrease in noise level Daytime $L_{A10,18h}$ dB Night-time $L_{night,outside}$ dB	0.1 - 2.9	82	1	12
	3.0 - 4.9	14	0	5
	5.0 - 9.9	29	0	17
	≥10	2	0	1

9.9.44 In the long term (2026 Do-Minimum to 2041 Do-Something) the same general pattern of change is observed as in the short term. At night in the long term, traffic noise levels at Foredown House and on Church Street/High Street are below the $L_{night,outside}$ threshold of 55 dB therefore no moderate or major increases are reported. The moderate and major reductions in the long term at night are in Winterbourne Stoke and Stonehenge Cottages.

9.9.45 Table 9.18 outlines the worst case change in annoyance due to the Scheme. With regards to annoyance, the 22 residential buildings identified as experiencing the greatest change in annoyance correspond to the 22 buildings on Church Street/High Street and Foredown House identified as experiencing a significant adverse effect. The majority of receptors experience a slight increase in annoyance. A 0.1 dB increase in noise equates to 9.8% increase in annoyance in the short term.

Table 9.18: Worst case change in traffic noise annoyance

Change in % Annoyed		Daytime
		Number of Residential Buildings
Increase in annoyance level	<10%	430
	10 <20%	1123
	20 <30%	75
	30 <40%	22
	≥40%	0
No change	0	6
Decrease in annoyance level	<10%	120
	10 <20%	1
	20 <30%	0
	30 <40%	0
	≥40%	0

Operational Traffic Noise – Above SOAEL

9.9.46 Table 9.19 details the number of residential buildings in the 600m study area which would have one or more facades above the daytime or night-time SOAEL for the four assessment scenarios.

9.9.47 The Scheme would result in an overall reduction in the number of residential buildings with one or more façade experiencing traffic noise levels above the SOAEL. This is due to the bypass of Winterbourne Stoke and the tunnelled section past Stonehenge Cottages. No residential building in the vicinity of the Scheme which experiences noise levels above the SOAEL experiences an increase of 1dB or more in the short term.

Table 9.19: Number of residential buildings above the SOAEL

Scenario	Day	Night
2026 DM	184	237
2041 DM	198	248
2026 DS	161	207
2041 DS	171	217

9.9.48 The majority of residential buildings which remain above the SOAEL are in close proximity to main roads within Amesbury such as the A345, which experience only a negligible change in traffic noise levels due to the Scheme.

Operational Traffic Noise – Noise Insulation Regulations

9.9.49 A preliminary consideration of properties which may qualify for noise insulation works under the Regulations has identified a single property – Lindisfarne at the northern end of Ratfyn Road. The property is close to the A303 at the very eastern end of the main scheme extent, though at a considerably higher ground level than the road. Based on the preliminary assessment the Noise Insulation Regulations criteria are just exceeded. A complete Noise Insulation Regulations assessment would be completed at a later stage of the project when the Scheme design is finalised and in accordance with the timescales set out in the Regulations. The magnitude of the change in traffic noise levels at this property are negligible in both the short and long term.

Operational Traffic Noise – Designated Sites

9.9.50 The traffic noise modelling area covers approximately 75% of the Parsonage Down SSSI. The south east corner of Parsonage Down SSSI is a minimum of 50m from the bypass around Winterbourne Stoke, though the Scheme is in a deep cutting at this location. As illustrated on Figure 9.4 the magnitude of the change in traffic noise levels in the opening year at the closest approach of the SSSI to the bypass is major or moderate for a very small area, less than 2% of the area of the SSSI which falls within the noise modelling study area, reducing to minor and negligible with increasing distance from the bypass. The majority of the site experiences a negligible change. Table 9.20 details the percentage of the area of the SSSI within the noise modelling area which falls below the daytime LOAEL, between the LOAEL and the SOAEL and above the SOAEL, as defined in Table 9.8 with regard to impacts on human receptors.

