Published Project Report
PPR490 Technical Annex

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Technical Annex to PPR490 The acoustic durability of timber noise barriers on England's strategic road network

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Transport Research Laboratory

Technical Annex to PPR490

The acoustic durability of timber noise barriers on England's strategic road network

by P A Morgan

Prepared for: Project Record: **387(387)HTRL**
Acoustic durability of noise barriers over time
Client: **Highways Agency, Research and Development (Pam Lowery)**

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Technical Referee	M J Ainge	27/05/2010

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Contents

Abstract

Timber noise barriers are one of the most common mitigation measures against traffic noise on England's Strategic Road Network. They are required not only to fulfil their acoustic function and structural design requirements in accordance with Highways Agency specifications, but also to retain their performance for a reasonably long life. The Agency's technical design guide, HA 66/95, stipulates that noise barriers should remain serviceable for 40 years and not require maintenance for 20 years.

Currently the Agency requires acoustic performance to have been assessed using recognised, standardised laboratory tests (EN 1793-1:1998 and EN 1793-2:1998) as appropriate to the barrier type. However, the Agency's specifications are only concerned with the performance of the barriers in new condition.

This report is a technical annex to the main report which presents the results of a study commissioned by the Agency to investigate the acoustic durability of timber noise barriers on the network. This has been achieved through a programme of in situ measurements using recently developed test methods described in the forthcoming standard prEN 1793-6:2010 to determine airborne sound insulation characteristics.

Introduction

This report contains a series of annexes providing additional information on the research reported in TRL report PPR490 (Morgan, 2010)[1].

[1] Morgan, P. A. (2010). *The acoustic durability of timber noise barriers on England's strategic road network (PPR490).* Crowthorne: Transport Research Laboratory.

Annex A Establishment of a new purpose-built noise barrier test facility

Three tasks within the current project have not been suitable for investigation using noise barriers installed at the roadside. These tasks investigated the effect on sound insulation performance of:

- Variation in short-term moisture content following treatment with preservative
- The presence of safety fences in close proximity to the noise barrier
- Variation in barrier dimensions with respect to acoustic certification

The original proposal was for these tests to be undertaken using TRL's existing Noise Barrier Test Facility (NBTF). The NBTF is a purpose-built facility constructed within the boundaries of the TRL test track and has previously used for other noise barrier related projects undertaken for the Highways Agency, e.g. Watts and Morgan (2005).

However a number of issues were identified by the Project Team after the start of the project which resulted in a review of the suitability of this facility:

- The noise barriers to be used in the moisture content study within the programme were potentially required to remain in place for the full duration of the project, i.e. until the end of December 2009
- Discussions between the Project Team and the managers of the TRL test track were unable to secure guarantees that the noise barrier would remain physically undisturbed for this period; the NBTF was constructed in the vicinity of TRL's Impact Test Facility and it was identified that there may be occasions, for safety reasons during large-scale crash testing, whereby the NBTF would have to be dismantled. Furthermore, there was a risk of permanent decommissioning of the facility during the lifetime of the project.

Neither the acoustic or structural integrity of the noise barriers could be guaranteed if the panels were to be taken out and re-installed.

These concerns were discussed by the Project Team and the Agency Project Sponsor. It was concluded that the most satisfactory solution was to establish up a brand new test facility at a location away from TRL where both the long-term availability and integrity could be well controlled.

A.1 Description of the new facility

With the cooperation of Charles Ransford and Sons Ltd, an accredited Sector Scheme 4 supplier of treated timber used in the construction of noise barriers on the HA Strategic Network, a new dedicated facility has been established. This facility is based in the grounds of Ransfords' sawmill at Bishops Castle, Shropshire, but has been designed by TRL. Furthermore, the facility is operated independently of Ransfords, thereby ensuring that all work undertaken by TRL is fully impartial.

The new facility was constructed in June 2008, initially comprising an 8-post barrier configuration, which allowed for the installation of 7 noise barrier panels with a maximum height of 4 m and a maximum width of 3 m. This was later extended by another 4 posts, allowing the installation of a total of 11 panels. Figure A.1. shows the test facility in its 7 panel configuration.

It is noted that this panel width deviated from the 4 m width required for certification/ acoustic labelling according to Part 5. However, the certification of products with panel widths of less than 4 m has been addressed in Part 6. Furthermore, the primary application of this facility within the current project is not certification but rather to address issues encountered on the HA Strategic Network). The subsequent drafting of CEN/TS 1793-6:2010 (CEN, 2010; hereafter referred to as 'Part 6') has eliminated the issue of panel width for certification, provided that the barrier under test is at least 6 m in length.

Figure A.1: TRL Noise Barrier Test Facility, Bishops Castle, Shropshire
(Posts for safety fence at right-hand end)

The facility was designed to also allow for the installation of a temporary open box beam safety fence in front of three of the panels at the right-hand end (Figure A.2). Two sets of posts allow the safety fence to be positioned at either 600 mm from the face of the noise barrier (this is the minimum permitted distance specified in Table 1 of DMRB Vol.2, Section 2, TD19/85, 'Safety Fences and Barriers') or 900 mm.

Figure A.2: View of barrier facility showing safety fence installation

The barrier is constructed close to the rear boundary of the sawmill.

Behind the barrier, there is approximately 6-7 m of level ground before a line of trees and a low hedge which delineate the sawmill boundary.

In front of the barrier there is approximately 1 m of level earth covered with loose stone aggregate, beyond which is a large open area of asphalt which covers several hundred square metres and extends to at least 60 m beyond the front of the barrier.

This area is used by Ransfords for the storage of bark chippings and timber waste (see Figure A.3).

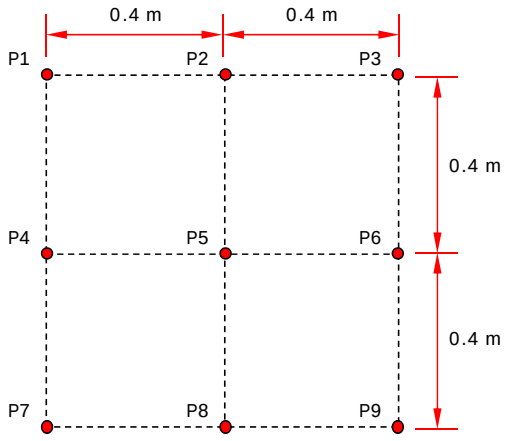
Figure A.3: Open asphalt area in front of the noise barrier facility

The facility has been designed primarily for conducting measurements using the

near-field test methodologies described in BS CEN/TS 1793-5 (BSI, 2003; hereafter referred to as ‘Part 5’) and CEN/TS 1793-4 (CEN, 2003). However, the layout of the facility potentially offers some limited possibilities for far-field performance assessment. In such instances, discussions with Ransfords and advanced notice would be required to determine if a suitable section of the asphalt storage area could be temporarily cleared.

Annex B The effect of using single / multiple free-field measurements on prEN 1793-6 results

The method prescribed in Part 5 for performing sound insulation measurements is based on the use of a single microphone at a single position for free-field measurements (i.e. the measurements in the absence of the barrier), namely position P5 at the centre of the measurement array, as shown in Figure B.1a. Free-field levels at the other microphone positions in the array are derived by applying path difference corrections to the free-field measurement.



Microphone positions viewed looking in the direction of the loudspeaker from the microphones

(a) Microphone positions and nomenclature

(b) Example free-field measurement setup

Figure B.1: Microphone position nomenclature and example free-field measurement setup

A revised methodology has been incorporated into Part 6. This specifies that free-field measurements should be taken at all 9 microphone positions, thereby eliminating any need for path difference corrections and potentially improving the accuracy of the method if the loudspeaker does not exhibit spherical spreading radiation characteristics.

Whilst the method can be followed by using moving a single microphone around the array (as would be done for the sound transmission measurements in the presence of the barrier), it increases the likelihood of using a 9-microphone array for the measurements thereby improving measurement efficiency since this eliminates the need to continually reposition a microphone. Furthermore the use of such an array potentially reduces health and safety risks for measurement teams when the method is applied at the roadside (of particular relevance to the current study), as follows:

- It reduces the amount of time operatives need to spend working at the roadside.
- Depending upon individual site conditions it also offers the potential to perform measurements with fewer operatives whilst still satisfying the necessary health and safety requirements for roadside working;
- Depending upon the height of the barrier being assessed, the Part 5 single-microphone approach and original TRL equipment setup requires the use of

steps/ladders to allow re-positioning of the microphone. This introduces additional risk which must be managed since barriers are frequently sited at locations where the ground immediately behind the barrier is uneven or slopes significantly away from the barrier.

It is noted that a lack of flat/level ground was identified as a significant issue for several of the barriers assessed in the current study, requiring in some cases the use of safety tethers for both staff and kit. The use of a full microphone array reduces the amount of time operatives will be required to work in these conditions.

The benefits of increased efficiency and reduced risk therefore enhance the suitability of the Part 6 method for routine roadside testing and potentially increases the range of site conditions under which it can be applied.

Early within the project, approval was given to upgrade the TRL measurement system to a full 9-microphone array. This was achieved after only 3 roadside assessments had been completed using the Part 5 methodology. The early-life moisture content assessment (Chapter 7; Morgan, 2010) and the safety barrier effects assessment (Chapter 6; Morgan, 2010) were also undertaken in the very early stages of the project and as such also used the original Part 5 methodology.

Figure B.2 shows the TRL 9-microphone array system, which uses 9 microphones in combination with a commercially available single-channel measurement system (MLSSA) and a 9-channel switchbox (all photographs were taken at the TRL Noise Barrier Test Facility). The switchbox is operated using a remote control unit based in the test vehicle housing the main PC control systems.

a) 9-microphone array b) Microphone switchbox c) Free-field measurement using 9-mic array

Figure B.2: Microphone array fitted with 9 microphones

The following sections present the results of a comparison between results obtained using the Part 5 and Part 6 methodologies for both single leaf reflective and sound absorptive barriers.

B.1 Direct comparison between methods using a single-microphone

Free-field measurements using a single microphone were taken at all 9 positions on the microphone array using a single microphone (i.e. the microphone was moved around the array as necessary). Transmitted measurements were similarly taken at all 9 positions.

Sound insulation performance results determined using the Part 5 methodology (a single free-field measurement at P5 and path-difference corrections) will be denoted in the following analysis by 'SM-Single'; results determined using the Part 6 methodology (free-field measurements at all 9 microphone positions) will be denoted by 'SM-Array'.

Measurements on the single-leaf reflective timber barrier were performed on the TRL Noise Barrier Test Facility using the same 3 m high barrier as for the safety fence effect study (Chapter6; Morgan, 2010). Figure B.3 compares the average airborne sound insulation spectra over the 9 microphone positions for the two sets of analysis, together with the corresponding single number ratings, DL_{SI}.

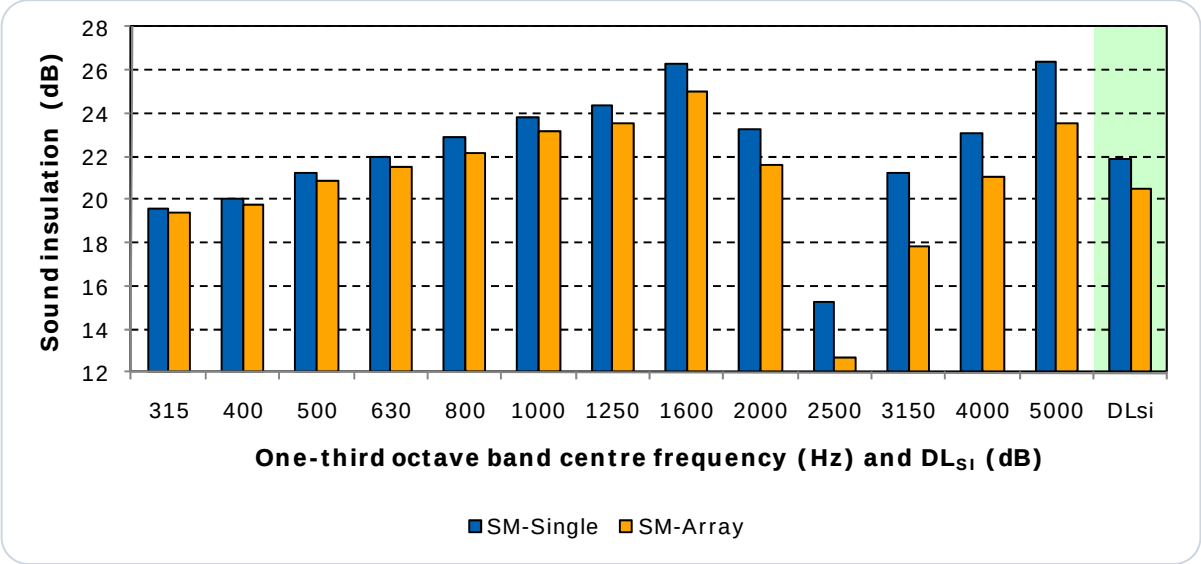
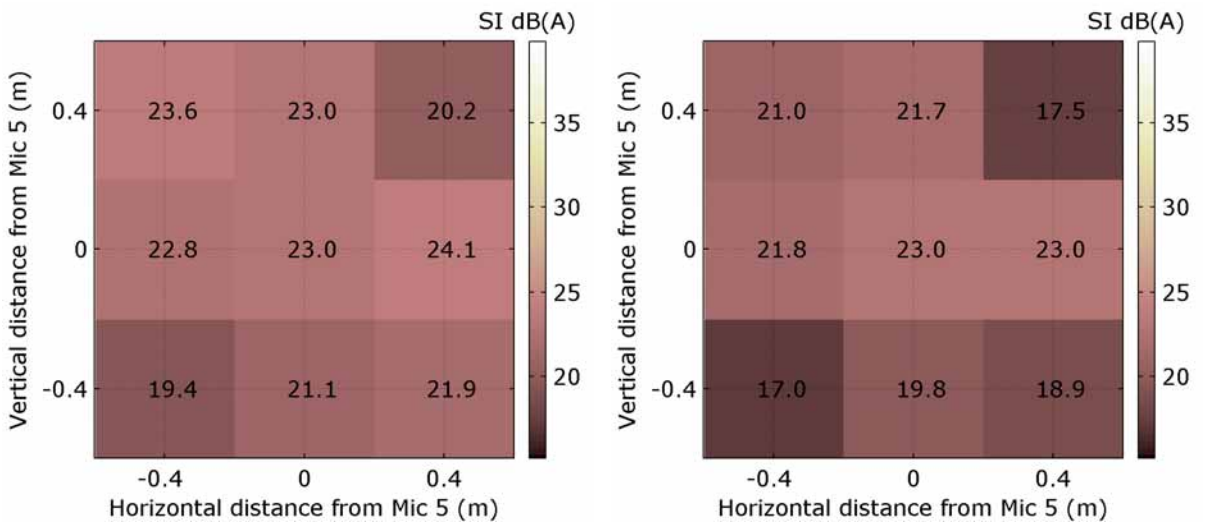


Figure B.3: Comparison of sound insulation performance derived using Part 5 and Part 6 methodologies for a single-leaf reflective timber barrier

In terms of the average single number rating DL_{SI} across all microphone positions, the Part 5 approach predicts a higher sound insulation performance by approximately 1.5 dB. In terms of the one-third octave band levels, it is observed that the Part 5 approach predicts higher sound insulation performance across the full frequency spectrum, with the greatest deviation from the Part 6 results of 2-3.5 dB occurring in the one-third octave bands 2.5 kHz and above.

Figure B.4 compares the DL_{SI} ratings calculated for the individual microphone positions. The darker colours indicate lower values of sound insulation. As for the average results, the Part 5 approach predicts higher sound insulation performance at all 9 microphone positions. It is observed that the differences at the corners of the array (microphones P1, P3, P7 and P9) are the greatest, being approximately of the order of 2.5-3 dB. The differences at positions P2, P4, P6 and P8 are approximately 1 dB. There is no difference between the results at the centre microphone position P5 since there is no path difference correction applied at this position in the Part 5 method.



(a) SM-Single (b) SM-Array

Figure B.4: Comparison of sound insulation performance at individual microphone positions derived using Part 5 and Part 6 methodologies for a single-leaf reflective timber barrier

Measurements on the sound absorptive barrier were performed at the roadside at a site on the M3 motorway. Section F.4 of Annex F provides full details of the barrier. Figure B.5 compares the average airborne sound insulation spectra over the 9 microphone positions for the two sets of analysis, together with the corresponding single number ratings, DL_{SI}.

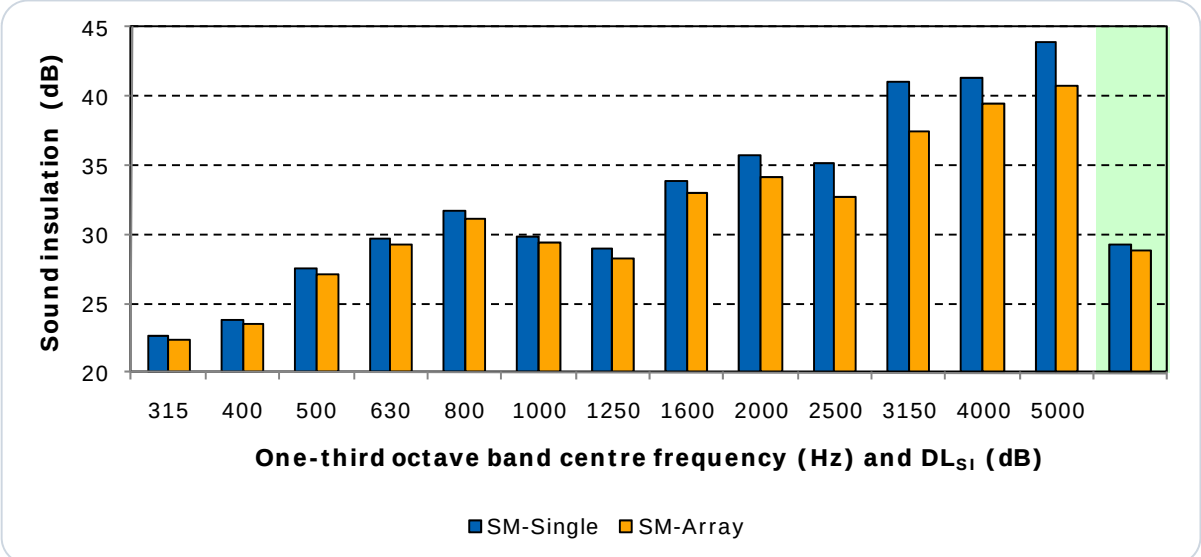
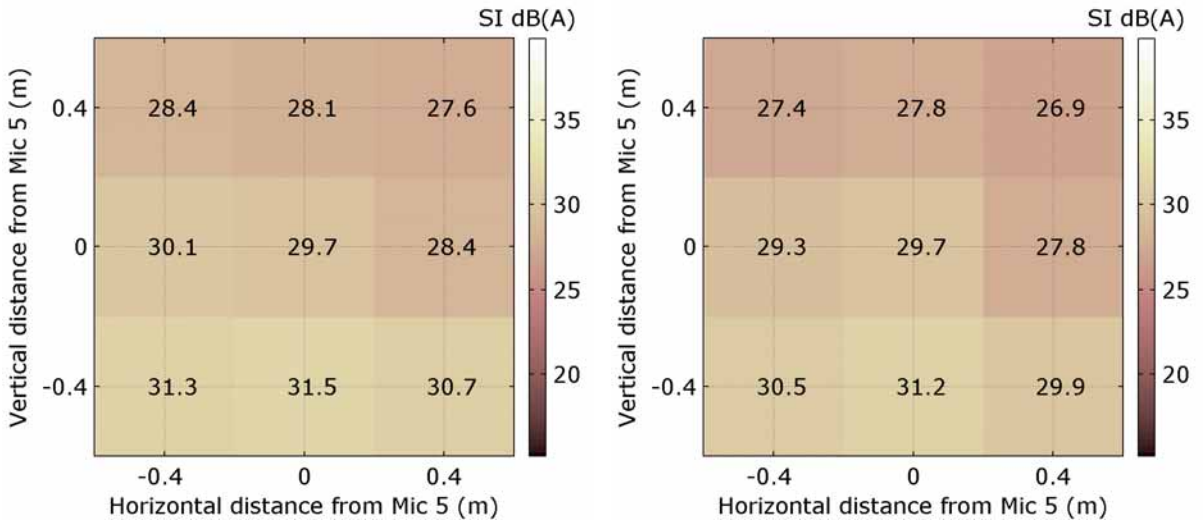


Figure B.5: Comparison of sound insulation performance derived using Part 5 and Part 6 methodologies for a sound absorptive timber barrier

Again, in terms of the average single number rating DL_{SI}, the Part 5 approach predicts a higher sound insulation performance by 0.5 dB. Similarly, in terms of the one-third octave band levels, it is observed that the Part 5 approach predicts higher sound

insulation performance across the full frequency spectrum, with the greatest deviation from the Part 6 results of 2.5-3.5 dB occurring in the one-third octave bands 2.5 kHz and above. It is observed that the introduction of the absorptive material effectively eliminates the degradation in acoustic performance seen around the third octave bands for the single-leaf reflective barrier (the cause of this dip in performance is a consequence of flexural vibrations along the face of the panel and is discussed in more detail in Section 7.3.2; Morgan, 2010).

Figure B.6 compares the DL_{SI} ratings calculated for the individual microphone positions. As for the average results, the Part 5 approach predicts higher sound insulation performance at all 9 microphone positions. It is observed that the differences at the corners of the array (microphones P1, P3, P7 and P9) are the greatest, being approximately of the order of 1 dB. The differences at positions P2, P4, P6 and P8 are less consistent being in the range 0.3-0.8 dB.



(a) SM-Single (b) SM-Array

Figure B.6: Comparison of sound insulation performance at individual microphone positions derived using Part 5 and Part 6 methodologies for a sound absorptive timber barrier

An evaluation of the free-field measurements used in each approach identifies the cause for this deviation. Converting the free-field transfer functions to dB levels is achieved using a modified version of equation (2.1), given by

$$\text{Free}-\text{field level}, FF_j = -10 \times \log_{10}\left\{\frac{\left(\frac{d_k}{d_i}\right)^2}{\int_{\Delta f_j}\left|F\left[h_i(t)w_i(t)\right]^2\right|df}\right\}\text{dB} \qquad \text{(B.1)}$$

Using the P5 free-field measurement from the assessment of the 3 m high single-leaf reflective barrier on the Noise Barrier Test Facility, Figure B.7 presents the one-third octave band free-field levels calculated using (B.1), i.e. applying an appropriate path difference correction to the P5 measurement, for the different microphone positions on

the array. This assumes that the loudspeaker exhibits spherical spreading radiation characteristics.

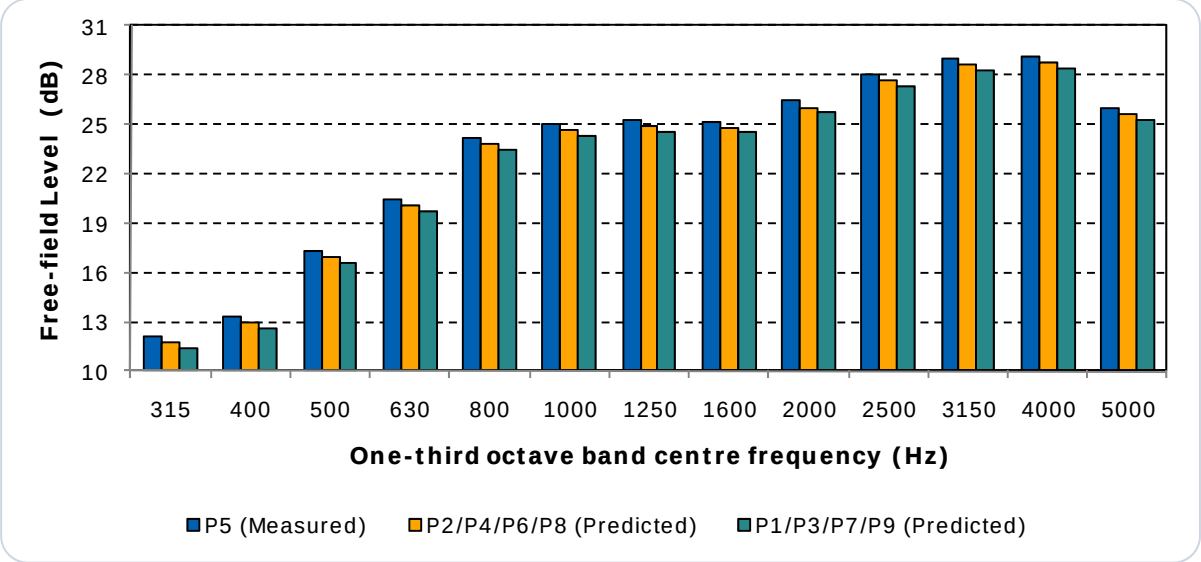


Figure B.7: Theoretical free-field levels at positions P1-P9 derived from equation (B.1)

The following Figures now compared those predicted levels with the actual measured levels obtained by moving the single microphone around the array.

Figure B.8 compares the predicted spectra corresponding to positions P2, P4, P6 and P8 with the measured levels at those positions. Similarly, Figure B.9 compares the predicted spectra corresponding to positions P1, P3, P7 and P9 with the measured levels at those positions.

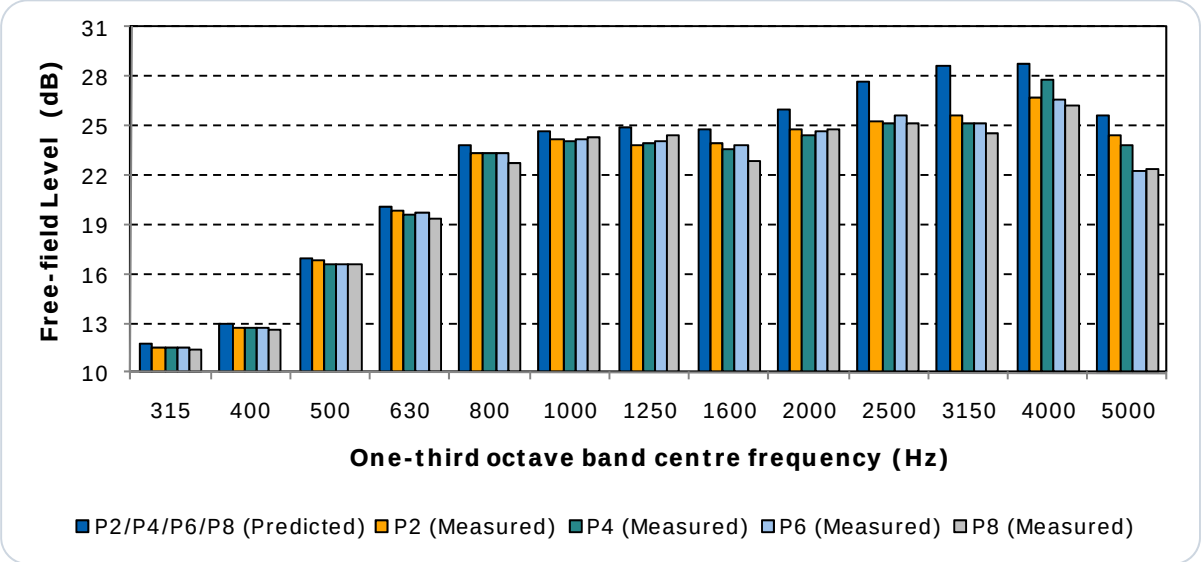


Figure B.8: Comparison of theoretical free-field level at positions P2, P4, P6 and P8 with equivalent spectra measured using the Part 6 method

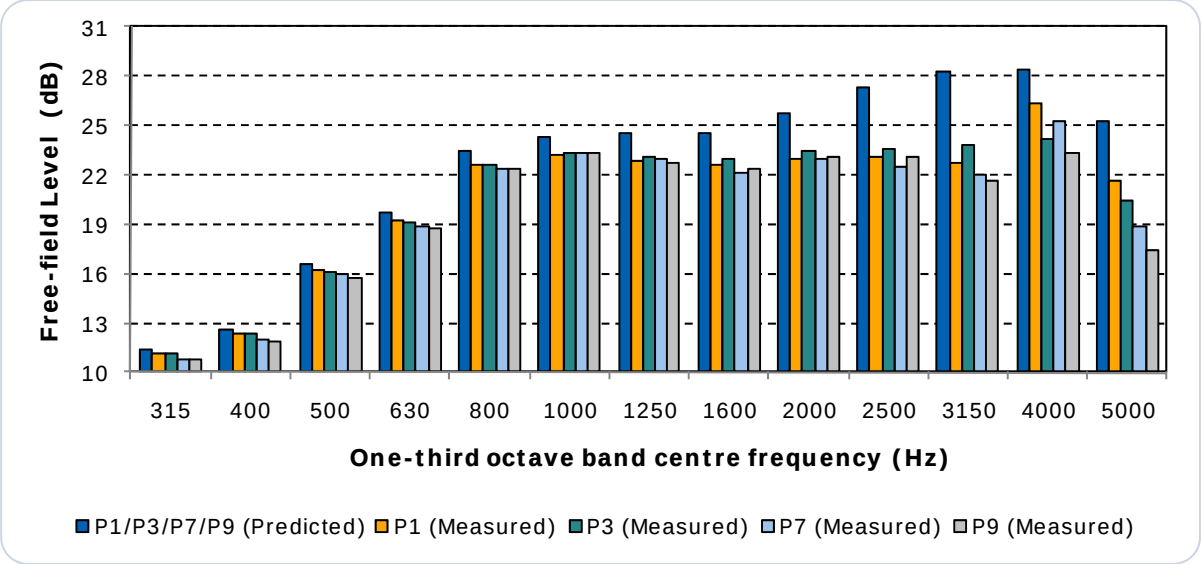


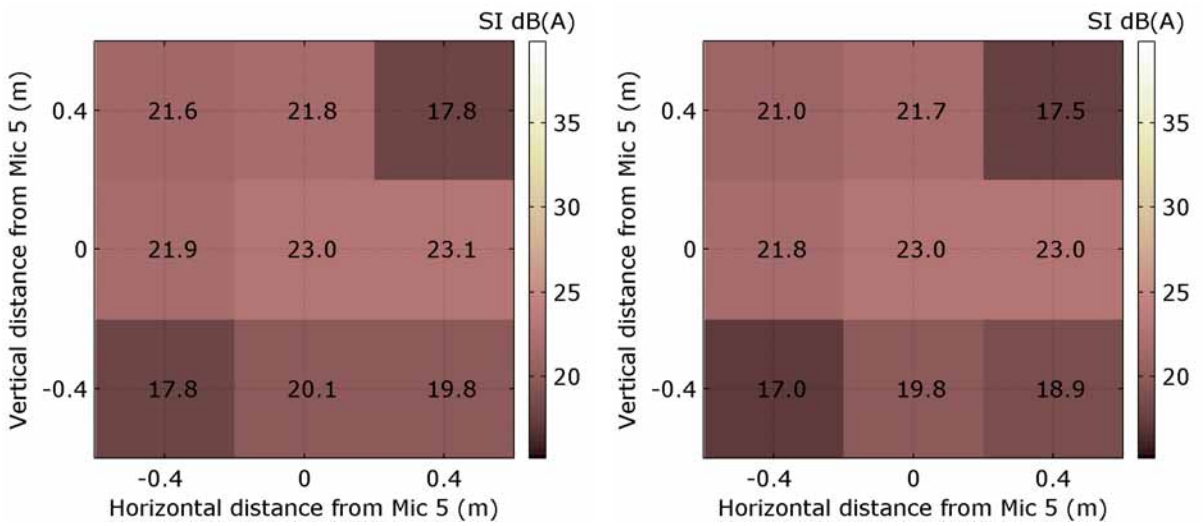
Figure B.9: Comparison of theoretical free-field level at positions P1, P3, P7 and P9 with equivalent spectra measured using the Part 6 method

In both Figures, it is observed that the actual performance of the speaker differs from the predicted spectra over the full frequency spectra. In the frequency bands below 1 kHz, the difference is less than 1 dB. However, significant differences of 4-6 dB are observed in the highest frequency bands, suggesting that the radiation characteristics of the loudspeaker do not correspond to spherical spreading.

Considering the measured levels at positions P2, P4, P6 and P8, the behaviour of the speaker is generally consistent, with differences between the positions being less than 0.5 dB, except at the 4 kHz and 5 kHz bands. For the measured levels at positions P1, P3, P7 and P9, the behaviour of the speaker is similarly consistent except in the frequency bands 3.15-5 kHz.

It must be noted that the levels at the different microphone positions are not recorded simultaneously, even using a full 9-microphone array (since the measurement system is only single channel), so measurements will be subject to any variations in temperature, wind speed and air pressure. However, since the propagation distances are small and all free-field measurements are generally completed within 30 minutes (based on 3 measurements at each microphone position), these effects are expected to be minimal.

Based on the above Figures, corrections to the theoretical free-field levels can be applied to adjust for the deficiencies in the speaker performance. For simplicity, it is assumed that the same frequency dependant correction can be applied to positions P2, P4, P6 and P8 and that a different frequency dependant correction can be applied to all the of the corner array positions (P1, P3, P7 and P9). Figure B.10 shows the effect of applying these corrections in the Part 5 calculations for the single-leaf reflective barrier and compares the results with the Part 6 method using the single microphone moved around the array. The difference in the average single number rating, DL_{SI}, reduces from 1.5 dB to 0.1 dB, whilst the difference in DL_{SI} at any single microphone position reduces to less than 1 dB.



(a) SM-Single (Correction applied to predicted free-field spectra)

(b) SM-Array

Figure B.10: Comparison of sound insulation performance at individual microphone positions derived using Part 5 methodology with corrections for speaker performance and Part 6 methodologies for a single-leaf reflective timber barrier

However, it is noted that this correction will be affected by the source/receiver separation, meaning that the accuracy of using fixed frequency corrections applicable for all barrier geometries would be reduced. The use of measured free-field levels at all times is therefore recommended.

It is therefore concluded that the switch to the Part 6 methodology, using measured free-field data at all of the microphone positions on the array is an improvement in the accuracy of the method, reducing errors caused the use of in accurate geometrical spreading corrections.

B.2 Comparison of the array approach using a single microphone and 9 separate microphones

These measurements were taken to compare the effect of performing Part 6 measurements using a single microphone moved around the 9 positions in the array (both free-field and transmitted; denoted 'SM-Array') with using a full 9-microphone array, i.e. individual microphones at each position in the array (denoted 'MM-Array'). It is noted that these measurements were only taken for the 3 m high reflective barrier on the TRL noise barrier test facility during preliminary testing of the 9-microphone array and switchbox.

Figure B.11 compares the average airborne sound insulation spectra over the 9 microphone positions for the two types of measurement, together with the corresponding single number ratings, DL_{SI}.

As would be expected, both the single number ratings and one-third octave band indices agree well, with differences being for the most part negligible; a difference of 0.5 dB is observed at 3.15 kHz.

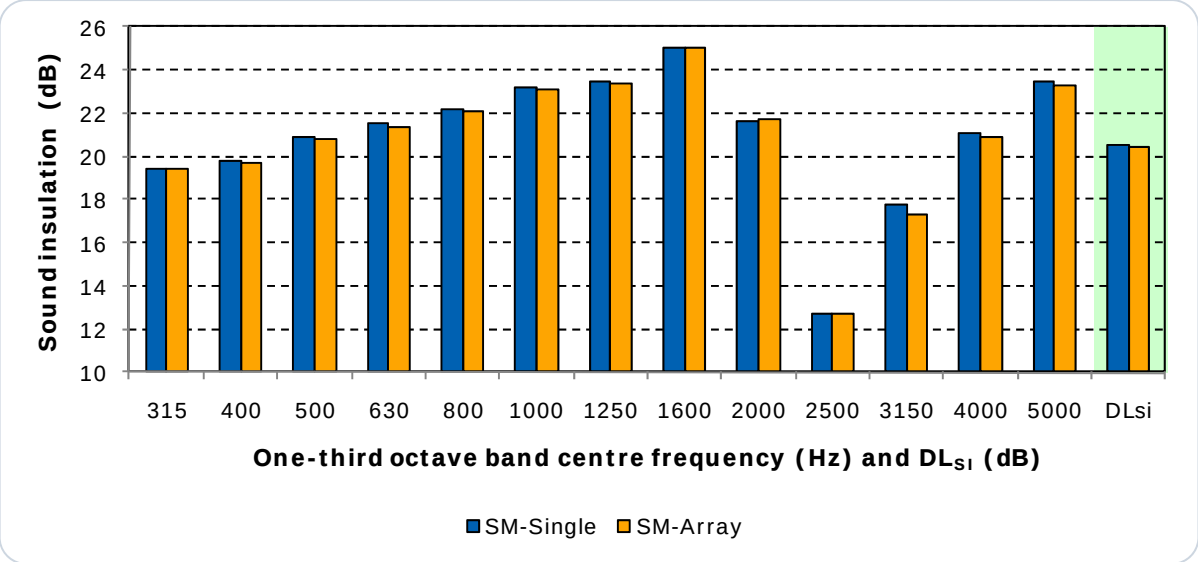
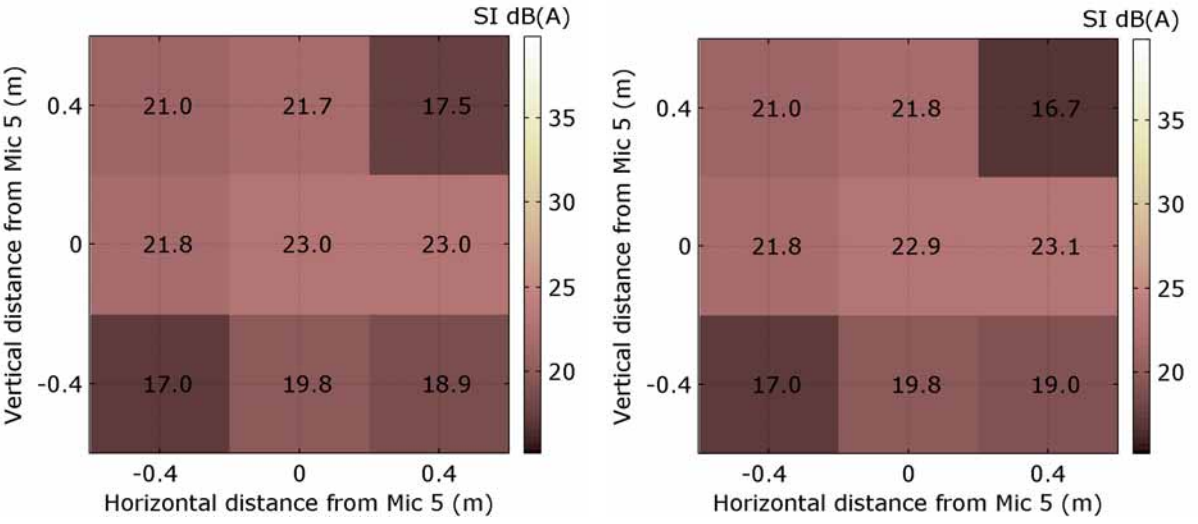


Figure B.11: Comparison of sound insulation performance derived the Part 6 methodology and either a single microphone moved around the array or a full 9-microphone array

Figure B.12 compares the DL_{SI} ratings for the individual microphone positions. Again the differences are negligible, with the exception of position P3. It is expected in this case that the error was due to an incorrectly positioned microphone in one of the measurements and not due to any failure in the methodology.



(a) SM-Array

(b) MM-Array

Figure B.12: Comparison of sound insulation performance at individual microphone positions derived using the Part 6 methodology and either a single microphone moved around the array or a full 9-microphone array

Conclusions

The use of a 9-microphone free-field measurement array improves the accuracy of the airborne sound insulation measurement method by eliminating any errors due to the use of incorrect path difference corrections as well as taking into account any deviation from spherical radiation characteristics by the loudspeaker source.

Annex C Accuracy of the prEN 1793-6 test method

This Annex presents the findings from a small-scale test programme evaluating the effects of small-scale variations in loudspeaker and microphone positioning on sound insulation performance when assessed using the test methods defined in Part 6. This is considered to be of particular relevance to in situ assessments at the roadside, when site conditions are frequently more difficult/restrictive than those encountered on purpose-built test facilities, e.g. there is less open space, sloping ground, hard shoulder working, etc. and it is possible that less stringent efforts can be made to ensure the accurate positioning of the loudspeaker and microphone arrays for the different measurements.

The assessment was undertaken using a 3 m high single-leaf reflective timber barrier constructed on the TRL Noise Barrier Test Facility (see Chapter 6 (Morgan, 2010) for further details regarding the specific construction of the noise barrier). The following deviations from the required source/receiver geometry were measured:

- *Incorrect horizontal separation (free-field conditions):* Errors in the horizontal separation of the loudspeaker and microphone array. Increases of +20 mm and +50 mm in the separation between the loudspeaker and microphone P5 (see Figure 2.1; Morgan, 2010), relative to the required separation for the barrier under assessment, were evaluated.

  Since the transmitted measurement used in the analysis will be the same for all three conditions (Horizontal offset = 0, +20, +50 mm), then if increasing the separation has any effect it should be to reduce the sound insulation performance of the barrier, since the measured free-field levels would be reduced by increasing separation.

- *Incorrect vertical alignment (free-field conditions):* Errors in the vertical alignment of the loudspeaker and microphone array, so that the axis between the loudspeaker and microphone P5 is no longer horizontal. This was achieved by offsetting the height of the *microphone array* by +20 and +50 mm above the required axis.

- *Incorrect vertical alignment (transmission conditions):* Errors in the vertical alignment of the loudspeaker and microphone array, so that the axis between the loudspeaker and microphone P5 is not horizontal. This was achieved by offsetting the height of the microphone array behind the barrier by +20 and +50 mm above the axis.

Whilst the range of deviations investigated was not extensive, e.g. the effects of horizontal non-alignment and changes in the angles of the microphone were not considered due to time restrictions, it is considered sufficient to provide an initial insight into the accuracy of the method.

In all cases, the evaluation of effects is performed by comparing the final one-third octave band sound insulation spectra for the test barrier, SI_j, which gives the average sound insulation performance over the 9 microphone positions, and the corresponding single number ratings of airborne sound insulation, DL_{SI}, with the results where the correct positioning of the loudspeaker and microphone array was used.

C.1 Results and evaluation

Figure C.1 compares results for those measurements where there was differing horizontal separation between the loudspeaker and microphone array during the free-field measurements with the reference condition using the correct positioning.

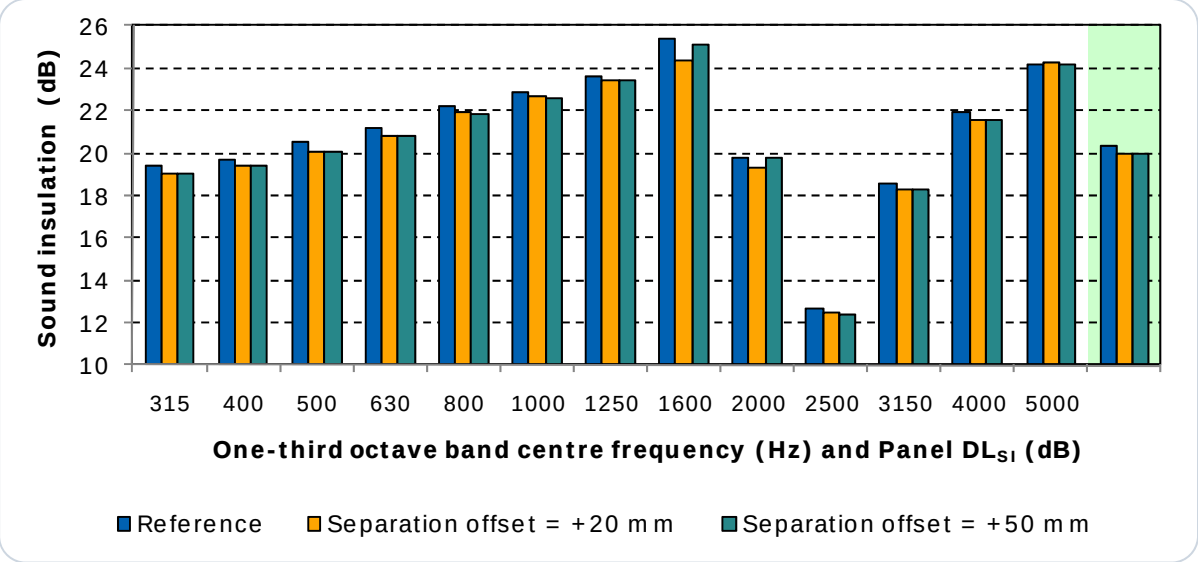


Figure C.1: Sound insulation performance of a single-leaf reflective timber barrier calculated using free-field measurements with different horizontal loudspeaker / microphone P5 separations

It is observed that the single number ratings, DL_{SI} are lower than measured on the same barrier some 14 months earlier (see Chapter 6; Morgan, 2010). It is noted that these earlier results were taken using a single free-field microphone (analysing the current results using a single free-field microphone increases the DL_{SI} value by 1 dB) and the barrier had been removed and reinstalled prior to the current tests.

The significant dip in performance in the frequency bands around 2.5 kHz, is as observed in earlier tests on this type of barrier, and discussed further in Section 7.3.2 (Morgan, 2010).

With the default free-field loudspeaker/P5 separation for the barrier under assessment increased by 20 mm, the Figure shows a decrease in the airborne sound insulation, DL_{SI}, of only 0.3 dB, which is negligible. Further increasing the separation to 50 mm has no additional effect. Considering the one-third octave band spectra, deviations in sound insulation relative to the reference case are generally less than 0.5 dB and therefore within the range of measurement accuracy of the method. Although a difference of approximately 1 dB is observed for the 20mm separation offset at 1600 Hz, this is still within the accuracy of the method.

Table C.1 – Table C.3 present the one-third octave spectra and DL_{SI} values corresponding to the individual microphone positions. Again, the differences are for the most part less than ±1 dB, with the limits being ±1.3 dB at individual frequencies/microphone positions. These differences are not considered to be significant.

Table C.1: Sound insulation indices for single-leaf reflective barrier reference condition (correct loudspeaker / microphone separation and alignment)

1 / 3 octave band centre frequency	Sound insulation indices SI for microphone positions P1-P9 & the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	20.3	21.2	19.2	20.3	21.6	20.2	16.6	18.0	18.3	19.4
400	20.8	21.6	19.5	20.8	22.5	20.8	16.6	18.3	18.5	19.7
500	24.8	22.3	20.5	21.8	20.6	21.5	16.6	19.5	19.6	20.5
630	26.5	24.1	21.5	21.2	19.9	22.4	17.4	20.5	21.2	21.2
800	26.9	27.8	23.2	20.3	19.7	24.0	19.0	21.9	24.2	22.2
1000	24.6	23.1	22.3	21.5	25.9	27.9	19.4	22.3	22.4	22.9
1250	21.8	23.1	21.1	31.9	30.0	27.7	21.0	22.3	22.4	23.6
1600	26.5	26.8	22.2	28.7	28.0	28.2	22.8	22.4	25.3	25.4
2000	23.0	24.1	18.2	22.0	21.3	21.2	16.8	17.5	17.4	19.8
2500	13.1	14.5	7.4	16.1	18.3	17.2	8.0	13.7	9.1	12.7
3150	18.1	27.5	12.2	23.8	30.3	22.3	14.1	17.5	13.7	18.6
4000	29.9	21.8	15.6	26.5	29.0	26.8	16.6	20.3	22.1	21.9
5000	27.1	22.0	18.1	36.5	35.8	28.0	23.4	19.8	20.6	24.2
DL_{SI}	21.7	22.3	17.1	21.8	22.5	23.1	16.5	19.6	18.2	20.3

Table C.2: Sound insulation indices for single-leaf reflective barrier with loudspeaker / microphone P5 horizontal separation increased by 20 mm during free-field measurements

1 / 3 octave band centre frequency	Sound insulation indices SI for microphone positions P1-P9 & the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	19.7	20.8	18.9	19.8	21.5	19.5	16.4	18.0	18.1	19.0
400	20.3	21.2	19.2	20.3	22.4	20.0	16.5	18.3	18.3	19.4
500	24.3	22.0	20.1	21.3	20.5	20.8	16.4	19.4	19.4	20.1
630	26.0	23.8	21.2	20.7	19.8	21.6	17.3	20.5	21.0	20.8
800	26.3	27.5	22.9	19.9	19.7	23.3	18.9	22.0	24.1	21.9
1000	24.0	22.9	22.1	21.0	25.9	27.3	19.3	22.5	22.4	22.7
1250	21.1	22.7	20.8	31.6	30.0	27.1	21.1	22.6	22.4	23.4
1600	25.4	25.7	21.6	27.5	27.0	26.9	22.4	21.8	24.6	24.4
2000	22.1	23.4	17.7	21.2	20.9	20.2	16.8	17.5	17.0	19.3
2500	12.7	14.4	6.9	15.8	18.2	16.4	8.3	14.1	9.2	12.5
3150	17.4	27.2	11.7	23.2	30.3	21.6	14.2	17.9	13.7	18.3
4000	29.2	21.6	15.4	25.9	28.5	26.0	17.1	20.8	22.3	21.6
5000	26.6	22.3	17.4	36.3	36.1	27.8	24.6	21.0	21.6	24.3
DL_{SI}	21.1	22.0	16.7	21.3	22.3	22.3	16.6	19.7	18.2	20.0

Table C.3: Sound insulation indices for single-leaf reflective barrier with loudspeaker / microphone P5 horizontal separation increased by 50 mm during free-field measurements

1 / 3 octave band centre frequency	Sound insulation indices SI for microphone positions P1-P9 & the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	19.9	20.7	18.6	20.2	21.2	19.8	16.5	18.0	17.8	19.0
400	20.4	21.2	18.8	20.7	22.1	20.3	16.5	18.3	18.0	19.4
500	24.4	21.8	19.8	21.7	20.2	21.1	16.5	19.4	19.0	20.1
630	26.1	23.6	20.8	21.0	19.5	22.0	17.3	20.4	20.7	20.8
800	26.4	27.4	22.6	20.1	19.4	23.6	18.9	21.8	23.8	21.8
1000	24.2	22.7	21.7	21.3	25.5	27.5	19.4	22.3	22.0	22.6
1250	21.4	22.6	20.5	31.8	29.7	27.4	21.0	22.4	22.1	23.4
1600	26.3	26.4	21.5	28.6	27.7	27.8	22.9	22.5	25.0	25.1
2000	22.8	23.8	17.6	22.0	21.2	21.0	17.1	17.8	17.4	19.8
2500	12.8	14.0	6.6	16.1	17.8	16.7	8.4	14.0	8.9	12.4
3150	17.7	27.1	11.4	23.7	29.7	21.9	14.3	17.9	13.6	18.3
4000	29.7	21.5	15.0	26.4	28.0	26.4	17.0	20.7	22.2	21.6
5000	27.3	22.3	17.7	36.7	35.4	27.7	24.3	20.7	21.3	24.2
DL_{SI}	21.3	21.9	16.4	21.7	22.1	22.7	16.6	19.7	18.0	20.0

It is therefore concluded that errors of up to 50 mm in the horizontal separation of the microphone and loudspeaker alone have negligible effect upon the assessment of sound insulation performance in terms of the single number rating, DL_{SI}.

