



HS2 London to the West Midlands Appraisal of Sustainability

Appendix 5 – AoS Technical Reports

A Report for HS2 Ltd

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Structure of the AoS report and appendices

Non Technical Summary
Main Report Volume 1
Main Report Volume 2 – Plans and Appraisal Framework
Appendix 1 – The Appraisal Process
Appendix 2 – Greenhouse Gas Emissions
Appendix 3 – Socio-economic Report
Appendix 4 – Associated Assessment Reports
Appendix 5 – AoS Technical Reports
Appendix 6 – March 2010 Preferred Scheme and Main Alternatives: AoS information

Explanatory Notes

This volume provides supporting documentation for the AoS report, including the following:

Reports on technical aspects of the appraisals for landscape, townscape and heritage; biodiversity; water and flood risk; noise; and, community integrity and accessibility; providing information to support the Main Report; and

Further analysis and case studies for health impacts (Appendix 5.6).

Calculated figures quoted in this Appraisal of Sustainability are estimates based on third party data sources and the engineering designs available at the time sustainability assessments were carried out. As far as possible these are an accurate reflection of the engineering drawings presented, however there may be minor discrepancies between these drawings and some calculated figures (e.g. lengths, areas, counts) quoted in the AoS reports.

The following table summarises the study buffers used for each topic¹:

Topic		Direct effects	Indirect effects
Landscape		50m either side of the route	Up to 3km from the route
Townscape		50m either side of the route	50-350m either side of the route
Heritage	Route	50m either side of the route	50-350m either side of the route
	stations	Within construction footprint	350m perimeter from construction footprint
Biodiversity (international sites)		50m either side of the route	10km from the route
Noise and Vibration (encompassing all potential contributions to noise impacts)		Not applicable	3km either side of the route ²
Construction effects (disturbance)	Route	Not applicable	100m either side of construction corridor
	stations	Not applicable	100m from station footprint
Community (demolitions)	Rural	25m either side of centre-line, followed by manual correction	50m either side of centre-line, followed by manual correction

¹ The 100m corridor used in these studies is based on 75m width required for a 2-track corridor plus 25m allowance for access. This is different to the 110m corridor assumed in the HS2 Summary Report

² A full summary of noise buffers is provided in **Table 1** in Appendix 5

Topic		Direct effects	Indirect effects
	Urban	<p>15m either side of centre-line, followed by manual correction; and,</p> <p>Impacts associated with stations and depots are based on proposed construction footprints (no buffering is adopted).</p>	<p>27.5m either side of centre-line, followed by manual correction; OR</p> <p>where against an existing railway, 40m from centerline on opposite side of new railway from existing railway, followed by manual correction; and,</p> <p>as the construction footprints for depots and stations are at an advanced level of design, it is assumed that any further land take would be minimal.</p>

Appendix 5.1

Landscape, Townscape and Heritage

Landscape, Townscape and Heritage Assessment Methodology

1. Introduction

1.1. Scope of appraisal

Gillespies, in association with Cotswold Archaeology, provided expertise on landscape, townscape and heritage resources for the Appraisal of Sustainability (AoS) for HS2 London to West Midlands. The focus of this work was to review landscape, townscape and heritage resources present in the areas through which potential HS2 route options passed, to assist with the sifting of the options and selection of the proposed route option and main alternatives, which were further assessed. This appendix describes the methods applied for the input on landscape, townscape and heritage matters to the AoS.

- 1.1.1. Given the strategic nature of the existing HS2 proposals, the focus of the study was given to potential impacts of the route proposals on national and regional landscape, townscape and heritage resources.

1.2. Method of appraisal

- 1.2.1. The landscape, townscape and cultural heritage features were assessed in terms of the key features of national and regional importance that could potentially be affected by the presence of HS2. The appraisal was broadly based upon WebTAG, the Department for Transport's (DfT) Guidance for appraising transport projects and in particular, the methodologies provided in WebTAG Unit 3.3.7 - The Landscape Sub-Objective, WebTAG Unit 3.3.8 - The Townscape Sub-Objective and WebTAG Unit 3.3.9 - The Heritage of Historic Resources Sub-Objective. All terms used here are as defined in *WebTAG*, the DfT's website for guidance on the conduct of transport studies³.
- 1.2.2. The appraisal was commensurate with the strategic nature and scale of the proposals and the extent of information available to undertake the appraisal. The appraisal was undertaken largely from GIS data, plans and written information. Aspects of the route were inspected, but no detailed surveys were undertaken. The specific method relating to each environmental element is described in the sections below.
- 1.2.3. The methods outlined below were applied both during the review of shortlisted route options and for appraisal of the proposed scheme.