Table 9.20: Percentage of area of the Parsonage Down SSSI within the noise modelling area

Daytime traffic noise levels $L_{Aeq,16h}$ dB (free-field)	Scenario % of area			
	2026 DM	2041 DM	2026 DS	2041 DS
Below LOAEL (50 dB)	100	100	99	98
Between LOAEL and SOAEL (50 to 63 dB)	0	0	1	2
Above SOAEL (63 dB)	0	0	0	0

9.9.51 As would be expected the proximity of the bypass to the south east corner of the SSSI results in a small percentage of the area increasing to above the LOAEL with the Scheme in operation. Further details on the impact of the Scheme on biodiversity features are provided in Chapter 8 Biodiversity.

9.9.52 The traffic noise modelling area covers approximately 50% of the WHS. Table 9.21 details the percentage of the area of the WHS within the noise modelling area which falls below the daytime LOAEL, between the LOAEL and the SOAEL and above the SOAEL, as defined in Table 9.7.

Table 9.21: Percentage of area of the WHS within the noise modelling area

Daytime traffic noise levels $L_{Aeq,16h}$ dB (free-field)	Scenario % of area			
	2026 DM	2041 DM	2026 DS	2041 DS
Below LOAEL (50 dB)	60	56	85	83
Between LOAEL and SOAEL (50 to 63 dB)	35	38	13	15
Above SOAEL (63 dB)	5	6	2	2

9.9.53 As would be expected the tunnelled section of the Scheme and the deep cuttings at the tunnel approaches reduces the area of the WHS experiencing the higher noise levels. As illustrated on Figure 9.4 a major reduction in traffic noise level is predicted along the tunnelled section of the Scheme, including at Stonehenge. Outside of the tunnelled section decreases in traffic noise levels occur on the existing A303 alignment and increases on the new alignment.

9.9.54 Further details on the impact of the Scheme on all cultural heritage receptors are provided in Chapter 6 Cultural Heritage.

Operational Traffic Vibration

9.9.55 A summary of the long term change in annoyance due to airborne vibration from road traffic due to the Scheme is provided in Table 9.22. A total of 202 residential buildings have been identified within 40m of the Scheme, existing A303 which is replaced by the Scheme, and the identified affected routes within the 1km study area.

Table 9.22: Long-term change in Do-Something traffic vibration annoyance (DM 2026 to DS 2041)

Change in % Annoyed		Daytime
		Number of residential buildings
Increase in annoyance level	<10%	65
	10 <20%	0
	20 <30%	0
	30 <40%	0
	≥40%	0
No change	0	127
Decrease in annoyance level	<10%	10
	10 <20%	0
	20 <30%	0
	30 <40%	0
	≥40%	0

9.9.56 Based on the façade with the worst case change in traffic noise levels from 2026 Do-Minimum to 2041 Do-Something, noise levels at 127 of the 202 residential buildings are below the cut off of 58 dB $L_{A10,18h}$, below which annoyance due to airborne vibration from road traffic is assumed to be zero, in both scenarios. This therefore accounts for the 127 residential buildings identified in Table 9.22 as experiencing no change in annoyance due to airborne vibration. The majority of the remaining residential buildings experience a small increase in annoyance level. This is due to a combination of the normal growth of traffic over time from 2026 to 2041 and the rerouting of traffic within Amesbury due to the closure of the Stonehenge Road access onto the A303. 10 residential buildings in Winterbourne Stoke, Stonehenge Cottages and Rollestone Crossroads experience a small decrease in annoyance based on the worst affected facade. The effect of the Scheme on operational airborne vibration impacts is classed as not significant.

Operational Traffic Noise – Affected routes

9.9.57 Table 9.23 details the short term (ST) and long term (LT) change in the Calculation of Road Traffic Noise (CRTN) Basic Noise Level (BNL) at the identified affected routes beyond the 1km wider study area due to the Scheme. The location of these roads is illustrated in Figure 9.2.