Figure C.2 compares results for measurements where there was differing vertical alignment between the loudspeaker and microphone array during the free-field measurements with the reference condition using the correct positioning.

With the microphone array vertically offset by 20 mm from the axis between the loudspeaker and microphone P5, the Figure shows an increase in the airborne sound insulation, DL_{SI}, of only 0.1 db, which is negligible. Further increasing the vertical offset to 50 mm results in a DL_{SI} value identical to that of the reference condition. Considering the one-third octave band spectra, deviations in sound insulation relative to the reference case are generally less than ±0.3 dB and therefore within the range of measurement accuracy of the method.

Tables C.4 – Table C.5 present the one-third octave spectra and DL_{SI} values corresponding to the individual microphone positions for the two cases where the microphone array is offset (the reference case is the same as Table C.1). Again, the differences are generally less than ±0.5 dB for both the DL_{SI} values and individual one-third octave band values.

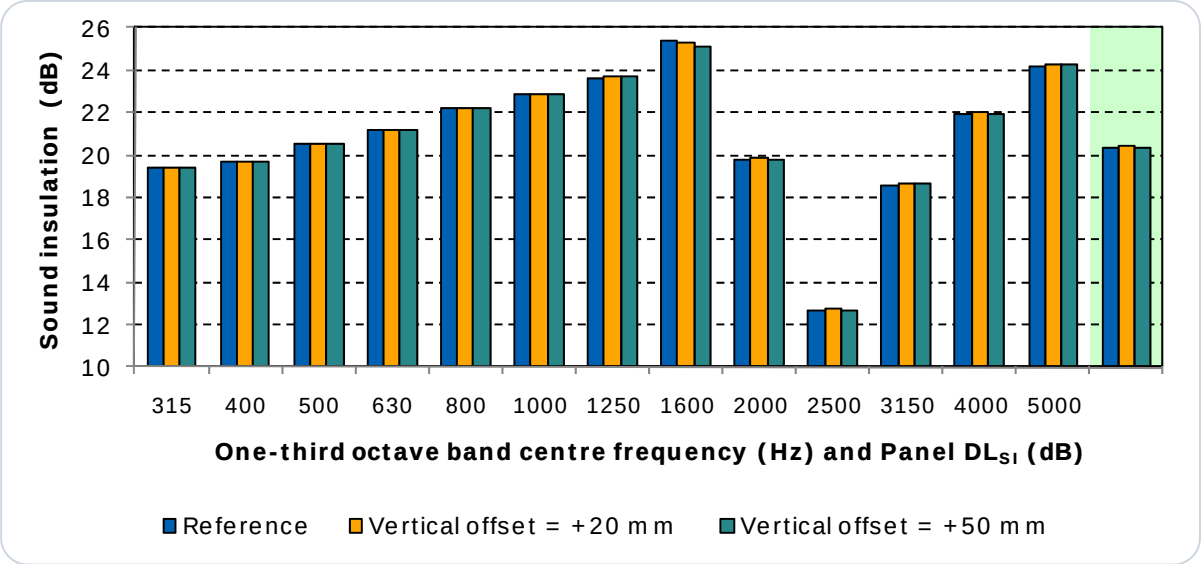


Figure C.2: Sound insulation performance of a single-leaf reflective timber barrier calculated using free-field measurements with different vertical alignments of loudspeaker and microphone P5

Table C.4: Sound insulation indices for single-leaf reflective barrier with loudspeaker / microphone P5 vertically offset by 20 mm during free-field measurements

1/3 octave band centre frequency	Sound insulation indices SI for microphone positions P1-P9 & the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	20.1	21.1	19.2	20.4	21.8	20.2	16.5	18.3	18.1	19.4
400	20.7	21.6	19.4	21.0	22.7	20.8	16.6	18.5	18.3	19.7
500	24.7	22.2	20.4	22.0	20.8	21.5	16.6	19.7	19.4	20.5
630	26.4	24.0	21.4	21.4	20.1	22.4	17.4	20.7	21.0	21.2
800	26.7	27.7	23.1	20.4	19.9	24.0	19.0	22.1	24.1	22.2
1000	24.4	23.1	22.2	21.6	26.1	27.9	19.4	22.6	22.2	22.9
1250	21.7	23.0	21.0	32.1	30.3	27.7	21.2	22.7	22.4	23.7
1600	26.5	26.7	22.0	28.7	28.0	28.1	22.8	22.6	25.2	25.3
2000	22.9	24.0	18.1	22.1	21.5	21.2	16.9	17.7	17.3	19.9
2500	13.0	14.3	7.2	16.3	18.6	17.2	8.3	14.1	9.1	12.8
3150	18.2	27.4	12.1	23.9	30.5	22.3	14.4	17.9	13.6	18.7
4000	30.1	21.8	15.4	26.7	29.0	26.8	17.0	20.6	22.3	22.0
5000	27.3	22.1	17.9	36.7	35.9	28.1	24.0	20.4	21.2	24.3
DL_{SI}	21.6	22.2	16.9	21.9	22.7	23.1	16.6	19.9	18.1	20.4

Table C.5: Sound insulation indices for single-leaf reflective barrier with loudspeaker / microphone P5 vertically offset by 50 mm during free-field measurements

1/3 octave band centre frequency	Sound insulation indices SI for microphone positions P1-P9 & the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	20.1	20.7	19.1	20.5	21.7	20.1	16.6	18.3	18.4	19.4
400	20.7	21.2	19.4	21.0	22.6	20.7	16.7	18.6	18.6	19.7
500	24.7	21.9	20.3	22.0	20.8	21.5	16.7	19.7	19.7	20.5
630	26.3	23.7	21.3	21.4	20.1	22.3	17.5	20.7	21.4	21.2
800	26.6	27.4	23.0	20.5	19.9	24.0	19.2	22.2	24.4	22.2
1000	24.3	22.7	22.1	21.5	26.1	27.9	19.6	22.7	22.6	22.9
1250	21.5	22.6	20.9	32.1	30.3	27.7	21.2	22.8	22.8	23.7
1600	26.2	26.3	21.8	28.7	28.0	27.4	22.7	22.2	25.4	25.1
2000	22.7	23.7	17.8	22.1	21.5	20.8	17.0	17.9	17.7	19.8
2500	12.5	13.7	6.7	16.1	18.5	17.2	8.5	14.4	9.5	12.7
3150	17.7	26.8	11.7	23.8	30.4	22.2	14.6	18.7	14.2	18.7
4000	29.6	21.4	15.0	26.7	28.9	26.6	17.0	21.1	22.7	21.9
5000	26.7	21.6	17.3	36.7	36.0	27.8	24.2	21.1	22.0	24.3
DL_{SI}	21.3	21.7	16.6	21.9	22.7	22.9	16.8	20.0	18.5	20.3

It is therefore concluded that errors of up to 50 mm in the vertical offset of the microphone and loudspeaker alone have negligible effect upon the assessment of sound insulation performance in terms of the single number rating, DL_{SI}.

Figure C.3 compares results for measurements where there was differing vertical alignment between the loudspeaker and microphone array during the sound transmission measurements with the reference condition using the correct positioning.

With the microphone array vertically offset by 20 mm from the axis between the loudspeaker and microphone P5, the Figure shows no increase in the airborne sound insulation, DL_{SI}. Further increasing the vertical offset to 50 mm results in an increase of 0.3 dB in the DL_{SI} value, which is negligible. Considering the one-third octave band spectra, deviations in sound insulation relative to the reference case are less than 0.5 dB except at 5 kHz and therefore within the range of measurement accuracy of the method.

Table C.6 – Table C.7 present the one-third octave spectra and DL_{SI} values corresponding to the individual microphone positions. For the 20 mm offset results, the difference in DL_{SI} values relative to the reference case is less than ±0.5 dB. In terms of the on-third octave band levels, the differences relative to the reference case are generally less than 0.5 dB, except at 5 kHz where the differences are significantly greater. For the 50 mm offset, the difference in DL_{SI} values relative to the reference case is within ±1 dB; for the third octave band results, the differences relative to the reference condition are generally larger, being for the most part ±1-2 dB, although differences up to ±4.5 dB are observed in some instances. The most significantly

affected microphone is P5, which might be expected since this is the microphone which is normally directly in line with the microphone.

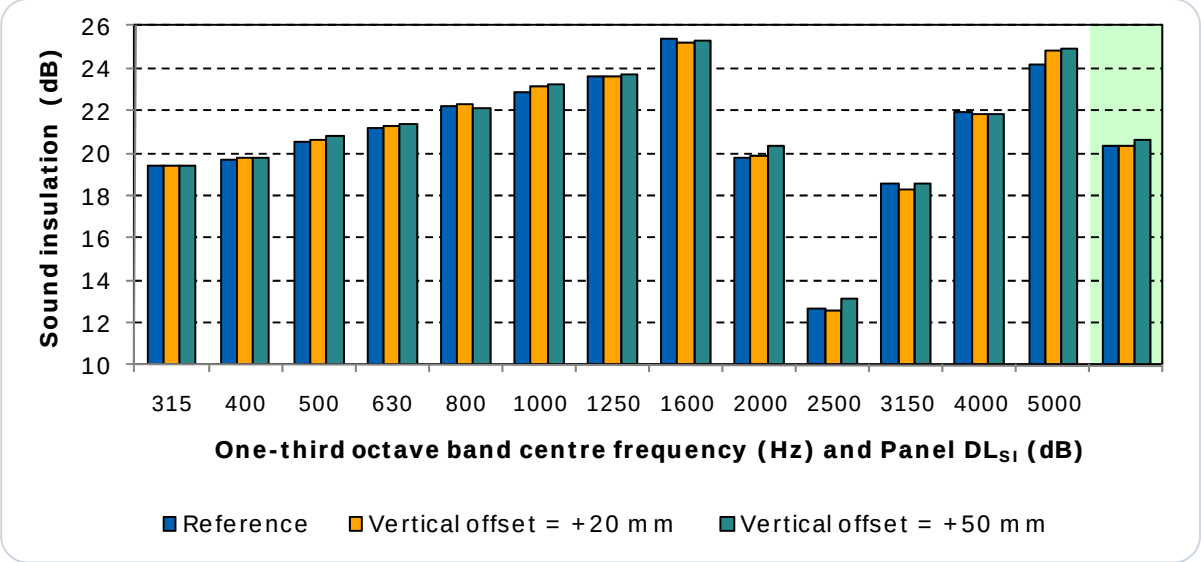


Figure C.3: Sound insulation performance of a single-leaf reflective timber barrier calculated using transmitted measurements with different vertical alignments of loudspeaker and microphone P5

Table C.6: Sound insulation indices for single-leaf reflective barrier with loudspeaker / microphone P5 vertically offset by 20 mm during transmission measurements

1/3 octave band centre frequency	Sound insulation indices SI for microphone positions P1-P9 & the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	20.0	20.7	18.9	20.3	22.0	20.2	16.9	18.3	18.7	19.4
400	20.4	21.1	19.1	20.9	23.0	20.8	17.0	18.5	18.8	19.8
500	24.6	21.9	20.0	22.2	21.0	21.5	17.0	19.9	20.0	20.6
630	26.3	23.6	21.0	21.5	20.2	22.4	17.8	20.9	21.7	21.3
800	26.4	26.7	22.6	20.5	20.0	23.9	19.3	22.2	25.0	22.3
1000	24.2	23.0	21.9	21.8	26.2	27.9	19.8	22.9	22.7	23.1
1250	21.7	23.1	20.7	32.1	30.5	27.3	21.6	22.0	22.5	23.6
1600	26.2	26.4	21.7	28.9	28.7	28.1	22.2	22.6	24.6	25.2
2000	22.8	24.0	18.3	22.3	22.2	20.6	17.0	17.3	17.7	19.9
2500	13.3	13.9	6.9	16.0	18.6	16.3	8.7	13.9	9.3	12.6
3150	17.1	26.7	11.9	23.0	29.6	22.2	14.2	17.0	13.9	18.3
4000	30.7	20.6	15.9	26.8	28.9	25.4	16.2	21.8	22.3	21.8
5000	29.1	22.7	19.5	32.0	33.9	26.5	25.2	20.7	20.0	24.8
DL_{SI}	21.5	21.9	16.7	21.9	22.8	22.8	16.9	19.8	18.4	20.3

Table C.7: Sound insulation indices for single-leaf reflective barrier with loudspeaker / microphone P5 vertically offset by 50 mm during transmission measurements

1 / 3 octave band centre frequency	Sound insulation indices SI for microphone positions P1-P9 & the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	19.8	20.6	18.7	20.0	21.9	20.2	16.8	18.8	19.0	19.4
400	20.1	20.9	18.8	20.4	22.9	20.7	16.9	19.0	19.2	19.8
500	24.5	21.6	19.9	22.4	21.3	21.7	17.0	20.4	20.2	20.8
630	26.0	23.0	20.8	21.7	20.4	22.6	17.7	21.3	21.9	21.4
800	25.5	25.3	22.2	20.5	20.1	24.2	18.9	22.4	25.4	22.1
1000	23.6	23.1	22.0	22.0	26.8	27.7	19.7	23.5	23.2	23.2
1250	21.8	23.9	20.8	33.0	31.6	27.0	22.3	21.7	22.2	23.7
1600	26.5	26.7	22.3	29.4	30.5	28.1	21.5	23.0	24.0	25.3
2000	22.4	24.4	18.8	23.3	24.9	20.7	16.5	17.7	18.0	20.3
2500	14.2	13.9	7.6	16.7	20.3	15.8	9.4	14.2	9.6	13.1
3150	17.4	25.6	12.4	24.6	30.3	23.6	14.2	17.1	13.7	18.6
4000	29.9	20.6	16.4	28.6	27.9	25.7	15.7	22.3	21.7	21.8
5000	30.6	24.4	20.4	32.8	31.3	24.8	26.2	20.1	19.1	24.9
DL_{SI}	21.7	21.9	17.2	22.2	23.5	22.7	17.0	20.1	18.6	20.6

As would be expected, the results for individual frequency bands at individual microphone positions are more sensitive to differences in the microphone positions than the free-field measurements, since the propagation paths through the barrier will be affected by the properties of the timber, and the presence of joints, splits and knots. However, when the results are averaged over all of the receiver positions, the effects are still negligible.

It is therefore concluded that errors of up to 50 mm in the vertical offset of the microphone and loudspeaker alone have negligible effect upon the assessment of sound insulation performance in terms of the single number rating, DL_{SI}. However analysis of individual one-third octave band results at individual microphone positions suggests that care should be taken in trying to accurately position the microphone array behind the barrier.

As a final evaluation, the performance of the barrier has been assessed using free-field measurements with a 50 mm error in the horizontal free-field separation of the loudspeaker and microphone array and the transmitted measurements where the position of the microphone array behind the barrier is offset by 50 mm. The results of this assessment compared to the reference case is presented in Figure C.4.

The sound insulation performance DL_{SI} shows no change when comparing the analysis using both horizontal and vertical offset measurements with the referenced case. Considering the one-third octave band spectra, the differences are less than ±0.5 dB except at 5 kHz and as such are negligible.

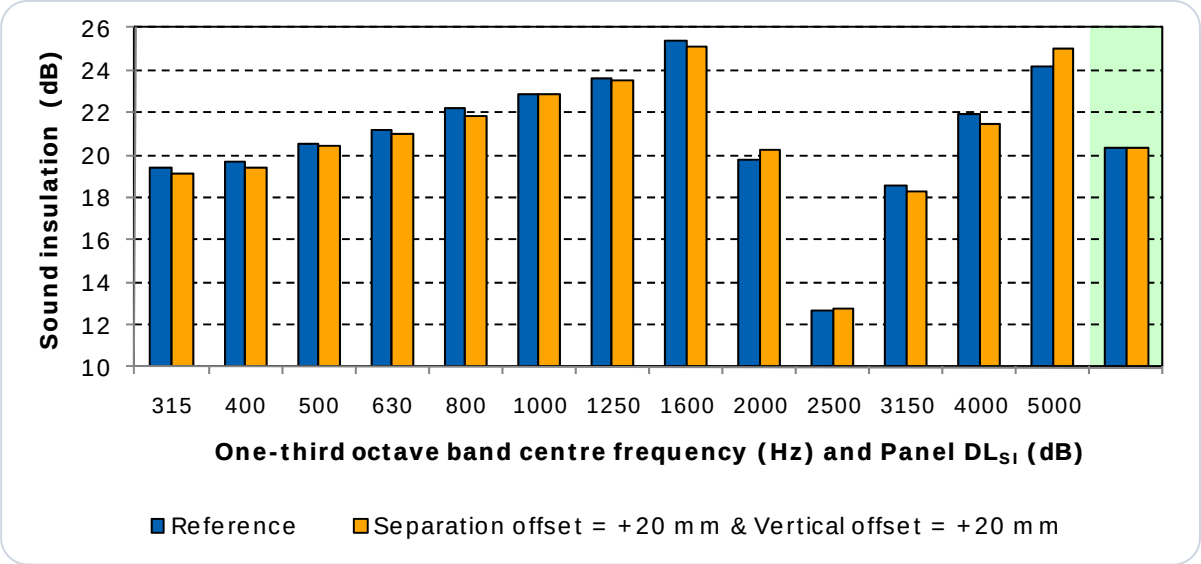


Figure C.4: Sound insulation performance of a single-leaf reflective timber barrier calculated using free-field measurements with different horizontal separations and transmitted measurements with different vertical alignments loudspeaker and microphone P5

Table C.8 presents the one-third octave band spectra and DL_{SI} values corresponding to the individual microphone positions for the assessment using the offset measurements.

Table C.8: Sound insulation indices for single-leaf reflective barrier with loudspeaker / microphone P5 horizontally offset during free-field measurements and vertically offset during transmission measurements

1/3 octave band centre frequency	Sound insulation indices SI for microphone positions P1-P9 & the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	19.3	20.1	18.1	19.8	21.5	19.7	16.7	18.7	18.5	19.1
400	19.7	20.5	18.2	20.3	22.5	20.3	16.9	19.0	18.8	19.4
500	24.1	21.2	19.2	22.2	20.9	21.3	16.9	20.3	19.7	20.4
630	25.6	22.5	20.1	21.5	20.0	22.2	17.6	21.2	21.4	21.0
800	25.0	24.9	21.6	20.3	19.7	23.8	18.8	22.3	25.0	21.8
1000	23.3	22.7	21.3	21.8	26.4	27.3	19.7	23.5	22.8	22.9
1250	21.4	23.4	20.1	32.9	31.3	26.7	22.3	21.8	21.9	23.5
1600	26.2	26.3	21.6	29.3	30.2	27.7	21.6	23.1	23.7	25.1
2000	22.2	24.1	18.2	23.3	24.7	20.4	16.8	18.1	18.0	20.2
2500	13.8	13.4	6.8	16.6	19.7	15.4	9.7	14.4	9.4	12.8
3150	17.0	25.2	11.6	24.5	29.7	23.2	14.5	17.6	13.6	18.3
4000	29.7	20.4	15.8	28.5	26.8	25.3	16.1	22.7	21.8	21.5
5000	30.9	24.6	20.0	32.9	30.8	24.5	27.1	20.9	19.8	25.0
DL_{SI}	21.3	21.4	16.4	22.1	23.1	22.3	17.2	20.2	18.4	20.3

For the DL_{SI} values at individual microphones, the difference to the reference case is less than ±1 dB. For the third-octave band results, similarly to the results presented in Table 6.1, there is a noticeable range of differences from ±5 dB at individual microphone positions. Microphone position P5 appears to be the most significant affected; this is the position that would normally be closest to the loudspeaker.

Again it is concluded that combined errors of up to 50 mm in the vertical and horizontal positioning of the microphone and loudspeaker alone have negligible effect upon the assessment of sound insulation performance in terms of the single number rating, DL_{SI}. Analysis of individual one-third octave band results at individual microphone positions suggests that care should be taken in trying to accurately position the microphone array behind the barrier.

Conclusions

Small errors of up to 50 mm in the horizontal separation between the loudspeaker and microphone array and in the vertical offset of the axis between the loudspeaker and microphone position P5 appear to have negligible effect upon the measurement of airborne sound insulation performance in terms of the single number rating DL_{SI}.

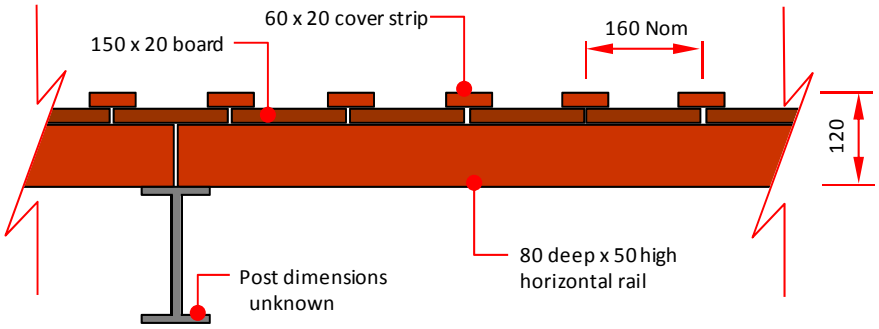
The thickness of the noise barrier defines the horizontal separation of the loudspeaker and microphone array. Depending upon how this is determined, e.g. by physical measurement of the barrier on site, from design plans/engineering drawings, etc. it is noted that small errors in the *horizontal separation* of the loudspeaker and microphone array may be unavoidable in the assessment of timber barriers. This is particularly the case for sound transmission measurements when measuring out from the barrier surface, particularly on aged barriers, due to warping of the timber, separation of cover strips from the main timbers, etc. although the errors are considered likely to be less than 10 mm. Similarly, if the *vertical placement* of the loudspeaker and microphone during the transmission measurements is made by measuring from the top of the barrier, small errors in vertical alignment may result due to distortion of any capping strip on the top of the barrier.

Based upon practical experience at the roadside, it appears that positioning of the test apparatus with an accuracy of ±10 mm should be readily achievable during free-field measurements. Once the position of the axis between the loudspeaker and microphone P5 has been determined on the faces of the barrier for the transmission measurements, positioning of the test apparatus with an accuracy of ±10 mm should be readily achievable.

Annex D Barrier cross-sections

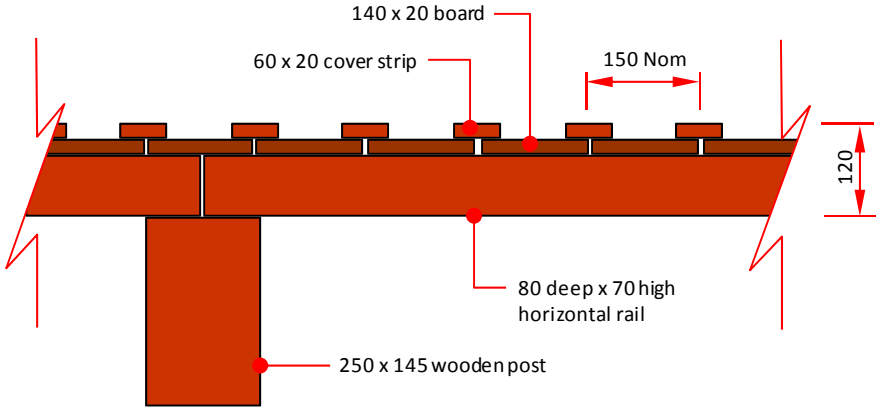
All acoustic elements in the following illustrations are timber constructions unless indicated otherwise. All dimensions are approximate and stated in millimetres.

D.1 Single-leaf reflective barrier: M1 J27-28 Eastbound



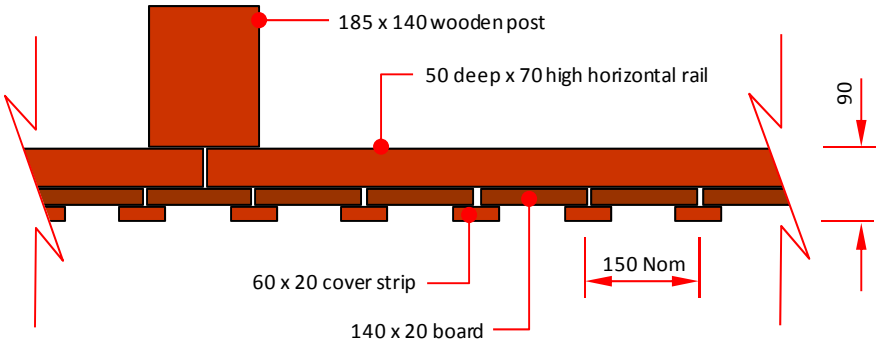
Traffic Facing Side

D.2 Single-leaf reflective barrier: M2 J2-3 Eastbound



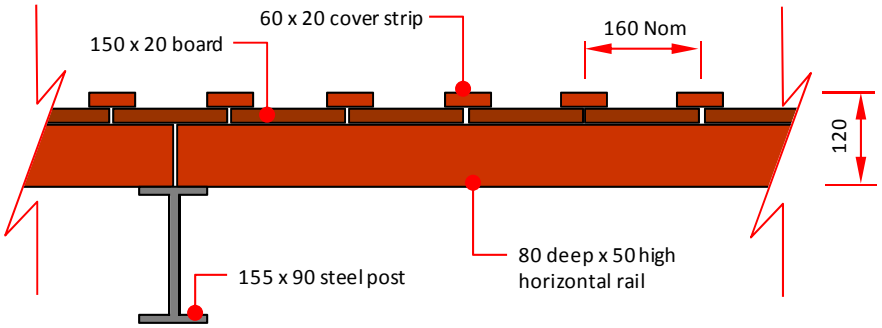
Traffic Facing Side

D.3 Single-leaf reflective barrier: M4 J7-8 / 9 Eastbound



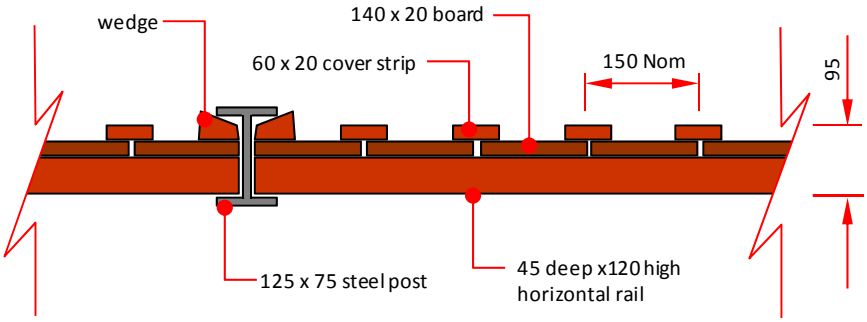
Traffic Facing Side

D.4 Single-leaf reflective barrier: M5 J11A-12 North & Southbound



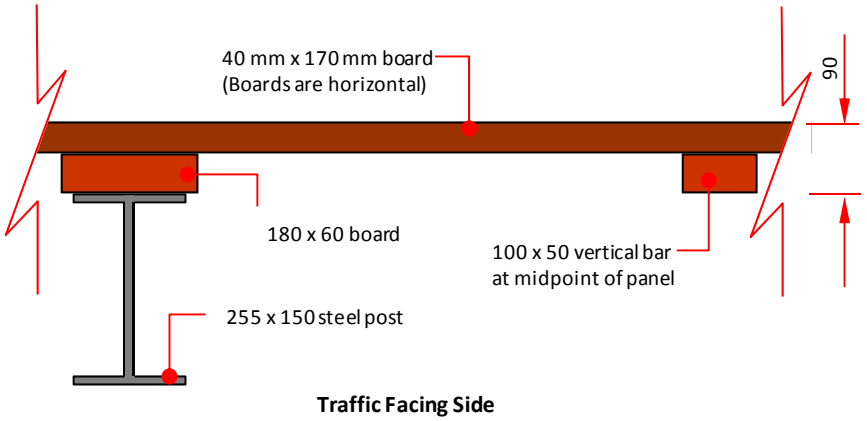
Traffic Facing Side

D.5 Single-leaf reflective barrier: M5 J18-19 Southbound



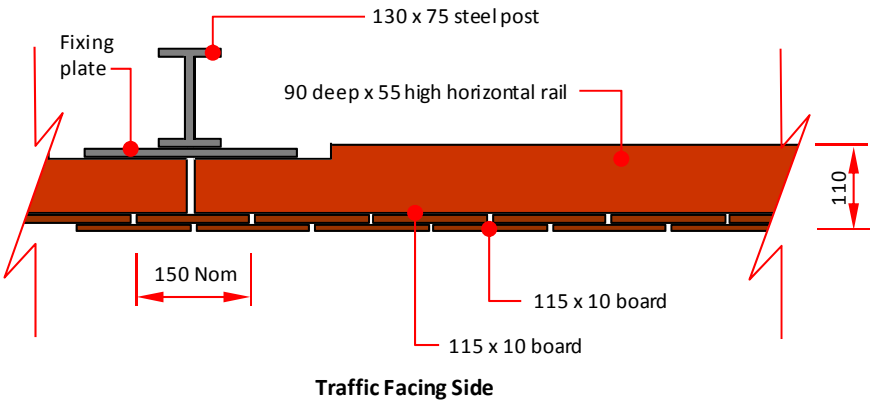
Traffic Facing Side

D.6 Single-leaf reflective barrier: M20 J10-11 East and Westbound

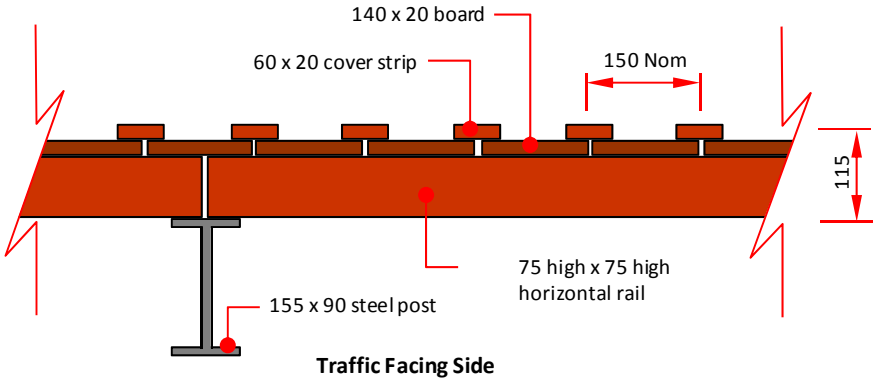


Traffic Facing Side

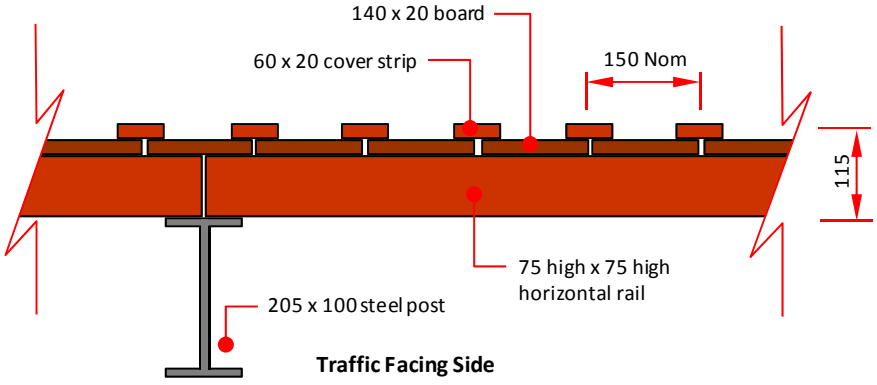
D.7 Single-leaf reflective barrier: M25 J6-7 Clockwise Done



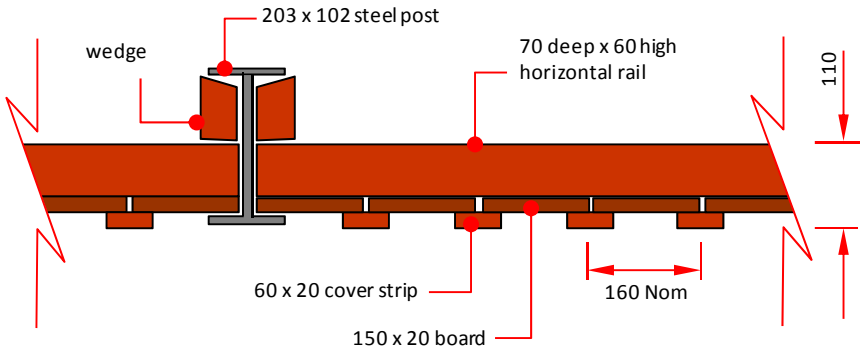
D.8 Single-leaf reflective barrier: M40 J1A-2 Eastbound



D.9 Single-leaf reflective barrier: M40 J2-3 Eastbound

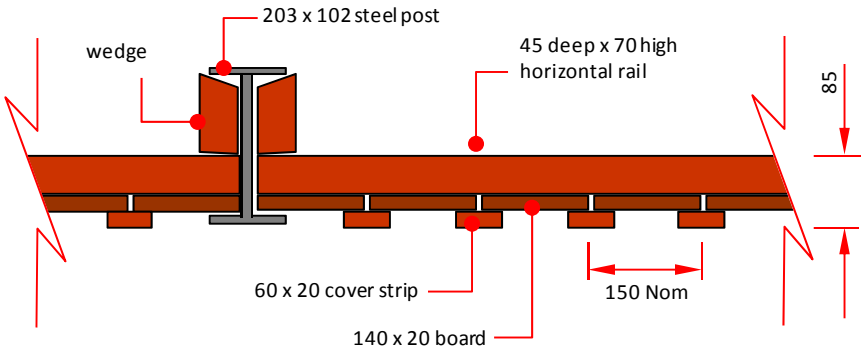


D.10 Single-leaf reflective barrier: TRL Noise Barrier Test Facilities 01



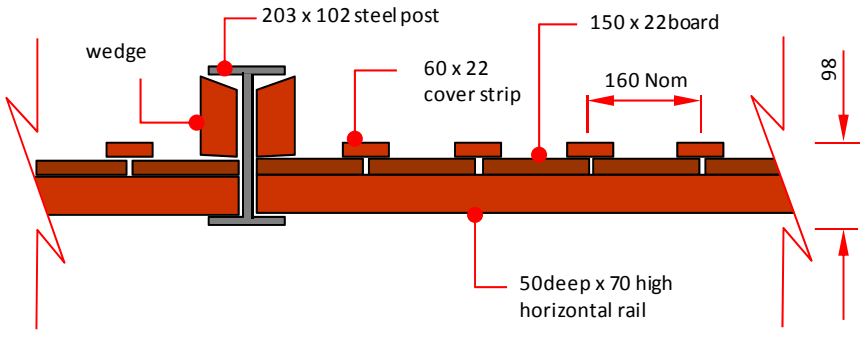
Traffic Facing Side

D.11 Single-leaf reflective barrier: TRL Noise Barrier Test Facilities 02



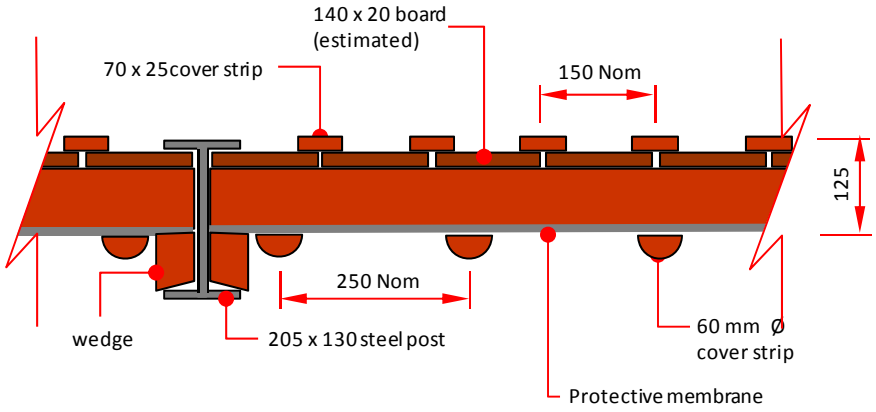
Traffic Facing Side

D.12 Single-leaf reflective barrier: TRL Noise Barrier Test Facilities 03 and 04



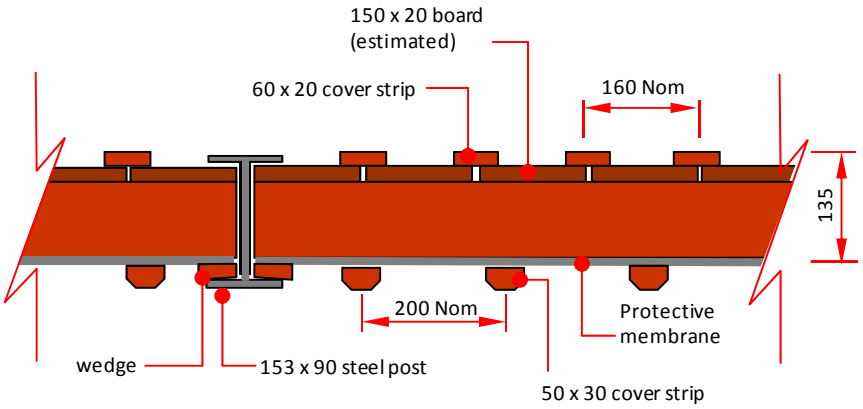
Traffic Facing Side

D.13 Sound absorptive barrier: M1 J11-12 Northbound



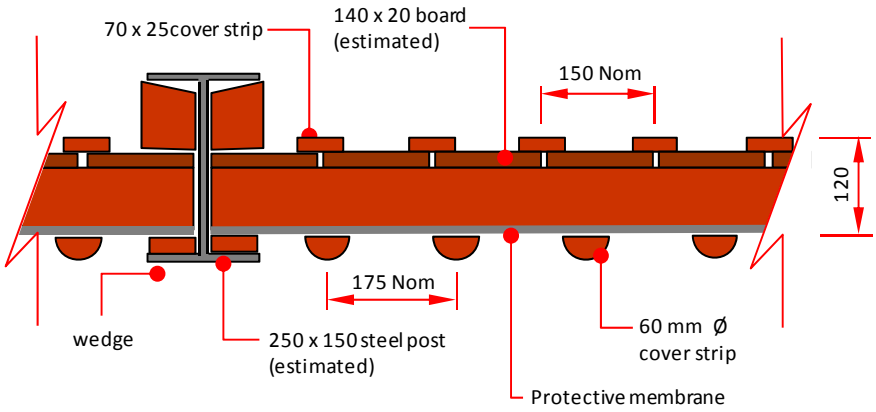
Traffic Facing Side

D.14 Sound absorptive barrier: M1 J24A-25 Southbound



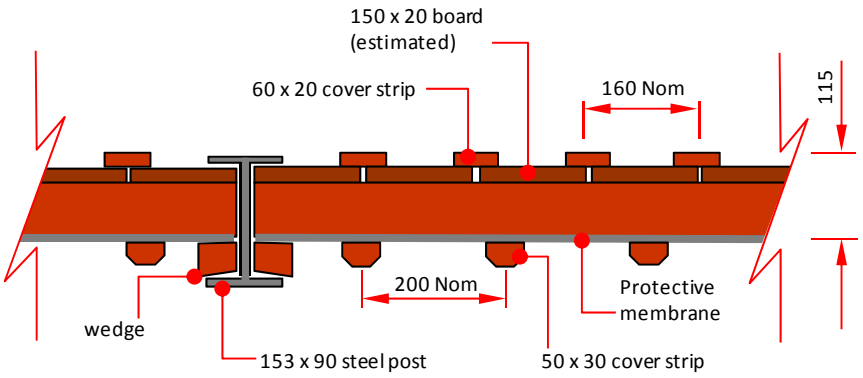
Traffic Facing Side

D.15 Sound absorptive barrier: M3 J4-4a Westbound



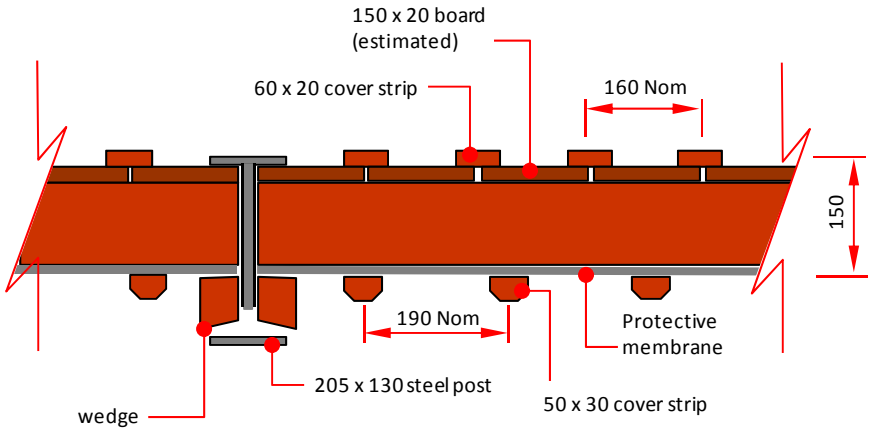
Traffic Facing Side

D.16 Sound absorptive barrier: M25 J12-13 Clockwise



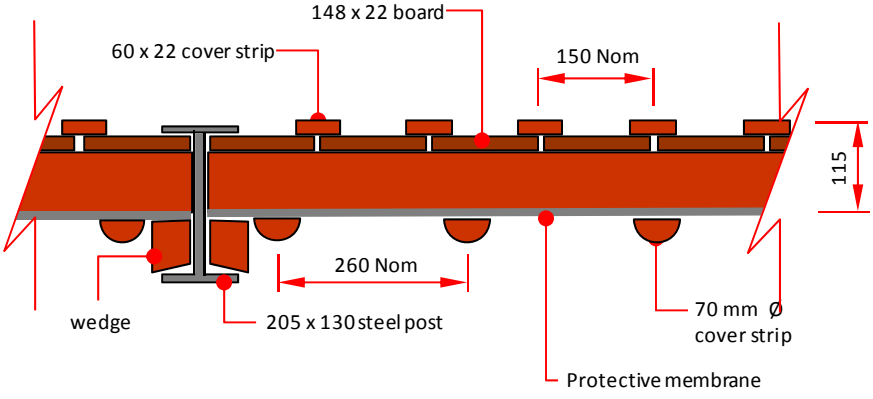
Traffic Facing Side

D.17 Sound absorptive barrier: TRL Noise barrier test facility 01



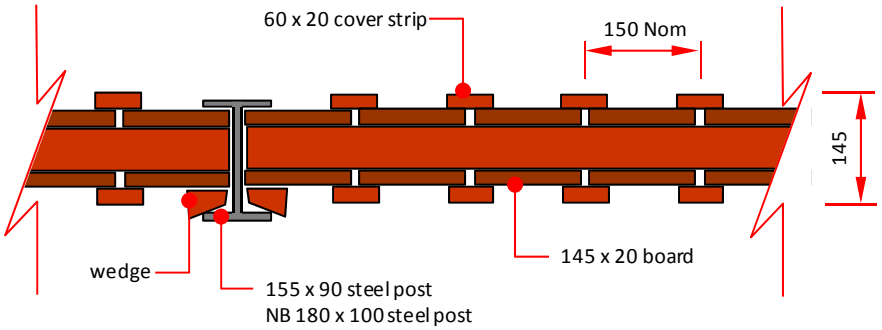
Traffic Facing Side

D.18 Sound absorptive barrier: TRL noise barrier test facility 02



Traffic Facing Side

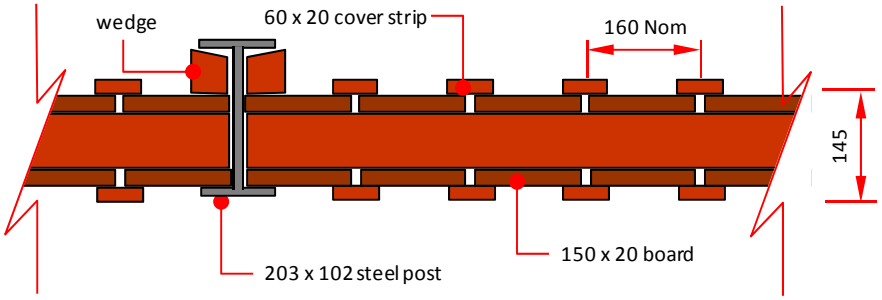
D.19 Double-leaf reflective barrier: M1 J8-9 North and Southbound



Traffic Facing Side

(Note: Board thickness and horizontal rail dimensions estimated)

D.20 Double-leaf reflective barrier: TRL noise barrier test facility 01 and 02



Traffic Facing Side

(Note: Board thickness and horizontal rail dimensions estimated)

Annex E Single-leaf reflective noise barriers: Detailed description and performance results

The tables in this Annex provide detailed information on the locations of each of the single-leaf reflective timber barriers tested within the study, together with construction information and dimensions, photographs, a summary of the airborne sound insulation measurements obtained for each tested panel (and post, where relevant) tested and the corresponding one-third octave band sound insulation spectra.

All tests were performed using the prEN 1793-6 approach (free-field measurements at all 9 microphone positions) unless otherwise stated.

E.1 Single leaf reflective barrier: M1, Junctions 27-28, Northbound

Barrier location	
Road / Junctions	M1, J27 – J28
Carriageway	Northbound
Nearest Marker Post	216/3 – 216/4 (216/3 + 80 m)
Latitude GPS reading in brackets	53.09410° (N 53° 5.646')
Longitude GPS reading in brackets	-1.30980° (W 1° 18.588')
OS Grid	SK 463 554
Approximate barrier orientation at coordinates (in direction of traffic)	SSE-ENE

Barrier details and site description					
Barrier type	Single-leaf reflective timber noise barrier. Constructed as a continuous length, full-height barrier with steel I-section posts on the front of the barrier. 'Plain' face on rear.				
Date constructed	October 2003* (Hansard site installation)				
Dimensions	**Height**	3.0 m	**Post spacing**	2.8 m	
	Barrier thickness	Mid-panel	0.125 m	(85 mm rail + 20 mm plank + 20 mm cover strip)	
		Across post	Not measured (Posts on front of barrier)		
Safety barrier details	Free-standing, corrugated profile safety fence. Positioned approximately 2.3 m in front of the noise barrier.				
General site layout in barrier vicinity	Flat ground in front of the noise barrier. Sloping ground immediately to the rear of the noise barrier.				

* Construction dates is estimated based on information provided the HA Managing Agent

Summary of measurement results (Frequency range: 315-5000 Hz)

Element	2008		2009		Notes
	DL_{SI} (dB)	Surface temp Front/Rear	DL_{SI} (dB)	Surface temp Front/Rear	
Panel PA1	18.8	Not measured	*Barrier unavailable for testing: Removed for road widening*		
Panel PA2	18.6	Not measured			

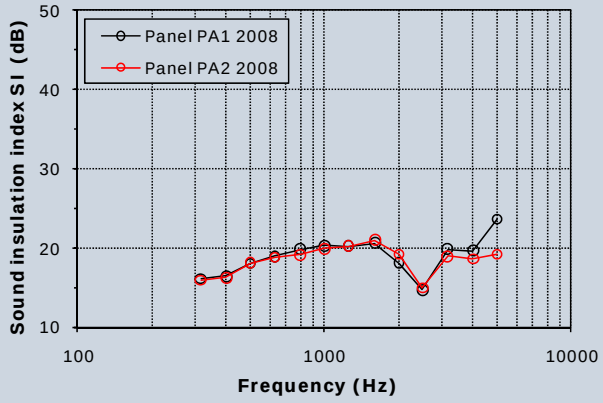
Photographs of the noise barrier at the test location	
 (a) General view of barrier from front	 (b) General view of barrier from rear
 (c) Detail of front of barrier	 (d) Detail of rear of barrier panel

Details of selected measurement positions	
Access	Measurement positions on the rear of the barrier are accessed via an unlocked emergency access gate in the barrier.
Panel PA1	Middle of 3rd panel to left of access gate (viewed from front), 1.5 m below top of barrier (45th plank from gate, 30 mm in from left hand edge).
Panel PA2	Middle of 2nd panel to left of access gate (viewed from front), 1.5 m below top of barrier (25th plank from gate, 55 mm in from left-hand edge).
Posts	Not assessed (the posts are on the front of the barrier).