1.3. Study area

- 1.3.1. The study area included the area of potential physical impact, and also those receptors adjacent to the proposed route which could be subject to non-physical effects (such as physical infrastructure or vibration, on setting, amenity value etc). Design Manual for Roads and Bridges (Volume 11, Section 3, Part 2, HA 208/07: Cultural Heritage: hereafter referenced as HA 208/07) produced by the Highways Agency (2007) is the most relevant document outlining a preferred corridor size. It recommends a study corridor of 300m either side of the edge of the scheme footprint at the scoping (route evaluation) stage for a trunk road (which are considered the closest proxy for railways). Assuming a nominal land take of 100m for the track etc, this would provide for a corridor 700m wide (350m either side of the centre line). A similar approach for the width of the corridor for appraisal has been used for all the work elements unless otherwise stated.

³ Tag Unit 1.1, Transport Analysis Guidance, New Approach to Appraisal, Department for Transport, United Kingdom, (www.dft.gov.uk/webtag), 2009

1.4. Evaluation

- 1.4.1. In assessing the impact a simplified evaluation system was applied which provided an overall evaluation for each of the route sub-sections based on the five point scale (double positive, minor positive, neutral, minor negative and major negative) rather than the standard WebTAG seven point scale which was considered too detailed in the absence of detailed information. This also provided consistency across all the work elements and with the AoS framework. Similarly, the cumulative evaluation for the entire route was based on the same five point scale.

2. Approach to Landscape Assessment

The core sustainability objective identified in the HS2 AoS framework methodology referring to landscape is to 'maintain and enhance existing landscape character'. The following evaluation criteria have been identified under this objective:

- Impacts on the coherence and distinctiveness of landscape resources of national importance crossed by surface or cut and cover sections; and
- Impacts on the coherence and distinctiveness of landscape resources of regional importance crossed by surface or cut and cover sections.

In order to assess the impact on landscape we have drawn on the guidance provided by the *Design Manual for Roads and Bridges* 11.3.5.8 and TAG Unit 3.3.7 – The Landscape Sub-Objective. This more detailed appraisal was then summarised to provide input into the overall AoS Framework.

2.1. Methodology – landscape specific proposals

- 2.1.1. The methodology for appraising landscape impact is set out in TAG Unit 3.3.7 and is based on the following staged approach:

- Stage 1: Describing countryside character;
- Stage 2: Appraise environmental capital;
- Stage 3: Appraise the proposal's impact;
- Stage 4: Produce overall assessment evaluation; and
- Stage 5: Produce cumulative evaluation for each route option.

- 2.1.2. These work stages are described in more detail below. We have used the key characteristics described in the WebTAG Landscape Assessment Worksheet; however as detailed information was not available we have not used the worksheet format to record the appraisal results from the stages identified above. The level of detail to which the landscape assessment and appraisal was undertaken was commensurate with the strategic nature of the HS2 proposals.

- 2.1.3. The data used to appraise landscape impacts are described in Annex A to this appendix.

Stage 1: Describing countryside character

- 2.1.4. The first stage described the landscape character areas at the national and regional level that the route sub-sections pass through. This information was obtained using the existing Landscape Character Assessments, in particular the Landscape Character Assessment defined by the Countryside Agency's own assessment work, as set out in Countryside Character, Volume 8: South West (Countryside Agency 1999).

- 2.1.5. In order to undertake this appraisal we utilised the written descriptions of Joint Character Areas and Landscape Character Types as the GIS data was unavailable. Use was also made of Regional Landscape Character Assessments (where available).

2.1.6. This provided a summary and description of the existing landscape character at the national and regional level and any discernible trends which would lead to degradation or loss of those characteristic features in the absence of the proposals.

Stage 2: Appraise environmental capital

2.1.7. The second stage appraised the environmental capital, at a broad strategic level, using a set of indicators to assess:

- Rarity / Importance;
- Social Importance; and
- Environmental.

2.1.8. Each of these indicators was applied to their relationships in overall landscape characteristics as identified through Stage 1. This provided a base level of environmental capital against which the impact of the proposal on that level of capital was appraised.

Stage 3: Appraise the proposal's impact

2.1.9. The third stage described and evaluated the impact of the proposals on each of the identified landscape features/attributes, taking account of the baseline environmental capital.

2.1.10. All impacts on the landscape, both adverse (damaging) and beneficial (enhancing), were, as far as possible, identified. The significance of each separate impact was then appraised and evaluated using the standard five point scale. The following criteria have been applied to evaluate the Landscape objective.