Table 9.23: Affected routes beyond 1km - Change in traffic noise levels

Link Ref.	Description	No. receptors within 50m		BNL $L_{A10,18h}$ dB at 10m from the road			
		Residential	Non-residential	2026 DS	2041 DS	ST Change	LT Change
62627_62643	A303/A36 junction, Deptford	0	0	65.4	66.1	+1.1	+1.8
62625_62624	A303/A36 junction, Deptford	0	0	58.1	58.0	-1.4	-1.5
62641_62636	A303/A36 junction, Deptford	2	0	57.8	57.6	-1.4	-1.6
62636_62637	A303/A36 junction, Deptford	0	0	63.6	64.6	+6.2	+7.2
62626_62636	A303/A36 junction, Deptford	0	0	65.6	66.2	+2.2	+2.8
62626_62636	A303/A36 junction, Deptford	0	0	65.6	66.2	+2.2	+2.8
62625_62633	A303/A36 junction, Deptford	0	0	60.4	60.7	-1.0	-0.7
62626_62633	A303/A36 junction, Deptford	0	0	60.3	60.1	-1.0	-1.2
9265_9412	Orchard End, Bulford	29	0	63.9	64.0	-1.1	-1.0
9995_9996	Bulford Droveway, Bulford	2	0	62.4	62.6	-1.0	-0.8

Link Ref.	Description	No. receptors within 50m		BNL $L_{A10,18h}$ dB at 10m from the road			
		Residential	Non-residential	2026 DS	2041 DS	ST Change	LT Change
9284_65923	Bulford Road, Bulford	6	0	60.1	60.3	-1.3	-1.1
75034_75035	The Packway, Larkhill	2	1	65.4	65.7	-1.7	-1.4
9283_75034	The Packway, Larkhill	33	0	65.1	65.5	-1.9	-1.5
9283_9426	The Packway, Larkhill	3	3	65.1	65.5	-1.9	-1.5
9426_65870	The Packway, Larkhill	1	0	65.6	66.0	-1.8	-1.4
65221C_65870	The Packway, Larkhill	0	0	64.5	65.0	-2.3	-1.8
9285_75043	London Road, Shrewton	17	0	62.2	62.7	-1.4	-0.9
9285_75042	London Road, Shrewton	29	0	62.2	62.7	-1.4	-0.9
9360_9405	Elston Lane, Shrewton	24	0	57.4	58.3	-1.3	-0.4
9360_9457	Elston Lane, Shrewton	12	0	57.4	58.3	-1.3	-0.4
9404_75042	High Street, Shrewton	27	1	60.0	60.8	-1.7	-0.9
9355_9404	High Street, Shrewton	13	1	60.5	61.1	-1.4	-0.8
9355_9403	High Street, Shrewton	52	1	58.8	59.5	-1.6	-0.9
9407_62753	A360 Maddington Street, Shrewton	33	1	66.0	66.7	-1.1	-0.4
62756_62757	B390 Chitterne Road, Shrewton to Chitterne	0	0	58.6	59.3	-2.1	-1.4
9335_62757	B390 Chitterne Road, Shrewton to Chitterne	4	0	64.7	65.5	-3.2	-2.4
9335_9336	B390 Chitterne Road, Shrewton to Chitterne	0	0	64.5	65.2	-3.3	-2.6
9336_9337	B390 Shrewton Road, Shrewton to Chitterne	0	0	64.3	65.1	-3.5	-2.7
9337_75046	B390 Bidden Lane, Chitterne	36	0	61.8	62.6	-3.3	-2.5
65265_75046	B390, Chitterne	6	0	64.2	65.0	-2.0	-1.2
9252_65265	B390, Chitterne	17	0	63.6	64.5	-2.3	-1.4
9252_75133	B390, Chitterne to A36 (Knook Camp)	1	0	63.6	64.5	-2.3	-1.4
75053_75133	B390, Chitterne to A36 (Knook Camp)	3	0	66.6	67.6	-2.3	-1.3
64913_75053	B390, Chitterne to A36 (Knook Camp)	13	0	64.2	65.0	-2.1	-1.3
61445_64913	B390, Chitterne to A36 (Knook Camp)	0	0	61.9	62.3	-2.4	-2.0

9.9.58 As illustrated on Figure 9.2 the vast majority of affected routes beyond the 1km study area are anticipated to experience a decrease in traffic noise levels, including east west routes to the north of the Scheme through Chitterne, Shrewton, and Larkhill.