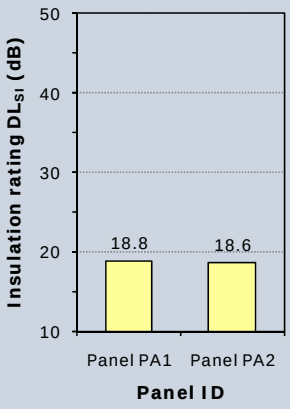
Physical condition of barrier during assessments	
2008 measurements	Structurally robust and generally in good condition. No obvious defects.
2009 measurements	Barrier no longer present –removed as part of the M1 J25-28 road widening scheme.

Panel PA1 and PA2: Sound insulation measurements

a) Third octave band sound insulation indices, SI_j



b) Single number rating of sound insulation, DL_{SI}



Panel PA1: Results from measurements taken in 2008

1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	14.2	17.0	19.8	16.0	15.7	16.9	15.8	15.0	16.5	16.1
400	14.4	17.4	21.5	16.3	16.0	17.3	16.0	15.0	16.9	16.4
500	15.5	16.4	17.5	20.2	21.4	19.4	19.6	16.8	18.3	18.0
630	17.6	18.2	19.2	20.2	21.2	20.2	18.9	17.1	18.9	18.9
800	22.7	23.5	26.8	19.2	19.4	20.5	17.3	17.2	19.2	19.8
1000	21.4	18.8	21.5	22.3	21.4	20.3	18.6	21.1	19.4	20.3
1250	21.4	17.2	20.1	22.8	16.1	19.6	24.7	25.4	25.0	20.2
1600	23.0	19.9	23.0	22.5	17.6	18.4	22.3	21.3	22.0	20.6
2000	16.8	17.6	16.5	18.2	22.1	19.0	17.6	22.3	16.9	18.1
2500	12.0	15.9	16.5	15.9	20.6	19.5	10.1	19.5	14.3	14.7
3150	17.2	27.2	21.3	19.9	24.3	25.6	15.2	18.5	24.1	19.8
4000	23.0	18.7	22.4	19.7	16.7	22.4	19.4	19.6	18.6	19.6
5000	24.8	203	28.0	26.8	24.3	23.6	24.2	25.6	20.9	23.6
DL_{SI} (0.3-5 kHz)	17.9	18.4	20.1	19.6	18.8	19.5	17.4	18.9	18.9	18.8

Panel PA2: Results from measurements taken in 2008

1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	18.2	17.7	15.1	16.5	16.2	15.6	14.6	14.7	15.5	15.9
400	18.9	18.5	15.5	17.3	16.7	15.8	14.7	14.6	15.8	16.2
500	17.7	17.9	15.7	19.2	19.9	19.3	17.5	17.7	20.3	18.1
630	19.3	20.0	17.1	19.6	19.5	18.8	17.8	18.2	19.6	18.8
800	24.5	27.1	20.3	19.8	18.1	17.1	17.5	18.1	17.7	19.1
1000	22.4	21.8	18.8	21.7	18.1	17.3	20.9	21.7	19.8	19.9
1250	18.5	22.5	19.1	17.7	16.4	22.5	25.7	23.3	28.3	20.2
1600	25.9	23.8	22.0	18.8	16.8	20.0	23.3	22.6	23.3	21.0
2000	21.6	17.5	15.2	22.1	18.4	20.9	22.5	19.7	20.9	19.2
2500	15.0	14.1	13.0	18.9	15.1	16.2	15.3	14.5	14.4	14.9
3150	18.8	19.4	17.9	19.8	25.3	19.0	16.2	19.2	18.5	18.9
4000	16.7	17.2	18.9	18.1	19.4	21.5	18.0	20.1	19.4	18.6
5000	14.2	25.0	20.7	17.3	21.4	25.3	16.3	24.8	21.3	19.2
DL_{SI} (0.3-5 kHz)	19.6	19.8	17.4	19.2	17.7	18.4	18.5	18.7	19.1	18.6

E.2 Single-leaf reflective barrier: M2, Junctions 2-3, Eastbound

Barrier location		
Road / Junctions	M2, J2 – J3	
Carriageway	Eastbound	
Nearest Marker Post	48/2 – 48/3 (48/2 + 20 m)	
Latitude GPS reading in brackets	51.37161° (N 51° 22.297')	
Longitude GPS reading in brackets	0.48130° (E 0° 28.878')	
OS Grid	TQ 728 665	
Approximate barrier orientation at coordinates (in direction of traffic)	NW-SE	

Barrier details and site description					
Barrier type	Single-leaf reflective timber noise barrier. Constructed as a continuous length, full-height barrier with timber posts on the front of the barrier. 'Plain' face on rear.				
Date constructed	July 2003*				
Dimensions	**Height**	3.0 m	**Post spacing**	2.8 m	
	Barrier thickness	Mid-panel	0.120 m	(80 mm rail + 20 mm plank + 20 mm cover strip)	
		Across post	Not measured (Posts on front of barrier)		
Safety barrier details	Free-standing, corrugated profile safety fence. Positioned approximately 4 m in front of the noise barrier.				
General site layout in barrier vicinity	Flat open ground in front of the noise barrier. Flat ground to the rear of the noise barrier with trees in the immediate vicinity of the barrier.				

* Construction date is estimated based on information provided by industry contacts. It is considered that the barrier may have been installed as part of the A2/M2 Cobham-J4 widening scheme.

Summary of measurement results (Frequency range: 315-5000 Hz)					
Element	**2008**		**2009**		**Notes**
	DL_{SI} (dB)	**Surface temp** Front/Rear	DL_{SI} (dB)	**Surface temp** Front/Rear	
Panel PA1	14.5	24.3°C/21.7°C	17.0	24.4°C/23.5°C	
Panel PA2	15.8	24.4°C/22.7°C	14.1	27.0°C/23.8°C	

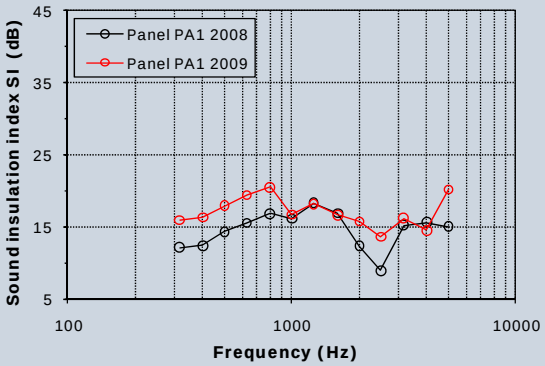
Photographs of the noise barrier at the test location	
 (a) General view of barrier from front	 (b) General view of barrier from rear
 (c) Detail of front of barrier	 (d) Detail of rear of barrier panel

Details of selected measurement positions	
Access	Measurement positions on the rear of the barrier are accessed via an unlocked emergency access gate in the barrier.
Panel PA1	Middle of 2nd panel to right of access gate (viewed from front), 1.5 m below top of barrier (27th timber to right of gate, 50 mm in from left-hand edge).
Panel PA2	Middle of 3rd panel to right of access gate (viewed from front), 1.5 m below top of barrier (46th timber to right of gate, 115 mm in from left-hand edge).
Posts	Not assessed (the posts are on the front of the barrier).

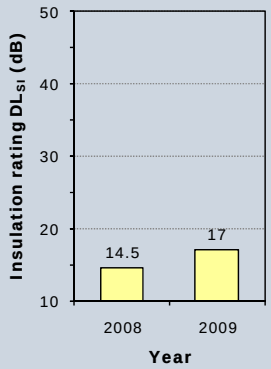
Physical condition of barrier during assessments	
2008 measurements	Structurally robust and generally in good condition. Some cover strips not totally flush with the main planking. Variable horizontal separation between the main vertical timbers (5-15 mm).
2009 measurements	Structurally robust and generally in good condition. Some cover strips not totally flush with the main planking. Variable horizontal separation between the main vertical timbers (5-15 mm). Some splitting of the horizontal rails has occurred.

Panel PA1: Sound insulation measurements

a) Third octave band sound insulation indices, SI_j



b) Single number rating of sound insulation, DL_{SI}



Panel PA1: Results from measurements taken in 2008

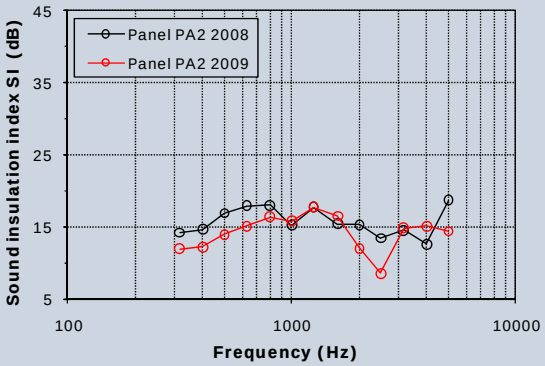
1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	11.9	11.2	10.7	13.3	14.2	13.8	11.7	11.8	11.0	12.1
400	12.1	11.4	11.0	13.6	14.8	14.3	11.9	12.0	11.2	12.4
500	17.2	17.0	15.6	12.5	13.0	12.0	15.1	15.6	15.1	14.3
630	18.8	18.8	17.4	13.6	13.1	13.2	16.9	17.6	17.8	15.5
800	17.8	17.4	17.5	16.5	13.8	16.5	17.7	18.3	20.2	16.8
1000	17.1	15.9	16.9	16.3	16.3	16.4	14.7	15.4	16.6	16.1
1250	17.3	17.6	15.1	24.0	21.8	20.7	16.6	18.4	16.5	18.3
1600	17.4	18.6	13.2	18.6	18.0	17.6	17.4	16.9	15.4	16.9
2000	14.3	13.6	13.5	11.0	10.5	10.8	15.4	15.1	11.8	12.3
2500	14.6	13.4	7.6	12.4	9.2	4.0	14.4	16.4	6.3	8.9
3150	15.0	20.8	11.9	12.1	15.6	16.5	19.0	19.1	13.8	15.2
4000	19.0	17.4	14.7	18.7	11.6	15.2	20.3	17.4	17.8	15.6
5000	20.0	16.7	18.9	15.9	12.9	12.6	16.5	18.7	11.3	15.0
DL_{SI} (0.3-5 kHz)	16.1	15.7	13.7	14.8	14.0	12.8	15.5	16.0	13.7	14.5

Panel PA1: Results from measurements taken in 2009

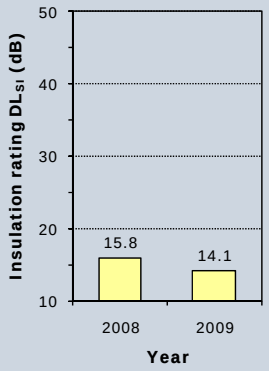
1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	14.2	14.8	13.2	17.9	18.7	19.8	15.4	15.5	16.1	15.9
400	14.6	15.2	13.4	18.8	19.7	21.1	15.8	15.9	16.6	16.3
500	18.5	19.5	19.0	15.1	16.8	18.3	16.3	20.5	22.6	17.9
630	21.9	21.7	18.9	16.9	18.6	17.9	18.3	23.7	23.0	19.4
800	25.2	21.0	16.1	24.2	23.8	17.7	22.9	23.1	19.6	20.5
1000	18.3	16.8	13.5	18.5	19.2	17.0	15.6	17.1	15.6	16.7
1250	17.9	19.7	15.5	21.1	27.6	19.7	15.0	18.4	15.3	18.2
1600	13.4	17.4	15.3	17.7	19.4	19.1	13.0	20.3	17.7	16.6
2000	17.3	17.2	13.2	13.9	18.4	13.4	14.3	22.0	17.5	15.7
2500	15.2	15.2	10.4	15.5	14.6	10.6	16.9	16.9	13.2	13.6
3150	24.9	16.0	16.3	18.9	14.6	15.1	20.4	14.9	17.2	16.2
4000	13.2	17.8	18.2	10.9	14.8	21.1	14.7	14.8	19.7	14.5
5000	16.4	22.4	20.6	18.4	25.2	22.0	18.2	20.7	21.1	20.2
DL_{SI} (0.3-5 kHz)	17.1	17.7	14.7	17.3	18.9	16.7	15.9	18.5	17.0	17.0

Panel PA2: Sound insulation measurements

a) Third octave band sound insulation indices, SI_j



b) Single number rating of sound insulation, DL_{SI}



Panel PA2: Results from measurements taken in 2008

1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	13.4	13.2	12.1	16.1	16.6	16.4	13.5	13.4	14.4	14.2
400	14.0	13.4	12.3	17.3	17.6	17.4	13.8	13.5	14.7	14.6
500	18.3	19.0	18.1	14.2	16.2	15.7	15.2	19.3	20.8	16.9
630	21.2	20.4	17.1	15.9	17.3	15.3	17.6	22.5	21.1	17.9
800	22.7	18.5	14.0	21.3	19.5	15.0	20.9	20.2	17.8	18.0
1000	17.8	16.4	12.8	16.3	17.8	14.6	13.6	15.2	14.4	15.2
1250	16.1	18.7	16.4	18.9	27.1	19.3	14.0	18.3	16.1	17.7
1600	14.5	15.2	12.4	17.9	17.5	17.3	14.1	16.1	14.8	15.4
2000	14.7	17.9	12.5	12.8	19.8	13.6	13.9	22.7	17.3	15.3
2500	12.9	13.8	13.2	16.1	10.9	14.9	15.5	12.8	17.7	13.4
3150	17.4	14.1	16.4	14.9	13.1	14.9	16.7	13.7	16.2	14.5
4000	12.5	14.7	15.2	9.4	12.0	14.9	14.3	13.7	16.0	12.6
5000	19.9	20.9	17.7	17.7	17.9	17.9	19.2	21.8	17.0	18.7
DL_{SI} (0.3-5 kHz)	16.2	16.4	13.9	16	16.9	15.6	14.9	16.5	16.2	15.8

Panel PA2: Results from measurements taken in 2009

1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	11.8	10.8	10.2	13.2	14.0	13.2	12.0	11.5	10.6	11.9
400	12.1	11.0	10.5	13.7	14.7	13.9	12.3	11.8	10.9	12.2
500	16.9	16.6	14.7	12.1	12.9	11.6	15.2	15.4	14.5	13.9
630	18.7	18.0	16.5	13.2	12.9	12.6	16.9	17.4	17.2	15.1
800	18.0	16.4	16.8	16.1	13.5	15.6	17.7	17.9	19.7	16.4
1000	16.9	15.2	15.9	16.4	16.3	15.9	14.6	15.1	16.1	15.8
1250	17.0	16.7	14.5	22.7	21.5	20.0	16.2	17.8	16.3	17.7
1600	16.8	17.8	12.6	18.5	18.5	16.9	17.6	17.0	15.0	16.5
2000	14.2	13.3	13.2	10.7	10.6	10.1	15.6	15.2	11.5	12.0
2500	15.3	13.0	7.2	12.2	9.6	3.3	14.5	16.0	6.1	8.5
3150	14.6	20.0	11.3	11.5	15.2	16.5	18.7	18.5	14.6	14.8
4000	17.5	16.5	14.2	18.7	10.9	15.0	20.7	17.3	19.3	15.1
5000	18.6	15.9	18.1	14.7	12.6	12.1	16.2	18.6	11.9	14.4
DL_{SI} (0.3-5 kHz)	15.9	15.1	13.2	14.5	13.9	12.2	15.5	15.7	13.4	14.1

E.3 Single-leaf reflective barrier: M4, Junctions 7-8/9, Eastbound

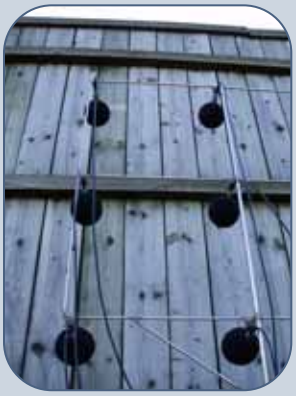
Barrier location	
Road/Junctions	M4, J7 – J8/9
Carriageway	Eastbound
Nearest Marker Post	41/4 – 41/3 (41/4 - 75 m)
Latitude	51.50995° (N 51° 30.597')
Longitude	-0.67512° (W 0° 40.507')
OS Grid	SU 919 798
Approximate barrier orientation at coordinates (in direction of traffic)	W-E

Barrier details and site description					
Barrier type	Single-leaf reflective timber noise barrier. Constructed as a continuous length, full-height barrier with timber posts on the rear of the barrier. 'Plain' face on traffic-facing side.				
Date constructed	July 2001* (Possible Hansard site installation)				
Dimensions	**Height**	3.0 m	**Post spacing**	2.4 m	
	Barrier thickness	Mid-panel	0.90 m	(50 mm rail + 20 mm plank + 20 mm cover strip)	
		Across post	Not measured (Posts on rear of barrier)		
Safety barrier details	Free-standing, open-box safety fence. Positioned approximately 0.73 m in front of the noise barrier.				
General site layout in barrier vicinity	Flat ground in front of the barrier. Sloping ground immediately to the rear of the noise barrier.				

* Construction date is estimated based on information provided by industry contacts.

Summary of measurement results (Frequency range: 315-5000 Hz)

Element	2008		2009		Notes
	DL_{SI} (dB)	Surface temp Front/Rear	DL_{SI} (dB)	Surface temp Front/Rear	
Panel PA1	*Barrier unavailable for testing: Poor weather & equipment failure*		18.6	12.7°C/13.9°C	
Panel PA2			17.8	14.3°C/15.2°C	

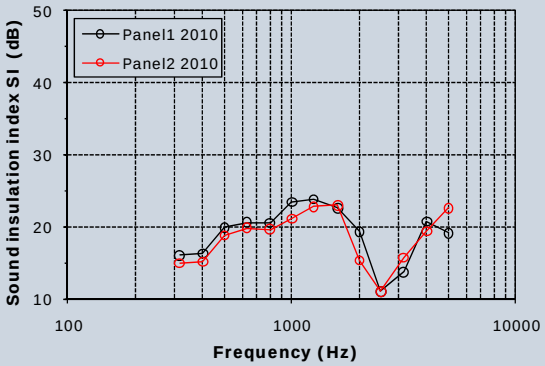
Photographs of the noise barrier at the test location	
 (a) General view of barrier from front	 (b) General view of barrier from rear
 (c) Detail of front of barrier	 (d) Detail of rear of barrier panel

Measurement positions	
Access	Measurement positions on the rear of the barrier are accessed via the end of the barrier.
Panel PA1	Middle of 8th panel (2nd full-height panel) from end of barrier, 1.5 m below top of barrier.
Panel PA2	Middle of 9th panel (3rd full-height panel) from end of barrier, 1.5 m below top of barrier.
Posts	Not assessed (the posts are on the rear of the barrier).

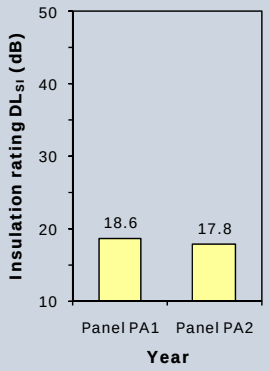
Physical condition of barrier during assessments	
2008 measurements	Not assessed due to equipment failure.
2009 measurements	In good condition, structurally robust with no obvious defects. Some minor splitting around the nails holding the vertical timbers onto the horizontal rails, although splits have not yet passed completely through the timbers. Some small gaps between the cover strips and the main planks. Some vertical splitting is observed in the posts.

Panel PA1: Sound insulation measurements

a) Third octave band sound insulation indices, SI_j



b) Single number rating of sound insulation, DL_{SI}



Panel PA1: Results from measurements taken in 2010

1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	15.3	17.9	17.3	15.0	18.8	16.7	14.1	15.8	14.0	16.0
400	15.8	18.8	18.0	15.1	19.7	16.9	14.2	16.2	14.1	16.3
500	20.9	21.1	22.7	19.8	20.1	17.5	21.6	19.5	18.8	19.9
630	20.9	22.3	22.5	21.2	20.8	18.7	22.5	19.8	19.1	20.6
800	19.4	24.0	20.8	21.1	21.9	21.1	19.8	19.4	17.9	20.5
1000	24.0	29.1	22.3	24.5	22.8	23.2	25.0	22.8	20.6	23.4
1250	21.3	25.1	21.0	28.4	25.3	24.1	25.9	23.0	22.1	23.8
1600	20.6	19.4	23.8	33.6	22.9	21.8	25.5	21.5	23.4	22.6
2000	20.9	23.4	27.1	15.9	19.4	22.0	16.0	19.8	21.1	19.3
2500	11.0	16.0	13.7	8.8	14.4	11.4	6.5	11.7	9.4	11.0
3150	17.9	21.0	15.8	11.5	19.6	9.8	9.8	16.6	10.6	13.7
4000	21.8	24.4	23.5	17.3	21.2	26.1	20.7	20.1	19.8	20.7
5000	20.6	23.5	18.9	19.2	19.4	21.5	15.2	18.9	14.2	19.1
DL_{SI} (0.3-5 kHz)	18.6	21.6	20.1	17.3	20.6	18.1	15.9	18.7	16.7	18.6

Panel PA2: Results from measurements taken in 2010

1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	14.9	18.1	15.7	14.9	16.7	15.9	11.7	14.7	13.6	14.9
400	15.2	18.8	15.9	15.1	17.0	16.1	11.7	15.1	13.7	15.1
500	20.4	21.5	22.0	15.0	18.3	19.3	18.0	21.1	21.0	18.8
630	21.6	22.0	21.8	16.1	19.9	20.8	18.3	23.0	20.9	19.8
800	20.9	22.0	19.5	18.0	22.5	21.8	16.2	21.7	18.0	19.6
1000	24.0	26.6	24.2	17.9	21.1	21.6	18.4	23.4	22.7	21.1
1250	22.3	25.3	23.9	20.3	23.6	25.0	19.7	24.6	23.7	22.8
1600	23.1	23.1	25.2	19.8	25.2	24.9	22.1	21.4	27.6	23.0
2000	20.8	18.9	16.2	15.5	15.6	12.2	17.7	16.4	12.7	15.3
2500	13.2	16.3	11.1	9.7	13.5	7.6	10.0	14.7	9.2	11.0
3150	20.6	22.4	14.4	15.3	24.9	12.6	16.1	19.0	8.1	15.7
4000	24.6	23.9	18.1	19.3	19.4	16.7	22.4	18.7	18.3	19.4
5000	23.8	26.0	17.8	23.0	22.5	23.7	22.0	23.7	17.3	22.6
DL_{SI} (0.3-5 kHz)	19.6	21.5	18.4	16.2	19.2	16.3	16.1	19.4	15.9	17.8

E.4 Single-leaf reflective barrier: M5, Junctions 11A-12, Northbound

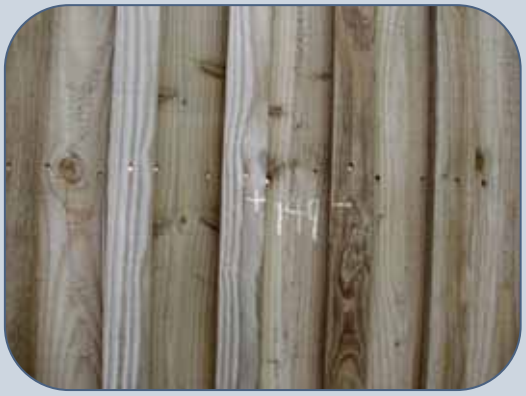
Barrier location	
Road / Junctions	M5, J11A - J12
Carriageway	Northbound
Nearest Marker Posts	89/9 – 89/8 (89/9 - 5 m)
Latitude GPS reading in brackets	51.83433° (N 51° 50.060')
Longitude GPS reading in brackets	-2.20372° (W 2° 12.223')
OS Grid	SO 860 150
Approximate barrier orientation at coordinates (in direction of traffic)	SE-NE

Barrier details and site description					
Barrier type	Single-leaf reflective timber barrier. Constructed as a continuous length, full-height barrier with I-section steel posts on the front of the barrier. 'Plain' face on rear.				
Date constructed	July 2002 (Hansard site installation)				
Dimensions	**Height**	3.0 m	**Post spacing**	3.0 m	
	Barrier thickness	Mid-panel	0.150 m	(100 mm rail + 25 mm plank + 25 mm cover strip)	
		Across post	Not measured (Posts on front of barrier)		
Safety barrier details	Free-standing open-box safety fence. Positioned approximately 1.7 m in front of the noise barrier.				
General site layout in barrier vicinity	Flat ground in front of the noise barrier. Approximately 1 m of flat ground immediately to the rear of the noise barrier with gently sloping ground beyond. Heavily overgrown when measurements were taken.				

* Construction date is estimated based on information provided by the Managing Agents/industry contacts.

Summary of measurement results (Frequency range: 315-5000 Hz)

Element	2008		2009		Notes
	DL_{SI}	Surface temp Front/Rear	DL_{SI}	Surface temp Front/Rear	
Panel PA1	20.1	Not measured	20.5	28.4°C/21.7°C	*2008 measurements used CEN/TS 1793-5 method (P5 free-field mic & path differences)*
Panel PA2	18.8	Not measured	18.8	25.8°C/21.9°C	

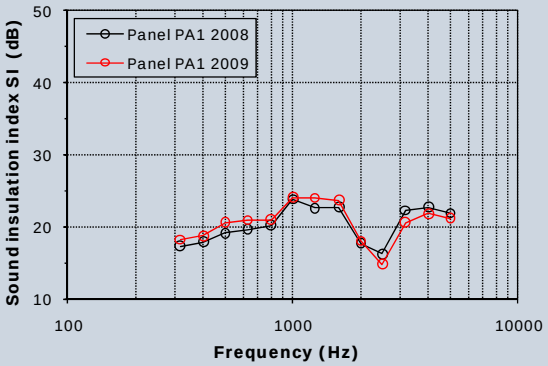
Photographs of the noise barrier at the test location	
 (a) General view of barrier from front	 (b) General view of barrier from rear
 (c) Detail of front of barrier	 (d) Detail of rear of barrier panel

Details of selected measurement positions	
Access	Measurement positions on the rear of the barrier are accessed via the end of the barrier.
Panel PA1	Middle of 3rd full panel from right-hand end of barrier, 1.5 m below top of barrier (149th timber from right-hand end, 15 mm in from right-hand edge). Position located just below horizontal rail.
Panel PA2	Middle of 2nd full panel from right-hand end of barrier, 1.5 m below top of barrier (129th timber from right-hand end, 50 mm in from right-hand edge). Position located just below horizontal rail.
Posts	Not assessed (the posts are on the front of the barrier)

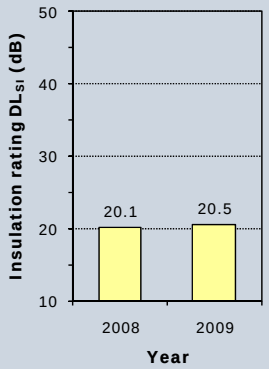
Physical condition of barrier during assessments	
2008 measurements	Generally in good condition, structurally robust with no obvious defects. Some small gaps (0-4 mm) between the cover strips and main planks. Horizontal separation between main planks variable (2 -10 mm).
2009 measurements	Generally in good condition, structurally robust with no obvious defects. Some small gaps (0-4 mm) between the cover strips and main planks. Horizontal separation between main planks variable (2 -10 mm).

Panel PA1: Sound insulation measurements

a) Third octave band sound insulation indices, SI_j



b) Single number rating of sound insulation, DL_{SI}



Panel PA1: Results from measurements taken in 2008

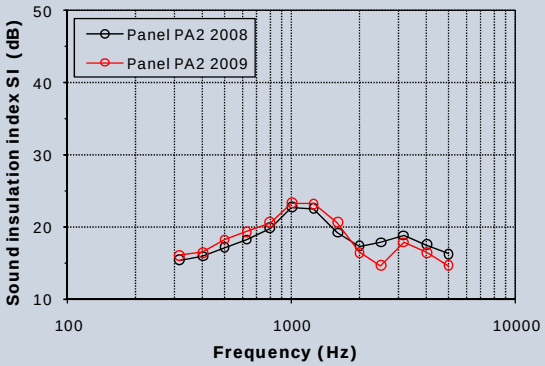
1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	17.0	17.0	16.9	17.4	18.2	19.0	15.9	16.0	19.8	17.3
400	17.7	17.5	17.5	18.1	19.3	20.6	16.1	16.2	20.7	17.9
500	16.9	17.8	19.5	18.9	21.3	22.3	16.9	19.9	22.8	19.1
630	18.7	18.8	20.7	18.6	20.9	20.2	17.6	20.4	21.7	19.6
800	24.8	20.8	21.7	18.6	20.6	18.8	18.6	20.0	20.8	20.2
1000	25.5	21.8	21.8	25.0	26.7	25.7	21.2	23.7	27.0	23.8
1250	21.8	23.6	22.7	20.8	21.3	23.0	22.6	24.2	24.3	22.6
1600	24.5	21.5	22.8	23.1	19.4	24.1	23.3	23.2	26.0	22.7
2000	17.8	17.7	17.6	16.5	18.3	17.9	16.1	22.2	17.8	17.7
2500	15.8	16.3	12.8	19.3	19.2	19.5	13.9	18.2	16.2	16.2
3150	22.8	24.8	18.3	25.7	25.6	24.6	24.1	21.9	19.9	22.3
4000	21.6	20.7	20.6	22.3	25.9	24.9	24.8	22.1	24.8	22.7
5000	22.5	21.7	24.7	26.2	21.1	31.9	22.5	16.5	25.3	21.9
DL_{SI} (0.3-5 kHz)	20.2	19.7	19.4	19.9	20.8	21.2	18.5	20.5	21.4	20.1

Panel PA1: Results from measurements taken in 2009

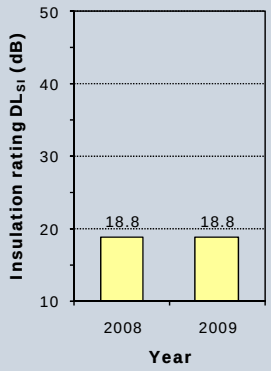
1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	18.3	19.0	17.9	17.9	19.0	19.5	16.8	16.3	20.6	18.2
400	18.9	19.4	18.4	18.4	19.3	20.3	17.1	16.4	21.3	18.7
500	18.4	20.3	21.9	19.9	23.1	23.8	17.8	20.2	24.8	20.6
630	19.9	21.3	22.4	19.6	23.0	21.7	18.4	20.4	23.2	20.9
800	24.9	22.9	21.7	19.3	22.4	19.8	19.3	19.7	21.4	21.0
1000	24.9	23.3	22.0	25.0	29.9	26.4	20.3	24.1	24.7	24.1
1250	22.0	24.7	23.7	24.7	25.2	25.9	23.2	23.9	23.0	24.0
1600	23.6	23.2	24.5	23.7	22.1	26.7	23.9	23.1	24.4	23.7
2000	15.8	20.3	16.7	17.2	21.8	19.6	13.8	23.0	16.4	18.0
2500	12.1	15.5	9.0	18.9	20.9	20.2	11.0	17.4	12.0	14.8
3150	18.3	23.4	14.5	25.5	27.3	22.9	23.9	18.4	14.6	20.6
4000	21.9	20.4	17.9	25.5	27.1	23.2	23.6	17.7	19.1	21.8
5000	19.2	24.1	18.9	31.6	24.4	25.2	19.9	14.9	21.9	21.2
DL_{SI} (0.3-5 kHz)	19.3	21.2	18.1	20.7	23.0	22.3	17.8	20.2	19.7	20.5

Panel PA2: Sound insulation measurements

a) Third octave band sound insulation indices, SI_j



b) Single number rating of sound insulation, DL_{SI}



Panel PA2: Results from measurements taken in 2008

1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	15.7	15.7	16.4	15.2	16.8	17.2	12.9	14.9	15.4	15.4
400	16.3	16.3	17.2	15.7	17.8	18.1	13.1	15.2	15.8	15.9
500	16.1	16.4	18.6	16.3	16.9	20.0	15.4	18.3	17.5	17.1
630	17.9	18.0	19.7	17.1	17.3	21.0	16.9	18.5	18.6	18.2
800	22.0	21.8	20.7	18.5	18.6	22.2	18.7	18.1	20.0	19.8
1000	19.5	21.8	20.5	23.2	23.8	28.6	25.2	23.3	24.4	22.7
1250	22.2	23.1	21.3	19.9	21.6	24.0	24.9	21.0	32.3	22.5
1600	21.6	18.6	25.0	18.3	16.5	21.9	17.1	17.1	25.2	19.2
2000	17.5	17.6	20.6	14.9	16.3	19.9	14.4	17.6	26.4	17.3
2500	17.5	20.1	17.5	19.2	18.7	25.3	14.0	14.8	25.7	17.8
3150	25.2	22.4	20.2	19.5	21.2	20.7	14.5	16.1	18.7	18.8
4000	19.3	16.3	14.2	20.6	18.5	20.9	21.2	15.7	16.2	17.5
5000	12.9	12.7	24.0	15.6	20.5	25.2	13.7	16.9	24.7	16.2
DL_{SI} (0.3-5 kHz)	18.7	18.9	19.7	18.0	18.6	21.7	16.9	17.9	20.6	18.8

Panel PA2: Results from measurements taken in 2009

1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	16.0	17.0	16.4	16.0	18.9	17.8	13.0	14.5	15.7	16.0
400	16.3	17.5	16.9	16.5	20.0	18.7	13.1	14.5	16.0	16.4
500	17.4	18.1	20.3	17.3	18.8	21.7	16.2	17.1	19.1	18.2
630	19.0	19.8	20.7	18.0	19.2	23.3	17.5	17.5	20.3	19.3
800	22.2	24.0	20.1	19.2	20.9	25.2	18.5	17.6	21.1	20.6
1000	20.4	22.8	20.1	24.1	25.0	28.2	26.8	22.9	24.9	23.3
1250	21.8	25.4	22.1	22.5	23.9	27.3	22.8	20.1	31.2	23.2
1600	22.0	20.7	27.8	18.8	19.0	25.1	17.7	18.9	27.2	20.6
2000	14.1	18.0	16.8	13.5	18.2	21.3	12.4	18.4	24.6	16.4
2500	10.4	20.4	12.5	14.4	21.4	24.0	9.5	11.7	21.1	14.6
3150	18.1	23.1	15.2	19.4	22.6	18.3	10.5	15.0	23.2	17.8
4000	19.1	14.3	12.0	20.9	18.5	18.6	19.7	13.1	12.8	16.4
5000	11.5	13.5	13.6	16.8	20.5	21.0	9.5	12.7	13.5	14.6
DL_{SI} (0.3-5 kHz)	17.3	20.0	18.1	18.0	20.6	22.7	15.5	17.0	20.5	18.8

E.5 Single-leaf reflective barrier: M5, Junctions 11A-12, Southbound

Barrier location	
Road / Junctions	M5, J11A - J12
Carriageway	Southbound
Nearest Marker Posts	89/5 – 89/6 (89/5 + 45 m)
Latitude GPS reading in brackets	51.83662° (N 51° 50.197')
Longitude GPS reading in brackets	-2.19997° (W 2° 11.998')
OS Grid	SO 863 153
Approximate barrier orientation at coordinates (in direction of traffic)	NE-SE

Barrier details and site description				
Barrier type	Single-leaf reflective timber barrier. Constructed as a continuous length, full-height barrier with I-section steel posts on the front of the barrier. 'Plain' face on rear.			
Date constructed	July 2002* (Hansard site installation)			
Dimensions	**Height**	3.0 m	**Post spacing**	3.0 m
	Barrier thickness	Mid-panel	0.150 m	(100 mm rail + 25 mm plank + 25 mm cover strip)
		Across post	Not measured (Posts on front of barrier)	
Safety barrier details	Free-standing open-box safety fence. Positioned approximately 1.8 m in front of the noise barrier.			
General site layout in barrier vicinity	Flat ground in front of the noise barrier. Flat ground to the rear of the noise barrier.			

* Construction date is estimated based on information provided by the Highways Agency Managing Agent and industry contacts.

Summary of measurement results (Frequency range: 315-5000 Hz)

Element	2008		2009		Notes
	DL_{SI}	Surface temp Front/Rear	DL_{SI}	Surface temp Front/Rear	
Panel PA1	19.6	30.6°C	*Barrier unavailable for testing: Road space unavailable*		*2008 measurements used CEN/TS 1793-5 method (P5 free-field mic & path differences)*
Panel PA2	19.1	Not Measured			

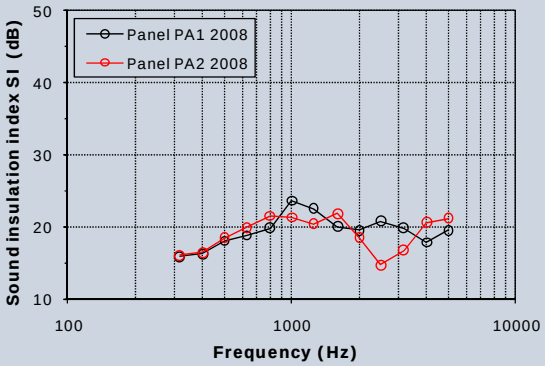
Photographs of the noise barrier at the test location	
 (a) General view of barrier from front	 (b) General view of barrier from rear
 (c) Detail of front of barrier	 (d) Detail of rear of barrier panel

Details of selected measurement positions	
Access	Measurement positions on the rear of the barrier are accessed via an emergency access gate in the barrier.
Panel PA1	Middle of 5th full panel to right of access gate (viewed from front), 1.5 m below top of barrier (89th timber from gate, 80 mm in from right-hand edge).
Panel PA2	Middle of 6th full panel to right of access gate (viewed from front), 1.5 m below top of barrier (109th timber from gate, 120 mm in from right-hand edge).
Posts	Not assessed (the posts are on the front of the barrier).

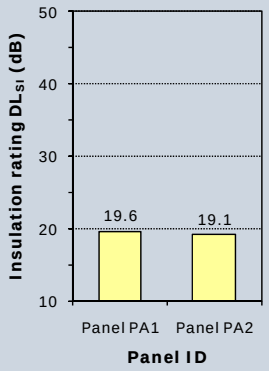
Physical condition of barrier during assessments	
2008 measurements	Generally in good condition, structurally robust with no obvious defects. Some small gaps (0-4 mm) between the cover strips and main planks. Horizontal separation between main planks variable (2 -10 mm).
2009 measurements	Physical condition not assessed as testing not undertaken due to unavailability of road space

Panel PA1: Sound insulation measurements

a) Third octave band sound insulation indices, SI_j



b) Single number rating of sound insulation, DL_{SI}



Panel PA1: Results from measurements taken in 2008

1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	18.5	16.0	16.8	17.4	18.9	17.6	13.6	13.0	14.6	19.6
400	19.3	16.5	17.7	18.4	19.7	18.7	13.7	13.2	14.8	15.8
500	18.8	18.3	16.0	20.2	18.5	19.6	16.7	18.0	17.3	16.2
630	20.5	20.3	17.9	20.2	18.1	19.2	17.9	18.5	17.6	18.0
800	25.7	23.8	25.2	20.2	18.3	19.0	18.8	17.7	17.6	18.8
1000	23.3	21.5	25.1	24.6	22.9	24.2	23.6	24.6	23.5	19.8
1250	21.2	20.6	23.4	22.3	20.7	23.4	23.6	24.8	24.9	23.6
1600	25.8	21.2	23.5	20.7	15.4	20.5	22.3	18.3	20.3	22.5
2000	20.6	20.5	25.3	17.4	17.7	22.1	18.3	18.1	20.2	20.0
2500	21.8	26.8	18.6	23.3	21.5	20.5	20.1	18.7	20.5	19.5
3150	23.7	22.2	16.3	22.8	22.7	19.8	19.0	22.1	16.9	20.8
4000	14.4	20.0	17.2	20.7	18.6	17.6	17.9	16.8	20.3	19.8
5000	25.8	17.1	17.0	20.4	18.2	20.9	19.8	19.6	23.0	17.8
DL_{SI} (0.3-5 kHz)	21.2	20.3	20.3	20.5	18.9	20.5	18.7	18.3	19.0	19.6

Panel PA2: Results from measurements taken in 2008

1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	16.8	15.7	15.8	17.0	18.3	18.2	13.9	15.2	14.9	16.0
400	17.8	16.1	16.3	17.7	19.2	19.2	14.1	15.3	15.1	16.4
500	19.0	17.0	19.0	16.7	19.0	20.1	18.7	17.5	21.6	18.5
630	20.6	19.5	21.8	18.1	20.0	20.2	20.4	18.1	22.3	19.9
800	23.7	26.7	26.3	21.9	20.9	20.1	20.6	18.6	20.5	21.5
1000	21.8	19.7	20.7	24.0	17.9	20.9	25.0	21.1	27.6	21.3
1250	18.8	20.1	21.5	21.6	16.9	21.9	22.8	20.4	23.5	20.4
1600	24.4	22.9	23.6	21.0	17.9	22.0	24.0	20.6	24.9	21.8
2000	17.1	18.6	17.8	19.1	16.8	17.3	20.3	20.4	20.9	18.5
2500	10.7	13.9	15.3	15.9	18.7	16.9	14.1	14.0	20.7	14.7
3150	12.2	14.4	21.8	18.0	18.9	24.5	14.8	17.5	21.0	16.7
4000	20.2	16.8	26.7	19.4	17.6	25.2	25.3	20.2	27.7	20.6
5000	24.7	17.4	21.5	24.6	19.5	20.5	25.3	21.9	22.3	21.2
DL_{SI} (0.3-5 kHz)	18.0	18.5	19.9	19.6	18.3	20.0	19.1	18.4	21.0	19.1

E.6 Single-leaf reflective barrier: M5, Junctions 18-19, Southbound

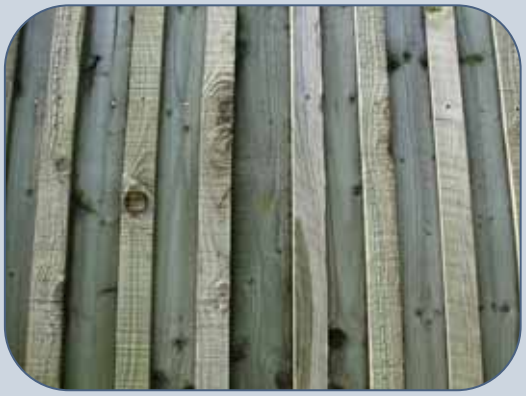
Barrier location	
Road / Junctions	M5, J18 - J19
Carriageway	Southbound
Nearest Marker Posts	144/1 – 144/2 (144/1 + 33 m)
Latitude GPS reading in brackets	51.48228° (N 51° 28.937')
Longitude GPS reading in brackets	-2.70008° (W 2° 42.005')
OS Grid	ST 514 761
Approximate barrier orientation at coordinates (in direction of traffic)	NE-SE

Barrier details and site description					
Barrier type	Single-leaf reflective timber barrier. Constructed using full-height panels in between I-section posts. 'Plain' face on rear of barrier.				
Date constructed	July 1999*				
Dimensions	**Height**	3.0 m	**Post spacing**	2.55 m	
	Barrier thickness	Mid-panel	0.085 m	(45 mm rail + 20 mm plank + 20 mm cover strip)	
		Across post	0.125 m	(125 mm I-section post)	
Safety barrier details	Free-standing open-box safety fence. Positioned approximately 1.45 m in front of the noise barrier.				
General site layout in barrier vicinity	Flat ground in front of the noise barrier. Sloping ground immediately to the rear of the noise barrier. Heavily overgrown.				

* Construction date is estimated based on information provided by industry contacts. It is considered that the barrier may have been installed as part of the M5 J18-19 widening scheme.

Summary of measurement results (Frequency range: 315-5000 Hz)

Element	2008		2009		Notes
	DL_{SI}	Surface temp Front/Rear	DL_{SI}	Surface temp Front/Rear	
Panel PA1	19.7	31.0°C/36.9°C	20.0	21.0°C/29.3°C	
Panel PA2	18.3	31.4°C/29.1°C	18.8	17.9°C/17.1°C	
Post PO1	17.5	Not measured	17.7	19.8°C/18.3°C	

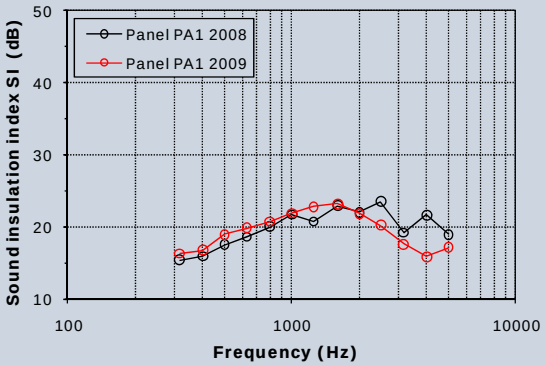
Photographs of the noise barrier at the test location	
 (a) General view of barrier from front	 (b) General view of barrier from rear
 (c) Detail of front of barrier	 (d) Detail of rear of barrier panel

Details of selected measurement positions	
Access	Measurement positions on the rear of the barrier are accessed via an emergency access gate in the barrier.
Panel PA1	Middle of 3rd panel to left of access gate (viewed from front), 1.5 m below top of barrier.
Panel PA2	Middle of 2nd panel to left of access gate (viewed from front), 1.5 m below top of barrier.
Post PO1	Post in-between 2nd and 3rd panel

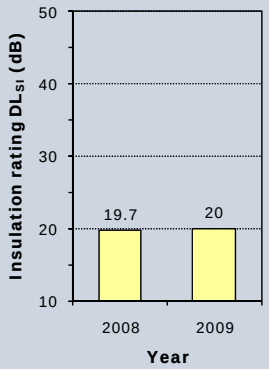
Physical condition of barrier during assessments	
2008 measurements	Generally in good condition. Structurally robust with no obvious defects.
2009 measurements	Generally in good condition. Structurally robust with no obvious defects.