--	Direct / Indirect Negative Physical and Visual impact on valuable areas of Landscape over an extended distance (in excess of 5km from edge of 100m route corridor)
-	Direct / Indirect Negative Visual Impact (assumed Zone of Visual Influence of 3km from the edge of the 100m route corridor).
0	No impact
+	Direct / Indirect Positive Visual Impact (Assumed Zone of Visual Influence of 3km from the edge of the 100m route corridor).
++	Direct / Indirect Positive Physical and Visual impact on valuable areas of Landscape over an extended distance (in excess of 5km from the edge of the 100m route corridor)

2.1.11. In the circumstance where there was an absence of detailed information, it was only possible to say whether an option was likely to have a positive, neutral, or negative impact. Any uncertainties over any of these aspects are generally explained in the comments within the framework.

2.1.12. Although the engineering design is at outline level, some consideration has been given to minimising landscape impacts through route design, vertical profile, landscaping and the adoption of mitigations such as 'green bridges'. These proposals would need to be further developed during detailed design to enhance mitigation effectiveness.

2.1.13. The appraisal process shows, at a strategic level, how the proposal could:

- Impact on or change the character of the landscape – effects on the nationally and regionally distinctive pattern of landscape elements; and
- Where possible, how visually intrusive the scheme could be upon the field of view and visual amenity – the value of strategic views in terms of what would be seen.

Stage 4: Overall assessment evaluation

2.1.14. The fourth stage derived an overall assessment evaluation based on the five point scale (major positive, minor positive, neutral, minor negative and major negative).

- 2.1.15. It was informed by the descriptive comments and evaluations for the impact described in Stage 3. In the circumstance where there was an absence of detailed information, it was only possible to say whether an option has a positive, neutral, or negative impact.
- 2.1.16. The qualitative box on the AoS Framework was also completed to summarise the overall effect of the route sub-section on the landscape.

Stage 5: Produce cumulative evaluation for each route option

- 2.1.17. Each sub-section of the route was assigned an evaluation, as reported in the AoS Frameworks (Volume 5). The evaluations for each sub-section were combined, in keeping with WebTAG principles, to establish an overall evaluation for whole route combinations.

2.2. Designations

- 2.2.1. The assessment of resource importance has been guided wherever possible by recognised policy judgements about the importance of features (and their associated elements), for example, designated landscape areas and features, such as Areas of Outstanding Natural Beauty (AONB) or National Parks. However, this does not provide a simple definition of importance.
- 2.2.2. The majority of landscape resources are however undesignated landscapes, which can also be of high quality and of great importance. Evaluation of these was, out of necessity, based on professional judgement informed by known public perception.
- 2.2.3. The following designations have been used to assess potential impacts on the national and regionally important landscape resources along the routes:

National Designations

- Area of Outstanding Natural Beauty (AONB); and
- National Parks.

Regional / Local Areas of Importance

- Country Parks; and
- Descriptions of the Joint Landscape Character Areas through which the routes pass have also been provided for information.

2.3. Assumptions and limitations

- 2.3.1. The level of detail to which the landscape assessment has been undertaken is commensurate with the strategic nature of the HS2 proposals and the data available with which to undertake the appraisals. It has also been largely dependent on the information and data made available both in terms of GIS data and the level of detail provided to the team on the specific nature of the HS2 proposals. For example, more detailed information was provided to the team for the stations, and as such, a more detailed appraisal has been conducted. For the appraisal of the route options, a more strategic level of assessment has been undertaken which draws on the key principles of the WebTAG approach.
- 2.3.2. Each route section has been considered using the GIS data available. The scoring criteria used within the overall assessment has been based around the presence or absence of national and regional landscape designations: AONB, National Parks and Country Parks.
- 2.3.3. The specific physical elements within the landscape designations were considered at a strategic level only, for example if the route was shown to cross a sensitive riparian habitat or large tract of mature woodland this was specifically noted and the name of the woodland or river was provided (where known), in order to emphasise the extent of the perceived impact. These notes were included irrespective of the actual quality of individual sub-

spaces within the wider context of the designated area, as these would only really be appreciated at a more localised level.

2.3.4. In terms of landscape impacts, it was seen to be significantly detrimental only where the route directly or indirectly affected an area designated as nationally or regionally important as these designations are applied specifically to landscape of notable value in terms of their rarity and environmental/social quality. The following principles were applied:

- double negative (--) evaluation: Where a direct impact was experienced, i.e. where the route (assuming a 100m track width) was shown to travel directly within a designated landscape of national or regional importance.
- single negative (-) evaluation: indirect impacts were those where national or regional designated areas fell within 3km of the edge of corridor. In these instances, it was assumed at this strategic level that the route would potentially affect the visual quality of the landscape (though topographic variations and physical obstructions at a local level may provide some screening).
- neutral (0) evaluation: has been given to those areas where no direct or indirect landscape impacts have occurred.
- positive (+ or ++) evaluations: none have been identified within this stage of assessment.