9.9.59 The only increases in traffic noise on affected routes are located at the slip roads of the A36/A303 junction at Deptford. The changes in traffic flows at this junction are due to more traffic using the main routes (A303 and A36) with the Scheme in operation, rather than using more minor side roads. Do-Minimum and Do-Something traffic flows on these slip roads are low and no sensitive receptors have been identified within 50m. Overall ambient noise levels in this area would be dominated by the mainline of the A36 and A303, not the slip roads. Adverse effects along affected routes beyond the 1km study area have therefore been classed as not significant.

9.9.60 The magnitude of the beneficial impact of the Scheme on affected routes reaches moderate in the short term on the section of the B390 between Chitterne and Shrewton, a total of 40 residential buildings have been identified within 50m of this section, mainly in Chitterne. This impact is classed as a significant beneficial effect.

Operational Traffic Noise - Consideration of 'Busy' periods

9.9.61 In the Do-Minimum scenario during 'busy' periods, in general more traffic uses the minor roads to the north through Larkhill, Shrewton and Chitterne as traffic avoids the A303 past Stonehenge. With the Scheme in operation this traffic remains on the A303. Therefore, the benefit of the Scheme on the minor roads to the north currently used as an alternative to the A303 is generally slightly greater in busy periods.

9.9.62 On the A303, in particular at Countess and past Stonehenge, in the Do-Minimum 'busy' scenario traffic noise levels are generally lower compared to the annual average weekday situation due to a number of factors including, lower speeds due to congestion, lower flows as the capacity is reduced by the congestion, and lower percentages of HDVs at the weekend. The magnitude of the adverse impact of the Scheme in the vicinity of Countess is therefore slightly larger in busy periods, as Do-Minimum noise levels are reduced. Conversely, the magnitude of the adverse impact on Church Street/High Street is slightly reduced as Do-Minimum traffic flows on these roads are higher in busy periods.

Summary of Operational Traffic Environmental Effects

9.9.63 A summary of the identified traffic noise environmental effects, including a summary of the justification for the significance conclusion is provided in Table 9.24.

Table 9.24: Summary of operational traffic environmental effects

Receptor	Magnitude of Impact in short term	Significance	Justification
Foredown House, Winterbourne Stoke	Major Increase	Significant adverse	Major increase in traffic noise at north façade facing bypass. Though noted major decrease at south façade and levels low, around the LOAEL. Road elevated on embankment (in false cutting) and viaduct introduces new physical features into the landscape and a new noise source from a new direction. Potential to change residents response to traffic noise
21 residential buildings and two community facilities on Church Street/High Street, Amesbury	Moderate/ Major Increase	Significant adverse	Major and moderate increases at closest facades to Church St/High St due to closure of Stonehenge Road access onto A303. Though noted absolute traffic flows and change in traffic flows low, impact amplified due to nature of the CRTN low flow correction procedure. Potential to change residents and users of the facilities response to traffic noise
50 residential buildings in Winterbourne Stoke, Stonehenge Cottages and north end of Stonehenge Road	Moderate/ Major Decrease	Significant beneficial	Major and moderate decreases due to bypass of Winterbourne Stoke, tunnelled section of A303 and closure of Stonehenge Road access to A303. Levels reduced from above to below SOAEL at some buildings. Potential to change residents response to traffic noise.
60 residential buildings in Amesbury mainly along Stonehenge Road, Church Street/High Street and Amesbury Abbey area near Countess flyover, plus 4 non-residential receptors in Amesbury	Minor Increase	Not significant	Minor increase in road traffic noise. Levels below SOAEL. Countess flyover introduces a new feature in the landscape in this area, however, magnitude of impact and number of minor increases in vicinity of Countess reduced considerably by noise barriers on the flyover. Unlikely to change residents and users of the non-residential receptors response to traffic noise
Remainder of receptors in study area, including majority of residential buildings and non-residential receptors in Amesbury	Minor decrease/ Negligible increase and decrease/ No change	Not significant	Magnitude of change not significant. Unlikely to change residents and users of the non-residential receptors response to traffic noise
40 residential buildings on B390 between Chitterne and Shrewton (outside detailed modelling area)	Moderate Decrease	Significant beneficial	Moderate reduction in traffic noise levels on affected route to the north due to transfer of traffic onto the A303. Potential to change residents response to traffic noise