Panel PA1: Sound insulation measurements

a) Third octave band sound insulation indices, SI_j



b) Single number rating of sound insulation, DL_{SI}



Panel PA1: Results from measurements taken in 2008

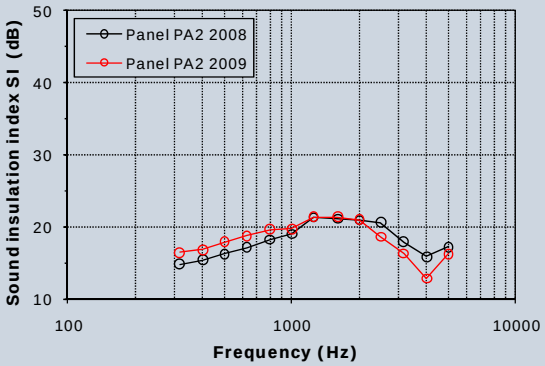
1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	15.2	16.3	17.1	14.7	15.9	14.3	13.7	17.0	16.0	15.4
400	15.9	17.2	18.1	14.9	16.5	14.6	13.8	17.6	16.2	15.9
500	17.7	15.8	16.0	20.5	20.9	20.5	16.4	16.4	16.7	17.5
630	19.2	17.1	17.0	20.7	20.1	21.1	18.7	18.0	17.8	18.6
800	21.1	20.2	20.0	18.9	18.5	19.3	22.1	22.0	19.6	20.0
1000	22.4	20.3	22.7	19.5	21.2	22.5	22.7	22.4	22.7	21.7
1250	18.6	18.8	20.9	19.3	23.5	26.3	18.9	21.2	25.1	2.7
1600	24.9	20.1	22.5	25.2	25.7	30.1	23.6	20.9	20.8	22.9
2000	25.6	22.8	23.4	18.8	20.8	24.8	20.4	21.6	24.6	22.0
2500	28.0	21.6	26.6	22.3	22.8	23.5	23.2	24.6	22.4	23.5
3150	18.0	20.0	24.1	15.7	20.6	19.2	21.1	24.2	17.1	19.2
4000	17.9	23.8	26.4	20.1	20.9	25.8	18.8	23.4	28.4	21.6
5000	19.5	17.2	24.5	21.2	13.6	25.2	22.4	18.6	21.1	18.9
DL_{SI} (0.3-5 kHz)	19.8	19.0	20.2	19.0	20.0	20.6	19.1	20.2	19.9	19.7

Panel PA1: Results from measurements taken in 2009

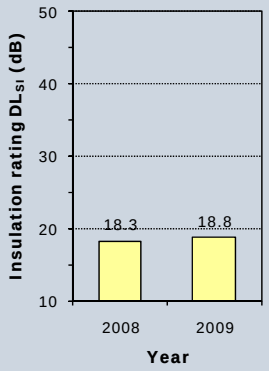
1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	16.1	19.3	18.3	14.9	17.6	16.7	13.3	17.3	16.4	16.3
400	16.7	20.5	19.1	15.1	18.1	16.9	13.3	17.7	16.4	16.7
500	18.7	17.7	18.0	21.0	23.7	22.9	15.7	18.6	17.4	18.9
630	20.3	19.0	19.1	20.6	22.0	23.0	17.8	19.3	18.4	19.8
800	22.9	23.1	22.7	18.2	19.5	20.8	21.4	20.6	20.5	20.7
1000	23.0	22.0	25.7	19.3	21.9	23.5	19.6	23.6	22.9	21.9
1250	23.3	21.3	22.5	21.5	23.3	27.5	22.3	21.9	25.0	22.8
1600	25.6	22.6	22.4	26.0	23.8	30.3	20.8	20.3	21.6	23.2
2000	25.9	27.1	20.7	19.9	21.1	24.7	18.5	20.8	26.3	21.8
2500	25.9	23.8	22.7	21.5	21.8	16.2	19.7	20.6	18.6	20.2
3150	16.0	20.6	17.4	15.4	18.9	17.3	16.9	19.0	15.5	17.6
4000	16.8	22.5	23.3	12.8	15.9	17.3	13.6	15.9	17.1	15.8
5000	20.8	21.0	17.1	17.2	15.6	20.6	13.9	16.0	16.0	17.1
DL_{SI} (0.3-5 kHz)	20.9	21.3	21.0	18.7	20.7	21.1	17.9	20.0	19.7	20.0

Panel PA2: Sound insulation measurements

a) Third octave band sound insulation indices, SI_j



b) Single number rating of sound insulation, DL_{SI}



Panel PA2: Results from measurements taken in 2008

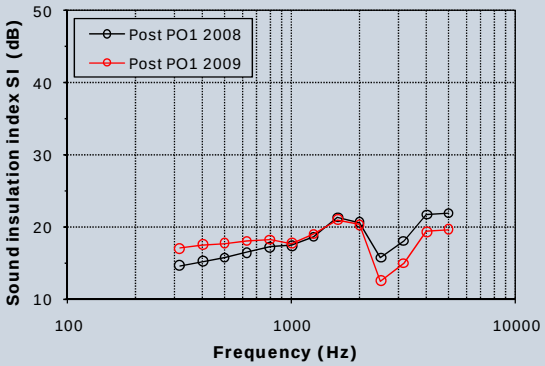
1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	14.4	17.3	14.9	14.7	14.3	14.3	15.0	15.5	14.0	14.8
400	14.9	18.8	15.3	15.4	14.7	14.6	15.5	16.0	14.3	15.4
500	15.3	15.5	16.5	18.5	19.0	18.8	15.4	15.8	14.0	16.2
630	16.3	15.9	18.3	18.3	18.2	21.2	15.7	17.1	15.7	17.1
800	17.2	17.3	21.1	17.2	16.6	22.2	16.4	20.0	19.5	18.2
1000	16.3	17.9	20.7	17.4	18.8	21.4	18.8	24.5	20.1	19.0
1250	23.9	19.1	25.7	22.3	20.6	24.4	19.8	20.3	20.2	21.3
1600	23.6	16.7	24.2	26.1	28.0	25.3	24.4	18.7	18.1	21.1
2000	26.1	22.0	19.0	23.9	26.4	21.4	20.3	18.6	18.1	20.9
2500	22.7	19.1	22.9	22.6	21.5	19.0	19.3	21.5	19.1	20.6
3150	18.0	13.9	21.1	18.2	19.3	19.2	21.7	17.0	17.6	17.9
4000	13.7	20.1	22.7	11.4	21.1	18.4	13.0	16.1	19.5	15.8
5000	15.9	16.4	24.2	16.4	13.0	19.6	18.2	22.0	18.7	17.2
DL_{SI} (0.3-5 kHz)	17.6	17.5	19.7	18.2	18.6	20	17.6	18.7	17.5	18.3

Panel PA2: Results from measurements taken in 2009

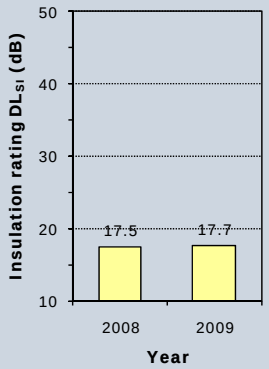
1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	16.4	18.7	17.2	16.0	15.0	16.1	17.0	17.6	15.4	16.4
400	17.0	19.6	17.9	16.1	15.2	16.5	17.4	18.1	15.7	16.8
500	16.0	17.5	19.0	19.8	21.7	22.0	16.2	16.9	15.5	17.9
630	16.8	18.4	20.6	19.3	21.3	24.6	16.7	18.0	16.4	18.7
800	18.7	20.4	23.5	17.8	18.7	23.3	18.1	21.5	18.7	19.6
1000	17.6	17.8	22.9	18.5	20.1	20.4	19.1	23.7	20.9	19.7
1250	20.3	20.4	26.8	22.0	22.8	22.5	20.4	20.9	19.2	21.4
1600	22.9	18.4	25.4	27.6	28.6	26.2	21.0	17.1	17.8	21.4
2000	26.0	23.4	19.0	24.1	22.1	21.9	19.0	18.6	19.2	21.0
2500	23.6	21.3	22.5	21.8	18.5	20.8	16.0	14.8	17.2	18.6
3150	16.9	14.1	20.1	16.2	21.7	16.2	16.0	13.7	12.6	16.3
4000	10.8	16.3	19.5	9.5	19.4	14.6	8.9	14.3	15.8	12.8
5000	12.7	16.8	15.4	14.8	19.9	14.8	16.8	19.8	13.4	16.2
DL_{SI} (0.3-5 kHz)	17.9	18.7	21.1	18.3	19.9	20.3	17.3	18.4	17.4	18.8

Post PO1: Sound insulation measurements

a) Third octave band sound insulation indices, SI_j



b) Single number rating of sound insulation, DL_{SI}



Post PO1: Results from measurements taken in 2008

1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	17.1	15.1	15.5	15.4	15.0	14.4	14.7	14.0	12.2	14.6
400	18.8	15.6	16.2	16.1	15.7	14.9	15.4	14.2	12.4	15.2
500	16.4	16.8	20.7	17.0	17.8	16.1	14.4	12.9	13.7	15.7
630	18.1	16.8	22.1	18.1	14.2	16.3	16.2	14.2	15.7	16.4
800	23.9	16.2	22.3	20.1	11.8	16.6	22.0	16.8	19.6	17.2
1000	22.3	15.4	29.9	27.2	12.6	20.1	21.7	13.9	18.8	17.4
1250	17.8	20.5	25.8	24.2	16.4	21.8	19.4	13.2	25.5	18.6
1600	20.9	25.1	26.4	26.5	18.5	26.2	19.5	19.2	19.7	21.3
2000	21.8	32.5	28.1	21.2	26.4	18.2	20.3	22.6	15.2	20.6
2500	14.7	33.0	22.3	12.5	20.6	14.6	12.1	20.3	14.8	15.7
3150	15.7	32.4	29.7	14.2	23.0	18.0	13.3	24.8	22.8	18.0
4000	21.3	30.9	24.6	20.3	24.2	22.0	17.3	22.4	22.8	21.7
5000	25.3	19.0	26.7	21.8	19.4	21.9	25.4	21.6	21.7	21.9
DL_{SI} (0.3-5 kHz)	19.0	18.0	22.4	18.9	15.1	17.8	17.4	15.4	16.9	17.5

Post PO1: Results from measurements taken in 2009

1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	18.3	18.0	17.5	16.7	18.1	17.6	16.4	16.7	14.6	17.0
400	18.9	18.8	18.6	17.0	18.6	18.2	16.8	17.0	14.7	17.5
500	17.0	20.2	2.2	19.0	19.7	18.8	15.7	15.6	15.3	17.7
630	18.2	19.6	23.6	20.3	15.8	18.6	17.0	16.5	16.7	18.0
800	22.7	18.1	24.9	21.9	13.2	18.6	20.9	17.6	19.7	18.2
1000	22.7	16.1	28.2	23.2	14.5	22.5	19.2	13.2	19.8	17.7
1250	17.6	20.3	24.8	26.0	16.0	24.2	21.0	15.3	22.4	19.0
1600	21.6	23.8	27.1	23.9	21.1	27.7	19.9	15.8	18.7	21.0
2000	21.4	31.5	31.5	18.0	28.2	16.6	18.0	23.8	16.2	20.3
2500	14.0	30.8	23.8	10.3	17.6	9.9	8.8	13.8	9.2	12.5
3150	15.8	32.8	24.0	11.5	20.0	10.9	10.4	17.1	14.8	14.9
4000	23.3	25.4	20.0	23.8	20.4	15.4	22.4	15.6	14.9	19.3
5000	24.0	23.3	26.7	18.9	17.8	20.2	17.4	19.3	17.2	19.6
DL_{SI} (0.3-5 kHz)	19.1	19.6	23.7	18.2	16.4	17.5	16.4	15.7	16.4	17.7

E.7 Single-leaf reflective barrier: M20, Junctions 10-11, Eastbound

Barrier location	
Road / Junctions	M20, J10 - J11
Carriageway	Eastbound
Nearest Marker Posts	96/7 – 96/8 (96/7 + 5 m)
Latitude GPS reading in brackets	51.10633° (N 51° 6.380')
Longitude GPS reading in brackets	0.97983° (E 0° 58.790')
OS Grid	TR 086 383
Approximate barrier orientation at coordinates (in direction of traffic)	WNW-ESE

Barrier details and site description					
Barrier type	Single-leaf reflective timber barrier. Constructed from horizontal timber elements as a continuous length with I-section steel posts on the front of the barrier. 'Plain' face on rear.				
Date constructed	October 2001*				
Dimensions	**Height**	3.0 m	**Post spacing**	2.4 m	
	Barrier thickness	Mid-panel	0.090 m	(40 mm plank + 50 mm cover strip)	
		Across post	Not measured (Posts on front of barrier)		
Safety barrier details	Open-box safety fence connected to barrier posts. Positioned approximately 0.8 m in front of the noise barrier.				
General site layout in barrier vicinity	Flat ground to the front of the noise barrier. Flat ground to the rear of the noise barrier.				

* Construction date is estimated based on information provided by industry contacts and TRL records.

Summary of measurement results (Frequency range: 315-5000 Hz)					
Element	**2008**		**2009**		**Notes**
	DL_{SI}	**Surface temp** Front/Rear	DL_{SI}	**Surface temp** Front/Rear	
Panel PA1	21.8	26.9°C/24.3°C	20.5	31.8°C/26.0°C	
Panel PA2	20.1	26.3°C /24.3°C	19.0	29.8°C/26.3°C	

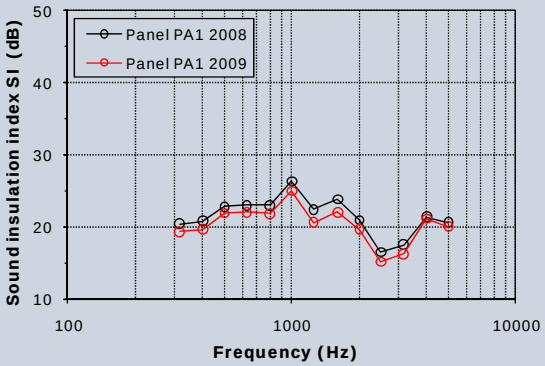
Photographs of the noise barrier at the test location	
 (a) General view of barrier from front	 (b) General view of barrier from rear
 (c) Detail of front of barrier	 (d) Detail of rear of barrier panel

Details of selected measurement positions	
Access	Measurement positions on the rear of the barrier are accessed via a padlocked emergency access gate in the barrier.
Panel PA1	2nd panel to right of access gate (viewed from front), 1.5 m below top of barrier (approximately 3.94 m from the access gate when measured on rear).
Panel PA2	3rd panel to right of access gate (viewed from front), 1.5 m below top of barrier (approximately 6.32 m from the access gate when measured on rear).
Posts	Not assessed (the posts are on the front of the barrier).

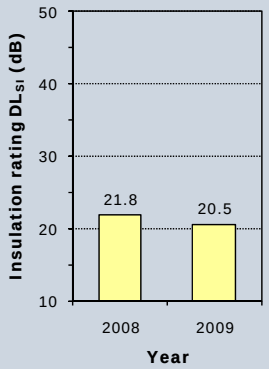
Physical condition of barrier during assessments	
2008 measurements	Structurally robust, but in relatively poor condition. Poor quality horizontal joints, although no daylight visible through gaps. Rubber seals between horizontal timbers hanging out on both front and rear. Large gap at foot of 2nd panel.
2009 measurements	Structurally robust, but in relatively poor condition. Poor quality horizontal joints, although no daylight visible through gaps. Rubber seals between horizontal timbers hanging out on both front and rear. Large gap at foot of 2nd panel- daylight visible.

Panel PA1: Sound insulation measurements

a) Third octave band sound insulation indices, SI_j



b) Single number rating of sound insulation, DL_{SI}



Panel PA1: Results from measurements taken in 2008

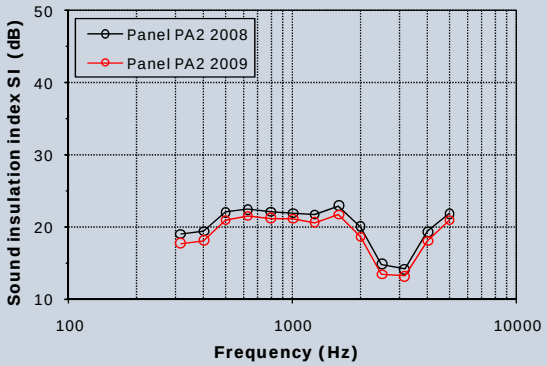
1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	17.9	21.0	19.0	21.0	22.3	21.8	20.0	21.6	20.2	20.4
400	18.0	21.8	19.4	21.2	23.0	22.8	20.4	21.9	20.5	20.8
500	21.2	20.8	21.8	24.6	24.1	26.9	22.8	22.3	23.4	22.8
630	21.5	22.2	22.6	23.1	24.8	26.4	22.1	22.2	23.4	23.0
800	21.2	26.0	23.4	21.5	25.6	25.3	21.1	22.3	22.7	23.0
1000	29.1	28.3	31.9	29.3	25.1	32.6	25.4	22.1	24.0	26.3
1250	23.2	23.0	25.4	27.3	19.5	26.8	27.2	17.8	26.9	22.4
1600	26.6	27.2	25.7	23.0	23.2	23.9	23.6	20.6	23.2	23.8
2000	16.8	18.8	17.1	24.1	27.1	25.3	20.2	23.8	22.7	20.9
2500	10.0	15.6	11.7	20.7	23.0	20.4	17.8	20.5	19.1	16.5
3150	13.5	19.3	19.7	20.3	25.1	15.7	13.0	16.1	17.0	17.5
4000	17.8	23.8	20.6	21.0	25.6	23.5	19.1	21.0	21.6	20.4
5000	19.4	20.2	20.1	21.8	28.8	25.0	16.0	17.8	17.7	20.6
DL_{SI} (0.3-5 kHz)	18.6	21.9	20.2	23.3	23.4	24.1	20.9	20.6	22.2	21.8

Panel PA1: Results from measurements taken in 2009

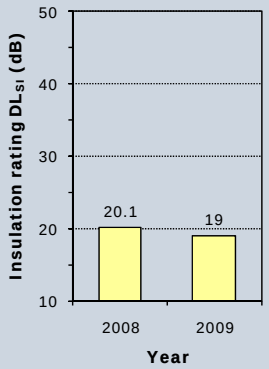
1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	16.5	19.4	17.4	19.9	21.1	21.1	19.3	21.5	18.9	19.3
400	16.6	20.0	17.6	20.2	21.7	21.7	19.7	22.3	19.2	19.6
500	20.0	20.3	20.2	23.7	23.3	25.3	21.8	22.2	22.7	21.9
630	20.4	21.3	20.9	22.1	23.7	24.9	21.2	22.0	22.7	22.0
800	20.2	23.4	21.7	20.5	24.0	24.0	20.4	22.1	21.6	21.8
1000	27.4	26.4	28.9	27.9	24.0	30.8	23.9	20.9	22.5	25.0
1250	22.2	20.6	23.2	25.0	18.0	28.0	25.6	15.7	25.7	20.6
1600	26.2	24.6	24.4	20.5	20.1	21.6	22.8	20.8	21.9	22.0
2000	15.8	17.7	15.9	22.1	25.6	23.9	19.1	22.3	19.7	19.6
2500	8.6	13.7	10.0	21.6	25.0	19.9	16.3	19.4	15.8	15.1
3150	12.3	16.0	15.4	18.3	24.2	14.9	12.8	15.5	14.7	16.2
4000	18.9	22.2	19.1	23.0	27.5	23.0	17.3	21.1	19.5	21.1
5000	19.2	19.4	15.5	23.0	24.4	25.3	15.3	18.7	14.3	20.0
DL_{SI} (0.3-5 kHz)	17.4	20.2	18.4	22.1	22.0	23.1	20.0	19.7	20.3	20.5

Panel PA2: Sound insulation measurements

a) Third octave band sound insulation indices, SI_j



b) Single number rating of sound insulation, DL_{SI}



Panel PA2: Results from measurements taken in 2008

1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	17.0	19.9	16.9	20.0	20.9	19.3	19.8	20.5	22.1	19.0
400	17.2	20.5	17.1	17.8	21.3	19.8	20.1	21.2	23.0	19.4
500	20.8	21.2	19.2	17.9	21.6	24.8	23.3	23.4	27.4	22.0
630	20.7	22.0	20.3	21.4	21.5	23.3	24.4	25.0	27.5	22.4
800	19.6	22.9	21.4	22.1	21.5	21.2	23.6	26.7	25.6	22.1
1000	20.1	20.6	22.3	21.5	22.1	26.4	20.6	21.9	24.5	21.9
1250	22.1	20.8	22.8	27.0	20.9	30.9	24.1	17.2	25.1	21.7
1600	25.6	21.8	32.1	20.9	20.5	28.9	21.0	23.4	24.9	22.9
2000	15.3	18.2	22.3	24.3	26.4	22.2	17.5	20.9	19.4	20.0
2500	7.7	14.9	15.8	15.4	23.9	13.1	15.4	21.3	18.1	14.8
3150	7.3	16.1	11.7	13.0	23.0	14.5	12.9	17.4	16.8	14.1
4000	15.7	24.0	16.8	16.7	27.6	22.7	15.9	23.0	20.4	19.3
5000	16.1	27.1	23.3	19.2	30.4	25.5	20.7	22.0	19.2	21.8
DL_{SI} (0.3-5 kHz)	15.8	20.1	19.6	20.0	21.9	21.1	19.6	21.1	22.6	20.1

Panel PA2: Results from measurements taken in 2009

1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	15.4	18.1	16.1	17.4	19.5	18.1	17.7	19.9	19.3	17.7
400	15.6	18.7	16.4	17.6	20.2	18.4	18.2	20.5	20.0	18.1
500	20.4	20.8	18.8	20.5	19.4	22.2	22.4	22.6	24.0	20.9
630	20.4	22.0	19.8	20.8	19.4	21.5	24.2	24.7	26.4	21.5
800	18.8	23.0	20.6	20.1	19.6	20.1	23.5	26.9	26.8	21.2
1000	19.4	20.6	21.7	21.2	20.1	23.4	20.6	21.3	24.0	21.1
1250	21.2	20.2	23.4	27.0	18.7	56.0	20.4	16.4	25.4	20.6
1600	24.8	23.2	32.0	19.5	18.8	25.2	18.8	21.6	24.6	21.7
2000	14.3	17.5	16.9	20.6	26.0	24.3	15.2	21.5	17.9	18.6
2500	7.1	13.9	11.3	13.0	20.9	13.7	13.3	24.9	14.5	13.4
3150	7.0	14.8	9.2	11.8	23.5	14.2	11.5	18.0	14.8	13.1
4000	17.3	21.9	14.6	15.6	25.2	18.2	15.2	22.7	16.9	18.0
5000	15.9	27.0	24.1	16.2	30.0	28.7	19.3	24.0	18.3	20.9
DL_{SI} (0.3-5 kHz)	15.2	19.5	17.5	18.6	20.1	20.3	18.2	20.8	20.8	19.0

E.8 Single-leaf reflective barrier: M20, Junctions 10-11, Westbound

Barrier location	
Road / Junctions	M20, J10 - J11
Carriageway	Westbound
Nearest Marker Posts	99/1 – 99/2 (99/2 - 15 m)
Latitude GPS reading in brackets	51.1000° (N 51° 6.000')
Longitude GPS reading in brackets	1.01383° (E 1° 0.830')
OS Grid	TR 111 377
Approximate barrier orientation at coordinates (in direction of traffic)	E-W

Barrier details and site description				
Barrier type	Single-leaf reflective timber barrier. Constructed from horizontal timber elements as a continuous length with I-section steel posts on the front of the barrier. 'Plain' face on rear.			
Date constructed	October 2001*			
Dimensions	**Height**	3.0 m	**Post spacing**	2.4 m
	Barrier thickness	Mid-panel	0.090 m	(40 mm plank + 50 mm cover strip)
		Across post	Not measured (Posts on front of barrier)	
Safety barrier details	Open-box safety fence connected to barrier posts. Positioned approximately 0.8 m in front of the noise barrier.			
General site layout in barrier vicinity	Flat ground to the front of the noise barrier. Flat ground to the rear of the noise barrier.			

* Construction date is estimated based on information provided by industry contacts and TRL records.

Summary of measurement results (Frequency range: 315-5000 Hz)

Element	2008		2009		Notes
	DL_{SI}	Surface temp Front/Rear	DL_{SI}	Surface temp Front/Rear	
Panel PA1	20.1	21.3°C/21.5°C	19.9	23.4°C /28.0°C	
Panel PA2	20.9	21.7°C /22.3°C	20.5	23.5°C /29.9°C	

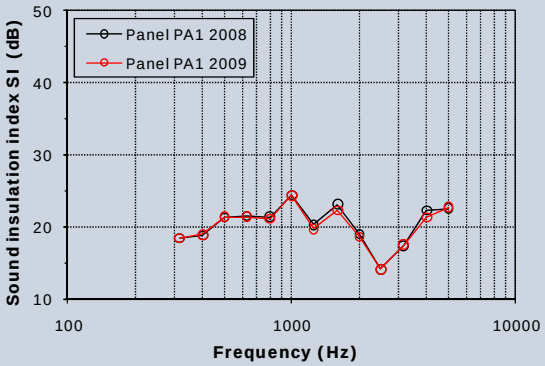
Photographs of the noise barrier at the test location	
 (a) General view of barrier from front	 (b) General view of barrier from rear
 (c) Detail of front of barrier	 (d) Detail of rear of barrier panel

Details of selected measurement positions	
Access	Measurement positions on the rear of the barrier are accessed via the end of the barrier.
Panel PA1	Middle of 7th panel from end of barrier, 1.5 m below top of barrier (approximately 10.835 m from end when measured on rear face).
Panel PA2	Middle of 6th panel from end of barrier, 1.5 m below top of barrier (approximately 8.455 m from end when measured on rear face).
Posts	Not assessed (the posts are on the front of the barrier).

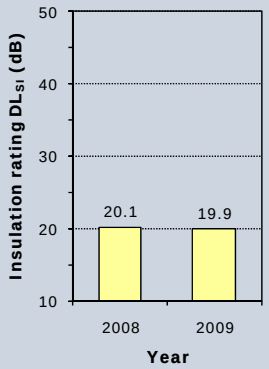
Physical condition of barrier during assessments	
2008 measurements	Structurally robust, but in relatively poor condition. Some warping of horizontal timbers, so barrier face not flat. Gaps between horizontal timbers (0-10 mm) with daylight visible through barrier in places on 1st panel. Rubber seals loose on front and rear. Gaps at foot of both panels.
2009 measurements	Structurally robust, but in relatively poor condition. Some warping of horizontal timbers, so barrier face not flat. Gaps between horizontal timbers (0-10 mm) with daylight visible through barrier in places on 1st panel. Rubber seals loose on front and rear. Gaps at foot of both panels.

Panel PA1: Sound insulation measurements

a) Third octave band sound insulation indices, SI_j



b) Single number rating of sound insulation, DL_{SI}



Panel PA1: Results from measurements taken in 2008

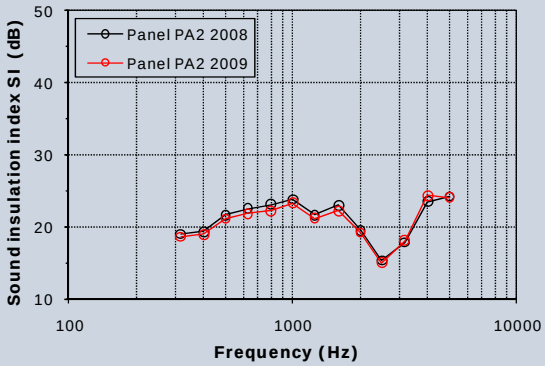
1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	15.4	17.2	16.6	19.6	22.9	20.7	17.1	20.1	20.2	18.4
400	15.5	17.5	16.9	20.2	24.5	21.4	17.5	21.0	21.1	18.8
500	18.7	19.9	21.2	20.7	22.6	23.4	21.2	22.3	24.6	21.3
630	19.3	20.3	20.9	20.7	22.8	22.3	21.2	23.3	26.0	21.5
800	19.3	20.4	19.7	21.1	23.7	21.3	20.2	25.3	26.5	21.4
1000	29.7	23.5	27.6	31.0	25.2	27.4	21.6	19.9	25.9	24.4
1250	17.8	24.3	24.9	24.2	20.0	23.4	19.8	14.2	22.6	20.3
1600	16.6	24.3	27.4	22.0	22.3	23.0	22.5	21.0	22.2	23.1
2000	14.3	17.7	13.4	22.0	33.6	26.2	17.9	26.1	25.7	19.0
2500	8.2	15.3	8.7	18.3	26.1	16.2	13.2	17.4	17.1	14.1
3150	11.2	18.4	12.6	20.5	24.3	22.8	18.3	18.4	16.8	17.4
4000	19.4	25.2	21.3	21.3	25.6	23.8	19.4	24.7	22.4	22.3
5000	16.7	23.2	22.5	24.1	27.7	29.8	20.1	25.8	17.5	22.5
DL_{SI} (0.3-5 kHz)	16.7	20.1	17.3	21.9	23.3	22.4	19.1	19.4	22.4	20.1

Panel PA1: Results from measurements taken in 2009

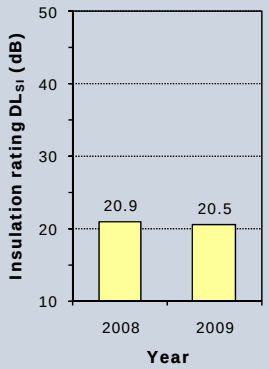
1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	15.0	17.6	16.3	19.0	22.5	20.9	17.7	20.7	20.9	18.4
400	15.2	18.0	16.4	19.4	23.8	21.5	18.1	21.8	22.0	18.9
500	18.7	19.7	20.5	21.2	23.0	24.4	21.2	22.7	25.2	21.4
630	19.1	19.9	19.6	21.4	23.0	23.2	21.1	23.7	26.4	21.4
800	18.7	19.9	18.0	21.5	23.7	21.9	20.2	25.5	27.3	21.1
1000	28.4	22.9	28.0	27.9	25.6	33.3	21.0	19.6	25.8	24.3
1250	24.8	23.9	25.8	25.5	19.9	22.5	19.0	13.8	21.4	19.7
1600	25.8	22.9	25.5	22.0	22.0	21.2	21.0	20.7	23.0	22.3
2000	14.2	15.9	12.3	22.8	33.2	26.2	18.6	25.5	26.1	18.6
2500	8.1	15.1	8.6	18.0	27.9	14.6	13.5	17.7	16.7	14.1
3150	10.5	16.8	13.3	19.2	23.2	22.6	17.4	21.3	18.5	17.5
4000	18.8	25.6	20.8	19.3	25.4	21.0	20.0	23.6	21.0	21.3
5000	17.6	24.6	22.4	23.4	25.3	25.4	20.0	29.6	19.0	22.7
DL_{SI} (0.3-5 kHz)	16.4	19.6	16.8	21.8	23.3	22.0	19.1	19.3	22.6	19.9

Panel PA2: Sound insulation measurements

a) Third octave band sound insulation indices, SI_j



b) Single number rating of sound insulation, DL_{SI}



Panel PA2: Results from measurements taken in 2008

1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	18.9	20.2	18.3	21.1	26.3	20.5	17.1	18.0	15.7	19.0
400	19.5	20.5	18.5	22.4	28.8	20.9	17.1	18.3	15.8	19.3
500	22.4	21.4	22.8	23.3	23.2	21.8	20.6	20.2	19.8	21.6
630	22.7	22.2	26.3	23.4	22.5	21.6	22.2	21.6	21.6	22.5
800	22.5	23.5	31.0	23.8	22.3	21.3	23.3	23.4	22.1	23.1
1000	27.5	25.7	27.0	30.6	22.1	23.3	23.3	20.9	22.3	23.8
1250	27.2	25.6	27.8	24.9	21.5	25.0	20.7	15.7	24.7	21.6
1600	28.2	25.8	29.1	22.8	24.0	20.6	23.6	20.9	19.7	23.0
2000	14.6	19.8	15.7	23.3	30.1	18.3	20.2	26.7	21.3	19.5
2500	10.0	17.1	9.7	20.6	24.1	22.7	18.5	21.9	10.3	15.3
3150	15.7	21.1	11.5	25.0	25.8	24.7	18.6	19.0	11.0	17.8
4000	23.2	28.7	17.5	24.7	29.2	27.2	24.4	24.0	17.3	23.5
5000	22.6	25.4	18.0	27.5	30.4	22.9	23.9	28.9	18.1	24.2
DL_{SI} (0.3-5 kHz)	18.9	22.4	18.6	23.9	23.4	21.7	20.9	19.9	17.9	20.9

Panel PA2: Results from measurements taken in 2009

1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	19.5	20.1	17.5	20.2	24.8	20.4	16.3	17.2	15.6	18.6
400	20.1	20.5	17.6	20.6	27.4	21.0	16.3	17.3	15.7	18.9
500	23.2	21.5	22.8	23.0	21.9	21.3	20.1	18.9	19.2	21.1
630	23.5	22.1	27.0	22.8	20.8	21.0	22.0	20.3	20.6	21.8
800	23.2	23.1	31.3	22.4	20.4	20.7	23.2	22.0	21.0	22.2
1000	28.3	26.8	25.9	32.5	20.9	23.4	23.3	20.0	21.4	23.3
1250	27.3	26.1	28.3	24.8	20.8	23.1	20.9	15.4	24.4	21.2
1600	29.0	24.6	28.5	21.6	22.3	19.6	22.7	20.8	20.1	22.2
2000	14.4	19.3	15.2	22.4	29.8	17.6	19.9	26.4	20.4	19.2
2500	10.2	15.8	8.8	20.0	25.1	21.6	17.3	21.5	9.5	15.0
3150	15.2	19.1	12.9	23.1	25.4	27.7	19.3	18.0	10.5	18.1
4000	23.0	26.9	19.4	27.0	28.3	26.6	24.9	24.6	18.1	24.3
5000	21.9	27.3	15.4	25.6	29.7	23.9	22.6	29.4	19.2	24.1
DL_{SI} (0.3-5 kHz)	19.1	21.9	18.2	23.0	22.2	21.1	20.5	19.2	17.4	20.5

E.9 Single-leaf reflective barrier: M25, Junctions 6-7, Clockwise

Barrier location	
Road / Junctions	M25, J6-J7
Carriageway	Clockwise
Nearest Marker Posts	45/3 – 45/4 (45/3 + 50 m)
Latitude GPS reading in brackets	51.26088° (N 51° 15.653')
Longitude GPS reading in brackets	-0.11657° (N 0° 0.6994')
OS Grid	TQ 315 529
Approximate barrier orientation at coordinates (in direction of traffic)	ESE – WNW

Barrier details and site description				
Barrier type	Single-leaf reflective timber barrier. Constructed as a continuous length, full-height barrier with I-section steel posts on the rear of the barrier. 'Plain' face on front.			
Date constructed	July 2000*			
Dimensions	**Height**	3.0 m	**Post spacing**	3.0 m
	Barrier thickness	Mid-panel	0.110 m	(20 mm plank + 90mm rail)
		Across post	Not measured (Posts on rear of barrier)	
Safety barrier details	Free-standing, open-box safety fence. Positioned approximately 0.75 m in front of the noise barrier.			
General site layout in barrier vicinity	Flat ground to the front of the noise barrier. Sloping ground immediately to the rear of the noise barrier.			

* Construction date is estimated based on information provided by industry contacts.

Summary of measurement results (Frequency range: 315-5000 Hz)

Element	2008		2009		Notes
	DL_{SI}	Surface temp Front/Rear	DL_{SI}	Surface temp Front/Rear	
Panel PA1	19.7	21.3°C/20.3°C	17.2	Not measured	
Panel PA2	19.5	Not measured	17.6	Not measured	

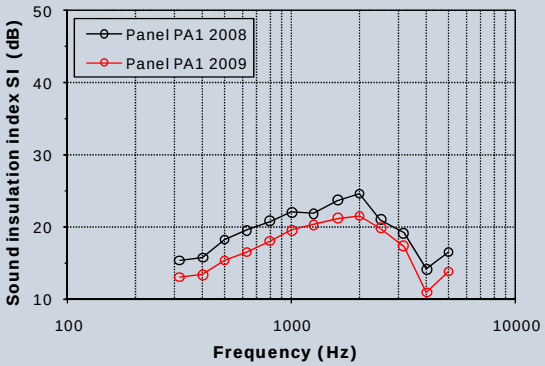
Photographs of the noise barrier at the test location	
 (a) General view of barrier from front	 (b) General view of barrier from rear
 (c) Detail of front of barrier	 (d) Detail of rear of barrier panel

Details of selected measurement positions	
Access	Measurement positions on the rear of the barrier are accessed via an emergency access gate in the barrier
Panel PA1	3rd panel to left of gate (viewed from front), 1.425 m above the ground (38th plank from gate, 40 mm in from left-hand edge)
Panel PA2	2nd panel to left of gate (viewed from front), 1.425 m above the ground (63rd timber from gate, 35 mm in from left-hand edge)
Posts	Not assessed (the posts are on the rear of the barrier).

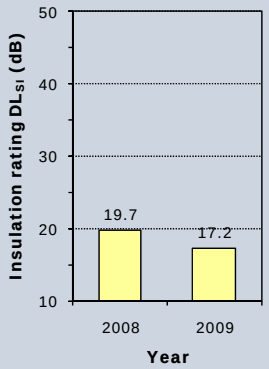
Physical condition of barrier during assessments	
2008 measurements	Reasonable condition, structurally robust. Some split timbers and knot holes. Ground level at rear of barrier lower than that at front.
2009 measurements	Barrier is structurally robust. Some warping and splitting of the planking, particularly on panel PA1, with daylight visible through the barrier in places. Several knotholes presented close to microphone position 5 on panel PA2.

Panel PA1: Sound insulation measurements

a) Third octave band sound insulation indices, SI_j



b) Single number rating of sound insulation, DL_{SI}



Panel PA1: Results from measurements taken in 2008

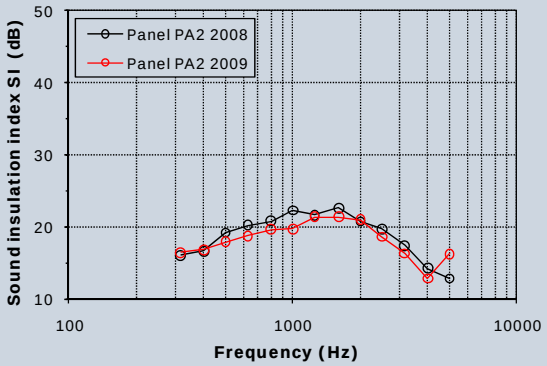
1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	16.3	18.5	17.5	13.5	15.8	15.6	13.3	15.5	14.2	15.3
400	17.1	19.3	18.8	13.8	16.0	16.2	13.3	15.9	14.4	15.7
500	19.5	18.3	19.8	18.2	18.7	17.0	19.1	16.2	18.5	18.2
630	20.6	19.1	21.2	19.8	19.4	19.1	20.0	17.1	21.2	19.5
800	21.4	21.3	24.2	19.5	19.6	25.2	18.3	18.9	24.1	20.8
1000	21.8	22.1	26.3	19.7	22.7	24.1	20.1	20.6	24.6	22.0
1250	20.6	22.4	21.6	19.8	23.9	23.0	21.6	22.5	21.7	21.8
1600	21.5	23.7	22.5	25.9	23.6	24.5	26.2	23.8	23.1	23.7
2000	22.5	23.6	23.0	27.9	25.1	23.7	25.7	27.2	24.1	24.6
2500	20.3	30.2	18.1	2.6	26.7	16.9	21.7	25.0	18.7	21.0
3150	18.1	26.5	20.7	15.3	29.7	19.3	12.4	23.5	19.4	19.1
4000	15.6	20.9	21.7	9.8	15.4	13.1	11.7	19.8	18.2	14.1
5000	15.7	20.0	18.1	13.2	18.7	14.5	15.5	21.2	16.9	16.5
DL_{SI} (0.3-5 kHz)	19.9	21.3	21.4	18.0	20.4	19.7	18.0	19.6	20.1	19.7

Panel PA1: Results from measurements taken in 2009

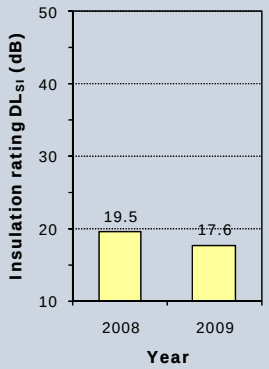
1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	13.1	15.0	15.1	10.8	13.1	14.7	11.1	13.7	12.7	13.0
400	13.6	15.5	16.3	10.9	13.3	15.3	11.4	14.1	13.0	13.3
500	15.2	16.2	16.6	13.5	16.9	14.7	15.6	14.7	15.7	15.3
630	16.5	17.0	18.1	15.3	17.0	16.2	17.3	15.3	17.6	16.5
800	18.5	18.2	22.3	17.4	16.3	20.5	17.4	16.0	20.1	18.0
1000	19.2	18.7	26.0	18.5	18.5	23.3	18.5	17.3	21.7	19.5
1250	18.4	19.3	21.5	19.2	19.2	24.1	22.0	19.6	21.1	20.3
1600	18.8	20.0	21.3	24.7	24.7	24.2	26.2	21.7	21.8	21.2
2000	19.5	19.5	21.5	24.1	24.1	23.3	22.9	24.0	20.4	21.5
2500	18.5	28.5	17.6	21.8	21.8	17.0	18.0	22.2	18.4	19.8
3150	16.5	24.0	19.4	12.4	12.4	20.4	9.7	20.6	17.3	17.3
4000	12.7	21.2	20.2	6.5	6.5	14.2	6.8	16.2	15.1	10.9
5000	13.5	18.2	16.9	9.8	9.8	12.9	12.3	14.2	12.4	13.8
DL_{SI} (0.3-5 kHz)	17.0	18.4	19.7	15.2	17.3	18.6	15.6	17.1	17.9	17.2

Panel PA2: Sound insulation measurements

a) Third octave band sound insulation indices, SI_j



b) Single number rating of sound insulation, DL_{SI}



Panel PA2: Results from measurements taken in 2008

1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	17.1	19.0	18.3	15	16.7	16.3	14.6	14.2	14.6	16.0
400	17.6	20.2	19.9	15.4	17.2	17	15.1	14.5	15.0	16.6
500	20.1	20.1	22.1	19.7	18.3	18.1	18.8	17.5	20.3	19.2
630	21.5	21.5	21.3	21	20.2	18.4	19.6	19.0	20.8	20.2
800	23.2	24.5	20.2	20.4	24.5	18.7	19.2	20.8	19.4	20.8
1000	24.8	23.0	22.6	20.3	25.4	19.9	19.8	26.8	24.0	22.3
1250	22.4	22.7	21.5	19.5	23.4	21.9	18.6	22.2	24.4	21.6
1600	24.1	24.7	20.6	22.1	27	21.4	20.2	23.0	22.1	22.6
2000	20.4	24.0	17.7	20.7	24.8	18.9	19.4	23.0	19.6	20.7
2500	22.7	21.3	26.7	17.6	18.5	20.6	17.9	19.8	20.5	19.7
3150	19.5	21.1	26.7	14.1	17.9	18.9	15.7	15.8	16.3	17.4
4000	14.5	18.4	16.5	11.6	14.5	14.4	13.3	16.0	12.6	14.2
5000	20.1	14.7	14.0	13.0	10.9	13.2	10.8	13.3	12.6	12.8
DL_{SI} (0.3-5 kHz)	21.0	21.8	20.4	18.3	20.3	18.8	17.8	19.3	19.1	19.5

Panel PA2: Results from measurements taken in 2009

1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	15.3	15.7	16.1	13.2	13.2	13.6	12.6	11.7	12.0	13.5
400	16.2	16.5	17.2	13.5	13.6	14.0	12.9	11.9	12.3	13.9
500	17.4	17.1	20.2	17.8	15.6	15.6	16.5	15.4	17.6	16.8
630	18.0	18.2	19.6	19.3	17.8	16.1	17.3	17.0	18.0	17.8
800	19.0	20.1	18.4	19.0	22.5	16.7	16.9	18.0	16.4	18.3
1000	22.7	21.5	20.3	18.4	25.0	19.0	17.4	25.6	20.3	20.5
1250	21.6	21.4	19.9	18.9	23.8	20.0	17.8	22.3	22.0	20.6
1600	23.4	24.3	19.7	19.3	24.8	20.5	17.2	22.4	20.1	20.9
2000	19.7	24.4	17.0	18.5	22.1	18.5	17.6	23.2	17.8	19.6
2500	20.8	17.3	24.2	15.5	16.9	18.1	15.3	18.3	16.4	17.3
3150	17.1	22.2	25.5	14.9	17.9	19.0	17.4	14.5	14.2	17.3
4000	11.3	18.4	15.6	12.4	15.2	12.9	15.7	16.4	11.4	13.9
5000	20.2	14.9	12.7	12.6	9.6	12.5	7.3	9.2	10.1	11.2
DL_{SI} (0.3-5 kHz)	18.8	19.5	18.8	17.0	18.4	17.0	15.9	17.2	16.5	17.6

E.10 Single-leaf reflective barrier: M40, Junctions 1A-2, Eastbound

Barrier location	
Road / Junctions	M40, J1A - J2
Carriageway	Eastbound
Nearest Marker Posts	35/0-34/9 (35/0 – 10m)
Latitude GPS reading in brackets	51.56895° (N 51° 34.137')
Longitude GPS reading in brackets	-0.56598° (W 0° 33.959')
OS Grid	SU 994 865
Approximate barrier orientation at coordinates (in direction of traffic)	WNW-ENE

Barrier details and site description				
Barrier type	Single-leaf reflective timber noise barrier. Constructed as a continuous length, full-height barrier with steel I-section posts on the front of the barrier. 'Plain' face on rear.			
Date constructed	July 1999*			
Dimensions	**Height**	3.0 m	**Post spacing**	3.0 m
	Barrier thickness	Mid-panel	0.105 m	(75 mm rail + 20 mm plank + 20 mm cover strip)
		Across post	Not measured (posts on front of barrier)	
Safety barrier details	No safety barrier present.			
General site layout in barrier vicinity	Sloping ground immediately in front of the noise barrier – barrier erected on the top of an embankment. Flat ground to rear of the noise barrier.			

* Construction date is estimated based on information provided by industry contacts.

Summary of measurement results (Frequency range: 315-5000 Hz)

Element	2008		2009		Notes
	DL_{SI}	Surface temp Front/Rear	DL_{SI}	Surface temp Front/Rear	
Panel PA1	*Barrier unavailable for testing: Road space unavailable*		18.9	35.8°C/27.9°C	
Panel PA2			16.2	34.0°C/26.3°C	

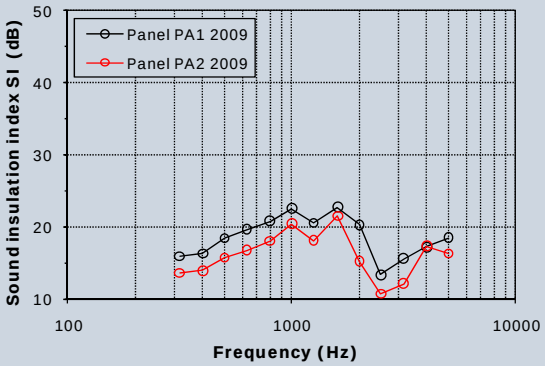
Photographs of the noise barrier at the test location	
 (a) General view of barrier from front	 (b) General view of barrier from rear
 (c) Detail of front of barrier	 (d) Detail of rear of barrier panel

Details of selected measurement positions	
Access	Measurement positions on the rear of the barrier are accessed via an unlocked emergency access gate.
Panel PA1	3rd panel to the right of the access gate (viewed from the front), 1.5 m below the top of the barrier.
Panel PA2	2nd panel to the right of the access gate (viewed from the front), 1.5 m below the top of the barrier.
Posts	Not assessed (the posts are on the front of the barrier)

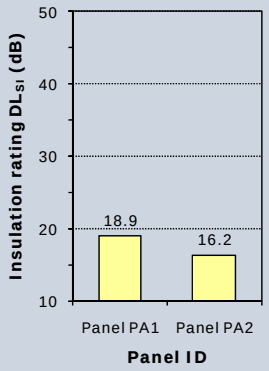
Physical condition of barrier during assessments	
2008 measurements	Not assessed due to unavailability of road space.
2009 measurements	Structurally robust and in good condition. Some poor fitting cover strips. Gaps between the ground and the gravel board present at the rear of the barrier. Graffiti present on the front of the barrier.

Panels PA1 and PA2: Sound insulation measurements

a) Third octave band sound insulation indices, SI_j



b) Single number rating of sound insulation, DL_{SI}



Panel PA1: Results from measurements taken in 2009

1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	17.3	18.4	16.0	14.8	14.3	13.6	16.9	18.5	16.6	15.9
400	18.0	19.5	16.6	14.9	14.4	13.7	17.7	19.8	17.1	16.3
500	19.1	19.3	18.7	18.1	16.3	17.4	21.2	18.5	20.7	18.4
630	18.6	19.0	19.1	20.6	18.9	19.9	21.0	18.8	21.2	19.6
800	18.3	19.1	19.4	24.5	25.5	22.2	20.1	20.2	20.8	20.8
1000	24.5	21.2	22.0	22.9	21.1	21.0	24.1	23.2	26.1	22.5
1250	21.5	20.8	21.7	19.5	19.3	18.8	21.0	21.0	25.0	20.5
1600	26.0	22.3	26.1	23.2	20.7	20.1	24.3	23.0	28.3	22.7
2000	24.6	22.8	30.1	19.8	20.8	16.2	20.8	18.8	23.6	20.3
2500	13.7	13.5	17.5	13.4	14.1	9.5	14.2	16.1	15.0	13.3
3150	10.9	14.4	18.0	13.2	24.0	14.0	13.5	17.6	16.3	15.6
4000	15.0	16.4	16.0	14.5	18.2	20.8	19.4	19.6	21.2	17.2
5000	15.7	20.4	13.6	17.1	22.4	20.4	14.5	21.8	17.5	18.5
DL_{SI} (0.3-5 kHz)	18.6	19.0	19.6	18.4	18.6	16.8	19.4	19.9	20.7	18.9

Panel PA2: Results from measurements taken in 2009

1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	15.4	15.5	15.7	11.9	11.2	11.9	14.1	16.3	15.4	13.6
400	16.1	16.2	16.4	11.9	11.3	12.0	14.5	17.2	16.0	13.9
500	18.7	16.3	16.6	15.6	14.3	13.9	18.0	15.2	15.2	15.7
630	17.8	15.9	16.1	18.0	17.1	16.2	19.0	15.5	15.7	16.7
800	16.5	15.9	15.9	20.0	21.8	21.8	19.1	17.0	17.1	18.0
1000	21.0	21.4	21.7	19.0	20.5	20.9	21.4	18.8	20.1	20.4
1250	23.8	18.6	16.2	20.6	18.4	15.2	24.8	16.7	17.5	18.1
1600	29.5	24.1	22.1	26.0	20.3	18.0	26.4	18.0	24.5	21.5
2000	17.1	22.1	15.1	11.6	17.7	12.3	17.3	15.1	18.9	15.2
2500	10.6	16.1	8.5	9.1	14.5	8.3	11.8	9.5	11.6	10.7
3150	8.9	16.5	10.9	9.9	16.3	10.5	9.2	13.2	13.2	12.1
4000	15.9	17.6	15.1	18.8	19.1	17.1	16.4	17.4	16.4	17.3
5000	15.1	24.3	14.7	13.0	24.8	17.8	8.9	19.6	15.6	16.3
DL_{SI} (0.3-5 kHz)	16.7	17.9	15.5	15.1	16.8	14.5	16.8	15.8	16.7	16.2

E.11 Single-leaf reflective barrier: M40, Junctions 2-3, Eastbound

Barrier location	
Road / Junctions	M40, J2-J3
Carriageway	Eastbound
Nearest Marker Posts	42/0 – 41/9 (42/0 - 5m)
Latitude GPS reading in brackets	51.59865° (N 51° 35.919')
Longitude GPS reading in brackets	-0.651667° (W 0° 39.100')
OS Grid	SU 934 897
Approximate barrier orientation at coordinates (in direction of traffic)	E-W

Barrier details and site description				
Barrier type	Single-leaf reflective timber barrier. Constructed as a continuous length, full-height barrier with I-section steel posts on the front of the barrier. 'Plain' face on front of barrier.			
Date constructed	July 1999			
Dimensions	**Height**	4.2 m	**Post spacing**	2.8 m nominal
	Barrier thickness	Mid-panel	0.115 m	(20mm cover strip + 20 mm plank + 75 mm rail)
		Across post	Not measured (posts on rear of barrier)	
Safety barrier details	Free-standing, corrugated profile safety fence. Positioned approximately 3 m in front of the noise barrier.			
General site layout in barrier vicinity	Flat ground to the front of the noise barrier with some paving. Electrical switch boxes in close proximity to the measurement position. Flat ground to the rear of the noise barrier with some paving. Electrical switch boxes in close proximity to the measurement position.			