2.4. Further assessment of the proposed route

2.4.1. Gillespies were asked to undertake a visibility study on the Chilterns AONB to inform the selection of a proposed route.

3. Approach to Townscape Assessment

3.1.1. The core sustainability objective identified in the AoS framework referring to townscape is to maintain and enhance existing townscape character. The following evaluation criteria have been identified under this objective:

- Impacts on the coherence and distinctiveness of townscape resources crossed by surface or cut and cover sections; and
- Numbers of strategically important views and/or key vistas physically affected.

3.1.2. In order to assess the impact on townscape, we have drawn on the guidance provided in TAG Unit 3.3.8 – The Townscape Sub-Objective and *Design Manual for Roads and Bridges* 11.3.5.8 which incorporates the principles of good practice urban design.

3.2. Methodology - townscape specific proposals

3.2.1. Our methodology for appraising the potential impact of HS2 on townscape was based on the guidance provided in WebTAG Unit 3.3.8 which identifies the following staged approach:

- Stage 1: Describing the existing urban character;
- Stage 2: Appraise the townscape capital;
- Stage 3: Appraise the impact;
- Stage 4: Produce overall assessment evaluation;
- Stage 5: Produce cumulative evaluation for each route option.

3.2.2. The level of detail to which the townscape assessment and appraisal was undertaken was commensurate with the strategic nature of the HS2 proposals. These work stages are described in more detail below.

Stage 1: Describe the existing urban character

- 3.2.3. The first stage described the urban character areas that the route sub-sections pass through.
- 3.2.4. Using the GIS data a buffer corridor of 100 metres width (which was seen as a direct physical impact) and 300 metres either side of the direct impact zone (described as an indirect impact) were plotted to assess the presence or absence of settlements (GIS data). As this data only included settlements over a certain size, the more detailed level plans provided by Arup were also assessed.
- 3.2.5. The urban character of the areas (city, town, village, hamlet) directly and/or indirectly affected by the route was described. The descriptions also sought to identify the key urban characteristics of the affected areas considering elements such as layout, density, scale of buildings, appearance, land use and cultural features.
- 3.2.6. This information was obtained through a number of sources including the GIS data and more detailed plans provided by Arup, local policy documents, Local Development Framework proposals maps and aerial and oblique aerial photographs where these were available online.
- 3.2.7. This stage of analysis provided a summary of the existing urban character directly and indirectly affected by the route.

Area of Impact

- 3.2.8. See 3.2.4 above.

Stage 2: Appraise the townscape capital

- 3.2.9. The second stage appraised the townscape capital in terms of its importance. This was evaluated using the following key documents (where available):
- Townscape Appraisals / Character Area Assessments;
 - Conservation Character Area Appraisals; and
 - Local Development Framework Policies.

Stage 3: Appraise the impact

- 3.2.10. This stage described and measured the potential impact of the proposals on the urban character established in stage 1, taking account of the townscape capital established in stage 2. As well as the qualitative assessment based on the detailed Arup drawings, a quantitative assessment was undertaken which measured the length of the route directly and indirectly affecting settlements.
- 3.2.11. Potential mitigation measures have generally not been addressed within the townscape assessment as the precise effects are unclear at this strategic level of detail. However, where a more detailed evaluation was undertaken such as for the stations, additional notes on potential mitigation have been provided in the qualitative statement.

Stage 4: Produce overall assessment evaluation

- 3.2.12. This stage derived an overall assessment evaluation for each route sub-section. In order to assign an evaluation for the townscape impact of the route corridor and stations, the assessment identifies and draws on aspects of the resource (character, importance and sensitivity) and the change brought about by the scheme (magnitude or scale of the change). Evaluation was based on the five point scale as follows:
- A double negative (--) evaluation was applied where direct townscape impacts would be considered significantly adverse in terms of their scale and the importance (value) of the

buildings which would be affected (this included for example townscape affected which was part of a designated Conservation Area).