Operational Plant/Fan noise

9.9.64 An assessment of the potential noise impacts associated with the continuous operation of plant at the service building at each portal has been completed. This has been based on currently available information on the number, location and noise levels of the potential plant. A worst case approach in terms of the number of plant operating at any one time has been taken. Further details of the noise sources are provided in Appendix 9.3.

9.9.65 Potential plant noise levels have been predicted at a selection of the closest identified receptors at Stonehenge Cottages, Stonehenge Road, Countess junction, Stonehenge Visitors Centre and Hill Farm Cottages. The highest predicted results are below 15 dB L_{Aeq} with levels at the majority of receptors considerably lower. Given the location of the service buildings in a deep cutting and the very small scale nature of the proposed plant this is as would be expected. Such low noise levels would not result in a significant adverse effect at nearby receptors. Existing background L_{A90} noise levels monitored across all the locations in the baseline survey reached an absolute minimum of around 20 dB during the very quietest part of the 8 hour night (see Appendix 9.4).

9.9.66 It is noted that at the detailed design stage the potential for removing the need for external plant would be investigated further.

9.9.67 An assessment of the potential noise impacts associated with the fans to be installed in the roof of the tunnel towards each end of each bore has been completed. This has been based on currently available reasonable worst case information on the number and location of the fans. The main purpose of the fans is to extract smoke out of the tunnel in the event of a fire. However, a maximum of 14 fans in each bore may also operate if exhaust emissions build up in the tunnel to an unacceptable level. To reach this level a high volume of traffic would need to be moving through the tunnel very slowly (less than 20km/hr) in each bore. This situation is not anticipated to occur on a regular basis as the aim of the Scheme is to alleviate congestion on the A303, and is very unlikely to occur at night. Further details of the fans are provided in Appendix 9.3.

9.9.68 Potential fan noise levels have been estimated at a selection of the closest identified receptors at Stonehenge Cottages, Stonehenge Road, Countess junction, Stonehenge Visitors Centre and Hill Farm Cottages. Based on the worst case assumption of the 14 fans in operation all being at the end of each bore, rather than split between each end, the highest predicted results are below 25 dB L_{Aeq} with levels at the majority of receptors considerably lower. Such low noise levels would not result in a significant adverse effect at nearby receptors. Existing background L_{A90} noise levels monitored across all the locations in the baseline survey reached an absolute minimum of around 28 dB during the very quietest part of the 16 hour day (late evening).

Compliance with policy

9.9.69 The key policy within NPSNN is in paragraph 5.195 '*The Secretary of State should not grant development consent unless satisfied that the proposals will meet the following aims, within the context of Government policy on sustainable development:*

a) *avoid significant adverse impacts on health and quality of life from noise as a result of the new development;*

b) *mitigate and minimise other adverse impacts on health and quality of life from noise from the new development; and*

c) *contribute to improvements to health and quality of life through the effective management and control of noise, where possible.*'

9.9.70 To maintain consistency with the EIA and DMRB terminology used throughout the assessment the discussion below refers to adverse effects rather than impacts.