* Construction date is estimated based on information provided by industry contacts.

Summary of measurement results (Frequency range: 315-5000 Hz)

Element	2008		2009		Notes
	DL_{SI}	Surface temp Front/Rear	DL_{SI}	Surface temp Front/Rear	
Panel PA1	*Barrier unavailable for testing: Road space unavailable*		17.4	26.4°C/23.2°C	
Panel PA2			19.0	28.4°C/23.9°C	

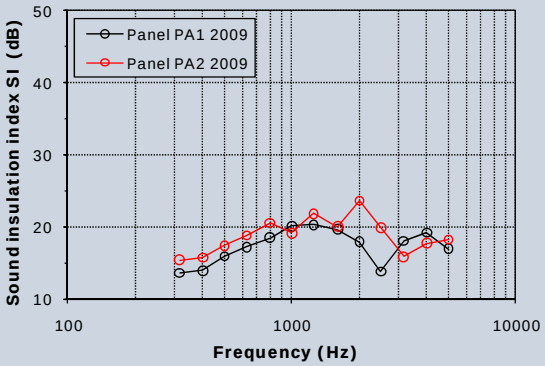
Photographs of the noise barrier at the test location	
 (a) General view of barrier from front	 (b) General view of barrier from rear
 (c) Detail of front of barrier	 (d) Detail of rear of barrier panel

Details of selected measurement positions	
Access	Measurement positions on the rear of the barrier are accessed via an unlocked emergency access gate in the barrier.
Panel PA1	Middle of 4th panel to left of gate (viewed from front), approximately 2.6 m below capping (72nd plank from gate, 60 mm to left of knot).
Panel PA2	3rd panel to left of gate (viewed from front), approximately 2.6 m below capping (40th plank from gate, 20 mm to right of gap between 40th/41st planks).
Posts	N/A (Post not integrated within barrier structure)

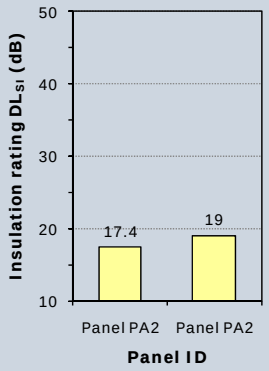
Physical condition of barrier during assessments	
2008 measurements	Not assessed in 2008 due to unavailability of road space.
2009 measurements	Structurally robust and generally in good condition. Some visible gaps between timbers

Panels PA1 and PA2: Sound insulation measurements

a) Third octave band sound insulation indices, SI_j



b) Single number rating of sound insulation, DL_{SI}



Panel PA1: Results from measurements taken in 2009

1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	14.1	17.6	14.0	12.3	14.5	11.9	13.8	13.7	13.0	13.6
400	14.4	19.1	14.4	12.3	14.7	11.8	14.2	14.3	13.3	13.9
500	18.5	16.8	20.6	14.3	13.4	14.5	18.4	15.4	18.4	15.9
630	19.2	18.0	22.1	15.6	14.7	15.7	20.5	17.1	18.8	17.2
800	18.2	21.9	19.7	17.4	18.4	16.6	20.7	20.4	17.0	18.5
1000	18.6	21.0	19.4	24.8	25.3	20.3	19.5	18.6	17.6	20.1
1250	17.9	24.8	18.5	20.1	20.9	26.5	18.0	20.9	20.0	20.3
1600	21.9	22.4	16.8	20.6	20.0	20.6	19.6	17.6	18.3	19.6
2000	25.1	23.1	20.2	15.9	14.8	16.2	19.9	22.9	19.5	17.9
2500	16.1	21.2	16.5	10.0	12.2	12.9	15.4	20.0	21.3	13.8
3150	16.9	22.2	17.8	12.4	21.8	24.4	14.0	19.9	24.5	18.0
4000	21.9	19.2	20.2	20.1	17.9	16.8	23.5	21.2	17.5	19.2
5000	18.0	23.8	19.0	15.5	22.5	10.9	21.6	18.2	14.9	16.9
DL_{SI} (0.3-5 kHz)	18.1	20.6	18.2	15.9	16.9	16.3	18.0	18.1	17.5	17.4

Panel PA2: Results from measurements taken in 2009

1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	16.5	16.6	16.6	15.3	13.5	13.8	16.4	15.7	16.7	15.4
400	17.0	17.2	17.3	15.4	13.6	13.8	16.7	16.1	17.5	15.7
500	19.0	18.4	19.0	14.3	14.9	17.0	20.1	18.9	21.8	17.4
630	21.5	19.1	19.5	15.7	17.1	17.7	23.0	21.7	22.2	18.8
800	24.3	19.3	19.0	19.3	22.2	17.6	24.6	26.7	20.4	20.5
1000	18.4	17.3	16.7	17.9	22.3	22.6	18.9	20.8	18.9	19.1
1250	22.3	21.1	19.2	20.3	22.2	23.3	24.5	23.9	20.8	21.8
1600	20.9	20.7	19.0	17.9	21.0	22.2	19.6	19.2	20.1	20.0
2000	24.9	25.2	25.2	20.4	25.3	21.9	23.8	25.0	24.6	23.6
2500	22.4	23.5	24.7	14.6	20.7	18.7	23.0	24.0	28.3	19.9
3150	16.2	17.0	19.8	11.6	15.0	16.8	20.1	22.8	21.6	15.8
4000	14.7	19.1	16.5	14.1	18.5	19.7	22.7	27.5	22.4	17.7
5000	22.3	21.3	15.8	17.3	16.5	18.0	20.1	21.9	20.6	18.2
DL_{SI} (0.3-5 kHz)	19.8	19.1	18.6	16.8	18.6	18.6	20.6	20.9	20.4	19.0

E.12 Single-leaf reflective barrier: TRL Noise Barrier Test Facilities 01

Referred to in Tables 5.1 and 5.4 (Morgan, 2010) as 'NBTF Crowthorne 1'.

Barrier details and site description				
Barrier type	Single-leaf reflective timber barrier. (SLReflect01) Constructed using 2.0 m high panels in between steel I-section posts. 'Plain' face on front of barrier.			
Date constructed	Original construction date: April 2004 (at Crowthorne NBTF). Reconstruction date: August 2009 (at Bishops Castle NBTF)			
Dimensions	**Height**	4.0 m	**Post spacing**	3.0 m
	Effective barrier thickness	Mid-panel	0.115 m (75 mm rail + 20 mm plank + 20 mm cover strip)	
		Across post	Not measured.	
Safety barrier details	No safety barrier present			
General site layout in barrier vicinity	Flat ground to the front of the noise barrier. Flat ground to the rear of the noise barrier.			

Summary of measurement results (Frequency range: 315-5000 Hz)

Element	**2004**		**2009**		**Notes**
	***DL*$_{SI}$**	**Surface temp** Front/Rear	***DL*$_{SI}$**	**Surface temp** Front/Rear	
Panel PA1	25.9	Unknown	19.0	20.0°C/20.4°C	Panels tested in 2004 and 2009 are from the same barrier but not exactly the same panels.

Physical condition of barrier during assessments	
2004 measurements	In good condition. Structurally robust with no obvious defects.
2009 measurements	Structurally robust and in good condition. New cover strip on front across the joints between the panels. Some knots splitting. New timber wedges.

Photographs of the noise barrier at the test location

(a) General view of barrier from front

(b) General view of barrier from rear

Photographs of the noise barrier at the test location (continued…)

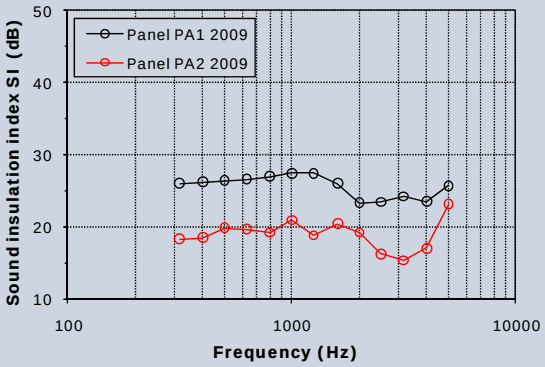
(c) Detail of front of barrier

(d) Detail of rear of barrier panel

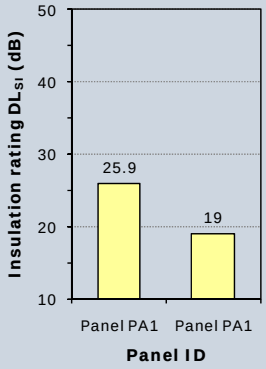
Details of selected measurement positions	
Access	Measurement positions on the rear of the barrier are accessed via the end of the barrier.
Panel PA1	Middle of centre panel on facility in 2004. Middle of sole panel on facility in 2009. 2.0 m below top of barrier in each case.
Panel PA2	Not assessed. Insufficient panels for assessment of a second panel.
Posts	Not assessed.

Panel PA1: Sound insulation measurements

a) Third octave band sound insulation indices, SI_j



b) Single number rating of sound insulation, DL_{SI}



Panel PA1: Results from measurements taken in 2004

1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	28.4	28	30.2	23.9	22.9	23.3	28.3	35.4	25.4	26
400	29.3	28.4	31.7	23.8	22.8	23.3	29.3	43.2	25.7	26.2
500	27.5	23.5	28.1	29.1	26.2	27.7	25.9	24.9	28.4	26.4
630	26.0	23.6	27.7	29.1	26.8	29.5	26.9	24.7	29.3	26.6
800	25.2	25.1	28.3	25.6	26.2	29.7	30.8	26.2	30.1	27.0
1000	30.9	31.1	32.9	21.3	24.8	27.7	31.3	30.5	37.0	27.4
1250	33.1	29.7	28.4	23.7	23.9	29.0	28.4	27.7	32.6	27.4
1600	26.2	27.7	28.2	24.0	27.3	28.8	26.4	22.6	27.0	26.0
2000	20.5	27.0	20.3	23.2	28.4	30.1	25.5	21.5	22.9	23.3
2500	22.2	28.8	26.3	28.1	26.5	27.6	20.7	19.1	23.0	23.4
3150	23.0	26.5	26.6	27.0	28.2	29.1	21.2	21.4	23.1	24.2
4000	23.1	22.5	21.3	29.5	33.6	29.9	22.5	21.6	21.9	23.5
5000	29.4	27.1	30.5	30.3	30.7	28.7	23.1	23.8	20.8	25.7
DL_{SI} (0.3-5 kHz)	25.7	26.6	26.7	24.2	25.6	27.8	26.4	24.5	26.8	25.9

Panel PA1: Results from measurements taken in 2009

1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	18.3	20.4	18.8	16.5	16.9	16.3	20.5	20.9	21.1	18.3
400	18.7	21.0	19	16.5	16.9	16.3	21.1	21.3	21.5	18.5
500	18.7	17.8	19.9	21.5	23.6	22.5	18.0	20.1	19.0	19.8
630	18.6	18.3	19.9	21.5	19.5	22.3	18.4	19.6	19.4	19.6
800	18.9	20.5	20	19.7	16.3	19.3	20.2	19.9	21.5	19.2
1000	22.2	22.7	22.2	21.1	17.7	17.0	24.3	26.6	28.5	20.9
1250	21.6	18.8	18.2	19.4	16.4	15.4	22.5	21.9	24.9	18.8
1600	17.1	22.8	19.1	21.8	19.9	19.1	25.4	21.6	24.5	20.4
2000	18.8	19.0	16.8	19.9	22.3	20.6	18.4	19.8	16.9	19.2
2500	15.0	10.6	16.9	24.3	23.7	27.6	20.4	13.1	19.4	16.2
3150	12.8	9.7	12.1	28.2	28.1	23.0	17.4	15.9	16.3	15.3
4000	17.0	13.1	11.0	28.9	32.3	31.0	20.5	14.8	14.4	17.0
5000	24.6	20.1	15.1	31.6	36.8	32.6	20.6	25.9	18.9	23.1
DL_{SI} (0.3-5 kHz)	18.5	17.4	18	20.3	18.5	18.5	20.6	19.6	20.6	19.0

E.13 Single-leaf reflective barrier: TRL Noise Barrier Test Facilities 02

Referred to in Tables 5.1 and 5.4 (Morgan, 2010) as 'NBTF Crowthorne 2'.

Barrier details and site description				
Barrier type	Single-leaf reflective timber barrier. (SLReflect02) Constructed using 2.0 m high panels in between steel I-section posts. 'Plain' face on front of barrier.			
Date constructed	Original construction date: April 2004 (at Crowthorne NBTF). Reconstruction date: August 2009 (at Bishops Castle NBTF)			
Dimensions	**Height**	4.0 m	**Post spacing**	3.0 m
	Effective barrier thickness	Mid-panel	0.095 m (45 mm rail + 25 mm plank + 25 mm cover strip)	
		Across post	Not measured.	
Safety barrier details	No safety barrier present			
General site layout in barrier vicinity	Flat ground to the front of the noise barrier. Flat ground to the rear of the noise barrier.			

Summary of measurement results (Frequency range: 315-5000 Hz)

Element	**2004**		**2009**		**Notes**
	DL_{SI}	**Surface temp** Front/Rear	DL_{SI}	**Surface temp** Front/Rear	
Panel PA1	22.7	Unknown	16.8	22.6°C/22.2°C	Panels tested in 2004 and 2009 are from the same barrier but not exactly the same panels.

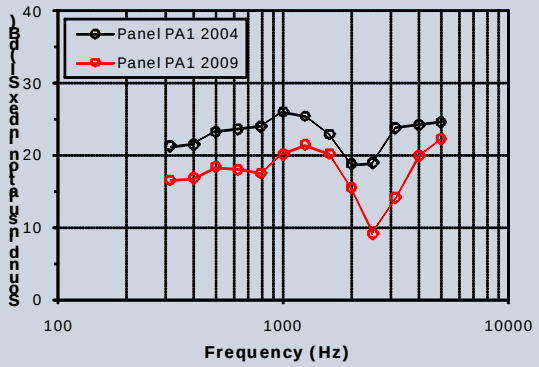
Physical condition of barrier during assessments	
2004 measurements	In good condition. Structurally robust with no obvious defects
2009 measurements	In average condition. Panels bowed. New cover strip on front across the joints between the panels. Some splitting of main timbers and knots splitting. New timber wedges. Poor seals at left-hand post.

Photographs of the noise barrier at the test location	
 (a) General view of barrier from front	 (b) General view of barrier from rear
 (c) Detail of front of barrier	 (d) Detail of rear of barrier panel

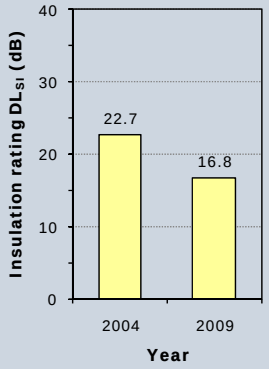
Measurement positions	
Access	Measurement positions on the rear of the barrier are accessed via the end of the barrier.
Panel PA1	Middle of centre panel on facility in 2004. Middle of sole panel on facility in 2009. 2.0 m below top of barrier in each case.
Panel PA2	N/A. Insufficient panels for assessment of a second panel.
Posts	N/A

Panel PA1: Sound insulation measurements

a) Third octave band sound insulation indices, SI_j



b) Single number rating of sound insulation, DL_{SI}



Panel PA1: Results from measurements taken in 2004

1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	23.8	20.3	21.4	21.8	22.0	19.7	21.1	22.1	19.7	21.2
400	24.7	20.5	21.6	22.4	22.5	19.8	21.4	22.7	19.9	21.5
500	23.1	24.3	22.1	26.8	24.4	22.5	24.6	21.4	21.7	23.2
630	24.5	24.3	22.2	27.4	23.3	23.3	24.5	21.7	23.6	23.6
800	28.1	23.4	22.5	26.5	22.4	23.9	23.7	22.9	26.2	24.0
1000	24.6	25.1	25.5	28.9	28.1	33.7	25.4	26.5	22.9	26.0
1250	22.9	24.3	26.3	29.1	28.4	33.3	23.9	24.8	23.7	25.4
1600	21.6	19.5	22.9	28.3	28.2	23.9	22.6	21.2	24.6	22.9
2000	15.2	18.5	17.2	21.4	27.8	20.3	17.1	19.9	19.7	18.7
2500	19.4	18.9	22.3	26.9	26.5	28.7	17.0	13.1	19.9	18.9
3150	25.7	23.9	26.3	27.0	28.3	27.5	21.2	20.2	22.3	23.8
4000	25.8	29.3	23.7	28.5	26.7	28.2	21.1	25.0	20.1	24.2
5000	28.3	21.5	27.4	30.6	33.6	31.4	24.2	20.3	22.6	24.6
DL_{SI} (0.3-5 kHz)	21.9	21.9	22.4	25.9	25.3	24.1	21.8	21.0	22.3	22.7

Panel PA1: Results from measurements taken in 2009

1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	17.1	17.6	20.2	15.8	17	16.6	15.2	16.4	14.5	16.5
400	17.5	18.0	21.3	16	17.5	16.9	15.5	16.8	14.6	16.8
500	19.3	18.8	21.1	18.1	19.6	20.0	16.0	17.8	15.9	18.3
630	20.5	19.4	21.4	16.9	17.6	18.7	16.1	17.7	16.5	18.0
800	22.2	20.4	22.3	15.5	15.9	17.0	16.1	17.5	17.0	17.5
1000	22.6	27.0	26.5	18.8	20.1	21.2	16.7	20.0	17.5	20.1
1250	18.1	25.2	24.0	23.8	23.8	24.9	19.7	19.4	19.2	21.4
1600	19.1	22.1	19.8	20.2	25.2	26.8	19.8	15.8	18.0	20.2
2000	13.8	13.2	14.3	19.8	15.6	15.5	17.8	19.0	13.1	15.4
2500	6.2	15.3	8.0	16.1	14.9	11.6	4.7	8.0	3.8	9.1
3150	13.5	22.5	7.5	16.4	22.8	17.2	9.0	19.5	8.4	14.1
4000	16.4	19.6	13.3	26.2	31.8	26.7	18.7	18.2	21.3	19.9
5000	18.0	20.7	17.2	27.6	34.3	24.5	19.9	20.6	19.0	22.2
DL_{SI} (0.3-5 kHz)	15.7	19.1	16.2	18.0	18.5	18.2	14.0	16.3	13.3	16.8

E.14 Single-leaf reflective barrier: TRL Noise Barrier Test Facilities 03

Referred to in Tables 5.1 and 5.4 (Morgan, 2010) as 'NBTF Bishops Castle 1'.

Barrier details and site description				
Barrier type	Single-leaf reflective timber barrier. Constructed using 2.0 m high panels in between steel I-section posts. 'Plain' face on rear of barrier.			
Date constructed	May 2008 at Bishops Castle NBTF			
Dimensions	**Height**	4.0 m	**Post spacing**	3.0 m
	Effective barrier thickness	Mid-panel	0.090 m (50 mm rail + 20 mm plank + 20 mm cover strip)	
		Across post	Not measured.	
Safety barrier details	No safety barrier present			
General site layout in barrier vicinity	Flat ground to the front of the noise barrier. Flat ground to the rear of the noise barrier.			

Summary of measurement results (Frequency range: 315-5000 Hz)

Element	**2008**		**2009**		**Notes**
	***DL*$_{SI}$**	**Surface temp** Front/Rear	***DL*$_{SI}$**	**Surface temp** Front/Rear	
Panel PA1	23.6 (Day 23)	37.6°C	19.9	28.3°C/23.8°C	

Physical condition of barrier during assessments	
2008 measurements	In good condition. Structurally robust with no obvious defects.
2009 measurements	In good condition. Structurally robust with no obvious defects.

Photographs of the noise barrier at the test location

(a) General view of barrier from front

(b) General view of barrier from rear

Photographs of the noise barrier at the test location (continued…)

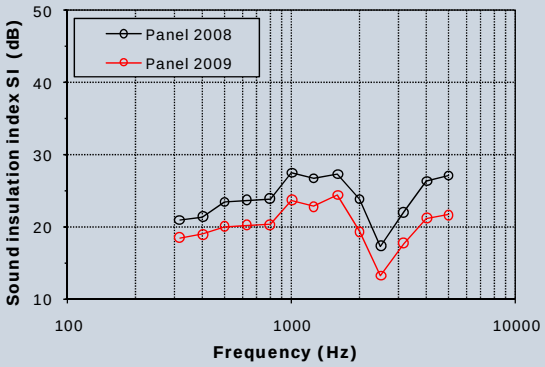
(c) Detail of front of barrier

(d) Detail of rear of barrier panel

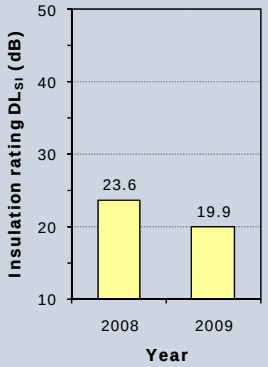
Details of selected measurement positions	
Access	Measurement positions on the rear of the barrier are accessed via the end of the barrier.
Panel PA1	2nd panel from left-hand end of barrier
Posts	Not assessed.

Panel PA1: Sound insulation measurements

a) Third octave band sound insulation indices, SI_j



b) Single number rating of sound insulation, DL_{SI}



Panel PA1: Results from measurements taken in 2008

1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	25.6	27.0	22.2	20.2	21.8	20.6	18.1	19.1	20.3	20.9
400	28.2	29.1	22.7	20.7	22.4	20.9	18.2	19.3	20.7	21.4
500	23.0	25.3	21.5	27.1	28.3	28.5	21.1	20.8	22.6	23.4
630	24.1	26.3	23.0	28.1	25.0	28.8	20.7	21.6	22.6	23.7
800	28.0	29.6	27.1	26.2	22.5	25.9	19.8	22.5	22.4	23.9
1000	27.5	28.1	26.6	33.7	31.8	33.3	24.2	24.6	27.7	27.5
1250	27.4	24.7	25.9	33.0	30.6	31.9	24.2	24.7	26.3	26.7
1600	29.1	26.4	26.8	30.7	34.5	28.7	24.9	23.2	31.4	27.3
2000	24.2	23.8	24.6	28.4	30.8	27.2	22.2	19.2	24.2	23.8
2500	17.3	19.0	17.3	22.0	24.7	26.9	12.9	12.9	24.1	17.3
3150	22.8	24.5	22.3	30.6	31.1	27.4	16.9	18.2	24.6	22.0
4000	23.5	28.1	22.9	29.9	33.5	32.5	24.9	25.4	27.3	26.3
5000	29.9	32.2	23.7	30.6	30.7	32.1	25.6	30.0	22.5	27.1
DL_{SI} (0.3-5 kHz)	24.7	25.5	23.7	26.6	26.4	27.0	20.2	20.5	24.1	23.6

Panel PA1: Results from measurements taken in 2009

1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	19.3	20.6	17.5	19.1	19.6	16.5	18.0	19.7	17.1	18.5
400	19.8	21.5	17.9	19.7	20.3	16.6	18.3	20.1	17.3	18.9
500	18.8	20.8	17.2	24.7	21.2	21.3	19.9	19.9	19.3	20.0
630	20.0	22.4	18.5	21.1	18.3	20.0	21.6	21.6	20.0	20.2
800	23.6	27.7	22.7	18.6	16.5	18.1	24.1	25.7	20.6	20.3
1000	26.0	24.8	22.6	26.1	23.3	26.0	22.5	21.6	22.5	23.7
1250	20.4	20.7	20.8	27.6	26.2	25.0	22.9	23.8	21.6	22.8
1600	24.0	23.7	23.7	26.1	28.1	26.8	22.0	21.4	26.8	24.4
2000	16.6	21.3	19.1	22.5	24.5	18.7	20.0	16.4	19.0	19.3
2500	9.6	14.6	10.4	16.0	18.8	18.2	9.8	10.9	13.9	13.2
3150	13.4	20.5	14.8	22.1	25.5	23.7	12.3	14.8	18.4	17.7
4000	17.8	26.0	14.0	27.5	26.7	29.0	20.4	20.7	22.5	21.2
5000	28.7	26.5	15.2	30.6	26.3	24.7	14.8	22.5	13.0	21.6
DL_{SI} (0.3-5 kHz)	18.2	21.5	18.0	21.7	20.9	20.6	18.3	19.0	19.4	19.9

E.15 Single-leaf reflective barrier: TRL Noise Barrier Test Facilities 04

Referred to in Tables 5.1 and 5.4 (Morgan, 2010) as 'NBTF Bishops Castle 2'.

Barrier details and site description				
Barrier type	Single-leaf reflective timber barrier. Constructed using 1.5 m high panels in between steel I-section posts. 'Plain' face on rear of barrier.			
Date constructed	May 2008 at Bishops Castle NBTF			
Dimensions	**Height**	3.0 m	**Post spacing**	3.0 m
	Effective barrier thickness	Mid-panel	0.090 m (50 mm rail + 20 mm plank + 20 mm cover strip)	
		Across post	Not measured.	
Safety barrier details	No safety barrier present			
General site layout in barrier vicinity	Flat ground to the front of the noise barrier. Flat ground to the rear of the noise barrier.			

Summary of measurement results (Frequency range: 315-5000 Hz)

Element	**2008**		**2009**		**Notes**
	***DL*$_{SI}$**	**Surface temp** Front/Rear	***DL*$_{SI}$**	**Surface temp** Front/Rear	
Panel PA1	23.6	Unknown	18.9	33.8°C/27.7°C	

Physical condition of barrier during assessments	
2008 measurements	In good condition. Structurally robust with no obvious defects.
2009 measurements	In good condition. Structurally robust with no obvious defects.

Photographs of the noise barrier at the test location

(a) General view of barrier from front

Note: There was no safety barrier present when measurements were taken

(b) General view of barrier from rear

Note: There was no safety barrier present when measurements were taken

Photographs of the noise barrier at the test location (continued…)

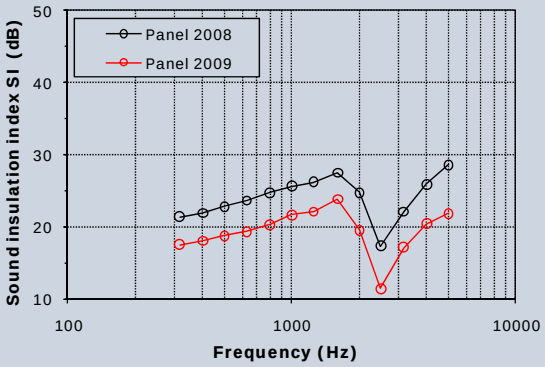
(c) Detail of front of barrier

(d) Detail of rear of barrier panel

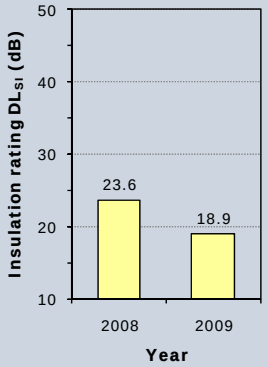
Details of selected measurement positions	
Access	Measurement positions on the rear of the barrier are accessed via the end of the barrier.
Panel PA1	2nd panel from left-hand end of barrier
Posts	Not assessed.

Panel PA1: Sound insulation measurements

a) Third octave band sound insulation indices, SI_j



b) Single number rating of sound insulation, DL_{SI}



Panel PA1: Results from measurements taken in 2004

1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	22.8	21.9	20.0	22.3	24.5	21.6	19.1	22.0	21.0	21.4
400	23.4	22.2	20.1	23.0	25.8	22.0	19.4	22.4	21.4	21.9
500	27.5	22.6	21.5	24.3	24.2	24.7	19.6	22.7	22.2	22.8
630	29.1	24.1	22.7	24.0	22.6	25.4	20.5	23.9	24.3	23.6
800	29.1	27.1	24.5	23.3	21.8	25.7	22.2	26.0	29.6	24.7
1000	26.4	24.8	24.3	24.5	28.6	31.5	24.6	24.5	25.6	25.6
1250	24.5	25.8	24.2	33.0	31.5	29.7	25.9	25.0	24.7	26.2
1600	28.5	27.5	25.0	32.4	32.0	31.2	26.7	24.9	26.5	27.5
2000	25.2	26.9	23.5	26.7	25.7	25.8	22.8	22.3	26.3	24.7
2500	22.0	18.0	12.7	21.2	22.3	21.3	15.2	17.4	16.1	17.3
3150	23.3	27.1	16.1	29.3	32.7	27.9	23.5	23.3	19.5	22.1
4000	24.7	28.7	20.7	28.7	27.8	30.2	25.7	26.2	29.4	25.9
5000	25.1	25.5	27.0	36.6	34.6	34.2	32.6	28.6	28.3	28.6
DL_{SI} (0.3-5 kHz)	25.6	24.2	20.9	25.1	25.4	26.0	21.7	23.3	23.3	23.6

Panel PA1: Results from measurements taken in 2009

1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	17.8	19.1	17.5	17.3	19.8	17.8	15.5	16.8	17.3	17.5
400	18.3	19.8	17.8	17.8	20.8	18.4	15.7	17.1	17.7	18.0
500	21.2	20.7	18.1	19.6	19.3	19.0	16.0	17.8	17.8	18.7
630	23.1	22.5	19.4	18.7	18.3	19.3	16.9	19.2	19.7	19.3
800	25.1	25.7	22.5	17.8	17.9	20.0	17.9	21.9	24.6	20.3
1000	24.0	21.5	21.6	22.7	24.0	27.4	16.7	20.5	21.3	21.6
1250	20.3	20.1	19.2	28.6	29.2	25.3	19.9	22.5	21.5	22.1
1600	24.1	22.5	21.5	28.5	25.8	27.4	22.0	20.5	25.3	23.8
2000	22.8	22.7	18.3	19.3	19.9	21.6	18.0	16.3	20.2	19.5
2500	11.2	11.9	7.2	13.9	15.7	16.1	8.0	10.3	9.5	11.4
3150	15.7	19.2	11.6	22.9	29.3	23.1	12.1	13.5	15.4	17.1
4000	22.3	20.3	14.3	26.6	30.4	25.4	15.5	20.7	18.5	20.4
5000	23.5	21.9	15.7	28.1	34.6	23.9	17.7	18.4	17.2	21.8
DL_{SI} (0.3-5 kHz)	19.7	19.9	16.4	19.8	20.7	21.1	15.7	17.7	18.2	18.9

Annex F Single-leaf sound-absorptive noise barriers: Detailed description and performance results

The tables in this Annex provide detailed information on the locations of each of the single-leaf sound-absorptive timber barriers tested within the study, together with construction information and dimensions, photographs, a summary of the airborne sound insulation measurements obtained for each tested panel (and post, where relevant) tested and the corresponding one-third octave band sound insulation spectra.

All tests were performed using the prEN 1793-6 approach (free-field measurements at all 9 microphone positions) unless otherwise stated.

F.1 Sound absorptive barrier: M1, Junctions 11-12, Northbound

Barrier location		
Road / Junctions	M1, J11 - J12	
Carriageway	Northbound	
Nearest Marker Posts	56/2 – 56/3 (56/2 + 17.5m)	
Latitude GPS reading in brackets	51.90767° (N 51° 54.448')	
Longitude GPS reading in brackets	-0.48115° (W 0° 28.869')	
OS Grid	TL 045 243	
Approximate barrier orientation at coordinates (in direction of traffic)	SSE – NNW	

Barrier details and site description					
Barrier type	Single-leaf absorptive timber barrier. Constructed using full-height panels in-between steel I-section posts.				
Date constructed	June 2004*				
Dimensions	**Height**	3.0 m	**Post spacing**	3.0 m	
	Barrier thickness	Mid-panel	0.157 m	(100mm panel + 25mm rear cover strip + 32 mm front cover strip)	
		Across post	0.148 m	(100 mm panel+ 25mm rear cover strip + 105 mm packing wedge on front)	
Safety barrier details	Free-standing open-box safety fence. Positioned approximately 0.8 m in front of the noise barrier.				
General site layout in barrier vicinity	Flat ground in front of the noise barrier. Approximately 1 m of level ground immediately to the rear of the noise barrier then sharply sloping ground.				

* Construction date is estimated based on information provided by industry contacts/Managing Agents.

Summary of measurement results (Frequency range: 315-5000 Hz)

Element	2008		2009		Notes
	DL_{SI}	Surface temp Front/Rear	DL_{SI}	Surface temp Front/Rear	
Panel PA1	28.0	°20.6C/36.4°C	27.0	22.3°C/41.3°C	
Panel PA2	28.9	°17.1C/18.7°C	26.0	25.6°C/30.0°C	
Post PO1	---	Not measured	27.5	26.0°C/34.6°C	

Photographs of the noise barrier at the test location

(a) General view of barrier from front

(b) General view of barrier from rear

(c) Detail of front of barrier

(d) Detail of rear of barrier panel

Details of selected measurement positions

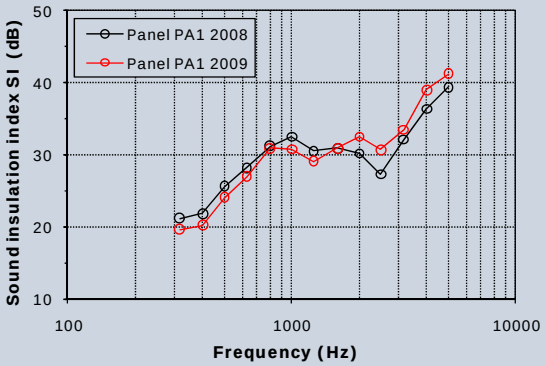
Access	Measurement positions on the rear of the barrier are accessed via an unlocked emergency access gate in the barrier
Panel PA1	Middle of 3rd panel to right of access gate (viewed from front), 1.5 m below top of barrier.
Panel PA2	Middle of 2nd panel to right of access gate (viewed from front), 1.5 m below top of barrier
Posts	Not measured in 2008 due to time restrictions

Physical condition of barrier during assessments

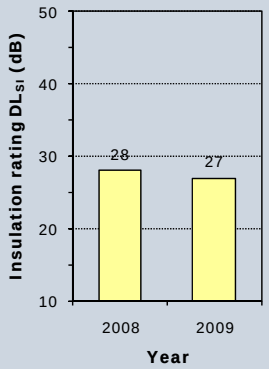
2008 measurements	Structurally robust and in good condition with no obvious defects.
2009 measurements	Structurally robust and generally in good condition. Some minor separation of the cover strips on the rear of the barrier. The protective membrane on the front of the barrier was damaged at the foot of the post between panels PA1 and PA2.

Panel PA1: Sound insulation measurements

a) Third octave band sound insulation indices, SI_j



b) Single number rating of sound insulation, DL_{SI}



Panel PA1: Results from measurements taken in 2008

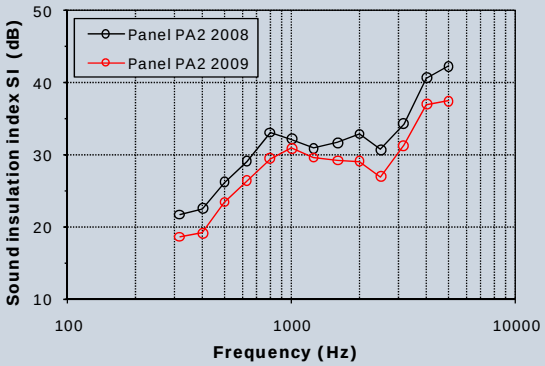
1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	20.1	20.0	22.7	21.2	21.7	22.9	20.8	20.4	21.6	21.2
400	20.4	20.3	23.2	21.8	22.3	23.7	21.3	21.5	22.5	21.8
500	26.1	24.3	25.0	24.4	26.7	26.1	26.0	25.4	27.4	25.6
630	30.6	27.9	26.7	26.3	29.8	28.9	28.2	27.9	29.7	28.2
800	32.9	37.6	30.1	28.9	32.0	35.5	28.6	30.1	30.6	31.2
1000	33.6	31.8	34.6	31.8	30.8	38.6	30.1	30.4	41.8	32.5
1250	29.0	28.8	32.6	32.2	29.0	32.6	31.7	29.2	34.7	30.5
1600	28.4	29.3	33.0	33.9	29.2	38.3	31.7	28.0	38.1	30.9
2000	28.5	29.3	28.4	39.0	28.5	31.5	32.5	28.9	38.9	30.2
2500	34.3	26.1	24.4	34.1	25.7	24.9	34.1	32.5	30.8	27.3
3150	37.5	30.3	29.7	44.1	32.7	28.4	37.0	38.5	31.6	32.1
4000	37.8	33.4	36.5	48.4	33.1	38.6	45.1	37.5	38.3	36.4
5000	37.4	41.0	36.8	40.5	44.2	37.4	39.6	38.7	36.9	39.4
DL_{SI} (0.3-5 kHz)	27.6	27.0	28.1	28.1	27.9	29.4	27.9	27.4	29.7	28.0

Panel PA1: Results from measurements taken in 2009

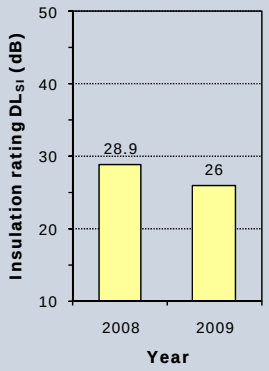
1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	21.0	18.9	18.7	19.8	20.0	20.1	18.6	19.5	19.8	19.6
400	22.1	19.4	19.1	20.6	20.7	20.6	19.2	19.9	20.6	20.2
500	24.7	23.8	22.7	25.1	25.2	24.3	23.3	24.3	23.8	24.1
630	27.0	27.7	25.6	28.9	29.0	26.6	26.1	27.7	25.3	27.0
800	32.3	36.1	31.6	33.6	33.8	29.2	29.4	31.7	26.6	30.9
1000	36.7	30.4	35.6	30.2	29.0	29.4	31.6	30.6	30.7	30.8
1250	32.8	29.4	32.2	30.3	28.5	26.4	28.4	30.2	27.6	29.1
1600	34.5	30.5	34.9	34.0	31.5	29.9	28.3	28.7	30.1	30.9
2000	33.8	30.2	35.5	38.1	36.4	31.8	28.6	30.9	34.6	32.5
2500	43.7	33.2	29.9	33.1	29.0	28.0	35.4	31.0	31.3	30.7
3150	35.9	38.2	32.6	36.3	33.1	28.8	42.0	39.9	35.2	33.5
4000	40.3	44.5	36.7	41.5	37.9	34.2	47.6	45.7	42.4	39.0
5000	43.4	41.9	36.1	41.5	40.2	43.7	49.7	45.1	36.8	41.3
DL_{SI} (0.3-5 kHz)	28.8	26.7	26.6	27.8	27.4	26.4	26.1	26.9	26.4	27.0

Panel PA2: Sound insulation measurements

a) Third octave band sound insulation indices, SI_j



b) Single number rating of sound insulation, DL_{SI}



Panel PA2: Results from measurements taken in 2008

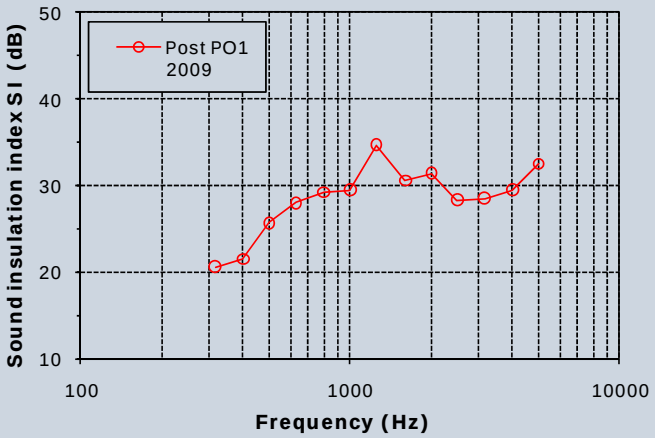
1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	23.2	20.6	20.8	23.4	21.5	22.1	22.2	20.4	21.9	21.7
400	23.9	21.6	21.1	24.2	22.2	23.3	23.2	20.9	22.7	22.5
500	25.3	25.7	25.2	27.1	26.4	27.2	27.1	25.8	26.5	26.2
630	27.7	29.3	28.3	30.0	29.6	29.5	29.5	29.7	28.3	29.1
800	36.8	37.0	34.5	37.4	32.2	31.2	32.0	33.3	29.6	33.1
1000	37.4	29.8	38.2	35.3	30.0	31.4	34.0	30.4	33.4	32.2
1250	35.4	29.4	33.3	34.5	29.8	28.4	31.9	31.6	30.1	30.9
1600	35.6	29.8	37.5	35.6	31.6	32.9	30.6	27.9	31.3	31.7
2000	36.2	32.0	38.8	35.8	34.5	31.3	30.0	30.2	35.5	32.9
2500	39.4	33.4	31.0	35.7	28.1	28.0	37.5	30.9	34.3	30.7
3150	36.6	36.7	34.9	37.2	33.0	30.4	41.0	40.6	35.8	34.3
4000	42.2	39.9	36.9	41.5	43.2	37.6	42.6	44.9	44.2	40.7
5000	40.9	40.8	39.7	42.6	45.5	41.0	51.3	45.5	39.5	42.3
DL_{SI} (0.3-5 kHz)	30.4	28.1	28.8	30.9	28.4	28.6	29.4	27.7	28.8	28.9

Panel PA2: Results from measurements taken in 2009

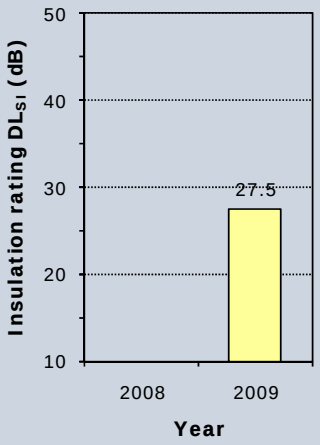
1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	17.3	18.4	20.4	18.2	19.6	19.8	18.0	18.3	18.2	18.6
400	17.5	18.9	21.2	18.6	20.1	20.4	18.6	18.8	18.8	19.1
500	23.8	22.3	23.3	22.6	24.1	24.1	24.0	22.8	24.2	23.4
630	29.1	25.5	25.0	25.2	27.1	27.0	26.8	25.8	27.2	26.4
800	33.6	34.8	27.9	27.7	30.8	32.7	26.8	29.1	28.0	29.5
1000	32.1	30.1	33.7	30.2	30.2	36.3	28.3	28.7	34.6	30.9
1250	27.8	27.4	32.4	32.3	28.3	31.5	30.6	29.2	30.7	29.6
1600	26.8	27.4	32.2	33.2	28.2	36.0	28.7	26.2	32.3	29.2
2000	27.7	27.2	29.1	35.7	27.5	31.0	31.2	27.3	36.7	29.1
2500	32.8	25.2	24.6	31.3	26.2	23.9	31.9	32.1	30.4	27.0
3150	36.8	29.4	30.3	42.4	31.6	27.5	35.3	36.3	31.0	31.3
4000	35.1	33.9	38.2	40.2	35.0	42.5	44.0	36.9	40.4	37.0
5000	35.3	37.2	35.0	38.3	41.8	36.0	47.4	36.6	35.0	37.5
DL_{SI} (0.3-5 kHz)	25.3	25.3	26.7	25.9	26.3	27.1	25.6	25.4	26.4	26.0

Post PO1: Sound insulation measurements

a) Third octave band sound insulation indices, SI_j



b) Single number rating of sound insulation, DL_{SI}



Post PO1: Results from measurements taken in 2009

1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	20.6	22.4	20.4	20.9	22.0	21.0	18.7	21.0	19.1	20.6
400	21.5	23.9	21.1	21.8	23.8	21.9	19.2	21.9	19.8	21.5
500	25.5	27.2	25.0	26.3	28.6	24.4	24.9	25.8	24.4	25.7
630	28.1	29.6	26.7	28.8	30.3	26.2	28.9	28.2	26.6	28.0
800	31.4	32.4	27.5	29.7	29.5	28.5	30.2	28.2	27.4	29.2
1000	33.5	32.2	30.7	28.8	27.5	32.0	30.3	25.7	32.7	29.5
1250	32.5	41.7	36.3	36.9	33.9	34.4	42.7	37.7	29.5	34.7
1600	31.1	30.3	33.8	32.1	26.8	34.3	34.3	33.0	28.3	30.6
2000	34.6	31.6	26.1	32.2	31.8	32.8	33.6	34.8	29.9	31.4
2500	35.7	33.7	29.2	25.9	25.4	28.2	29.8	32.8	29.8	28.3
3150	27.2	31.0	28.9	23.4	27.7	31.0	35.5	34.7	34.6	28.5
4000	34.6	25.9	31.0	27.4	27.0	31.5	38.2	34.9	32.6	29.5
5000	37.6	34.4	28.4	28.0	36.6	31.1	31.1	37.2	31.8	32.5
DL_{SI} (0.3-5 kHz)	28.2	29.4	27.0	27.4	27.7	27.7	27.0	27.5	26.4	27.5

F.2 Sound absorptive barrier: M1, Junctions 24a-25, Southbound

Barrier location	
Road / Junctions	M1, J24A – J25
Carriageway	Southbound
Nearest Marker Posts	191/5 – 191/4 (191/5 - 15 m)
Latitude GPS reading in brackets	52.89672° (N 52° 53.803')
Longitude GPS reading in brackets	-1.29850° (W 1° 17.910')
OS Grid	SK 473 334
Approximate barrier orientation at coordinates (in direction of traffic)	NE-SE

Barrier details and site description					
Barrier type	Single-leaf absorptive timber barrier. Constructed using stacked panels in-between steel I-section posts, i.e. 2 panels are used to achieve the full height of the barrier. Horizontal joint between the stacked panels is at mid-height.				
Date constructed	September 2004*				
Dimensions	**Height**	4.0 m	**Post spacing**	2.4 m	
	Barrier thickness	Mid-panel	0.165 m		
		Across post	0.165 m	(Post thinner than barrier)	
Safety barrier details	Free-standing open-box safety fence. Positioned approximately 1.7 m in front of the noise barrier.				
General site layout in barrier vicinity	Flat ground in front of the noise barrier. Approximately 1 m of level ground immediately to the rear of the noise barrier then gently sloping ground				

* Construction date is estimated based on information provided by Managing Agents/industry contacts.

Summary of measurement results (Frequency range: 315-5000 Hz)

Element	2008		2009		Notes
	DL_{SI}	Surface temp Front/Rear	DL_{SI}	Surface temp Front/Rear	
Panel PA1	33.3	23.0°C/15.9°C	31.9	18.7°C/25.2°C	
Panel PA2	31.2	26.1°C/15.9°C	30.2	22.1°C/19.3°C	
Post PO1	---	Not measured	30.7	22.9°C/18.4°C	

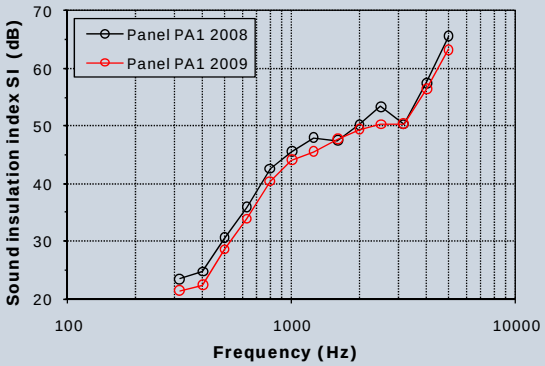
Photographs of the noise barrier at the test location	
 (a) General view of barrier from front	 (b) General view of barrier from rear
 (c) Detail of front of barrier	 (d) Detail of rear of barrier panel

Details of selected measurement positions	
Access	Measurement positions on the rear of the barrier are accessed via an unlocked emergency access gate in the barrier
Panel PA1	Middle of 4th panel to right of access gate (viewed from front), 2.3 m below underside of capping piece *(equivalent to approx 1.6 m above ground)*
Panel PA2	Middle of 3rd panel to right of access gate (viewed from front), 2.3 m below underside of capping piece *(equivalent to approx 1.6 m above ground)*
Posts	Post in between 3rd and 4th panels

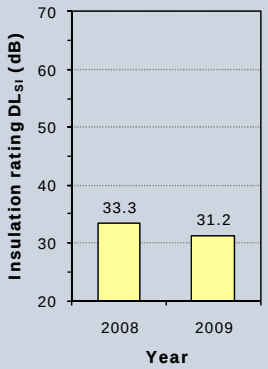
Physical condition of barrier during assessments	
2008 measurements	Good condition, structurally robust with no obvious defects
2009 measurements	Good condition, structurally robust with no major defects. Some cover strips on front in poor condition.

Panel PA1: Sound insulation measurements

a) Third octave band sound insulation indices, SI_j



b) Single number rating of sound insulation, DL_{SI}



Panel PA1: Results from measurements taken in 2008

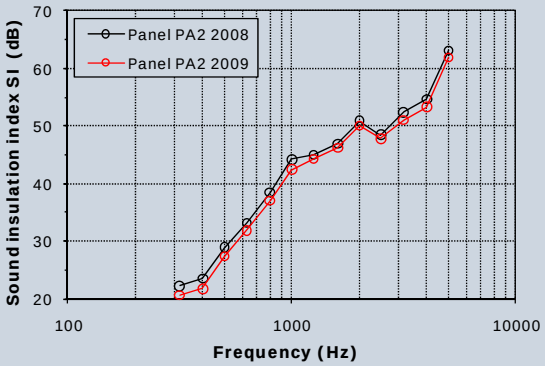
1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	19.9	21.7	22.4	24.3	25.5	22.9	30.7	29.3	24.7	23.4
400	20.5	22.7	23.5	26.5	27.8	24.2	37.2	36.1	26.4	24.7
500	26.8	28.0	30.0	32.1	33.7	31.1	37.2	35.9	32.6	30.6
630	32.3	32.6	36.1	36.8	39.0	40.8	39.5	37.3	38.1	35.9
800	40.9	39.8	38.6	43.5	47.8	45.3	58.8	41.1	49.9	42.6
1000	41.5	46.3	41.9	51.2	47.7	49.9	53.0	44.9	45.7	45.6
1250	47.7	45.8	47.6	51.8	45.5	48.6	51.5	49.7	50.9	48.0
1600	44.2	50.6	52.1	43.8	48.6	49.1	49.8	49.5	49.1	47.5
2000	43.7	53.4	51.1	49.7	52.9	52.7	52.9	53.1	54.1	50.2
2500	47.0	55.3	51.3	54.6	55.4	54.5	57.9	58.0	54.0	53.4
3150	45.0	50.3	49.6	46.3	58.4	53.9	49.8	55.3	53.2	50.3
4000	53.3	57.0	56.2	57.3	59.1	58.1	60.4	61.7	61.4	57.5
5000	64.3	65.4	62.0	65.3	69.4	65.4	63.9	68.7	64.4	65.6
DL_{SI} (0.3-5 kHz)	29.5	31.3	32.2	34.6	35.9	33.2	41.4	39.4	34.9	33.3

Panel PA1: Results from measurements taken in 2009

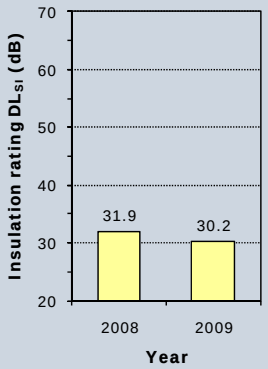
1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	18.3	18.8	20.5	22.0	22.9	21.3	26.5	27.6	22.1	21.4
400	18.8	19.6	21.5	23.3	24.5	22.3	32.2	33.4	22.9	22.4
500	24.5	26.5	27.1	30.2	31.6	29.1	34.3	34.1	29.7	28.6
630	29.3	32.5	31.6	35.5	38.7	37.3	37.0	36.0	36.9	33.9
800	38.6	42.5	36.9	36.6	45.3	40.7	49.0	41.9	49.8	40.4
1000	38.8	41.9	42.7	56.5	45.1	50.1	55.4	45.0	44.1	44.1
1250	41.5	42.9	41.9	48.1	47.5	47.2	50.6	51.2	53.1	45.6
1600	49.1	47.5	49.6	45.5	49.7	46.3	55.2	46.9	46.4	47.7
2000	45.8	49.5	57.3	45.9	48.9	51.7	56.1	51.1	53.8	49.4
2500	47.2	53.0	50.5	46.6	50.8	51.7	51.3	55.4	53.0	50.3
3150	43.1	52.9	48.1	49.1	54.8	51.4	49.5	55.7	49.9	50.4
4000	54.5	57.8	49.2	57.3	59.8	58.2	61.7	63.4	52.8	56.4
5000	61.8	63.5	57.4	63.0	67.7	62.7	68.2	62.0	61.5	63.3
DL_{SI} (0.3-5 kHz)	27.7	28.7	30.0	31.9	33.2	31.3	37.6	37.9	32.0	31.2

Panel PA2: Sound insulation measurements

a) Third octave band sound insulation indices, SI_j



b) Single number rating of sound insulation, DL_{SI}



Panel PA1: Results from measurements taken in 2009

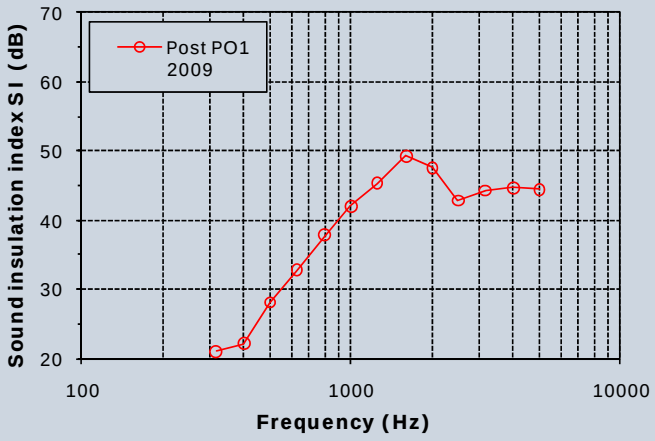
1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	20.4	20.3	21	23.2	24.2	21.8	23.8	23.8	24.8	22.2
400	21.2	21.1	22.6	24.4	27.4	23.2	24.3	25.4	27	23.5
500	26.5	26.5	27.1	29.6	31.0	29.7	29.7	32.3	33.2	28.9
630	30.8	31.2	30.9	33.0	33.4	37.2	34.4	37.5	38.5	33.2
800	39.0	38.9	38.0	35.7	36.6	41.5	42.2	38.2	45.3	38.5
1000	46.9	41.1	40.9	45.7	42.7	52.0	44.6	46.2	47.2	44.2
1250	41.9	44.5	50.1	41.5	44.1	51.6	48.3	48.8	48.8	45.0
1600	45.7	43.7	50.0	47.6	45.1	52.8	47.3	48.8	51.5	46.9
2000	47.2	48.9	53.2	47.9	53.3	60.3	49.4	58.1	53.4	50.9
2500	43.6	49.4	54.0	44.9	48.8	61.0	47.6	50.5	56.2	48.5
3150	47.8	53.8	53.5	48.6	55.1	61.2	51.9	53.1	52.8	52.4
4000	52.6	55.0	52.2	54.7	57.6	55.5	53.5	56.7	53.8	54.7
5000	62.3	63.3	61.2	64.3	64.6	63.2	60.8	64.9	59.2	63.1
DL_{SI} (0.3-5 kHz)	29.8	29.8	30.7	32.5	34.0	32.0	33.1	33.9	35.3	31.9

Panel PA2: Results from measurements taken in 2009

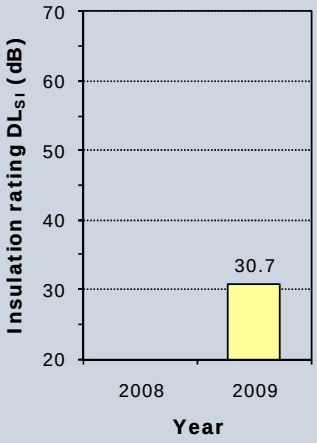
1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	18.6	18.1	19.0	21.3	22.8	21.2	22.4	22.7	23.1	20.6
400	19.1	18.5	19.8	22.8	24.9	22.8	23.3	23.7	24.8	21.7
500	24.7	24.9	24.9	28.2	29.6	29.4	28.8	31.3	30.3	27.4
630	29.3	29.8	28.9	31.9	32.5	36.2	33.4	38.0	35.4	31.9
800	37.7	36.6	34.8	34.9	35.2	38.7	40.4	38.1	48.5	37.0
1000	45.5	38.2	43.9	42.4	39.9	53.1	42.1	44.0	48.1	42.4
1250	41.0	41.5	46.7	41.8	43.4	50.2	49.4	46.6	56.6	44.3
1600	45.5	42.5	46.8	47.8	45.7	54.5	47.5	45.0	48.6	46.2
2000	46.6	46.2	53.3	47.6	52.4	59.3	50.0	56.0	54.2	50.1
2500	42.7	49.0	50.2	44.0	48.9	56.0	47.4	50.9	53.1	47.8
3150	44.9	52.3	50.8	46.9	54.3	60.0	50.9	52.3	52.9	51.0
4000	53.4	50.1	55.2	52.5	56.5	53.7	50.7	56.3	57.2	53.3
5000	58.2	61.2	58.5	68.0	63.4	62.8	61.3	62.9	58.4	61.9
DL_{SI} (0.3-5 kHz)	28.0	27.5	28.3	30.9	32.3	31.4	31.9	32.6	33.2	30.2

Post PO1: Sound insulation measurements

a) Third octave band sound insulation indices, SI_j



b) Single number rating of sound insulation, DL_{SI}



Post PO1: Results from measurements taken in 2009

1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	19.6	19.7	20.1	19.7	22.1	21.4	22.2	23.0	24.6	21.0
400	20.3	20.7	20.9	20.4	23.6	22.8	23.0	24.6	27.4	22.1
500	26.0	26.4	26.7	27.2	29.8	28.7	29.5	29.6	33.2	28.1
630	30.4	30.4	31.6	32.8	34.2	34.6	35.6	33.6	38.4	32.8
800	35.0	36.9	37.6	35.1	36.5	42.1	42.1	40.9	46.0	37.8
1000	43.3	43.0	48.8	38.9	39.5	50.0	40.8	40.6	47.4	42.0
1250	41.2	46.5	49.0	41.6	46.1	47.6	45.8	51.9	50.1	45.3
1600	52.2	50.3	47.3	46.7	51.7	48.9	48.3	50.4	51.0	49.3
2000	46.4	46.6	51.4	44.0	45.9	48.4	51.0	59.5	54.9	47.6
2500	42.2	44.0	43.3	41.4	41.3	40.7	50.6	50.8	47.9	42.8
3150	43.6	46.0	43.0	42.4	46.3	40.4	50.7	53.3	43.7	44.3
4000	45.0	44.9	48.7	43.5	44.1	44.1	47.1	45.6	44.6	44.7
5000	43.0	46.4	41.8	45.1	44.7	43.9	44.7	45.1	40.5	44.4
DL_{SI} (0.3-5 kHz)	28.9	29.3	29.7	29.2	31.9	31.4	31.9	32.7	35.3	30.7

F.3 Sound absorptive barrier: M3, Junctions 4-4a, Westbound

Barrier location		
Road / Junctions	M3, J4-J4A	
Carriageway	Westbound	
Nearest Marker Posts	53/6 – 53/7 (53/6 + 7 m)	
Latitude GPS reading in brackets	51.31023° (N 51° 18.614')	
Longitude GPS reading in brackets	-0.77138° (W 0° 46.283')	
OS Grid	SU 857 575	
Approximate barrier orientation at coordinates (in direction of traffic)	NE-SE	

Barrier details and site description					
Barrier type	Single-leaf absorptive timber barrier. Constructed using stacked panels in between steel I-section posts, i.e. 2 panels are used to achieve the full height of the barrier.				
Date constructed	March 2006*				
Dimensions	**Height**	4.0 m	**Post spacing**	3.0 m	
	Barrier thickness	Mid-panel	0.150		
		Across post	0.250		
Safety barrier details	Free-standing open-box safety fence. Positioned approximately 1.45 m in front of the noise barrier.				
General site layout in barrier vicinity	Flat ground in front of the noise barrier. Gently sloping ground to the rear of the noise barrier, with trees in very close proximity to the barrier.				

* Construction date is estimated based on information provided by industry contacts.

Summary of measurement results (Frequency range: 315-5000 Hz)					
Element	**2008**		**2009**		**Notes**
	***DL*$_{SI}$**	**Surface temp** Front/Rear	***DL*$_{SI}$**	**Surface temp** Front/Rear	
Panel PA1	28.8	26.4°C/25.1°C	29.5	18.4°C/20.7°C	*2008 measurements used CEN/TS 1793-5 method (P5 free-field mic & path differences)*
Panel PA2	30.8	28.2°C/24.2°C	31.4	21.2°C/19.1°C	
Post PO1	29.1	23.7°C/29.7°C	27.9	18.0°C/19.6°C	

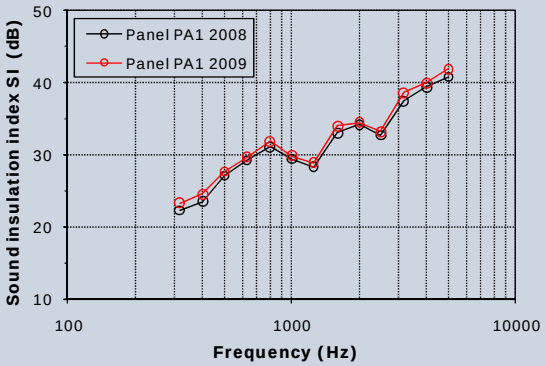
Photographs of the noise barrier at the test location	
 (a) General view of barrier from front	 (b) General view of barrier from rear
 (c) Detail of front of barrier	 (d) Detail of rear of barrier panel

Details of selected measurement positions	
Access	Measurement positions on the rear of the barrier are accessed via a padlocked emergency access gate in the barrier.
Panel PA1	Middle of 3rd panel to right of access gate (viewed from front), 2.3 m below underside of capping piece *(equivalent to approx. 1.6 m above ground)*
Panel PA2	Middle of 4th panel to right of access gate (viewed from front), 2.3 m below underside of capping piece *(equivalent to approx. 1.6 m above ground)*
Posts	Post in between 3rd and 4th panels

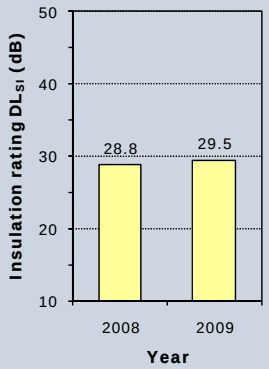
Physical condition of barrier during assessments	
2008 measurements	Structurally robust and in good condition with no obvious defects.
2009 measurements	Structurally robust and in good condition with no obvious defects.

Panel PA1: Sound insulation measurements

a) Third octave band sound insulation indices, SI_j



b) Single number rating of sound insulation, DL_{SI}



Panel PA1: Results from measurements taken in 2008

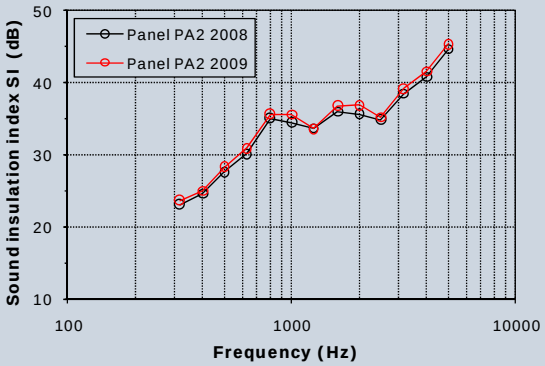
1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	24.9	23.9	22.6	21.8	21.1	20.7	23.6	22.2	22.0	22.3
400	28.5	25.3	23.7	23.0	21.5	21.4	25.6	23.6	23.4	23.5
500	28.1	28.5	24.6	27.4	27.1	24.7	29.8	28.8	27.3	27.1
630	29.5	30.3	26.6	29.2	30.7	26.9	29.9	32.0	30.2	29.2
800	31.4	30.4	31.5	29.7	33.1	29.4	28.8	33.8	35.4	31.1
1000	25.2	25.6	25.4	32.4	47.3	32.8	34.3	35.3	33.5	29.4
1250	23.6	25.4	24.5	32.7	37.5	30.0	34.0	43.3	30.1	28.3
1600	29.1	29.5	31.1	40.4	42.6	35.4	31.6	42.9	33.3	33.0
2000	33.2	31.7	37.0	36.3	35.5	30.4	34.9	41.9	37.5	34.2
2500	31.4	31.6	33.6	32.8	31.0	33.2	34.2	34.8	45.1	32.7
3150	39.0	45.6	37.0	32.9	36.7	38.8	41.1	41.2	39.9	37.5
4000	37.0	45.6	43.2	37.1	39.9	36.1	41.7	46.9	40.6	39.4
5000	43.0	57.7	44.0	36.2	39.1	40.5	46.4	47.6	42.8	40.8
DL_{SI} (0.3-5 kHz)	27.4	27.8	26.9	29.3	29.7	27.8	30.5	31.2	29.9	28.8

Panel PA1: Results from measurements taken in 2009

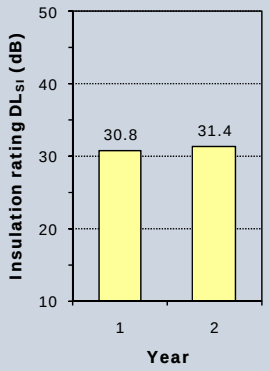
1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	25.3	24.8	23.6	23.0	22.0	22.2	23.9	23.0	23.8	23.3
400	27.2	26.3	25.4	24.0	22.6	23.2	25.3	24.2	25.8	24.5
500	27.6	29.7	25.2	28.8	27.5	25.7	30.5	29.7	28.3	27.7
630	29.1	31.5	27.2	30.1	31.0	27.7	31.3	33.2	30.3	29.7
800	31.2	31.6	32.8	29.9	35.1	30.9	30.2	34.4	34.1	31.9
1000	25.1	26.9	25.6	33.7	45.6	33.4	35.0	37.1	33.5	29.9
1250	24.2	26.1	25.0	32.8	36.7	31.5	34.7	41.6	29.6	28.9
1600	30.1	31.1	31.2	40.7	41.9	36.3	33.1	39.1	33.9	34.0
2000	34.2	32.2	37.1	36.8	35.3	30.6	35.7	42.8	39.2	34.5
2500	31.6	31.4	32.7	32.8	31.8	35.0	36.2	35.2	46.1	33.2
3150	39.1	46.1	38.0	34.9	38.1	38.5	43.3	41.5	40.2	38.6
4000	38.0	44.3	42.9	38.7	40.9	36.1	44.8	47.7	41.8	40.0
5000	43.2	55.5	42.0	37.7	41.0	40.3	50.1	49.7	43.9	41.9
DL_{SI} (0.3-5 kHz)	27.6	28.8	27.5	30.2	30.5	29.1	31.2	31.9	30.8	29.5

Panel PA2: Sound insulation measurements

a) Third octave band sound insulation indices, SI_j



b) Single number rating of sound insulation, DL_{SI}



Panel PA2: Results from measurements taken in 2008

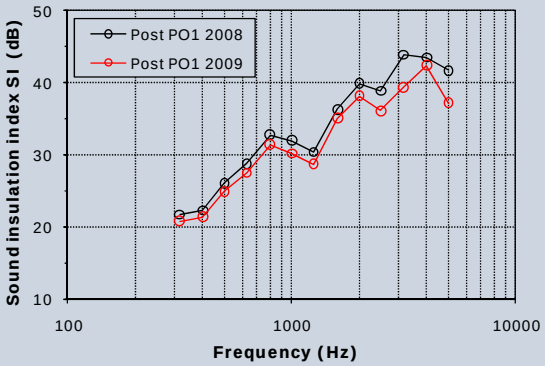
1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	24.9	24.5	22.3	23.3	23.1	20.3	23.3	25.1	22.6	23.1
400	28.0	26.4	23.1	26.5	24.3	20.9	25.2	27.8	24.2	24.6
500	26.4	28.7	25.0	31.8	30.8	24.2	30.2	28.6	27.8	27.6
630	28.4	31.5	27.5	34.6	32.6	27.0	34.3	30.3	30.7	30.1
800	42.9	40.6	35.5	35.3	31.2	32.4	46.7	35.5	35.6	35.1
1000	33.2	35.6	31.2	35.1	35.5	33.3	41.4	38.2	33.1	34.5
1250	30.8	32.1	33.2	34.4	34.4	33.6	37.6	34.9	35.7	33.7
1600	38.1	33.8	37.6	40.6	35.2	36.0	37.9	34.8	35.2	36.0
2000	42.8	39.6	38.5	40.7	30.8	36.5	42.9	37.9	33.8	35.7
2500	42.2	44.7	39.9	38.1	31.1	32.5	39.7	35.9	36.2	34.9
3150	43.8	50.0	35.8	34.6	44.6	34.2	38.6	41.4	38.2	38.5
4000	52.6	46.7	43.4	44.9	37.3	37.6	43.2	42.5	38.7	40.8
5000	49.4	54.1	45.4	49.9	43.3	39.5	47.5	51.5	39.3	44.7
DL_{SI} (0.3-5 kHz)	31.4	32.1	29.4	32.5	30.7	28.1	32.8	32.5	30.6	30.8

Panel PA2: Results from measurements taken in 2009

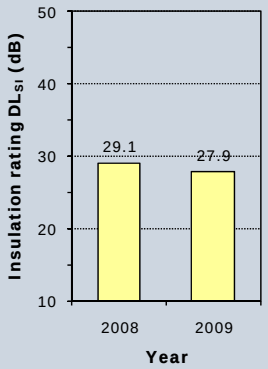
1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	25.9	23.7	23.1	25.0	23.8	21.8	24.2	24.7	22.8	23.7
400	28.3	25.1	24.5	26.0	24.9	22.5	25.7	26.5	24.3	25.0
500	27.5	28.2	26.6	32.3	30.6	26.4	29.5	28.1	28.2	28.3
630	29.5	31.3	29.1	36.2	32.6	29.3	32.9	30.2	31.0	30.9
800	42.6	42.2	36.0	36.2	32.1	32.9	51.3	36.3	35.1	35.7
1000	33.2	34.9	32.3	36.2	38.1	34.7	41.3	39.8	36.6	35.6
1250	30.9	33.9	32.3	33.5	34.3	33.9	35.3	36.7	34.1	33.6
1600	36.2	34.7	35.9	40.9	37.6	37.3	42.2	34.6	37.0	36.8
2000	40.2	40.3	38.9	42.2	32.8	36.5	42.5	37.3	35.7	36.9
2500	39.3	39.6	38.5	36.4	32.5	34.1	36.8	34.7	37.7	35.2
3150	44.7	47.8	37.1	35.8	45.4	34.9	38.9	42.5	37.6	39.2
4000	48.9	47.6	44.0	47.6	40.1	36.7	47.5	44.6	38.4	41.6
5000	50.4	55.4	47.2	48.5	43.8	40.0	48.2	55.7	39.6	45.4
DL_{SI} (0.3-5 kHz)	32.0	31.7	30.4	33.1	31.5	29.7	33.0	32.2	31.1	31.4

Post PO1: Sound insulation measurements

a) Third octave band sound insulation indices, SI_j



b) Single number rating of sound insulation, DL_{SI}



Post PO1: Results from measurements taken in 2008

1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	22.0	22.5	23.9	22.2	20.8	20.4	22.9	21.6	20.0	21.7
400	22.7	23.1	25.0	22.9	21.0	20.9	24.4	22.3	20.7	22.3
500	28.2	23.5	27.6	29.1	24.0	25.8	28.9	24.9	26.6	26.1
630	32.8	25.4	30.1	33.8	25.5	29.9	32.8	27.0	31.2	28.8
800	39.6	31.0	35.1	37.1	27.0	39.9	44.1	30.2	35.4	32.8
1000	35.2	32.1	33.6	32.5	29.5	33.4	37.7	28.2	32.8	32.0
1250	33.4	33.0	37.1	30.3	27.9	35.8	41.7	24.7	31.1	30.4
1600	37.4	34.5	36.0	34.5	37.7	37.6	41.5	33.8	39.0	36.3
2000	41.9	39.3	39.2	45.5	39.2	37.2	39.5	41.5	40.2	39.9
2500	41.2	39.4	40.3	37.9	38.2	34.2	39.3	47.6	44.2	38.9
3150	46.0	45.7	43.8	43.2	50.6	38.8	44.4	45.2	47.3	43.9
4000	44.2	44.0	52.3	41.1	42.2	44.0	41.7	46.6	43.3	43.5
5000	45.1	49.0	46.4	41.5	35.8	38.3	48.5	46.4	46.2	41.7
DL_{SI} (0.3-5 kHz)	30.7	28.6	31.4	30.3	27.0	29.0	32.1	27.3	28.7	29.1

Post PO1: Results from measurements taken in 2009

1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	20.4	21.3	23.4	20.9	19.8	20.4	21.6	21.2	19.3	20.8
400	20.9	21.9	24.6	21.7	20	21.0	22.8	22.0	19.7	21.4
500	26.3	23.0	25.9	26.9	22.8	24.9	27.3	23.6	26.9	24.9
630	30.5	24.8	28.1	30.8	24.5	28.5	31.0	25.2	32.5	27.5
800	38.1	29.1	34.9	34.6	26.8	39.2	42.3	28.3	32.7	31.4
1000	34.2	30.1	31.0	32.1	27.4	32.0	38.2	26.6	31.2	30.2
1250	31.4	30.7	35.9	31.6	26.1	34.0	37.1	23.7	28.4	28.7
1600	35.3	35.1	37.5	35.0	36.6	35.9	34.4	32.5	35.2	35.1
2000	41.1	37.5	37.4	40.5	40.2	36.3	35.6	39.6	37.1	38.2
2500	37.2	39.0	36.2	33.7	39.3	31.7	36.4	45.1	42.5	36.1
3150	42.6	42.9	38.5	38.3	45.9	34.0	40.1	44.9	38.8	39.4
4000	43.4	41.8	45.3	44.7	43.0	40.7	42.4	42.6	39.4	42.4
5000	40.0	47.8	41.5	37.0	34.1	33.8	47.5	45.0	37.5	37.2
DL_{SI} (0.3-5 kHz)	28.9	27.5	30.3	29.1	25.9	28.5	30.5	26.2	27.7	27.9

F.4 Sound absorptive barrier: M25, Junctions 12-13, Clockwise

Barrier location	
Roads/Junctions	M25, J12 – J13
Carriageway	Clockwise
Nearest Marker Posts	86/3 – 86/4 (86/3 + 27 m)
Latitude GPS reading in brackets	51.42333° (N 51° 25.400')
Longitude GPS reading in brackets	-0.54050° (W 0° 32.430')
OS Grid	TQ 015 703
Approximate barrier orientation at coordinates (in direction of traffic)	S-N

Barrier details and site description				
Barrier type	Single-leaf absorptive timber barrier. Constructed using full-height panels in between steel I-section posts.			
Date constructed	June 2003*			
Dimensions	**Height**	3.0 m	**Post spacing**	3.0 m
	Barrier thickness	Mid-panel	0.145 m	(30mm front cover strip + 95 mm absorptive panel + 20mm rear cover strip)
		Across post	0.169 m	(95 mm absorptive panel + 54 mm exposed post at front + 20 mm exposed post at rear)
Safety barrier details	Free-standing open-box safety fence. Positioned approximately 2.10 m in front of the noise barrier.			
General site layout in barrier vicinity	Flat ground in front of the noise barrier. A mix of flat/sloping ground immediately to the rear of the noise barrier.			

* Construction date is estimated based on information provided by industry contacts.

Summary of measurement results (Frequency range: 315-5000 Hz)

Element	2008		2009		Notes
	DL_{SI}	Surface temp Front/Rear	DL_{SI}	Surface temp Front/Rear	
Panel PA1	34.5	20.0°C/17.5°C	31.7	26.7°C/22.3°C	
Panel PA2	33.5	19.2°C/16.7°C	31.7	25.1°C/22.0°C	
Post PO1	35.3	19.9°C/18.8°C	33.1	25.5°C/23.9°C	

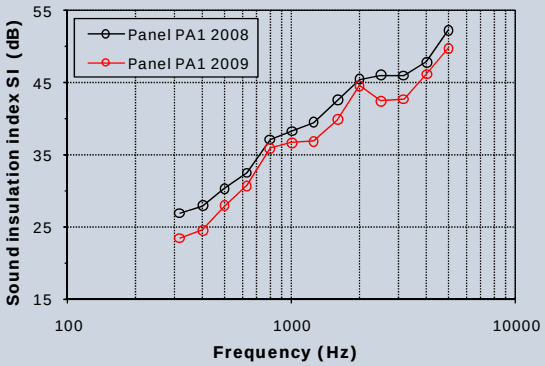
Photographs of the noise barrier at the test location	
 (a) General view of barrier from front	 (b) General view of barrier from rear
 (c) Detail of front of barrier	 (d) Detail of rear of barrier panel

Measurement positions	
Access	Measurement positions on the rear of the barrier are accessed via a padlocked emergency access gate in the barrier.
Panel PA1	Middle of 2nd panel to right of access gate (viewed from front), 1.5 m below top of barrier
Panel PA2	Middle of 3rd panel to right of access gate (viewed from front), 1.5 m below top of barrier
Posts	Post in between 2nd and 3rd panels.

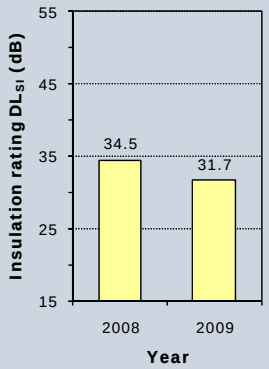
Physical condition of barrier during assessments	
2008 measurements	Structurally robust. In good condition with no obvious defects.
2009 measurements	Structurally robust. In good condition with no obvious defects.

Panel PA1: Sound insulation measurements

a) Third octave band sound insulation indices, SI_j



b) Single number rating of sound insulation, DL_{SI}



Panel PA1: Results from measurements taken in 2008

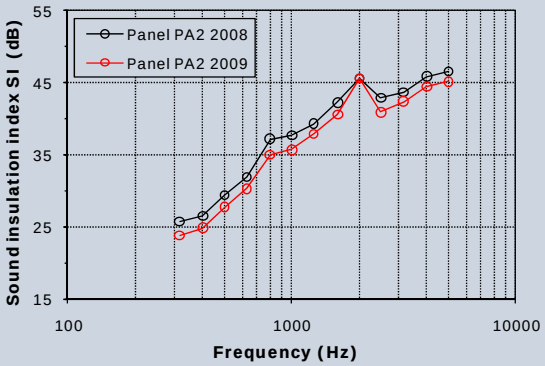
1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	31.6	26.9	27.7	28.8	28.7	27.2	27.7	25.1	22.9	26.9
400	36.5	28.3	30.5	31.4	29.7	28.3	28.0	25.4	23.3	27.9
500	34.6	32.1	31.5	34.7	32.7	30.2	31.1	26.7	26.4	30.3
630	35.8	35.5	33.3	38.1	35.3	32.4	33.5	28.5	28.6	32.5
800	41.0	44.5	38.9	46.1	41.1	37.9	37.1	32.8	31.8	37.1
1000	40.9	46.9	41.3	38.7	51.1	38.4	35.6	35.2	34.2	38.3
1250	37.6	48.9	36.7	41.8	43.3	36.2	39.0	40.9	40.5	39.5
1600	44.7	42.5	40.9	47.2	45.5	38.2	42.3	43.6	45.8	42.6
2000	42.0	49.4	48.3	45.9	50.1	46.2	44.2	43.1	44.4	45.5
2500	47.4	44.3	48.5	43.8	46.2	47.6	49.2	46.0	46.9	46.1
3150	44.2	47.9	43.6	47.4	47.2	44.4	44.9	46.6	47.0	46.0
4000	49.1	52.7	47.6	49.8	49.5	50.0	43.4	47.6	44.1	47.9
5000	51.0	51.2	53.8	54.2	54.0	53.7	47.7	52.0	53.0	52.3
DL_{SI} (0.3-5 kHz)	38.4	36.0	35.6	37.7	37.0	34.3	34.6	31.6	30.4	34.5

Panel PA1: Results from measurements taken in 2009

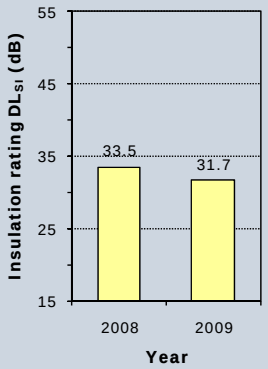
1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	26.3	25.1	23.8	25.9	26.5	22.9	24.0	20.5	20.2	23.4
400	28.5	27.3	24.4	28.0	29.9	24.3	25.2	20.9	20.4	24.5
500	32.6	29.6	28.4	32.8	31.3	27.4	30.6	24.2	23.3	27.9
630	35.6	32.0	31.9	36.9	33.3	30.5	34.4	26.8	26.0	30.7
800	40.2	37.7	40.4	42.5	37.8	38.0	37.3	31.3	31.1	35.9
1000	37.7	37.9	39.1	37.6	40.4	35.3	36.2	35.9	33.3	36.7
1250	36.2	36.2	35.6	38.4	38.7	33.4	40.5	40.2	39.8	36.9
1600	39.1	39.1	36.4	44.7	41.1	36.8	44.9	44.5	46.1	39.9
2000	41.0	47.9	46.9	42.6	47.1	49.3	44.1	47.6	40.5	44.6
2500	47.2	43.0	42.3	39.9	41.1	46.6	45.1	41.3	44.8	42.5
3150	42.2	40.9	40.0	44.6	44.3	41.5	46.4	43.4	43.8	42.7
4000	48.2	45.3	46.2	46.6	45.5	50.0	45.1	45.4	44.6	46.2
5000	47.1	49.9	50.5	50.5	54.8	48.9	44.7	50.7	50.0	49.8
DL_{SI} (0.3-5 kHz)	34.8	33.4	32.1	35.0	35.1	31.2	33.0	28.5	27.9	31.7

Panel PA2: Sound insulation measurements

a) Third octave band sound insulation indices, SI_j



b) Single number rating of sound insulation, DL_{SI}



Panel PA2: Results from measurements taken in 2008

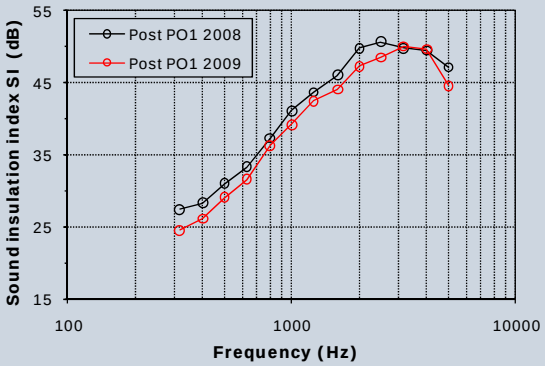
1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	26.0	25.6	24.5	25.4	28.7	26.3	26.2	26.5	23.4	25.7
400	26.3	26.7	25.1	26.6	29.5	27.6	27.1	27.2	24.0	26.5
500	29.6	27.9	28.1	32.1	33.2	30.3	28.7	27.8	28.8	29.4
630	32.8	30.5	31.0	37.4	35.5	32.7	30.8	29.3	31.1	31.9
800	48.4	42.6	41.7	50.1	37.8	37.3	36.5	33.2	32.1	37.2
1000	39.5	35.5	37.0	45.4	36.1	40.0	35.9	37.3	38.9	37.7
1250	38.9	38.2	36.0	42.5	39.1	37.9	39.3	43.4	44.2	39.3
1600	41.7	41.5	39.7	45.6	41.0	42.8	41.5	46.7	46.8	42.3
2000	47.5	49.1	47.0	47.0	48.9	49.8	38.8	47.6	43.1	45.6
2500	43.8	47.2	40.6	54.7	41.0	45.1	38.1	46.3	42.2	42.9
3150	48.6	42.6	45.3	47.8	41.0	45.9	44.8	46.5	43.6	43.7
4000	45.5	44.6	50.8	44.5	45.8	49.7	47.6	44.4	48.7	45.9
5000	52.3	49.0	45.7	48.4	44.7	46.1	48.8	47.5	41.9	46.6
DL_{SI} (0.3-5 kHz)	34.0	33.0	32.4	35.0	35.7	34.3	33.2	32.9	31.7	33.5

Panel PA2: Results from measurements taken in 2009

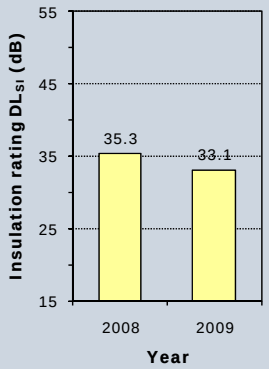
1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	25.9	24.5	24.0	24.4	25.7	23.8	22.9	23.2	21.1	23.8
400	27.4	25.5	25.1	25.5	27.3	24.8	23.4	23.8	21.8	24.8
500	30.9	26.7	27.5	31.6	30.2	28.4	26.1	25.0	26.6	27.7
630	34.1	29.3	30.1	37.4	32.4	31.5	28.8	26.6	29.2	30.3
800	45.9	40.9	37.7	46.8	34.5	37.1	35.9	29.9	30.5	35.0
1000	39.4	33.3	36.1	41.5	32.7	36.3	33.4	37.0	39.6	35.7
1250	38.8	34.8	34.8	44.1	37.0	40.0	38.6	40.9	38.9	37.9
1600	41.2	38.0	37.9	46.1	37.9	44.1	39.7	46.6	48.1	40.6
2000	48.1	44.5	47.5	48.0	48.3	46.2	41.5	46.7	42.0	45.6
2500	43.5	47.1	41.6	48.7	38.1	40.4	37.4	43.9	40.3	40.9
3150	47.3	44.9	44.9	43.2	40.1	43.5	41.4	44.6	43.3	42.4
4000	43.3	42.2	50.5	45.7	44.2	54.6	44.5	43.8	41.2	44.5
5000	50.3	46.1	44.6	45.5	44.2	43.5	46.3	48.6	41.3	45.2
DL_{SI} (0.3-5 kHz)	34.6	31.6	31.8	34.1	32.9	32.2	30.5	30.0	29.6	31.7

Post PO1: Sound insulation measurements

a) Third octave band sound insulation indices, SI_j



b) Single number rating of sound insulation, DL_{SI}



Post PO1: Results from measurements taken in 2008

1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	27.7	28.4	32.2	29.2	28.9	30.0	23.3	24.3	28.5	27.4
400	28.8	30.6	35.4	30.3	30.6	30.9	23.6	25.1	29.5	28.3
500	30.8	30.0	40.8	30.2	32.4	36.1	26.9	29.7	32.7	31.0
630	33.3	32.1	40.9	31.8	34.0	40.5	28.7	33.5	34.8	33.3
800	41.0	45.4	39.2	35.9	36.9	45.1	30.7	39.6	37.4	37.3
1000	39.6	43.3	44.0	39.1	48.8	46.3	35.6	41.4	43.1	41.1
1250	41.9	42.8	40.3	45.4	46.3	43.7	41.9	52.8	45.0	43.7
1600	45.2	50.1	43.7	48.7	45.6	49.4	45.1	46.5	43.6	46.1
2000	49.4	52.7	55.6	48.5	50.0	53.1	45.6	49.0	49.2	49.8
2500	47.3	52.0	51.5	48.7	55.2	55.6	51.0	49.0	48.7	50.7
3150	52.0	53.0	48.0	50.6	52.0	50.9	44.4	51.1	45.9	49.8
4000	57.9	50.7	51.3	52.7	48.8	54.2	44.8	48.5	45.0	49.5
5000	51.6	49.7	53.8	50.3	53.6	55.8	38.0	44.2	44.4	47.2
DL_{SI} (0.3-5 kHz)	35.5	36.1	40.3	35.5	36.8	39.0	30.7	33.4	36.4	35.3

Post PO1: Results from measurements taken in 2009

1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	26.2	26.4	27.1	25.7	23.8	27.0	23.0	21.1	25.1	24.5
400	29.7	29.2	30.8	27.4	26.1	30.8	23.6	21.5	26.6	26.1
500	31.6	30.5	33.2	26.5	30.5	31.8	25.5	27.5	30.9	29.1
630	33.8	33.0	35.6	28.3	33.4	34.0	27.2	33.7	33.6	31.6
800	39.4	45.4	41.9	34.3	36.1	41.1	30.4	39.0	36.3	36.3
1000	36.9	43.4	45.7	37.4	41.6	39.3	34.2	43.1	44.8	39.2
1250	38.2	42.1	45.3	42.8	44.3	41.6	44.5	43.8	47.5	42.5
1600	44.8	44.5	43.0	44.0	44.2	42.9	45.8	46.3	43.0	44.1
2000	48.8	52.7	52.4	45.9	51.2	49.7	40.7	47.2	47.4	47.3
2500	45.5	54.6	51.6	45.2	50.6	53.3	45.8	47.7	48.3	48.5
3150	53.0	56.7	52.6	53.4	55.3	47.7	42.4	48.1	50.0	50.1
4000	61.5	50.1	52.2	53.9	50.0	53.1	47.2	46.8	43.8	49.7
5000	49.2	48.5	49.6	47.5	49.9	48.4	34.9	41.1	43.2	44.6
DL_{SI} (0.3-5 kHz)	35.0	35.4	36.9	32.4	33.4	36.0	30.0	30.5	34.1	33.1

F.5 Sound absorptive barrier: TRL Noise Barrier Test Facilities 01

Referred to in Tables 5.2 and 5.5 (Morgan, 2010) as 'NBTF Crowthorne 1'.

Barrier details and site description				
Barrier type	Single-leaf sound absorptive timber barrier. (SLAbsorb01) Constructed using 2.0 m high panels in between steel I-section posts. 'Plain' face on front of barrier.			
Date constructed	Original construction date: June 2004 (at Crowthorne NBTF). Reconstruction date: August 2009 (at Bishops Castle NBTF)			
Dimensions	**Height**	4.0 m	**Post spacing**	3.0 m
	Effective barrier thickness	Mid-panel	0.180 m	20 mm cover strip + 20 mm plank + 110 mm rail + 30 mm cover strip
		Across post	Not measured due to time constraints.	
Safety barrier details	No safety barrier present			
General site layout in barrier vicinity	Flat ground to the front of the noise barrier. Flat ground to the rear of the noise barrier.			

Summary of measurement results (Frequency range: 315-5000 Hz)					
Element	**2004**		**2009**		**Notes**
	***DL*$_{SI}$**	**Surface temp** Front/Rear	***DL*$_{SI}$**	**Surface temp** Front/Rear	
Panel PA1	32.1	Unknown	29.2	26.2°C/24.5°C	Panels tested in 2004 and 2009 are from the same barrier but are not exactly the same panels. 2004 measurements used CEN/TS 1793-5 method (P5 free-field mic & path differences)

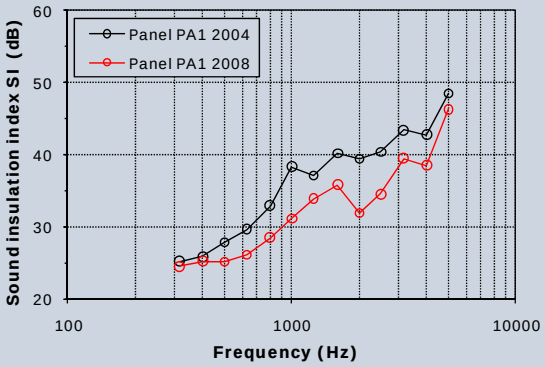
Physical condition of barrier during assessments	
2004 measurements	In good condition. Structurally robust with no obvious defects
2009 measurements	In reasonable condition. On the front of the barrier, new absorptive material has been inserted into a 0.7m x 0.3m area on the lower panel where the original rockwool and protective membranes had been removed.

Photographs of the noise barrier at the test location	
 (a) General view of barrier from front	 (b) General view of barrier from rear
 (c) Detail of front of barrier	 (d) Detail of rear of barrier panel

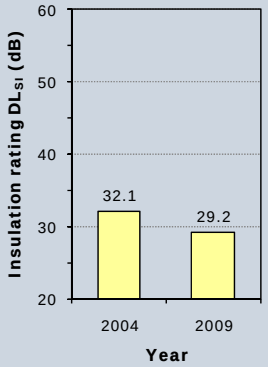
Measurement positions	
Access	Measurement positions on the rear of the barrier are accessed via the end of the barrier.
Panel PA1	Middle of centre panel on facility in 2004. Middle of sole panel on facility in 2009. 2.0 m below top of barrier in each case.
Panel PA2	Not assessed. Insufficient panels for assessment of a second panel.
Posts	Not assessed.

Panel PA1: Sound insulation measurements

a) Third octave band sound insulation indices, SI_j



b) Single number rating of sound insulation, DL_{SI}



Panel PA1: Results from measurements taken in 2004

1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	24.1	21.0	25.0	24.9	23.8	27.3	30.4	29.3	29.9	25.2
400	24.7	21.1	25.4	25.6	24.0	27.8	38.1	31.7	31.7	25.8
500	24.1	24.8	27.8	33.7	30.8	31.9	26.2	30.4	31.0	27.8
630	26.0	26.7	29.6	40.8	33.5	35.2	27.4	30.3	32.5	29.6
800	33.8	28.5	32.6	37.8	32.0	39.2	33.6	31.0	37.6	32.9
1000	38.1	36.2	38.7	38.9	37.1	35.1	45.8	40.1	44.4	38.3
1250	35.3	37.2	39.2	34.2	34.3	38.7	43.1	39.7	39.6	37.1
1600	41.6	43.5	42.6	34.1	39.3	42.4	44.7	43.4	44.5	40.2
2000	38.5	38.7	43.9	37.6	36.2	41.2	38.5	43.0	46.5	39.4
2500	41.0	39.3	46.4	41.8	34.0	45.2	41.6	50.6	45.7	40.4
3150	49.2	43.7	47.1	39.8	37.9	49.4	44.9	52.0	46.6	43.4
4000	48.2	40.6	42.6	42.2	38.4	45.4	47.1	42.9	48.7	42.8
5000	51.7	48.8	48.9	49.1	41.7	55.8	53.9	52.0	59.4	48.5
DL_{SI} (0.3-5 kHz)	30.2	28.5	32.1	33.2	31.5	34.7	33.5	34.3	36.4	32.1

Panel PA1: Results from measurements taken in 2009

1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	24.1	23.8	24.4	26.9	27.4	24.4	26.8	23.5	21.9	24.5
400	24.5	24.4	25.1	28.4	29.2	25.2	28.1	24.0	22.1	25.2
500	25.6	24.5	22.1	30.8	31.8	26.2	25.3	24.9	21.8	25.1
630	27.7	26.0	23.5	32.4	29.0	25.1	26.8	26.3	23.3	26.1
800	35.1	30.0	29.6	34.8	26.9	24.0	33.6	29.1	27.5	28.5
1000	36.6	32.6	34.8	38.0	30.0	26.4	35.8	32.8	28.8	31.1
1250	36.3	34.1	37.3	34.4	30.5	31.0	39.8	38.6	35.3	33.9
1600	38.2	34.0	34.8	42.7	33.9	34.3	40.5	35.8	38.0	35.8
2000	35.2	34.0	31.9	35.0	29.3	27.7	37.6	36.5	38.8	31.9
2500	37.8	32.3	35.1	34.4	38.7	30.6	39.9	36.1	36.3	34.5
3150	45.9	38.3	41.7	41.1	40.8	42.6	36.2	39.5	33.9	39.5
4000	40.7	40.1	34.1	44.3	45.2	39.4	38.7	40.6	30.9	38.5
5000	45.9	53.6	43.1	53.4	49.2	45.1	41.0	44.1	44.0	46.3
DL_{SI} (0.3-5 kHz)	30.7	29.2	28.4	33.6	30.0	27.0	31.5	29.4	27.0	29.2

F.6 Sound absorptive barrier: TRL Noise Barrier Test Facilities 02

Referred to in Tables 5.2 and 5.5 (Morgan, 2010) as 'NBTF Crowthorne 2'.

Barrier details and site description				
Barrier type	Single-leaf sound absorptive timber barrier. (SLAbsorb02) Constructed using 2.0 m high panels in between steel I-section posts. 'Plain' face on front of barrier.			
Date constructed	Original construction date: October 2004 (at Crowthorne NBTF). Reconstruction date: August 2009 (at Bishops Castle NBTF)			
Dimensions	**Height**	4.0 m	**Post spacing**	3.0 m
	Effective barrier thickness	Mid-panel	0.150 m	22 mm plank + 22 mm cover strip + 75mm rail + 30 mm cover strip
		Across post	Not measured due to time constraints.	
Safety barrier details	No safety barrier present			
General site layout in barrier vicinity	Flat ground to the front of the noise barrier. Flat ground to the rear of the noise barrier.			