9.9.71 With regards to identifying sustainable mitigation measures, factors including the cost versus the benefit, engineering practicality, any other impacts (such as landscape/visual) and consultation /stakeholder engagement responses are considered.

Construction

9.9.72 Significant adverse effects occur for construction noise and vibration levels above the SOAEL (see Table 9.3 and paragraph 9.3.17) which potentially occur for more than 10 days in 15, or 40 days in 6 months. Adverse effects occur at construction noise or vibration levels between the LOAEL and SOAEL. The third aim applies to all construction noise levels.

9.9.73 With regard to the first aim, a significant adverse effect is predicted at this stage at two locations; receptors in close proximity to Countess Roundabout and a receptor north of Winterbourne Stoke. This is due to the close proximity of these receptors to construction activities and the duration of the works. The assessment includes a range of mitigation measures as detailed in section 9.8 including: selection of quiet and low vibration equipment and methodologies; review of construction programme and methodology to consider low noise/low vibration methods; optimal location of equipment on site to minimise noise disturbance; the provision of acoustic enclosures around static plant, where necessary; use of less intrusive alarms, such as broadband vehicle reversing warnings; no start-up or shut down of vibratory plant e.g. rollers or compactors, within 50m of receptors and compliance with standard working hours, as recommended by Wiltshire Council, of 7:30am-6pm Monday-Friday and 07:30am-1pm Saturday for the majority of the works. The mitigation measures, and policies on noise insulation and temporary re-housing during construction, would be set out in the CEMP. An OEMP is provided in Appendix 2.2.

9.9.74 As detailed above the contractors would review the proposed working methods to consider all sustainable mitigation measures, with the aim of avoiding significant effects. However, at this stage it is anticipated that significant adverse effects are likely to remain. This is acceptable in the context of sustainable development as factors including engineering practicality, cost versus benefit etc., as outlined above must be considered. On this basis the first aim is met during construction.

9.9.75 With regard to the second aim, adverse effects between the LOAEL and SOAEL are predicted at this stage at a range of receptors. The mitigation and minimisation measures outlined above and detailed in section 9.8 would be applied throughout the works, and therefore would benefit all receptors experiencing construction noise or vibration, including those with levels between the LOAEL and SOAEL. The restriction on the working hours at Countess Roundabout and north of Winterbourne Stoke has been made in order to minimise disturbance to nearby receptors from construction noise. There is an engineering requirement for tunnelling and directly associated activities, namely the STP, SLPP and the delivery of segments, to be undertaken on a 24 hour, 7 days a week basis. The location of these works, including the compound which is remote from sensitive receptors, was made in part to demonstrate that the second aim is met. Construction impacts between the LOAEL and SOAEL are acceptable in the context of sustainable development as factors including engineering practicality, cost versus benefit etc., as outlined above, must be considered. On the basis of the above mitigation and minimisation measures the second aim is met during construction.

9.9.76 Construction noise and vibration by its nature introduces a new noise or vibration source into the existing environment and is temporary in duration, therefore the opportunity to improve existing noise levels are very limited.

Operation

9.9.77 Significant operational adverse noise effects occur at traffic noise levels above the SOAEL (see Table 9.7) and adverse effects occur at traffic noise levels between the LOAEL and SOAEL. The third aim applies to all traffic noise levels. Table 9.19 details the number of residential buildings in the study area which are above the SOAEL with and without the Scheme. Almost all the remaining residential buildings are between the LOAEL and the SOAEL, with and without the Scheme, as the night time LOAEL is set at a low level.

9.9.78 With regard to the first aim, mitigation measures incorporated within the Scheme design have reduced traffic noise levels from above the SOAEL to below the SOAEL at all affected properties in Winterbourne Stoke and Stonehenge Cottages. This is through the selection of a route alignment which bypasses Winterbourne Stoke, and setting the route within a tunnel and deep cutting within the WHS past Stonehenge Cottages.