Summary of measurement results (Frequency range: 315-5000 Hz)					
Element	**2004**		**2009**		**Notes**
	***DL*$_{SI}$**	**Surface temp** Front/Rear	***DL*$_{SI}$**	**Surface temp** Front/Rear	
Panel PA1	40.4	Unknown	30.7	25.6°C/25.3°C	Panels tested in 2004 and 2009 are from the same barrier but are not exactly the same panels. 2004 measurements used CEN/TS 1793-5 method (P5 free-field mic & path differences)

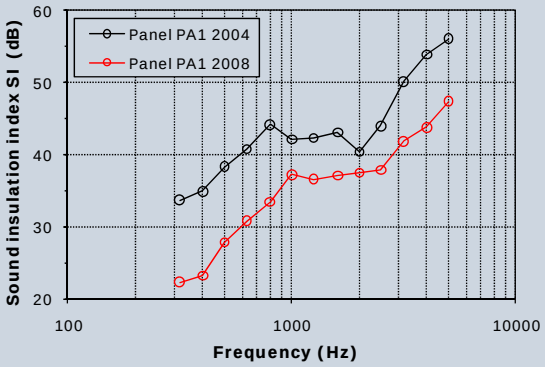
Physical condition of barrier during assessments	
2004 measurements	In good condition. Structurally robust with no obvious defects
2009 measurements	Generally in good condition. Some gaps between the cover strips and main planking on the rear of the panels.

Photographs of the noise barrier at the test location	
 (a) General view of barrier from front (2004)	 (b) General view of barrier from rear (2004)
 (c) Detail of front of barrier (2009)	 (d) Detail of rear of barrier panel (2009)

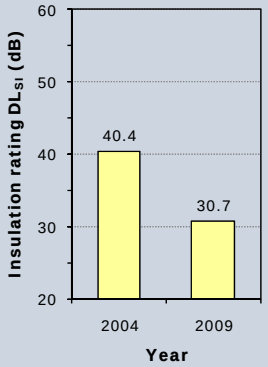
Measurement positions	
Access	Measurement positions on the rear of the barrier are accessed via the end of the barrier.
Panel PA1	Middle of centre panel on facility in 2004. Middle of sole panel on facility in 2009. 2.0 m below top of barrier in each case.
Panel PA2	Not assessed. Insufficient panels for assessment of a second panel.
Posts	Not assessed.

Panel PA1: Sound insulation measurements

a) Third octave band sound insulation indices, SI_j



b) Single number rating of sound insulation, DL_{SI}



Panel PA1: Results from measurements taken in 2004

1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	33.8	35.7	37.2	32.5	35.9	39.6	30.5	31.3	34.1	33.7
400	34.6	37.2	39.3	34.7	38.8	44.9	31.0	31.8	35.1	34.9
500	35.8	38.4	39.4	39.6	41.3	38.8	35.9	38.8	39.4	38.3
630	38.3	40.7	41.0	43.7	44.2	40.5	38.3	44.5	41.1	40.8
800	47.3	46.3	44.8	50.6	56.4	52.3	39.0	43.0	41.1	44.2
1000	44.4	41.5	42.9	47.4	49.6	48.8	40.4	38.2	39.4	42.1
1250	44.2	42.5	42.3	47.3	52.5	47.5	40.3	39.1	39.2	42.3
1600	42.1	42.6	42.1	46.1	44.7	50.8	46.9	44.6	38.6	43.1
2000	40.5	37.3	38.0	47.2	41.4	49.8	38.7	43.0	39.8	40.4
2500	48.8	45.1	44.9	47.1	51.2	45.4	42.1	43.6	39.3	44.0
3150	50.7	54.8	53.6	49.3	57.0	48.6	53.3	53.2	44.9	50.2
4000	50.9	53.7	57.9	55.7	58.7	53.6	53.5	56.9	51.3	53.9
5000	55.1	53.8	59.2	64.2	60.2	57.8	52.5	54.4	58.4	56.1
DL_{SI} (0.3-5 kHz)	40.2	40.7	41.5	41.9	44.1	44.9	37.7	38.6	39.1	40.4

Panel PA1: Results from measurements taken in 2009

1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	25.6	24.6	25.4	23.6	21.5	23.1	20.6	20.9	19.5	22.3
400	27.7	26.2	28.4	24.6	22.2	24.2	21.0	21.4	20.0	23.2
500	30.8	29.8	27.0	30.6	29.6	29.9	25.7	26.7	23.8	27.8
630	32.9	32.3	28.4	36.2	40.5	35.2	28.0	29.9	26.3	30.8
800	35.5	35.4	33.5	42.3	43.1	41.1	29.0	30.8	29.0	33.4
1000	40.3	40.9	43.0	41.7	37.5	37.9	35.8	33.9	33.6	37.2
1250	39.8	40.0	37.5	38.6	38.9	35.4	34.8	34.3	34.3	36.6
1600	36.7	41.3	38.4	39.0	36.7	37.2	36.5	33.6	39.0	37.1
2000	40.2	42.5	33.6	39.1	41.8	36.3	38.4	36.8	34.3	37.5
2500	38.0	50.8	37.6	41.8	40.5	40.4	32.8	34.2	37.1	37.9
3150	38.8	47.4	47.7	47.0	45.4	44.1	37.5	40.0	35.7	41.9
4000	50.9	49.0	45.3	43.7	49.4	46.2	39.9	42.2	37.4	43.8
5000	54.0	49.1	44.5	52.2	53.7	52.6	41.4	44.1	40.4	47.4
DL_{SI} (0.3-5 kHz)	33.8	33.3	32.2	32.9	31.1	32.0	28.4	29.0	27.3	30.7

Annex G Double-leaf reflective noise barriers: Detailed description and performance results

The tables in this Annex provide detailed information on the locations of each of the double-leaf reflective timber barriers tested within the study, together with construction information and dimensions, photographs, a summary of the airborne sound insulation measurements obtained for each tested panel (and post, where relevant) tested and the corresponding one-third octave band sound insulation spectra. It is also clearly identified whether the sound insulation measurements were taken using the CEN/TS 1793-5 approach (i.e. a single free-field microphone and path difference corrections) or the prEN 1793-6 approach (free-field measurements at all 9 microphone positions).

G.1 Double-leaf reflective barrier: M1, Junctions 8-9, Northbound

Barrier location	
Road / Junctions	M1, J8 – J9
Carriageway	Northbound
Nearest Marker Posts	44/1-44/2 (44/2 – 52m)
Latitude GPS reading in brackets	51.78218° (N 51° 46.931')
Longitude GPS reading in brackets	-0.41150° (W 0° 24.690')
OS Grid	TL 096 104
Approximate barrier orientation at coordinates (in direction of traffic)	S-N

Barrier details and site description					
Barrier type	Double-leaf reflective timber barrier. Constructed using full-height panels in between I-section posts.				
Date constructed	October 2008				
Dimensions	**Height**	3.0 m	**Post spacing**	3.0 m	
	Barrier thickness	Mid-panel	0.145 m	(20 mm cover strip + 105 mm thick panel + 20 mm cover strip)	
		Across post	0.155 m	(155 mm x 90 mm I-section post)	
Safety barrier details	Free-standing, corrugated profile safety fence. Positioned approximately 0.7 m in front of the noise barrier.				
General site layout in barrier vicinity	Road section is on a slight downward slope. Flat ground to the front of barrier with a concrete French drain. Upward gently sloping ground behind the barrier.				

* Construction date is estimated based on information provided by industry contacts.

Summary of measurement results (Frequency range: 315-5000 Hz)					
Element	**2008**		**2009**		**Notes**
	***DL*$_{SI}$**	**Surface temp** Front/Rear	***DL*$_{SI}$**	**Surface temp** Front/Rear	
Panel PA1	*Barrier unavailable for testing: Still being constructed*		34.0	16.1°C/16.1°C	
Panel PA2			35.1	16.3°C/15.9°C	
Post PO1			33.1	16.1°C/16.0°C	

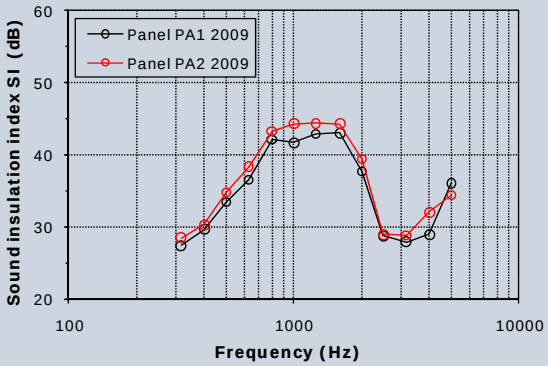
Photographs of the noise barrier at the test location	
 (a) General view of barrier from front	 (b) General view of barrier from rear
 (c) Detail of front of barrier	 (d) Detail of rear of barrier panel

Measurement positions	
Access	Measurement positions on the rear of the barrier are accessed via the end of the barrier.
Panel PA1	Middle of 1st full width panel from the end of the barrier (panel 7), 1.5 m below top of barrier
Panel PA2	Middle of 2nd full width panel from the end of the barrier (panel 8), 1.5 m below top of barrier
Posts	Post in between 1st and 2nd full width panels from the end of the barrier (panels 7 and 8)

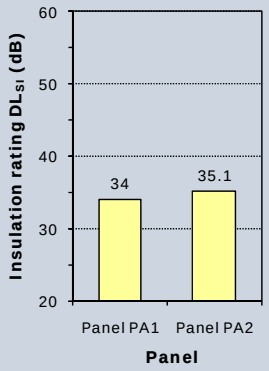
Physical condition of barrier during assessments	
2008 measurements	Barrier not tested as still under construction.
2009 measurements	Barrier in good condition, structurally robust with no obvious defects.

Panels PA1 and PA2: Sound insulation measurements

a) Third octave band sound insulation indices, SI_j



b) Single number rating of sound insulation, DL_{SI}



Panel PA1: Results from measurements taken in 2009

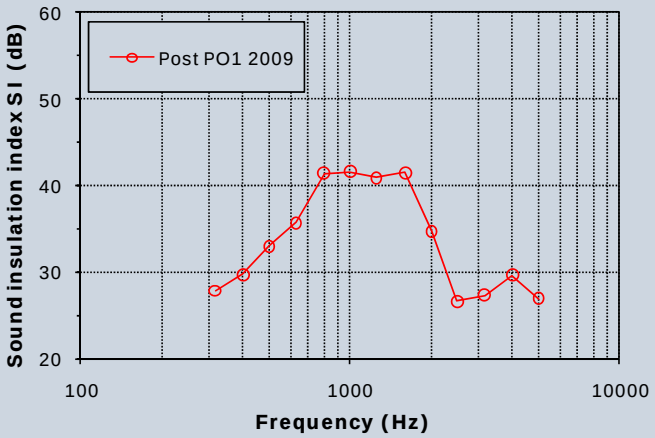
1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	30.0	31.3	31.1	24.9	25.9	24.6	29.5	29.5	28.1	27.4
400	40.2	35.4	35.7	25.9	27.5	25.1	36.6	35.0	39.7	29.6
500	37.9	37.4	37.4	30.7	31.9	29.8	36.7	36.1	37.0	33.4
630	38.7	38.5	38.8	34.9	35.9	34.0	37.7	37.3	38.4	36.5
800	41.3	39.8	41.2	42.7	45.6	50.3	40.4	39.9	43.0	42.1
1000	41.5	42.7	48.8	38.1	40.1	42.6	45.1	45.2	41.0	41.7
1250	49.8	48.8	43.1	39.5	43.1	40.3	42.7	46.8	45.5	42.9
1600	47.5	45.9	44.4	40.9	45.5	42.5	43.5	45.3	38.8	43.0
2000	35.0	35.6	36.1	43.2	41.9	39.6	37.6	35.4	37.8	37.7
2500	23.5	30.3	27.4	36.6	38.9	36.1	24.7	28.0	23.8	28.7
3150	27.0	24.9	27.8	31.1	40.1	36.4	25.7	24.3	26.7	27.9
4000	27.4	23.7	30.0	32.1	34.2	35.3	29.3	29.6	26.9	28.9
5000	32.8	40.5	37.6	47.2	40.6	35.7	30.8	31.3	33.6	36.1
DL_{SI} (0.3-5 kHz)	33.2	34.0	35.3	33.3	34.9	33.1	33.5	34.0	33.0	34.0

Panel PA2: Results from measurements taken in 2009

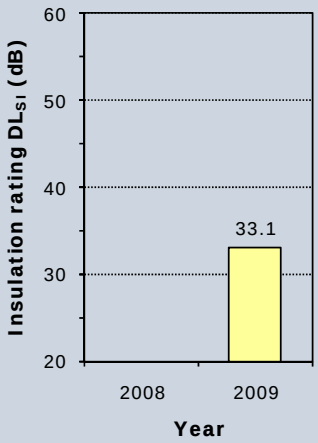
1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	29.4	32.2	33.1	25.9	25.7	26.9	31.4	31.8	29.7	28.5
400	30.4	35.9	38.7	26.4	26.8	28.4	44.4	36.1	33.0	30.3
500	35.6	38.0	41.3	32.3	31.9	32.0	40.0	38.2	38.2	34.8
630	39.1	40.4	43.4	37.6	36.1	35.4	39.7	39.5	40.4	38.3
800	41.3	46.7	46.6	47.4	43.3	49.8	40.3	41.3	40.1	43.3
1000	41.1	47.2	46.5	47.7	45.7	45.3	43.0	43.4	41.0	44.3
1250	41.2	42.9	58.1	44.3	45.3	39.9	48.6	48.7	51.0	44.4
1600	39.8	46.7	45.8	44.0	44.5	44.6	44.8	42.9	46.5	44.3
2000	38.3	41.6	38.5	37.3	46.1	41.4	36.8	41.7	36.2	39.4
2500	27.2	31.8	26.7	36.3	37.9	33.1	22.9	27.9	25.7	28.9
3150	26.3	34.3	26.2	38.6	38.4	29.4	24.6	28.0	23.7	28.8
4000	29.5	36.3	29.8	34.9	38.3	36.6	25.8	34.8	27.8	32.0
5000	34.9	34.8	43.9	38.9	36.7	32.7	29.1	32.2	28.7	34.4
DL_{SI} (0.3-5 kHz)	34.0	38.6	35.5	34.7	34.8	34.7	32.5	36.0	33.1	35.1

Post PO1: Sound insulation measurements

a) Third octave band sound insulation indices, SI_j



b) Single number rating of sound insulation, DL_{SI}



Post PO1: Results from measurements taken in 2009

1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	28.0	29.4	29.0	25.8	28.3	26.9	28.3	27.2	30.0	27.8
400	29.9	30.9	33.2	27.2	30.4	28.9	32.3	27.7	32.5	29.7
500	35.2	38.7	37.8	30.4	30.0	30.8	37.0	33.7	37.2	33.0
630	38.4	46.2	38.4	33.4	32.3	33.4	38.9	39.1	39.2	35.7
800	40.1	43.1	37.3	42.4	47.9	45.8	39.2	44.0	39.5	41.4
1000	43.4	40.8	39.4	44.0	42.6	42.6	42.7	39.0	43.0	41.6
1250	43.7	39.7	39.3	42.9	40.4	38.3	46.0	40.4	48.1	40.9
1600	41.1	38.8	46.6	43.3	40.5	44.2	46.1	38.4	43.0	41.5
2000	37.6	35.0	34.6	37.6	39.4	37.7	33.6	31.1	32.9	34.7
2500	25.9	24.5	24.5	33.7	39.5	34.7	24.2	24.5	22.5	26.6
3150	23.9	22.9	25.9	29.9	40.7	34.1	28.3	25.7	26.8	27.3
4000	28.3	27.0	29.0	33.2	33.9	32.3	28.9	26.7	29.0	29.6
5000	31.2	26.2	25.4	38.9	28.9	27.4	26.6	22.1	21.7	26.9
DL_{SI} (0.3-5 kHz)	32.8	32.0	32.6	33.7	35.1	34.2	32.9	31.1	31.6	33.1

G.2 Double-leaf reflective barrier: M1, Junctions 8-9, Southbound

Barrier location	
Road / Junctions	M1, J8 – J9
Carriageway	Southbound
Nearest Marker Posts	44/1-44/2 (44/2 – 52m)
Latitude GPS reading in brackets	51.81090° (N 51° 48.654')
Longitude GPS reading in brackets	-0.41493° (W 0° 24.896')
OS Grid	TL 093 136
Approximate barrier orientation at coordinates (in direction of traffic)	N-S

Barrier details and site description					
Barrier type	Double-leaf reflective timber barrier. Constructed using full-height panels in between I-section posts.				
Date constructed	October 2008				
Dimensions	**Height**	3.0 m	**Post spacing**	3.0 m	
	Barrier thickness	Mid-panel	0.145 m	(20 mm cover strip + 105 mm thick panel + 20 mm cover strip)	
		Across post	0.180 m	(180 mm x 90 mm I-section post)	
Safety barrier details	No safety barrier present: Noise barrier located on the top of an embankment.				
General site layout in barrier vicinity	Sloping ground to the front of the noise barrier (Barrier is located on an embankment) Flat ground to the rear of the noise barrier.				

* Construction date is estimated based on information provided by industry contacts.

Summary of measurement results (Frequency range: 315-5000 Hz)					
Element	**2008**		**2009**		**Notes**
	***DL*$_{SI}$**	**Surface temp** Front/Rear	***DL*$_{SI}$**	**Surface temp** Front/Rear	
Panel PA1	*Barrier unavailable for testing: Still being constructed*		31.0	18.7°C/22.4°C	
Panel PA2			31.1	23.5°C/21.1°C	
Post PO1			33.3	20.3°C/20.5°C	

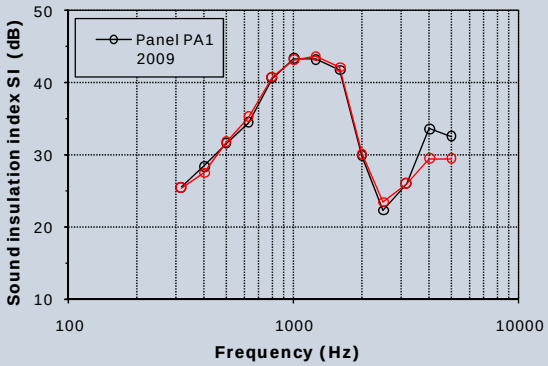
Photographs of the noise barrier at the test location	
 (a) General view of barrier from front	 (b) General view of barrier from rear
 (c) Detail of front of barrier	 (d) Detail of rear of barrier panel

Measurement positions	
Access	Measurement positions on the rear of the barrier are accessed via the end of the barrier.
Panel PA1	2nd panel from the left-hand end of the barrier (viewed from the traffic side), 1.5 m below the top of the barrier.
Panel PA2	3rd panel from the left-hand end of the barrier (viewed from the traffic side), 1.5 m below the top of the barrier.
Posts	Post in between the 2nd and 3rd panels from the left-hand end of the barrier.

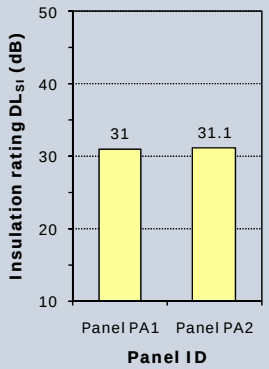
Physical condition of barrier during assessments	
2008 measurements	Barrier not tested as still under construction.
2009 measurements	Barrier in good condition, structurally robust with no obvious defects. Some small gaps around the posts at the foot of the gravel boards. The gravel boards are flush with the ground with only a very limited amount buried.

Panels PA1 and PA2: Sound insulation measurements

a) Third octave band sound insulation indices, SI_j



b) Single number rating of sound insulation, DL_{SI}



Panel PA1: Results from measurements taken in 2009

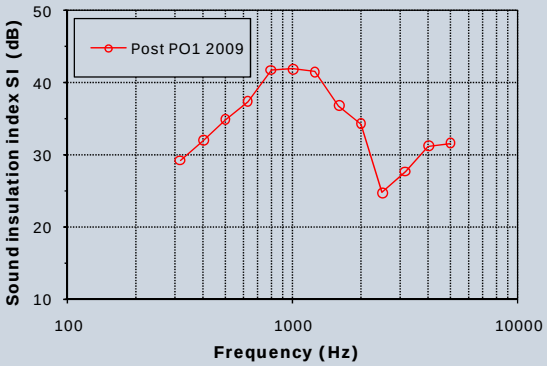
1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	26.7	26.3	26.5	26.4	25.2	25.1	25.2	24.3	25.4	25.5
400	31.5	30.6	29.6	32.5	27.5	28.1	26.8	26.1	28.2	28.4
500	34.1	35.9	31.6	31.6	31.0	29.5	31.8	32.8	30.5	31.6
630	36.1	37.4	34.1	33.7	34.5	32.2	35.2	38.8	33.0	34.5
800	39.6	36.7	45.5	43.8	48.8	43.9	38.3	39.8	39.5	40.7
1000	43.0	44.4	46.8	41.8	43.3	39.4	45.4	49.5	45.7	43.4
1250	42.8	43.4	43.6	43.5	42.5	43.0	43.9	43.2	44.7	43.3
1600	45.5	41.5	37.7	43.9	43.7	39.0	48.3	45.5	42.6	41.8
2000	33.9	29.9	37.5	33.7	33.8	35.2	25.3	25.7	29.4	29.9
2500	22.7	29.0	19.8	25.7	33.7	24.2	18.4	20.2	17.4	22.3
3150	32.7	26.3	21.1	30.5	35.3	35.2	23.4	21.5	22.5	26.0
4000	33.4	29.5	28.5	36.3	38.9	37.3	33.5	37.8	30.8	33.6
5000	35.8	32.7	30.4	35.4	38.3	36.9	27.2	31.8	25.3	32.6
DL_{SI} (0.3-5 kHz)	32.5	33.1	29.4	33.4	34.0	32.0	28.1	28.7	27.8	31.0

Panel PA2: Results from measurements taken in 2009

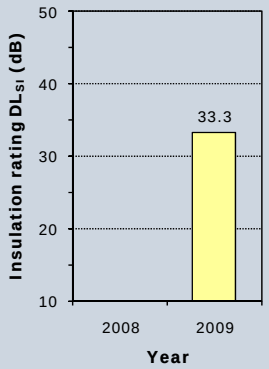
1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	23.5	25.5	27.9	24.2	24.7	26.0	24.2	25.9	27.8	25.4
400	25.4	27.8	31.8	26.7	26.7	28.0	25.4	27.6	31.4	27.5
500	33.5	33.0	38.7	29.3	29.9	30.7	31.1	34.9	33.6	31.8
630	37.7	36.1	43.8	32.3	33.3	33.9	35.5	43.1	36.0	35.3
800	34.5	37.4	43.9	44.8	49.0	48.2	38.1	42.7	41.8	40.8
1000	55.0	46.7	46.3	41.9	44.3	42.4	39.9	42.6	42.7	43.2
1250	43.2	43.4	43.9	42.9	41.2	48.0	49.3	48.5	41.1	43.7
1600	44.5	40.7	45.4	43.0	40.5	40.9	50.7	41.5	43.1	42.2
2000	30.4	34.3	24.4	35.7	33.4	36.4	32.2	29.0	26.1	30.1
2500	24.8	26.2	16.8	32.1	36.0	37.4	22.5	22.4	17.8	23.4
3150	24.3	28.5	22.8	29.0	33.2	39.5	23.5	22.5	19.9	26.0
4000	28.8	30.2	34.0	30.0	34.7	33.9	24.4	27.7	30.8	29.5
5000	30.1	29.4	29.6	34.6	34.4	31.7	23.7	27.6	25.0	29.5
DL_{SI} (0.3-5 kHz)	30.6	32.6	27.5	32.5	33.3	34.5	29.6	30.4	27.7	31.1

Post PO1: Sound insulation measurements

a) Third octave band sound insulation indices, SI_j



b) Single number rating of sound insulation, DL_{SI}



Post PO1: Results from measurements taken in 2009

1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	30.5	33.0	31.3	29.8	29.0	28.3	28.7	27.5	28.0	29.2
400	36.3	41.7	36.0	32.8	31.8	32.4	31.3	28.6	29.6	32.0
500	37.8	42.1	33.6	35.0	32.9	33.8	37.0	35.6	33.9	34.9
630	38.1	40.9	35.5	37.8	35.2	36.5	38.3	41.2	37.8	37.4
800	38.3	39.5	53.0	51.6	42.6	49.5	37.0	39.6	46.4	41.8
1000	41.0	39.9	45.1	47.4	44.3	43.1	43.7	38.7	40.1	41.9
1250	38.1	41.1	41.7	45.9	42.9	41.8	44.6	38.1	47.3	41.5
1600	39.0	34.8	39.6	39.2	38.3	34.7	37.7	36.6	35.1	36.8
2000	32.3	33.8	30.2	37.4	42.2	35.2	33.0	33.4	34.5	34.3
2500	22.0	23.7	17.9	32.4	32.6	29.5	22.1	26.6	24.9	24.7
3150	23.9	25.9	23.9	32.7	35.5	30.0	24.3	29.1	23.4	27.7
4000	29.9	30.8	24.8	34.6	35.1	32.9	33.1	31.4	28.4	31.2
5000	28.6	33.4	22.4	35.3	39.1	37.0	33.8	34.2	26.3	31.6
DL_{SI} (0.3-5 kHz)	31.5	33.1	28.6	36.9	36.3	34.8	31.6	33.2	31.9	33.3

G.3 Double-leaf reflective barrier: TRL Noise Barrier Test Facilities 01

Referred to in Tables 5.3 and 5.6 (Morgan, 2010) as 'NBTF Crowthorne 1'.

Barrier details and site description				
Barrier type	Double-leaf reflective timber barrier. (DLReflect01) Constructed using 2.0 m high panels in between steel I-section posts. 'Plain' face on front of barrier.			
Date constructed	Original construction date: May 2004 (at Crowthorne NBTF). Reconstruction date: August 2009 (at Bishops Castle NBTF)			
Dimensions	**Height**	4.0 m	**Post spacing**	3.0 m
	Effective barrier thickness	Mid-panel	0.150 m	20 mm cover strip + 20 mm plank + 70 mm rail + 20 mm plank + 20 mm cover strip
		Across post	Not measured.	
Safety barrier details	No safety barrier present			
General site layout in barrier vicinity	Flat ground to the front of the noise barrier. Flat ground to the rear of the noise barrier.			

Summary of measurement results (Frequency range: 315-5000 Hz)					
Element	**2004**		**2009**		**Notes**
	***DL*$_{SI}$**	**Surface temp** Front/Rear	***DL*$_{SI}$**	**Surface temp** Front/Rear	
Panel PA1	25.9	Unknown	19.0	29.1°C/22.8°C	Panels tested in 2004 and 2009 are from the same barrier but are not exactly the same panels. 2004 measurements used CEN/TS 1793-5 method (P5 free-field mic & path differences)

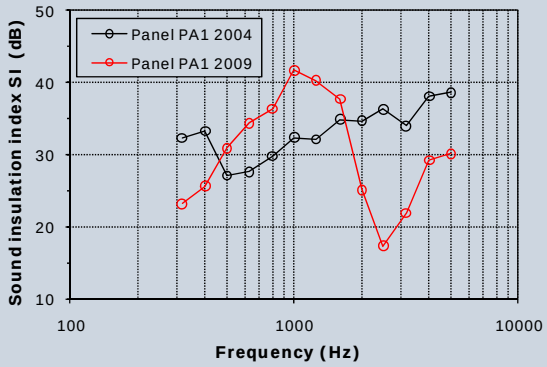
Physical condition of barrier during assessments	
2004 measurements	In good condition. Structurally robust with no obvious defects
2009 measurements	In reasonable condition. New cover strips placed across the horizontal joints. Some warping of cover strips and splitting across knots.

Photographs of the noise barrier at the test location	
 (a) General view of barrier from front (2004)	 (b) General view of barrier from rear (2004)
 (c) Detail of front of barrier (2004)	 (d) Detail of rear of barrier panel (2004)

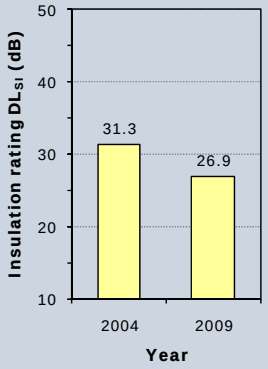
Measurement positions	
Access	Measurement positions on the rear of the barrier are accessed via the end of the barrier.
Panel PA1	Middle of centre panel on facility in 2004. Middle of sole panel on facility in 2009. 2.0 m below top of barrier in each case.
Panel PA2	N/A. Insufficient panels for assessment of a second panel.
Posts	N/A

Panel PA1: Sound insulation measurements

a) Third octave band sound insulation indices, SI_j



b) Single number rating of sound insulation, DL_{SI}



Panel PA1: Results from measurements taken in 2004

1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	33.2	34.8	34.1	35.5	36.2	33.4	31.0	28.9	30.0	32.3
400	35.5	37.1	40.2	39.3	39.5	34.5	31.1	28.9	30.1	33.3
500	27.8	26.0	27.1	30.3	23.5	25.5	30.4	29.6	29.7	27.1
630	28.6	26.3	27.8	30.4	23.7	25.3	32.5	30.6	30.7	27.6
800	32.6	28.7	31.0	32.2	25.8	26.2	40.3	32.1	33.3	29.8
1000	45.4	43.2	32.3	35.6	28.4	28.5	34.0	32.0	34.5	32.4
1250	39.1	37.2	34.9	34.5	27.6	27.5	38.9	34.2	33.1	32.1
1600	41.6	39.7	34.5	40.2	32.9	29.2	38.8	36.5	36.4	34.9
2000	42.6	38.2	33.8	34.1	35.0	29.7	34.3	36.8	40.7	34.7
2500	42.3	40.7	34.6	46.8	37.8	37.9	35.9	32.3	33.7	36.3
3150	37.7	35.0	31.4	46.7	39.5	36.6	29.4	37.0	31.8	34.0
4000	43.5	41.9	37.0	42.1	40.1	36.7	36.4	35.1	37.8	38.1
5000	47.6	40.5	37.4	45.4	42.7	40.1	37.9	34.0	36.9	38.6
DL_{SI} (0.3-5 kHz)	34.2	31.9	31.8	34.2	28.0	28.2	34.2	32.2	32.9	31.3

Panel PA1: Results from measurements taken in 2009

1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	24.1	22.3	22.4	23.1	23.4	21.9	24.4	24.0	24.9	23.2
400	25.9	24.9	25.0	25.8	26.6	24.3	26.9	24.9	27.3	25.6
500	30.0	30.2	27.7	32.6	33.3	29.2	34.3	32.2	34.1	30.9
630	33.3	34.2	30.6	39.0	38.8	33.5	35.6	34.6	34.7	34.4
800	42.2	38.0	43.9	41.5	40.2	43.3	32.8	32.0	32.3	36.4
1000	41.3	40.3	41.0	44.7	50.8	52.1	41.2	37.9	40.0	41.7
1250	41.5	39.3	41.7	44.7	41.6	49.3	36.3	38.9	38.1	40.3
1600	38.4	35.9	38.0	35.5	36.7	41.3	41.0	37.5	39.9	37.7
2000	21.7	32.7	23.9	29.6	29.0	25.9	25.6	22.6	22.7	25.1
2500	12.3	27.1	15.2	26.5	29.7	22.3	13.9	16.0	12.6	17.3
3150	16.2	20.8	20.9	25.6	31.9	38.2	16.9	26.2	18.0	21.9
4000	34.0	24.6	29.5	32.4	30.7	35.8	26.0	29.0	27.8	29.2
5000	32.5	25.4	31.1	38.2	38.3	37.2	27.7	30.9	20.8	30.1
DL_{SI} (0.3-5 kHz)	23.1	29.3	25.4	31.2	32.2	29.4	24.4	26.0	23.5	26.9

G.4 Double-leaf reflective barrier: TRL Noise Barrier Test Facilities 02

Referred to in Tables 5.3 and 5.6 (Morgan, 2010) as 'NBTF Crowthorne 2'.

Barrier details and site description				
Barrier type	Double-leaf reflective timber barrier. (DLReflect02) Constructed using 2.0 m high panels in between steel I-section posts. 'Plain' face on front of barrier.			
Date constructed	Original construction date: November 2004 (at Crowthorne NBTF). Reconstruction date: August 2009 (at Bishops Castle NBTF)			
Dimensions	**Height**	4.0 m	**Post spacing**	3.0 m
	Effective barrier thickness	Mid-panel	0.150 m	20 mm cover strip + 20 mm plank + 70 mm rail + 20 mm plank + 20 mm cover strip
		Across post	Not measured.	
Safety barrier details	No safety barrier present			
General site layout in barrier vicinity	Flat ground to the front of the noise barrier. Flat ground to the rear of the noise barrier.			

Summary of measurement results (Frequency range: 315-5000 Hz)					
Element	**2004**		**2009**		**Notes**
	DL_{SI}	**Surface temp** Front/Rear	DL_{SI}	**Surface temp** Front/Rear	
Panel PA1	22.7	Unknown	16.8	30.7°C/21.9°C	Panels tested in 2004 and 2009 are from the same barrier but are not exactly the same panels. 2004 measurements used CEN/TS 1793-5 method (P5 free-field mic & path differences)

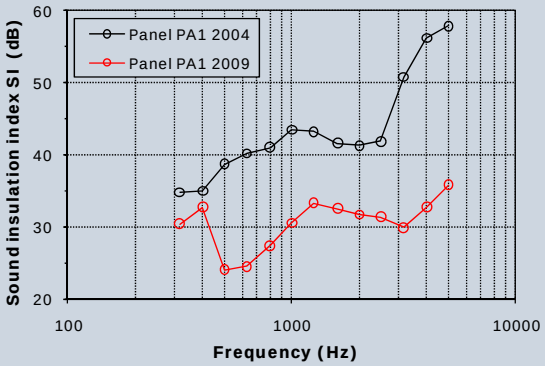
Physical condition of barrier during assessments	
2004 measurements	In good condition. Structurally robust with no obvious defects
2009 measurements	In good condition. New cover strips across horizontal joints. Cover strips in good condition.

Photographs of the noise barrier at the test location	
 (a) General view of barrier from front (2004)	 (b) General view of barrier from rear (2004)
 (c) Detail of front of barrier (2004)	 (d) Detail of rear of barrier panel (2004)

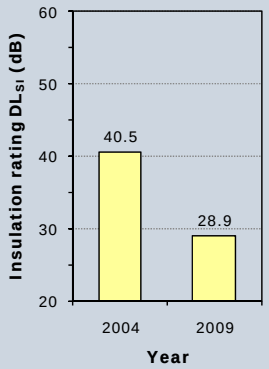
Measurement positions	
Access	Measurement positions on the rear of the barrier are accessed via the end of the barrier.
Panel PA1	Middle of centre panel on facility in 2004. Middle of sole panel on facility in 2009. 2.0 m below top of barrier in each case.
Panel PA2	Not assessed. Insufficient panels for assessment of a second panel.
Posts	Not assessed.

Panel PA1: Sound insulation measurements

a) Third octave band sound insulation indices, SI_j



b) Single number rating of sound insulation, DL_{SI}



Panel PA1: Results from measurements taken in 2004

1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	36.3	40.0	42.9	33.3	34.8	33.1	33.7	37.2	31.6	34.8
400	38.0	41.4	45.6	33.6	34.7	33.1	33.7	37.1	31.5	35.0
500	42.0	41.5	39.6	36.2	37.6	39.5	40.3	37.9	37.5	38.7
630	43.8	42.7	40.7	36.4	39.9	42.7	42.3	38.9	39.7	40.2
800	44.6	46.2	46.2	36.3	43.3	41.7	41.0	41.0	39.2	41.0
1000	43.0	50.3	49.3	45.8	39.5	40.1	46.4	43.4	45.3	43.5
1250	43.3	50.5	45.2	43.5	42.1	42.2	42.6	40.7	43.7	43.2
1600	47.5	44.2	45.9	52.1	42.5	42.5	45.8	37.2	37.1	41.6
2000	49.3	43.7	42.7	41.9	38.1	42.6	44.1	38.7	39.7	41.3
2500	51.5	43.2	47.5	51.0	38.7	43.4	44.7	39.7	37.5	41.9
3150	53.0	53.7	52.9	51.8	45.0	50.2	53.9	53.8	53.4	50.8
4000	59.0	58.7	55.4	60.3	53.5	57.6	59.3	52.3	57.0	56.2
5000	63.2	59.6	61.0	56.3	57.0	59.1	56.1	57.9	56.1	57.9
DL_{SI} (0.3-5 kHz)	43.1	44.7	44.5	39.0	39.5	39.8	40.9	39.7	38.1	40.5

Panel PA1: Results from measurements taken in 2009

1/3 octave band centre freq.	Sound insulation indices SI for microphone positions 1-9 and the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	30.8	31.5	29.0	31.2	31.1	30.4	28.3	30.0	32.3	30.4
400	34.2	36.4	32.0	33.7	32.8	31.7	29.6	32.5	34.8	32.7
500	24.2	23.1	25.8	21.7	22.8	26.7	23.2	25.6	25.3	24.0
630	25.0	24.3	26.3	22.1	22.9	26.4	24.2	25.9	26.6	24.5
800	29.9	31.9	28.9	24.2	24.6	27.0	28.6	28.4	33.4	27.4
1000	34.7	35.0	31.9	25.9	28.4	30.6	35.2	32.3	34.3	30.5
1250	33.9	34.9	33.9	29.5	30.3	37.0	43.9	36.6	34.5	33.3
1600	33.5	36.6	35.4	27.4	29.4	37.2	36.7	41.9	38.8	32.5
2000	37.4	32.6	32.1	26.9	30.7	34.7	30.4	37.5	38.8	31.7
2500	31.8	31.0	26.4	30.2	39.4	36.1	26.2	38.6	34.0	31.4
3150	24.3	29.1	23.7	37.6	36.5	39.0	25.8	35.4	34.9	29.9
4000	30.3	32.4	25.8	35.3	36.8	38.8	29.7	41.5	39.6	32.7
5000	31.5	36.1	32.4	36.4	39.8	39.5	33.7	38.6	34.4	35.8
DL_{SI} (0.3-5 kHz)	29.7	29.9	29.2	26.0	27.3	30.4	28.7	30.8	31.8	28.9

Annex H Detailed sound insulation spectra from early life moisture content study

The following Tables present the one-third octave band sound insulation spectra measured at each microphone position during the investigations into the effects of early life moisture content on airborne sound insulation performance (see Chapter 7; Morgan, 2010).

It is noted that only the spectra from the assessment using the full 4.0 m height of the barrier are presented.

The average on-third octave band sound insulation over the 9 microphone positions are plotted in Figure 7.4 (Morgan, 2010), and the corresponding single number ratings of airborne sound insulation, DL_{SI}, are presented in Table 7.4 (Morgan, 2010).

Table H.1: One-third octave band sound insulation indices - Day 4

1/3 octave band centre frequency	Sound insulation indices SI for microphone positions P1-P9 & the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
200	24.7	29.5	26.0	24.2	28.9	23.2	25.8	30.6	24.1	25.7
250	24.3	30.1	25.7	24.4	30.2	22.9	26.2	36.0	23.8	25.8
315	27.3	28.7	28.4	27.0	26.9	27.6	28.2	27.2	28.2	27.7
400	30.9	28.2	29.8	29.4	25.9	36.2	28.9	25.4	34.8	28.8
500	38.1	29.6	23.5	28.2	26.5	24.7	23.1	24.5	25.2	25.7
630	27.6	32.7	25.8	35.4	33.3	26.2	28.5	31.7	25.9	28.5
800	30.3	38.0	32.3	29.6	28.6	33.5	27.3	30.9	30.8	30.4
1000	32.2	31.2	32.1	32.2	31.9	31.0	27.4	27.7	29.2	30.1
1250	30.1	30.9	31.6	33.7	42.4	34.9	28.4	34.3	33.6	32.1
1600	31.7	29.9	31.6	34.6	39.9	32.6	32.1	32.6	38.3	32.8
2000	31.0	26.1	33.3	38.3	38.9	28.8	27.2	25.3	29.5	29.0
2500	32.4	32.0	37.9	31.5	30.2	27.8	23.1	20.6	24.0	26.1
3150	43.7	37.0	37.8	39.9	34.4	31.9	35.3	28.8	31.3	33.7
4000	35.1	36.5	36.3	37.3	37.3	36.9	33.9	37.1	33.4	35.7
5000	32.7	36.4	34.0	39.5	34.8	38.4	33.9	40.6	32.8	35.1
DL_{SI} (0.2-5 kHz)	30.1	30.5	29.5	30.7	30.8	29.0	27.3	27.6	28.6	29.2

Table H.2: One-third octave band sound insulation indices - Day 6

1/3 octave band centre frequency	Sound insulation indices SI for microphone positions P1-P9 & the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
200	24.3	32.0	26.8	20.8	26.3	21.6	24.6	27.9	21.4	24.0
250	24.0	33.8	26.6	20.4	26.0	21.2	24.1	29.1	21.1	23.7
315	28.4	31.2	28.2	23.9	25.6	25.7	25.9	26.4	25.5	26.3
400	38.3	30.4	28.9	28.3	25.5	35.0	26.5	25.3	33.1	28.5
500	38.5	31.4	25.2	28.0	27.3	26.5	21.8	23.3	24.8	25.7
630	27.9	33.3	25.5	40.0	34.0	27.4	27.8	31.2	26.9	28.9
800	31.1	34.0	31.3	30.5	28.7	37.1	25.8	29.8	30.8	30.1
1000	33.2	30.8	31.2	32.0	32.7	31.2	26.7	28.3	30.6	30.2
1250	31.7	32.0	32.3	34.7	38.2	34.8	27.1	32.8	34.2	32.1
1600	33.1	31.1	31.8	36.0	42.6	32.1	31.5	31.6	38.1	33.1
2000	32.5	27.7	34.7	35.0	39.9	28.9	25.1	24.1	30.9	28.7
2500	31.5	32.9	38.3	29.9	31.3	27.6	20.1	19.6	26.2	25.1
3150	38.6	37.6	37.1	37.9	37.5	32.8	28.7	27.7	32.1	32.5
4000	34.4	41.1	41.4	36.1	40.3	36.1	31.5	39.4	33.7	35.8
5000	34.6	34.3	34.6	38.6	33.9	41.2	29.7	35.3	31.5	33.8
DL_{SI} (0.2-5 kHz)	30.8	31.6	29.7	29.2	30.6	28.9	25.6	26.8	28.4	28.7

Table H.3: One-third octave band sound insulation indices – Day 8

1/3 octave band centre frequency	Sound insulation indices SI for microphone positions P1-P9 & the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
200	21.4	27.5	24.2	19.6	24.5	20.1	21.8	25.2	22.1	22.3
250	21.3	28.9	24.0	19.4	25.4	19.9	22.2	26.5	22.4	22.4
315	26.0	27.9	27.0	22.9	25.2	24.3	24.3	24.8	26.8	25.2
400	36.7	27.5	28.9	26.9	25.2	31.5	25.2	24.1	32.4	27.4
500	32.4	27.2	23.4	25.7	25.8	24.6	21.1	23.1	24	24.4
630	27.0	28.3	24.8	38.6	34.5	27.3	23.8	29.6	25.3	27.1
800	29.4	35.0	32.4	31.1	28.4	33.9	24.7	29.1	28.5	29.3
1000	32.1	28.7	30.2	32.9	31.9	31.4	24.5	27.0	30.0	29.0
1250	30.5	28.6	29.3	33.0	38.4	34.0	25.8	31.4	34.2	30.4
1600	33.8	28.1	31.3	34.0	44.8	32.4	29.2	31.7	38.3	32
2000	30.1	24.5	30.4	35.4	42.2	28.9	23.4	23.5	28.2	27.1
2500	27.7	25.7	26.1	28.0	32.5	25.8	18.1	18.2	21.0	22.5
3150	37.1	32.0	31.1	37.6	35.9	30.9	28.9	26.8	26.7	30.3
4000	36.4	32.5	31.2	33.6	40.2	36.3	29.1	34.8	30.5	32.7
5000	29.3	35.0	30.7	37.3	32.5	36.1	32.0	34.3	29.3	32.1

DL_{SI} (0.2-5 kHz)	28.8	28.2	27.9	28.2	30.0	27.8	23.9	25.7	27.1	27.1

Table H.4: One-third octave band sound insulation indices - Day 23

1/3 octave band centre frequency	Sound insulation indices SI for microphone positions P1-P9 & the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
200	17.1	20.3	19.0	16.3	19.8	17.8	18.4	19.7	17.4	18.2
250	17.8	21.3	20.2	16.7	21.7	18.2	19.7	22.0	18.3	19.2
315	22.0	22.8	23.7	19.1	20.2	19.9	21.2	19.0	21.6	20.8
400	31.7	24.2	26.6	21.1	19.7	21.1	21.4	17.9	24.5	21.8
500	22.6	25.9	18.2	18.4	22.3	19.5	15.7	18.0	17.6	18.9
630	22.5	25.7	20.1	27.9	26.0	24.9	20.6	23.1	21.7	22.9
800	27.2	29.4	26.8	26.7	22.2	26.2	20.0	22.9	23.2	24.0
1000	27.8	27.5	24.6	29.7	28.2	27.8	23.2	23.5	25.1	25.8
1250	25.9	24.9	25.6	29.2	32.1	30.4	23.8	24.7	26.1	26.3
1600	28.1	26.3	26.4	29.0	33.5	27.8	24.1	23.2	31.0	26.8
2000	24.2	23.7	24.5	28.2	30.5	27.2	22.3	19.1	24.1	23.7
2500	17.3	19.0	17.4	22.0	24.7	27.0	12.9	12.9	24.2	17.3
3150	22.6	24.2	22.2	30.1	30.8	27.2	16.8	18.2	24.5	21.9
4000	23.5	28.0	22.8	30.0	32.9	31.9	24.8	25.3	27.2	26.2
5000	29.1	32.1	23.7	30.5	30.7	32.0	25.4	29.6	22.3	26.9
DL_{SI} (0.2-5 kHz)	23.4	24.6	22.5	23.6	24.7	24.2	19.8	20.2	22.8	22.5

Table H.5: One-third octave band sound insulation indices – Day 37

1/3 octave band centre frequency	Sound insulation indices SI for microphone positions P1-P9 & the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
200	16.2	18.4	17.6	15.9	18.1	16.2	17.5	18.6	16.0	17.0
250	16.9	19.4	18.4	16.2	19.1	16.3	18.2	20.5	16.1	17.7
315	21.0	20.8	21.6	19.0	19.4	18.8	21.0	19.3	19.0	19.9
400	27.4	21.9	24.5	21.5	19.7	21.1	22.3	18.7	21.7	21.5
500	18.8	22.5	18.7	17.4	22.9	20.5	15.2	18.3	17.8	18.6
630	21.7	24.8	20.5	22.1	23.7	25.6	22.5	24.1	20.7	22.5
800	26.9	30.7	27.5	24.6	21.0	25.7	22.0	24.4	20.3	23.7
1000	26.5	27.0	25.6	28.9	26.9	28.1	25.0	24.9	23.6	26.0
1250	24.6	23.7	25.9	30.9	29.9	28.7	25.2	26.0	25.5	26.2
1600	26.0	25.9	27.4	27.8	28.1	29.7	23.4	23.7	28.3	26.2
2000	21.9	23.6	25.1	26.2	26.5	25.2	23.5	19.6	22.5	23.3
2500	16.4	18.9	17.5	22.7	22.6	26.1	15.8	15.6	19.3	18.3
3150	19.5	25.7	20.9	28.6	31.5	28.9	17.6	20.1	20.8	21.7
4000	22.5	31.5	24.3	32.3	32.1	33.3	23.6	24.9	28.0	26.3

5000	28.1	25.9	21.7	30.6	29.9	31.1	24.6	26.3	20.7	25.1
DL_{SI} (0.2-5 kHz)	21.9	23.6	22.5	22.7	23.4	23.6	20.8	21.3	21.1	22.2

Table H.6: One-third octave band sound insulation indices – Day 51

1/3 octave band centre frequency	Sound insulation indices SI for microphone positions P1-P9 & the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
200	17.2	20.1	18.4	16.4	19.1	15.4	18.6	20.6	16.7	17.8
250	17.4	21.6	18.5	16.5	20.2	15.4	20.0	22.3	17.0	18.2
315	21.8	21.5	21.5	19.2	19.6	18.5	23.0	20.5	19.7	20.4
400	29.6	21.6	24.3	21.5	19.5	22.1	24.0	19.7	22.0	22.0
500	20.0	23.0	21.4	17.2	23.7	20.6	15.8	18.4	18.5	19.2
630	21.4	24.4	19.7	23.5	24.9	26.2	21.4	23.4	20.6	22.4
800	26.1	31.3	28.3	25.2	21.6	26.8	22.6	24.5	22.1	24.5
1000	26.0	26.4	25.8	28.4	25.5	28.9	24.1	22.5	23.4	25.2
1250	24.9	23.9	24.8	30.4	28.9	29.4	24.6	24.0	25.3	25.7
1600	25.9	25.9	25.0	28.8	30.4	30.1	25.8	24.5	28.6	26.7
2000	22.3	23.2	23.7	28.7	29.2	24.8	23.6	19.5	20.3	22.9
2500	16.8	18.8	18.6	22.8	25.9	31.8	15.1	16.5	21.0	18.8
3150	19.1	28.2	24.8	30.5	35.6	27.6	16.3	21.3	21.1	21.9
4000	21.9	31.7	25.4	32.6	33.6	30.6	23.0	25.8	23.1	25.7
5000	27.4	27.6	25.6	31.6	33.5	31.9	24.4	27.2	19.6	25.6
DL_{SI} (0.2-5 kHz)	22.2	23.9	22.9	23.1	24.0	23.6	20.9	21.5	21.4	22.5