9.9.79 The majority of the remaining residential buildings above the SOAEL following the opening of the Scheme are in close proximity to main roads within

Amesbury such as the A345. Such routes are already above the SOAEL without the Scheme and experience only a negligible change in traffic noise levels due to the Scheme. The purpose of the Scheme to improve traffic conditions on the A303 by grade separating Countess Roundabout results in small increases in traffic on roads connecting to the junction. The introduction of mitigation measures along existing roads which already experience high noise levels, to mitigate the negligible effect of the Scheme, is not sustainable. Such roads in built up areas have many residential and commercial buildings fronting onto the road, therefore mitigation measures such as barriers are not a practical engineering option and would have other adverse impacts including visual and access difficulties.

9.9.80 With regard to the second aim, a range of further mitigation measures have been incorporated into the design as outlined in section 9.8. These include the use of false cuttings on the bypass north of Winterbourne Stoke with a particular aim of minimising the impact at Foredown House; maximising the extent of the tunnel portals and Green Bridge Four; use of a noise absorbent finish at the entrance/exit of the tunnel and Green Bridge Four; minimising the extent of vertical concrete retaining walls at Countess flyover; use of a thin surfacing system which results in lower levels of noise generation than a standard hot rolled asphalt surface at speeds at and above 75km/hr; inclusion of 1.8m high absorptive noise barriers between the slip roads on both the north and south side of Countess flyover; and inclusion of a 1.5m high solid parapet on the south side of the River Till viaduct.

9.9.81 The decision to include noise barriers at Countess flyover was made in part to demonstrate the second aim is met. The extent of the noise barriers between the slip roads has been maximised within the physical constraints of the flyover. The proposed height of the barriers has resulted from determining a balance between the noise benefit and the visual impact. Feedback from the public consultation events and organisations such as Wiltshire Council identified the likely benefits of noise barriers at Countess flyover.

9.9.82 A solid parapet at the River Till is not deemed essential noise mitigation to comply with policy, within the context of sustainable development as it reduces the adverse noise impact at a single property. However, it does provide both noise and visual benefits. In addition, feedback from the public consultation events and organisations such as Wiltshire Council was in favour of a solid barrier. Therefore, for these reasons a solid parapet is included in the Scheme design.

9.9.83 The inclusion of all the above identified mitigation and minimisation measures demonstrates that, within the context of sustainable development, at receptors between the LOAEL and the SOAEL the Scheme meets the requirements of the second aim. No areas where additional mitigation would be appropriate, within the context of sustainable development, have been identified i.e. considering engineering practicality, cost/benefit, other potential impacts such as landscape/visual and consultation responses.

9.9.84 With regard to the third aim to ‘improve where possible’, the bypass of Winterbourne Stoke and the use of a tunnel/deep cuttings through the WHS results in significant improvements in traffic noise levels. The noise barriers at Countess are a reasonable balance between the reduction in the traffic noise impact at a significant number of properties and the visual impact of the barriers. On this basis the third aim has been met.

Summary of residual significant effects

9.9.85 Table 9.25 summarises the residual significant effects during construction and Table 9.26 during operation. A full summary of all effects, including those identified as not significant, is provided in Appendix 9.5.

Table 9.25: Summary of significant effects – construction

Receptor	Attribute	Impact	Design and Mitigation Measures	Impact Magnitude	Residual Effect
Closest receptors at Countess Roundabout	Noise	Noise levels exceeding the SOAEL for short periods, in consecutive quarters, during construction of the bridge and flyover	Use of BPM and compliance with the control measures detailed in the CEMP	Exceeds SOAEL	Significant adverse
Receptor to north of Winterbourne Stoke	Noise	Noise levels exceeding the SOAEL for short periods, in consecutive quarters, during construction of the bridge and deck installation	Use of BPM and compliance with the control measures detailed in the CEMP	Exceeds SOAEL	Significant adverse

Table 9.26: Summary of significant effects – operation

Receptor	Attribute	Impact	Design and Mitigation Measures	Impact Magnitude	Residual Effect
Receptor to north of Winterbourne Stoke	Operational Traffic Noise	Increase in traffic noise levels. Note impact occurs from the opening of the bypass at the start of Phase 2 of the construction works	Horizontal and vertical alignment, maximising height of false cuttings, use of solid parapet at River Till viaduct, use of thin surfacing (which results in lower levels of noise generation than a standard hot rolled asphalt surface)	Major adverse	Significant adverse
Receptors along Church Street/High	Operational Traffic Noise	Increase in traffic noise levels. Note impact occurs from the	-	Moderate/Major adverse	Significant adverse

Receptor	Attribute	Impact	Design and Mitigation Measures	Impact Magnitude	Residual Effect
Street Amesbury		permanent closure of the Stonehenge Road access onto the A303 at the start of the construction works			
Receptors in Winterbourne Stoke	Operational Traffic Noise	Decrease in traffic noise levels	Bypass of Winterbourne Stoke	Up to Major beneficial	Significant beneficial
Stonehenge, Stonehenge Cottages and north end of Stonehenge Road	Operational Traffic Noise	Decrease in traffic noise levels	Tunnel, absorptive finish inside each end of tunnel	Major beneficial	Significant beneficial
Receptors along B390 Chitterne to Shrewton	Operational Traffic Noise	Decrease in traffic noise levels	Transfer of traffic onto the A303	Moderate beneficial	Significant beneficial

9.10 Monitoring of significant effects

9.10.1 The OEMP sets out monitoring to be undertaken during the construction stage to ensure that the mitigation measures embedded in the Scheme design are appropriately implemented. As detailed in section 9.8 the performance specification of specific operational mitigation measures would be confirmed at the detailed design stage to ensure the performance assumed in the assessment is achieved, and surveys to ensure that measures are installed as required, would be undertaken. On that basis, no further monitoring of significant effects is proposed.

References

Ref 9.1: Highways Agency (2011), Design Manual for Roads and Bridges (DMRB) Volume 11, Section 3, Part 7, HD 213/11 Revision 1.

Ref 9.2: Highways England (2015), Interim Advice Note 185/15 Updated traffic, air quality and noise advice on the assessment of link speeds and generation of vehicle data into 'speed-bands' for users of DMRB Volume 11, Section 3, Part 1 'Air Quality and Volume 11, Section 3. Part 7 Noise.

Ref 9.3: Defra (2010), Noise Policy Statement for England (NPSE).

Ref 9.4: Department for Communities and Local Government (2014), Planning Practice Guidance - Noise (PPG-N).

Ref 9.5: Wiltshire County Council (2015) Wiltshire County Council Core Strategy.

Ref 9.6: British Standards Institution (2014), BS 5228:2009 + A1:2014 Code of Practice for noise and vibration control on construction and open sites.

Ref 9.7: DoT, Welsh Office (1988), Calculation of Road Traffic Noise (CRTN).

Ref 9.8: British Standards Institution (1993), BS 7385-2: 1993 Evaluation and measurement for vibration in buildings – Part 2: Guide to damage levels from ground borne vibration.

Ref 9.9: ISO (2010), ISO 4866:2010 Mechanical vibration and shock. Vibration of fixed structures. Guidelines for the measurement of vibrations and evaluation of their effects on structures.

Ref 9.10: Transport Research Laboratory (TRL) (2002), Converting the UK traffic noise index $L_{A10,18h}$ to EU noise indices for noise mapping.

Ref 9.11: WHO (1999), Guidelines for Community Noise.

Ref 9.12: WHO (2009), Night Noise Guidelines for Europe.

Ref 9.13: British Standards Institution (2014), BS 4142:2014 Methods for rating and assessing industrial and commercial sound.

Ref 9.14: British Standards Institution (2013), BS 7445: 2003 Description and measurement of environmental noise.

Ref 9.15: TRL Report 429 (2000), Ground borne vibration caused by mechanised construction works.

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