Table H.7: One-third octave band sound insulation indices - Day 65

1/3 octave band centre frequency	Sound insulation indices SI for microphone positions P1-P9 & the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
200	17.2	19.9	17.9	16.3	19.6	15.8	18.9	20.5	16.6	17.8
250	17.6	21.3	18.4	16.5	20.6	15.9	19.7	22.5	17.0	18.3
315	21.8	21.4	21.7	19.8	20.6	18.7	22.7	20.4	19.7	20.6
400	30.7	21.6	25.2	23.5	20.7	21.9	24.2	19.6	22.4	22.5
500	21.1	22.9	19.1	17.7	22.9	19.8	16.4	19.2	18.4	19.2
630	21.3	24.7	19.8	22.8	23.5	25.4	20.6	24.1	20.8	22.2
800	26.9	31.7	27.2	25.7	21.8	25.7	23.2	25.1	22.0	24.7
1000	25.9	26.3	25.4	28.2	26.7	28.2	23.4	22.9	23.7	25.2
1250	24.7	23.5	25.0	29.9	31.7	29.3	25.3	25.5	25.0	26.0
1600	26.3	25.8	26.6	28.7	32.3	31.3	27.6	25.5	30.0	27.7
2000	22.3	24.0	23.3	28.5	28.9	23.8	23.5	19.9	22.2	23.3
2500	16.6	18.8	16.6	22.1	22.3	23.4	15.4	14.9	19.9	17.9
3150	23.2	24.5	20.2	29.8	30.4	30.6	19.5	20.5	25.2	23.1

4000	21.9	30.9	20.7	31.8	27.2	32.4	24.5	26.3	27.8	25.3
5000	31.6	29.5	23.8	35.5	27.8	30.3	21.6	26.3	24.8	26.2
DL_{SI} (0.2-5 kHz)	22.5	23.9	22.0	23.2	24.2	23.3	21.3	21.5	21.8	22.5

Table H.8: One-third octave band sound insulation indices – Day 79

1/3 octave band centre frequency	Sound insulation indices SI for microphone positions P1-P9 & the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
200	17.0	19.3	17.6	16.0	18.4	15.2	17.9	19	15.9	17.1
250	17.2	20.7	17.9	16.1	19.7	15.3	18.5	20.9	16.1	17.6
315	21.3	21.1	20.9	19.3	19.8	18.0	20.9	19.1	19.0	19.8
400	30.9	21.4	24.1	22.9	20.1	21.0	22.2	18.2	22.0	21.6
500	21.2	22.5	19.0	17.8	22.5	19.1	15.9	17.6	17.2	18.7
630	21.5	24.5	19.6	22.4	22.3	23.6	19.6	22.5	19.2	21.3
800	26.4	30.3	26.1	25.1	21.6	24.5	22.5	23.9	20.9	23.8
1000	26.5	26.3	25.0	28.4	26.2	27.4	22.8	22.3	22.8	24.8
1250	24.7	24.0	23.5	27.6	30.1	27.5	23.9	24.5	23.9	25.1
1600	26.3	26.0	25.8	26.5	30.4	31.5	24.4	23.7	29.7	26.5
2000	20.9	22.7	22.1	26.8	28.1	23.8	21.5	18.3	20.8	21.9
2500	15.8	17.7	15.0	21.3	21.4	24.3	14.1	13.2	20.0	16.8
3150	22.1	23.8	18.5	29.5	29.6	29.6	18.9	19.2	25.6	22.1
4000	23.4	30.1	21.6	32.8	29.1	31.4	24.6	25.5	28.3	26.0
5000	29.0	30.4	23.8	34.3	26.6	30.1	22.8	25.6	23.4	26.0
DL_{SI} (0.2-5 kHz)	22.2	23.4	21.2	22.8	23.5	22.6	20.2	20.1	20.8	21.7

Table H.9: One-third octave band sound insulation indices – Day 93

1/3 octave band centre frequency	Sound insulation indices SI for microphone positions P1-P9 & the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
200	15.6	17.8	15.8	15.1	17.4	15.1	17.8	18.7	15.8	16.4
250	15.8	19.7	15.7	15.3	17.9	15.0	18.6	20.1	16.0	16.7
315	19.9	20.6	19.0	19.0	18.6	17.4	20.9	18.4	18.2	19.0
400	28.5	21.2	23.1	24.2	19.2	19.9	22.0	17.6	20.0	20.9
500	18.5	22.5	17.9	17.6	21.4	18.8	15.5	16.8	16.9	18.0
630	19.6	24.2	18.6	20.8	21.0	23.3	21.3	22.9	19.7	20.9
800	26.2	31.8	25.4	24.2	20.4	23.6	22.6	23.7	19.9	23.2
1000	25.7	25.7	24.5	27.1	25.3	26.8	23.0	22.6	23.0	24.6
1250	22.8	23.6	23.5	26.4	27.6	26.7	24.3	25.5	23.6	24.6
1600	26.3	25.8	26.8	25.4	28.1	28.3	23.1	23.7	29.6	25.9
2000	20.3	22.0	22.7	25.6	25.1	22.1	21.8	18.0	20.7	21.5
2500	14.8	17.6	15.5	19.7	20.8	23.4	13.4	13.3	19.4	16.4

3150	21.2	25.6	20.9	27.9	29.8	30.1	19.7	21.0	26.7	23.2
4000	21.3	30.3	21.1	30.5	27.7	33.3	24.2	26.6	28.2	25.3
5000	29.4	29.9	22.5	33.1	26.4	31.0	21.6	25.8	25.1	25.7
DL_{SI} (0.2-5 kHz)	20.8	23.0	20.7	22.0	22.2	22.0	20.2	20.0	20.5	21.2

Table H.10: One-third octave band sound insulation indices – Day 107

1/3 octave band centre frequency	Sound insulation indices SI for microphone positions P1-P9 & the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
200	16.6	18.9	17.2	16.0	18.5	15.1	17.5	19.5	15.6	17.0
250	17.0	20.0	17.5	16.3	19.5	15.2	18.2	21.0	15.8	17.5
315	21.3	21.1	20.6	19.6	19.9	18.1	20.8	19.2	18.5	19.8
400	30.9	21.9	23.9	23.2	20.4	21.4	22.3	18.4	21.1	21.7
500	20.2	22.7	19.3	18.0	22.2	19.7	16.0	18.2	17.7	18.9
630	21.8	25.1	20.0	22.2	22.3	24.2	20.9	23.1	19.6	21.8
800	27.0	30.5	27.0	25.3	21.8	24.8	22.3	24.4	20.8	24.0
1000	26.7	26.3	25.1	28.0	25.8	27.8	23.1	22.8	23.4	25.1
1250	24.8	24.7	24.2	27.1	29.2	27.3	24.6	26.2	24.7	25.6
1600	27.5	26.2	26.7	26.5	29.3	29.3	23.5	23.9	30.0	26.4
2000	22.0	24.0	23.5	27.2	27.9	24.1	21.5	18.5	21.4	22.5
2500	16.1	18.4	15.9	21.0	21.9	25.2	13.3	12.9	20.8	16.8
3150	22.2	25.1	20.4	29.1	29.5	29.9	18.8	19.6	27.1	22.8
4000	22.7	30.5	22.6	32.3	29.6	31.9	24.0	27.8	28.1	26.3
5000	28.8	31.2	24.3	33.0	27.5	31.3	21.7	24.5	24.3	26.0
DL_{SI} (0.2-5 kHz)	22.3	23.8	21.8	22.8	23.5	22.8	20.1	20.4	21.1	21.9

Annex I Detailed sound insulation spectra from short-term changes in moisture content study

The following Tables present the one-third octave band sound insulation spectra measured at each microphone position during the investigations into the effects of short-term changes in moisture content on airborne sound insulation performance (see Chapter 8; Morgan, 2010).

These spectra correspond to measurements on a 3.0 m high barrier.

The corresponding single number ratings of airborne sound insulation, DL_{SI}, are plotted in Figure 8.2 (Morgan, 2010)

Table I.1 – Table I.11 correspond to the results taken in July 2009. Table I.12 – Table I.11 correspond to the results taken in October 2009.

Table I.1: One-third octave band sound insulation indices
July 2009, dry barrier (30 minutes before 'rainfall')

1/3 octave band centre frequency	Sound insulation indices SI for microphone positions P1-P9 & the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	17.8	19.1	17.5	17.3	19.8	17.8	15.5	16.8	17.3	17.5
400	18.3	19.8	17.8	17.8	20.8	18.4	15.7	17.1	17.7	18.0
500	21.2	20.7	18.1	19.6	19.3	19	16.0	17.8	17.8	18.7
630	23.1	22.5	19.4	18.7	18.3	19.3	16.9	19.2	19.7	19.3
800	25.1	25.7	22.5	17.8	17.9	20.0	17.9	21.9	24.6	20.3
1000	24.0	21.5	21.6	22.7	24.0	27.4	16.7	20.5	21.3	21.6
1250	20.3	20.1	19.2	28.6	29.2	25.3	19.9	22.5	21.5	22.1
1600	24.1	22.5	21.5	28.5	25.8	27.4	22.0	20.5	25.3	23.8
2000	22.8	22.7	18.3	19.3	19.9	21.6	18.0	16.3	20.2	19.5
2500	11.2	11.9	7.2	13.9	15.7	16.1	8.0	10.3	9.5	11.4
3150	15.7	19.2	11.6	22.9	29.3	23.1	12.1	13.5	15.4	17.1
4000	22.3	20.3	14.3	26.6	30.4	25.4	15.5	20.7	18.5	20.4
5000	23.5	21.9	15.7	28.1	34.6	23.9	17.7	18.4	17.2	21.8
DL_{SI} (0.3-5 kHz)	19.7	19.9	16.4	19.8	20.7	21.1	15.7	17.7	18.2	18.9

Table I.2: One-third octave band sound insulation indices
July 2009, wet barrier (0 minutes after 'rainfall')

1/3 octave band centre frequency	Sound insulation indices SI for microphone positions P1-P9 & the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	18.6	20.0	18.2	18.3	20.5	18.6	16.2	17.6	18.4	18.4
400	19.1	20.8	18.6	18.8	21.5	19.1	16.4	17.9	18.9	18.9
500	21.9	21.7	18.8	20.9	21.1	20.9	16.8	19.0	18.9	19.8
630	23.7	23.0	20.1	19.6	20.0	20.8	17.6	20.3	20.8	20.4
800	25.8	25.3	23.0	18.4	19.3	20.7	18.6	22.1	25.1	21.0
1000	25.4	22.6	22.3	24.2	25.3	29.0	17.1	20.9	21.9	22.3
1250	21.8	20.6	20.1	29.1	30.1	25.4	20.4	23.7	22.6	23.0
1600	25.1	23.2	22.0	30.0	27.4	29.0	22.8	22.0	26.2	24.8
2000	24.9	24.4	19.8	20.3	21.8	22.8	19.1	17.1	20.6	20.6
2500	12.4	11.7	7.7	13.4	16.6	17.2	8.0	11.0	9.1	11.7
3150	16.5	19.6	11.7	21.8	27.2	22.0	11.5	13.4	15.4	17.0
4000	24.6	20.3	14.7	26.7	27.4	25.0	14.5	20.5	18.8	20.2
5000	21.6	22.8	15.6	28.5	35.2	22.5	19.0	17.2	17.6	21.6
DL_{SI} (0.3-5 kHz)	20.8	20.3	17.0	20.4	22.0	22.1	16.0	18.4	18.5	19.5

Table I.3: One-third octave band sound insulation indices
July 2009, wet barrier (20 minutes after 'rainfall')

1/3 octave band centre frequency	Sound insulation indices SI for microphone positions P1-P9 & the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	18.6	19.9	18.2	18.3	20.3	18.5	16.5	17.9	18.0	18.4
400	19.1	20.8	18.6	18.8	21.2	19.0	16.6	18.2	18.4	18.8
500	22.0	21.1	18.7	21.0	20.5	21.0	17.1	19.3	18.4	19.7
630	23.9	22.6	20.0	19.6	19.3	20.8	17.9	20.5	20.3	20.3
800	26.0	25.8	23.4	18.2	18.6	20.6	18.8	22.5	25.3	20.9
1000	25.0	22.4	21.9	23.6	24.9	29.4	17.7	21.7	21.5	22.4
1250	21.7	20.8	20.1	29.6	29.5	25.3	20.6	23.8	22.1	23.0
1600	25.1	23.4	21.8	29.9	27.2	29.0	22.6	22.3	25.7	24.8
2000	24.0	24.3	19.4	20.4	21.2	23.0	19.4	17.7	20.4	20.7
2500	11.7	12.0	7.4	13.4	16.3	17.1	8.3	11.5	9.0	11.7
3150	16.2	19.6	11.6	21.8	27.4	22.7	12.0	13.9	15.3	17.1
4000	23.8	20.2	14.7	26.8	27.4	25.9	14.9	20.9	18.1	20.3
5000	20.6	23.1	15.2	28.3	34.5	23.6	19.2	17.8	17.2	21.6
DL_{SI} (0.3-5 kHz)	20.4	20.4	16.7	20.3	21.5	22.1	16.4	18.8	18.3	19.5

Table I.4: One-third octave band sound insulation indices
July 2009, wet barrier (40 minutes after 'rainfall')

1/3 octave band centre frequency	Sound insulation indices SI for microphone positions P1-P9 & the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	18.9	19.9	18.2	18.7	20.0	18.3	16.4	17.5	18.1	18.4
400	19.5	20.6	18.6	19.2	20.8	18.9	16.5	17.8	18.5	18.8
500	22.1	21.2	18.7	21.3	20.6	20.8	16.8	18.9	18.7	19.7
630	23.9	22.8	20.1	19.9	19.4	20.7	17.7	20.2	20.6	20.3
800	26.3	26.2	23.6	18.5	18.7	20.5	18.7	22.3	25.5	21.0
1000	25.0	22.6	22.0	24.0	25.1	29.2	17.7	21.3	21.8	22.5
1250	21.8	21.1	20.2	30.0	29.7	25.1	20.5	23.5	22.3	23.1
1600	25.1	23.7	21.8	30.2	27.1	28.6	22.6	21.9	25.9	24.7
2000	24.0	24.5	19.6	20.8	21.3	22.6	19.3	17.5	20.7	20.7
2500	11.6	12.2	7.4	13.8	16.5	16.8	8.3	11.5	9.4	11.8
3150	16.1	20.0	11.7	22.6	27.8	22.8	12.3	13.7	15.5	17.2
4000	23.7	20.3	14.7	27.3	27.0	25.7	14.9	20.8	18.4	20.4
5000	20.4	22.6	15.1	28.9	35.0	23.6	19.6	18.0	17.5	21.6
DL_{SI} (0.3-5 kHz)	20.5	20.6	16.8	20.7	21.6	21.9	16.4	18.6	18.5	19.6

Table I.5: One-third octave band sound insulation indices
July 2009, wet barrier (60 minutes after 'rainfall')

1/3 octave band centre frequency	Sound insulation indices SI for microphone positions P1-P9 & the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	19.1	20.3	18.7	18.6	20.1	18.5	16.5	17.6	18.3	18.6
400	19.8	21.2	19.1	19.2	20.8	19.1	16.7	18.0	18.8	19.0
500	22.7	21.6	19.2	21.4	20.9	21.1	16.9	18.9	18.8	20.0
630	24.5	23.2	20.6	19.9	19.7	21.1	17.8	20.2	20.7	20.5
800	26.3	26.7	23.9	18.6	19.1	21.1	19.0	22.6	25.9	21.3
1000	25.4	23.4	22.6	24.5	25.5	30.0	18.1	21.7	22.2	22.9
1250	21.8	21.6	20.6	29.9	29.9	25.5	20.6	23.9	22.3	23.3
1600	25.0	24.3	22.3	29.6	26.8	28.6	22.7	22.1	25.6	24.8
2000	24.2	25.0	20.2	20.8	21.4	23.0	19.5	17.8	20.8	21.0
2500	11.8	12.6	7.8	14.0	16.8	17.2	8.7	12.0	9.5	12.1
3150	16.2	20.5	12.0	22.8	27.8	23.5	12.7	13.8	15.3	17.4
4000	23.3	20.8	15.0	27.1	26.9	26.2	15.2	21.3	18.5	20.6
5000	21.0	23.2	15.2	29.3	36.1	24.1	19.8	19.0	18.3	22.2
DL_{SI} (0.3-5 kHz)	20.6	21.1	17.2	20.8	21.8	22.3	16.6	18.9	18.7	19.9

Table I.6: One-third octave band sound insulation indices
July 2009, wet barrier (80 minutes after 'rainfall')

1/3 octave band centre frequency	Sound insulation indices SI for microphone positions P1-P9 & the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	19.2	20.4	18.9	18.9	20.5	18.7	16.4	17.8	18.2	18.7
400	19.8	21.2	19.3	19.4	21.2	19.2	16.6	18.1	18.7	19.1
500	23.2	21.7	19.7	21.7	21.1	21.0	17.0	19.4	18.9	20.2
630	24.9	23.3	21.1	20.1	19.9	21.1	17.9	20.7	20.9	20.7
800	26.2	26.9	24.3	18.7	19.2	21.2	19.0	22.7	25.9	21.4
1000	25.8	23.3	22.8	24.9	25.6	29.9	18.1	21.8	22.0	23.1
1250	21.9	21.5	21.0	30.9	30.7	25.4	20.4	24.2	22.3	23.4
1600	24.9	24.4	22.8	29.4	27.2	28.2	22.6	22.5	25.8	25.0
2000	24.1	24.7	20.2	20.6	21.3	22.6	19.3	17.7	20.0	20.8
2500	12.3	12.9	8.3	14.3	17.1	17.1	8.9	12.1	9.6	12.4
3150	16.3	21.5	13.3	22.3	28.4	23.9	12.9	14.0	16.0	18.0
4000	23.4	21.1	15.5	27.1	27.2	26.2	16.1	21.8	19.3	21.2
5000	22.2	23.9	15.5	29.4	37.0	23.8	19.8	19.9	18.2	22.6
DL_{SI} (0.3-5 kHz)	20.9	21.2	17.7	21.0	22.0	22.3	16.7	19.1	18.7	20.1

Table I.7: One-third octave band sound insulation indices
July 2009, wet barrier (100 minutes after 'rainfall')

1/3 octave band centre frequency	Sound insulation indices SI for microphone positions P1-P9 & the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	19.4	20.5	18.9	19.2	20.4	18.8	16.5	17.7	18.4	18.8
400	19.9	21.3	19.3	19.5	21.1	19.3	16.7	18.0	18.7	19.2
500	23.3	21.9	19.7	21.6	20.8	21.0	17.2	19.4	18.8	20.2
630	25.1	23.6	21.1	20.0	19.6	21.2	18.0	20.8	20.7	20.7
800	26.3	27.3	24.2	18.7	18.8	21.4	18.9	22.7	26.2	21.4
1000	25.7	23.5	22.9	24.5	25.0	29.8	18.0	21.9	22.2	23.0
1250	21.7	21.6	21.0	31.1	30.7	25.6	20.6	24.3	22.2	23.4
1600	25.0	24.5	22.8	29.1	27.0	27.9	22.9	22.6	25.7	25.1
2000	23.6	24.8	20.0	20.3	20.9	22.2	18.8	17.7	20.0	20.5
2500	12.5	13.4	8.6	14.3	16.9	17.4	8.8	12.2	9.7	12.5
3150	16.8	22.2	13.7	22.4	28.6	24.6	13.2	14.1	16.0	18.3
4000	23.3	21.4	15.8	27.5	27.6	26.5	16.7	22.1	19.3	21.5
5000	23.6	24.0	16.0	29.7	36.5	23.7	20.4	20.4	18.0	23.1
DL_{SI} (0.3-5 kHz)	21.1	21.5	17.9	20.9	21.7	22.4	16.8	19.2	18.8	20.1

Table I.8: One-third octave band sound insulation indices
July 2009, wet barrier (120 minutes after 'rainfall')

1/3 octave band centre frequency	Sound insulation indices SI for microphone positions P1-P9 & the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	19.2	20.8	18.6	19.0	20.1	18.8	16.6	17.7	18.0	18.6
400	19.9	21.5	19.0	19.3	20.8	19.3	16.7	17.9	18.4	19.1
500	23.4	21.6	19.2	21.6	20.7	20.9	17.0	19.3	18.5	20.0
630	25.1	23.3	20.7	19.9	19.5	21.2	17.8	20.6	20.5	20.6
800	26.3	27.5	24.1	18.4	18.8	21.5	18.8	22.5	25.8	21.3
1000	25.8	23.5	22.7	24.4	25.0	29.6	17.8	21.6	21.6	22.8
1250	21.8	21.5	20.7	30.8	30.7	25.5	20.6	24.0	21.8	23.3
1600	24.8	24.3	22.6	28.8	26.9	27.7	22.9	22.3	25.5	24.9
2000	23.5	25.1	19.7	20.1	20.9	22.0	18.7	17.4	19.6	20.3
2500	12.6	13.3	8.4	14.3	16.9	17.3	8.7	11.6	9.4	12.4
3150	16.7	22.2	13.4	22.4	28.9	24.8	13.3	13.8	16.0	18.2
4000	23.4	21.1	15.6	27.2	27.9	26.6	16.8	21.7	19.1	21.4
5000	23.5	24.0	15.9	29.0	36.6	23.7	20.3	19.8	17.8	22.9
DL_{SI} (0.3-5 kHz)	21.1	21.5	17.6	20.8	21.7	22.4	16.7	18.8	18.5	19.9

Table I.9: One-third octave band sound insulation indices
July 2009, wet barrier (140 minutes after 'rainfall')

1/3 octave band centre frequency	Sound insulation indices SI for microphone positions P1-P9 & the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	19.4	21.0	18.7	19.1	20.2	18.9	16.3	17.5	18.2	18.7
400	19.9	21.8	19.1	19.7	21.1	19.5	16.5	17.8	18.7	19.1
500	23.4	21.9	19.2	21.9	20.7	20.8	16.8	19.2	18.7	20.0
630	25.3	23.5	20.6	20.1	19.5	21.1	17.6	20.5	20.7	20.6
800	26.7	27.5	23.9	18.6	18.7	21.5	18.5	22.3	26.1	21.2
1000	25.9	23.6	22.4	24.5	24.8	29.5	17.6	21.6	22.0	22.7
1250	21.8	21.7	20.7	30.8	30.7	25.6	20.3	23.9	22.0	23.3
1600	24.8	24.4	22.6	29.3	26.9	27.6	22.7	22.1	25.6	24.8
2000	23.7	25.2	19.6	20.3	20.7	21.8	18.5	17.2	20.0	20.3
2500	12.6	13.5	8.4	14.5	16.8	17.4	8.4	11.4	9.8	12.4
3150	16.5	22.3	13.3	22.7	28.8	25.1	12.9	13.7	16.1	18.0
4000	23.2	21.2	15.6	27.7	28.0	26.7	16.3	21.2	19.3	21.2
5000	23.6	24.2	16.3	29.5	36.4	23.8	19.7	19.3	17.8	22.8
DL_{SI} (0.3-5 kHz)	21.1	21.7	17.6	21.0	21.6	22.4	16.4	18.7	18.7	19.9

Table I.10: One-third octave band sound insulation indices
July 2009, wet barrier (160 minutes after 'rainfall')

1/3 octave band centre frequency	Sound insulation indices SI for microphone positions P1-P9 & the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	19.4	20.7	18.4	18.9	20.3	18.5	16.3	17.4	18.2	18.6
400	20.0	21.6	18.8	19.4	21.1	18.9	16.4	17.7	18.7	19.0
500	23.6	21.6	19.1	21.6	20.8	20.6	16.8	19.1	18.6	19.9
630	25.4	23.2	20.6	20.0	19.8	21.0	17.6	20.5	20.6	20.5
800	26.7	27.5	24.1	18.5	19.2	21.6	18.6	22.5	26.2	21.4
1000	25.9	23.6	22.7	24.7	25.5	30.0	17.9	21.9	22.3	23.0
1250	21.7	21.6	20.6	30.4	31.0	25.6	20.3	23.9	22.0	23.3
1600	24.7	24.2	22.4	29.2	26.8	27.6	22.7	22.1	25.4	24.7
2000	23.6	25.5	19.8	20.3	21.0	22.2	18.9	17.5	20.4	20.6
2500	12.6	13.4	8.3	14.6	17.2	17.4	8.6	11.8	10.0	12.5
3150	16.5	22.0	12.9	22.7	29.2	25.1	12.8	13.5	15.7	17.9
4000	23.1	21.3	15.4	27.4	28.2	26.5	15.7	21.6	19.2	21.0
5000	23.6	24.3	16.2	28.9	36.8	24.1	19.4	19.8	18.5	23.0
DL_{SI} (0.3-5 kHz)	21.1	21.5	17.5	20.9	21.9	22.3	16.5	18.8	18.9	20.0

Table I.11: One-third octave band sound insulation indices
July 2009, wet barrier (180 minutes after 'rainfall')

1/3 octave band centre frequency	Sound insulation indices SI for microphone positions P1-P9 & the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	19.4	20.9	18.5	19.1	20.5	18.8	16.5	17.6	18.2	18.7
400	19.9	21.8	18.9	19.5	21.4	19.3	16.7	17.8	18.7	19.1
500	23.5	21.6	19.1	21.8	20.9	20.9	17.0	19.2	18.7	20.1
630	25.3	23.3	20.6	20.1	19.8	21.2	17.7	20.6	20.6	20.6
800	26.7	27.8	24.1	18.7	19.1	21.7	18.7	22.6	26.1	21.4
1000	25.8	23.8	22.8	24.9	25.4	30.3	18.0	21.9	22.3	23.1
1250	21.5	21.8	20.7	30.3	31.1	25.7	20.4	24.1	22.0	23.3
1600	24.9	24.3	22.5	29.5	26.9	27.8	22.8	22.2	25.4	24.9
2000	23.7	25.7	19.9	20.5	21.0	22.2	18.9	17.5	20.5	20.6
2500	12.7	13.7	8.3	14.7	17.1	17.5	8.7	11.6	10.0	12.5
3150	16.5	21.8	12.8	22.9	29.1	25.2	12.8	13.6	15.7	17.9
4000	23.0	21.4	15.4	27.4	28.4	26.7	16.2	21.6	19.2	21.2
5000	23.9	24.2	16.3	29.1	36.7	24.4	19.1	19.5	18.2	22.9
DL_{SI} (0.3-5 kHz)	21.1	21.7	17.6	21.1	21.9	22.5	16.6	18.8	18.9	20.1

Table I.12: One-third octave band sound insulation indices
October, dry barrier (15 mins before 'rainfall')

1/3 octave band centre frequency	Sound insulation indices SI for microphone positions P1-P9 & the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	22.4	16.9	18.5	20.3	16.1	17.5	22.0	16.5	17.4	17.9
400	24.6	17.1	19.2	21.5	16.2	17.9	24.4	16.5	17.8	18.4
500	15.4	19.3	20.4	17.3	19.7	21.2	17.4	18.6	17.3	18.4
630	16.9	21.7	22.3	18.6	20.5	19.9	18.8	20.9	18.2	19.7
800	27.7	27.0	27.3	24.4	20.8	18.3	27.0	25.7	20.2	22.5
1000	20.1	22.5	25.6	28.2	28.5	23.7	23.3	21.4	20.5	23.3
1250	23.0	22.2	21.7	29.3	27.1	27.9	27.7	21.0	19.2	23.4
1600	20.4	19.4	24.7	23.5	24.1	26.2	21.7	18.8	23.4	22.0
2000	20.5	16.4	17.2	27.4	21.9	17.7	27.3	17.2	16.2	18.9
2500	14.8	22.4	11.5	19.5	26.0	19.6	16.3	17.3	11.5	16.8
3150	11.9	18.5	19.1	20.9	26.3	26.0	12.4	14.4	20.0	17.8
4000	18.2	18.8	16.9	29.9	31.4	23.8	22.0	19.2	20.0	21.5
5000	18.9	16.7	17.9	29.5	27.0	24.1	18.1	23.5	14.8	20.5
DL_{SI} (0.3-5 kHz)	18.9	20.0	19.6	22.5	21.8	20.8	20.7	19.2	18.0	20.3

Table I.13: One-third octave band sound insulation indices
October 2009, wet barrier (0 minutes after 'rainfall')

1/3 octave band centre frequency	Sound insulation indices SI for microphone positions P1-P9 & the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	22.8	17.2	19.0	20.8	16.5	18.0	22.0	16.7	18.1	18.3
400	25.1	17.3	19.6	22.0	16.6	18.5	24.2	16.8	18.5	18.7
500	15.7	20.2	21.5	18.0	20.3	22.1	17.8	18.7	18.1	19.0
630	17.2	22.7	23.1	19.3	21.4	21.0	19.1	21.0	18.9	20.3
800	27.3	26.8	26.6	24.6	21.9	19.5	26.3	25.6	20.3	23.1
1000	20.9	23.9	26.9	28.0	29.4	25.1	23.5	21.0	20.4	23.7
1250	23.6	23.0	22.7	29.3	27.0	27.9	27.9	21.6	20.0	24.0
1600	20.7	19.8	25.2	24.4	25.3	27.7	21.9	19.0	23.8	22.6
2000	21.7	17.4	18.3	27.6	22.8	18.2	28.5	17.3	16.9	19.5
2500	14.8	21.8	11.6	19.3	26.9	19.0	16.3	17.7	11.9	16.8
3150	11.1	17.5	18.4	20.6	26.4	26.1	11.4	13.2	20.0	16.9
4000	17.3	17.9	16.8	28.2	30.6	24.3	21.0	18.2	20.1	20.8
5000	18.1	16.5	18.0	28.5	26.3	24.8	17.8	23.3	15.2	20.3
DL_{SI} (0.3-5 kHz)	19.0	20.5	20.0	22.9	22.5	21.5	20.5	19.2	18.4	20.7

Table I.14: One-third octave band sound insulation indices
October 2009, wet barrier (15 minutes after 'rainfall')

1/3 octave band centre frequency	Sound insulation indices SI for microphone positions P1-P9 & the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	23.2	17.3	18.7	20.7	16.4	17.9	22.1	16.8	18.1	18.3
400	25.8	17.4	19.4	22.1	16.5	18.4	24.4	16.8	18.5	18.7
500	15.8	20.3	21.2	17.8	20.3	21.9	17.7	18.6	18.3	18.9
630	17.3	22.8	22.9	19.0	21.4	20.8	19.0	20.9	19.1	20.2
800	27.6	27.1	26.4	24.4	21.7	19.3	26.6	25.6	20.6	23.0
1000	20.9	23.9	26.7	28.0	29.1	24.7	23.2	21.1	20.7	23.7
1250	23.8	23.1	22.4	29.5	27.1	28.0	27.8	21.6	20.1	24.0
1600	20.8	19.9	25.0	24.1	24.9	27.5	22.1	19.2	23.9	22.5
2000	21.5	17.4	18.3	27.3	22.5	18.4	28.2	17.5	17.1	19.6
2500	14.5	22.0	11.6	19.0	26.4	19.0	16.4	17.5	11.8	16.8
3150	11.0	17.5	18.2	20.5	26.2	26.3	11.4	13.3	20.1	16.9
4000	17.5	18.0	16.7	28.0	30.6	24.0	20.9	18.2	20.1	20.8
5000	18.0	16.6	18.2	28.5	26.4	24.3	17.9	23.4	15.5	20.4
DL_{SI} (0.3-5 kHz)	19.0	20.6	19.9	22.7	22.3	21.4	20.5	19.2	18.5	20.7

Table I.15: One-third octave band sound insulation indices
October 2009, wet barrier (30 minutes after 'rainfall')

1/3 octave band centre frequency	Sound insulation indices SI for microphone positions P1-P9 & the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	23.5	17.2	19.3	20.8	16.4	18.1	22.1	16.8	17.8	18.3
400	26.4	17.3	20.0	22.0	16.5	18.5	24.1	16.9	18.2	18.7
500	15.8	20.2	21.5	17.9	20.3	22.2	17.5	18.6	17.9	18.9
630	17.3	22.8	23.2	19.1	21.2	20.8	19.0	20.9	18.6	20.2
800	27.8	27.3	27.3	24.2	21.3	19.1	27.0	25.8	20.2	22.9
1000	20.9	23.7	26.9	28.1	29.3	25.0	23.0	21.2	20.6	23.7
1250	24.0	22.9	22.7	29.7	27.1	28.1	27.9	21.5	19.7	23.9
1600	20.7	20.0	25.5	24.3	24.9	27.4	22.2	19.1	23.4	22.6
2000	21.3	17.0	18.7	27.4	22.7	18.6	28.3	17.6	16.7	19.6
2500	14.7	21.9	12.0	19.1	26.2	19.3	16.5	17.4	11.4	16.8
3150	11.0	17.5	18.5	20.7	26.3	26.8	11.6	13.4	19.9	17.0
4000	17.5	17.8	16.9	28.1	30.7	24.0	21.1	18.3	19.7	20.9
5000	18.0	16.4	18.6	28.7	26.7	24.7	17.9	23.6	15.0	20.4
DL_{SI} (0.3-5 kHz)	19.0	20.5	20.3	22.8	22.3	21.5	20.6	19.3	18.2	20.7

Table I.16: One-third octave band sound insulation indices
October 2009, wet barrier (45 minutes after 'rainfall')

1/3 octave band centre frequency	Sound insulation indices SI for microphone positions P1-P9 & the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	23.6	17.3	19.3	20.6	16.7	18.0	22.0	16.5	17.8	18.3
400	26.8	17.4	19.9	21.9	16.8	18.5	24.0	16.6	18.2	18.7
500	15.7	20.2	21.3	17.5	20.7	22.1	17.3	18.5	18.0	18.8
630	17.2	22.9	23.1	18.7	21.6	20.6	18.7	20.8	18.6	20.1
800	28.1	27.7	27.6	23.9	21.6	18.9	26.7	25.6	20.1	22.9
1000	20.8	23.7	26.8	27.9	29.4	24.7	23.0	21.1	20.7	23.7
1250	24.2	22.9	22.7	29.2	27.3	27.9	27.5	21.2	19.5	23.8
1600	20.5	20.2	25.6	23.9	25.2	27.1	22.0	18.8	23.2	22.5
2000	21.2	17.3	18.6	27.1	23.0	18.4	27.7	17.2	16.3	19.5
2500	14.5	22.2	11.9	18.7	26.6	19.2	16.2	17.2	11.2	16.7
3150	11.0	17.9	18.5	20.4	26.8	26.4	11.6	13.2	20.2	17.0
4000	17.6	18.1	16.7	27.7	31.3	23.8	21.1	18.3	19.6	20.9
5000	18.3	16.6	18.4	28.5	27.1	24.0	17.5	22.8	15.0	20.3
DL_{SI} (0.3-5 kHz)	19.0	20.6	20.3	22.5	22.6	21.3	20.4	19.0	18.1	20.6

Table I.17: One-third octave band sound insulation indices
October 2009, wet barrier (60 minutes after 'rainfall')

1/3 octave band centre frequency	Sound insulation indices SI for microphone positions P1-P9 & the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	23.7	17.2	19.2	20.4	16.6	18.1	21.9	16.6	17.9	18.3
400	26.9	17.4	19.7	21.6	16.6	18.7	23.8	16.6	18.3	18.7
500	15.6	20.2	21.3	17.5	20.5	22.2	17.4	18.5	18.1	18.8
630	17.1	22.8	23.1	18.7	21.4	20.7	18.8	20.8	18.8	20.1
800	28.2	27.9	27.7	24.1	21.6	18.9	26.7	25.5	20.2	22.9
1000	20.6	23.5	26.9	27.8	28.9	24.7	23.3	21.1	20.9	23.7
1250	24.4	22.7	22.7	29.2	27.2	28.1	27.7	21.1	19.6	23.8
1600	20.3	19.9	25.7	23.8	24.9	27.1	22.0	18.7	23.5	22.3
2000	21.0	17.1	18.5	27.2	22.8	18.3	27.6	17.2	16.5	19.4
2500	14.3	22.1	11.9	18.7	26.4	19.3	16.3	17.2	11.4	16.7
3150	11.1	17.9	18.8	20.5	26.7	26.5	11.7	13.3	20.3	17.1
4000	17.8	18.1	16.7	27.4	31.1	23.8	21.6	18.4	20.1	21.0
5000	18.5	16.4	18.5	28.6	27.0	23.9	17.9	22.6	14.8	20.3
DL_{SI} (0.3-5 kHz)	18.9	20.5	20.3	22.4	22.4	21.4	20.5	19.0	18.2	20.6

Table I.18: One-third octave band sound insulation indices
October 2009, wet barrier (75 minutes after 'rainfall')

1/3 octave band centre frequency	Sound insulation indices SI for microphone positions P1-P9 & the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	23.9	17.5	19.4	20.8	16.3	17.9	21.9	16.6	17.8	18.3
400	26.9	17.6	20.1	22.1	16.4	18.3	23.8	16.6	18.2	18.7
500	15.6	20.3	21.5	17.5	20.2	22.0	17.1	18.4	17.9	18.8
630	17.1	22.9	23.3	18.8	21.2	20.5	18.5	20.7	18.7	20.0
800	28.1	28.1	28.0	24.3	21.3	18.7	26.6	25.6	20.1	22.8
1000	20.6	23.5	27.1	27.8	28.5	24.6	23.1	21.2	20.6	23.6
1250	24.5	22.8	23.0	29.2	26.8	27.9	27.4	21.1	19.4	23.7
1600	20.3	20.0	25.9	23.7	24.4	26.8	21.7	18.7	23.2	22.2
2000	21.0	17.4	18.7	27.2	22.0	18.1	27.1	17.1	16.2	19.3
2500	14.4	22.4	12.2	18.7	25.7	19.2	16.1	17.2	11.2	16.7
3150	11.2	18.1	19.2	20.6	25.8	26.4	11.6	13.4	20.2	17.1
4000	17.8	18.5	16.8	27.4	30.3	23.6	21.6	18.5	20.0	21.1
5000	18.5	16.7	18.6	28.6	26.9	23.8	17.8	22.6	14.6	20.3
DL_{SI} (0.3-5 kHz)	19.0	20.7	20.5	22.5	22.1	21.2	20.3	19.0	18.0	20.5

Table I.19: One-third octave band sound insulation indices
October 2009, wet barrier (90 minutes after 'rainfall')

1/3 octave band centre frequency	Sound insulation indices SI for microphone positions P1-P9 & the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	23.9	17.5	19.5	21.2	16.4	18.1	22.3	16.8	17.8	18.5
400	26.9	17.6	20.2	22.5	16.4	18.5	24.2	16.9	18.1	18.8
500	15.6	20.3	21.5	17.9	20.4	22.3	17.4	18.6	17.9	18.9
630	17.2	22.9	23.3	19.2	21.4	20.7	18.8	20.9	18.6	20.1
800	28.0	28.1	28.1	24.7	21.5	18.9	26.8	25.8	20.0	23.0
1000	20.7	23.6	27.2	28.1	28.7	24.9	23.4	21.4	20.6	23.8
1250	24.5	22.8	23.0	29.4	27.0	28.1	27.6	21.3	19.4	23.8
1600	20.2	20.0	26.1	24.0	24.5	27.0	21.8	18.9	23.1	22.3
2000	20.9	17.3	18.6	27.6	22.2	18.4	27.1	17.3	16.2	19.4
2500	14.4	22.6	12.2	19.1	25.9	19.5	16.2	17.3	11.1	16.7
3150	11.3	18.3	19.3	21.0	26.0	26.5	11.8	13.6	20.4	17.3
4000	17.9	18.5	16.6	27.6	30.5	23.9	21.7	18.6	19.9	21.1
5000	18.6	16.6	18.6	28.9	27.1	23.9	18.0	23.1	14.7	20.4
DL_{SI} (0.3-5 kHz)	19.0	20.7	20.5	22.9	22.3	21.4	20.5	19.2	18.0	20.7

Table I.20: One-third octave band sound insulation indices
October 2009, wet barrier (105 minutes after 'rainfall')

1/3 octave band centre frequency	Sound insulation indices SI for microphone positions P1-P9 & the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	24.0	17.6	19.7	21.0	16.6	17.9	22.0	16.8	17.8	18.4
400	27.2	17.7	20.4	22.3	16.7	18.3	24.1	16.8	18.2	18.9
500	15.7	20.4	21.5	17.7	20.5	22.1	17.2	18.6	17.9	18.8
630	17.2	22.9	23.3	19.0	21.5	20.5	18.6	20.9	18.5	20.1
800	28.1	28.1	28.2	24.6	21.7	18.7	26.6	25.9	19.9	22.9
1000	20.6	23.5	27.4	27.8	28.6	24.7	23.1	21.4	20.5	23.7
1250	24.7	22.7	23.2	29.2	27.0	28.0	27.4	21.3	19.4	23.8
1600	20.2	19.8	26.2	23.9	24.4	26.9	21.6	18.8	23.0	22.2
2000	20.9	17.2	18.8	27.5	22.2	18.3	26.7	17.3	16.2	19.4
2500	14.4	22.5	12.4	18.9	25.9	19.4	16.0	17.3	11.1	16.7
3150	11.4	18.2	19.5	20.9	26.0	26.3	11.6	13.6	20.2	17.3
4000	18.0	18.4	16.8	27.4	30.6	23.8	21.6	18.6	20.0	21.1
5000	18.8	16.4	18.7	28.8	27.1	23.5	17.8	22.8	14.4	20.3
DL_{SI} (0.3-5 kHz)	19.0	20.6	20.7	22.7	22.3	21.2	20.3	19.2	18.0	20.6

Table I.21: One-third octave band sound insulation indices
October 2009, wet barrier (120 minutes after 'rainfall')

1/3 octave band centre frequency	Sound insulation indices SI for microphone positions P1-P9 & the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	23.9	17.3	19.6	20.8	16.3	17.9	21.8	16.6	18.0	18.3
400	26.9	17.4	20.2	22.2	16.4	18.3	23.8	16.7	18.3	18.7
500	15.7	20.3	21.4	17.5	20.4	22.1	17.2	18.4	18.1	18.8
630	17.2	22.9	23.2	18.8	21.4	20.5	18.6	20.7	18.8	20.0
800	28.0	28.0	28.2	24.4	21.5	18.7	26.5	25.6	20.2	22.9
1000	20.6	23.4	27.1	27.6	28.5	24.7	23.2	21.2	20.7	23.6
1250	24.7	22.7	22.9	29.1	26.8	28.0	27.4	21.1	19.5	23.8
1600	20.1	19.8	26.0	23.6	24.4	26.9	21.4	18.7	23.2	22.1
2000	20.8	17.2	18.6	27.4	22.0	18.4	26.7	17.1	16.4	19.3
2500	14.4	22.5	12.3	18.8	25.8	19.5	16.1	17.3	11.3	16.8
3150	11.4	18.2	19.4	20.7	25.8	26.3	11.6	13.4	20.5	17.2
4000	17.9	18.4	16.7	27.1	30.2	23.8	21.6	18.5	20.1	21.1
5000	18.6	16.4	18.5	28.5	27.0	23.6	17.9	22.4	14.7	20.3
DL_{SI} (0.3-5 kHz)	19.0	20.6	20.5	22.5	22.1	21.2	20.3	19.0	18.2	20.6

Table I.22: One-third octave band sound insulation indices
October 2009, wet barrier (135 minutes after 'rainfall')

1/3 octave band centre frequency	Sound insulation indices SI for microphone positions P1-P9 & the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	24.1	17.5	19.8	21.3	16.4	18.2	22.0	16.9	17.8	18.5
400	27.3	17.6	20.5	22.8	16.5	18.6	23.9	16.9	18.2	18.9
500	15.7	20.5	21.6	18.0	20.4	22.5	17.2	18.6	17.9	18.9
630	17.3	23.1	23.4	19.2	21.4	20.8	18.6	20.9	18.6	20.2
800	28.0	28.2	28.4	25.0	21.6	18.9	26.6	25.8	20.0	23.0
1000	20.6	23.6	27.5	27.9	28.5	24.9	23.2	21.4	20.5	23.7
1250	24.7	22.9	23.2	29.3	26.8	28.2	27.3	21.3	19.3	23.8
1600	20.0	20.0	26.3	23.9	24.3	27.1	21.3	18.8	23.0	22.2
2000	20.9	17.4	18.7	27.7	22.1	18.6	26.5	17.3	16.2	19.4
2500	14.2	22.8	12.5	19.1	25.9	19.8	16.1	17.3	11.1	16.8
3150	11.4	18.4	19.7	21.0	25.8	26.5	11.6	13.7	20.3	17.3
4000	18.1	18.6	16.8	27.5	30.3	24.0	21.6	18.5	20.0	21.2
5000	18.7	16.6	18.8	29.1	27.1	23.7	18.0	23.1	14.6	20.4
DL_{SI} (0.3-5 kHz)	19.0	20.8	20.8	22.9	22.2	21.5	20.3	19.2	18.0	20.7

Table I.23: One-third octave band sound insulation indices
October 2009, wet barrier (150 minutes after 'rainfall')

1/3 octave band centre frequency	Sound insulation indices SI for microphone positions P1-P9 & the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	24.1	17.4	19.7	21.3	16.4	18.1	22.0	16.6	18.0	18.4
400	26.8	17.5	20.4	22.8	16.5	18.5	24.0	16.6	18.4	18.8
500	15.9	20.4	21.5	17.9	20.4	22.3	17.4	18.4	17.9	18.9
630	17.4	23.0	23.3	19.2	21.4	20.6	18.8	20.8	18.6	20.2
800	28.2	28.1	28.4	25.0	21.6	18.8	26.7	25.6	20.1	23.0
1000	20.8	23.5	27.4	27.8	28.5	24.8	23.4	21.2	20.7	23.7
1250	24.9	22.7	23.2	29.4	26.8	28.0	27.5	21.1	19.5	23.8
1600	20.2	19.8	26.3	23.9	24.3	26.9	21.4	18.7	23.2	22.2
2000	21.0	17.2	18.9	27.8	22.1	18.4	26.5	17.0	16.5	19.4
2500	14.5	22.6	12.6	19.2	25.9	19.6	16.2	17.3	11.4	16.9
3150	11.6	18.3	19.8	21.1	25.8	26.4	11.8	13.5	20.3	17.3
4000	18.2	18.4	17.0	27.6	30.2	23.8	21.8	18.6	20.3	21.2
5000	18.9	16.4	18.9	29.1	27.2	23.6	18.3	22.4	14.7	20.4
DL_{SI} (0.3-5 kHz)	19.2	20.6	20.8	22.9	22.2	21.3	20.5	19.0	18.1	20.7

Table I.24: One-third octave band sound insulation indices
October 2009, wet barrier (165 minutes after 'rainfall')

1/3 octave band centre frequency	Sound insulation indices SI for microphone positions P1-P9 & the mean									
	SI_1	SI_2	SI_3	SI_4	SI_5	SI_6	SI_7	SI_8	SI_9	SI
315	24.2	17.6	19.9	21.1	16.6	18.1	21.9	16.6	18	18.5
400	27.1	17.7	20.6	22.2	16.6	18.6	23.8	16.7	18.4	18.9
500	15.7	20.5	21.5	17.8	20.6	22.5	17.3	18.4	18.3	19.0
630	17.2	23.1	23.3	19.1	21.6	20.8	18.7	20.7	19.0	20.2
800	28.0	28.3	28.5	25.0	21.8	18.9	26.7	25.7	20.3	23.1
1000	20.6	23.6	27.5	27.7	28.7	25.0	23.4	21.2	20.9	23.8
1250	24.8	22.9	23.2	29.3	27.0	28.1	27.5	21.1	19.7	23.9
1600	20.0	19.9	26.3	23.9	24.4	27.1	21.4	18.7	23.3	22.2
2000	20.8	17.4	18.9	27.9	22.3	18.5	26.5	17.0	16.5	19.4
2500	14.3	22.9	12.6	19.3	26.1	19.8	16.2	17.3	11.4	17.0
3150	11.5	18.4	19.8	21.1	26.0	26.7	11.8	13.5	20.7	17.4
4000	18.1	18.6	17.0	27.6	30.4	24.0	21.7	18.5	20.3	21.3
5000	18.9	16.7	19.1	29.3	27.5	24.0	18.2	22.6	15.0	20.6
DL_{SI} (0.3-5 kHz)	19.0	20.8	20.9	22.9	22.4	21.5	20.5	19.1	18.3	20.7

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Technical Annex to PPR490
The acoustic durability of timber noise barriers on England's strategic road network

Timber noise barriers are one of the most common mitigation measures against traffic noise on England's Strategic Road Network. They are required not only to fulfil their acoustic function and structural design requirements in accordance with Highways Agency specifications, but also to retain their performance for a reasonably long life. The Agency's technical design guide, HA 66/95, stipulates that noise barriers should remain serviceable for 40 years and not require maintenance for 20 years.

Currently the Agency requires acoustic performance to have been assessed using recognised, standardised laboratory tests (EN 1793-1:1998 and EN 1793-2:1998) as appropriate to the barrier type. However, the Agency's specifications are only concerned with the performance of the barriers in new condition.

This report is a technical annex to the main report which presents the results of a study commissioned by the Agency to investigate the acoustic durability of timber noise barriers on the network. This has been achieved through a programme of in situ measurements using recently developed test methods described in the forthcoming standard prEN 1793-6:2010 to determine airborne sound insulation characteristics.

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F: +44 (0) 1344 328005
E: trl@ihs.com
W: http://emeastore.ihs.com

Price code: 4X

ISSN 0968-4093

ISBN 978-1-84608-884-1

PP4R90 Annex