- A single negative (-) evaluation was applied where indirect townscape impacts would occur and where direct townscape impacts are not considered significantly adverse in terms of their scale and the importance (value) of the buildings which would be affected.
- A neutral (0) value was given to those areas where no direct or indirect townscape impacts would occur.
- No positive impacts (+, ++) were identified within the assessment.
- For heritage resources there is the potential for adverse effects, where buildings would be demolished or altered, or where the setting of buildings would be adversely changed as a result of the proposed development. The significance of these changes would depend on their scale and the importance (value) of the buildings which would be affected.

Stage 5: Produce cumulative evaluation for each route option

3.2.13. Each sub-section of the route was assigned an evaluation, as reported in the AoS Frameworks. The evaluations for each sub-section were combined, in keeping with WebTAG principles, to establish an overall evaluation for whole route combinations.

3.3. Limitations

Data and drawings

3.3.1. Each route section has been considered from the GIS data and drawings supplied by Arup. All drawing references are to Arup drawing numbers.

Views

3.3.2. No GIS data for regionally significant or statutorily protected views or vistas was found during the assessment process. Therefore, in order to fill this gap, for London a review of the *Draft Revised London View Management Framework* (June 2009) was undertaken. Efforts were also made to capture locally important views and vistas through an assessment of Conservation Area Character Appraisals and Local Development Frameworks Proposals Maps. This approach and the scoring system designated to this aspect of the appraisal has been based on information available on Councils' websites.

Designations

3.3.3. Assessing the importance of the townscape is straightforward where recognised policy judgements about the importance of features (and their associated elements) have been made, for example, through the planning process and designated structures and areas, such as listed buildings, registered parks and gardens and conservation areas. However, it must be recognised that the majority of the urban environment comprises undesignated townscapes, which can also be of high quality and of great importance. At this strategic level of appraisal, research based on local planning policy and aerial photography was used to support an expert view of the importance of undesignated townscape desktop.

3.3.4. The designation used within the overall assessment has been the presence or absence of settlements within the GIS data. As this data only includes settlements over a certain size, further research was undertaken of Local Authority Local Plans, Conservation Area Appraisals, etc. to determine the significance of townscape resources along the corridor. The heritage value of conservation areas or listed buildings has not been quantitatively assessed within the townscape section to ensure that it is not double counted. However, Conservation Area designations have been used as a qualitative indication of townscape quality, coherence and importance.

4. Approach to Cultural Heritage Assessment

4.1.1. Gillespies, in association with Cotswold Archaeology, used the following two stage methodology for the assessment of Cultural Heritage.

4.2. Assessment of route options

Evaluation criteria

- 4.2.1. The appraisal considered cultural heritage receptors of Very High; High and Medium Value. The criteria for these designations are shown in **Table 1**, which draws heavily from the *Design Manual for Roads and Bridges* (Volume 11, Section 3, Part 2, HA 208/07: Cultural Heritage: hereafter referenced as HA 208/07) produced by the Highways Agency (2007). This is the most up-to-date and rigorous methodology available for cultural heritage assessment which has been endorsed by Government. **Table 1**, below, is the standard approach adopted by Cotswold Archaeology for assessing cultural heritage value, and draws heavily from Tables 5.1, 6.1 and 7.1 of Annexes 5, 6 and 7 respectively in HA 208/07.
- 4.2.2. For the purposes of the assessment it is convenient to structure discussion in the appraisal around the three generally accepted components of cultural heritage:
- Archaeological Remains;
 - Historic Buildings; and
 - Historic Landscape.
- 4.2.3. The receptors listed in **Table 1** of this appendix are those which would be considered in a standard Environmental Statement. As this study is strategic in nature, it is acceptable to prioritise the receptors to be considered at this stage of appraisal.
- 4.2.4. A number of receptors were mapped during earlier stages of work, and some additional receptors identified around possible station locations and route pinch points. This stage of appraisal considered those receptors highlighted in italics in the table, which is heavily dictated by the availability of national, regional and local GIS data sets. As there is no nationally available source of GIS data on the extent of Conservation Areas it was not possible to consider this source during early stages of assessment. No consideration was given to very important or important receptors which are not subject to designation. Consideration of historic landscape was restricted to designed landscapes which are designated as registered Parks and Gardens.

Table 1 – Classification of cultural heritage features

Resource value	Description
Very High	<i>World Heritage Sites.</i> Assets of acknowledged international importance. Assets that can contribute significantly to acknowledged international research objectives. Historic landscapes of international value (designated or not) and extremely well preserved historic landscapes with exceptional coherence, time depth, or other critical factor(s).
High	<i>Scheduled monuments</i> and undesignated assets of Schedulable quality and importance. Grade I and II* Listed buildings (Scotland category A). Other Listed buildings that can be shown to have exceptional qualities in their fabric or associations not adequately reflected in their Listing grade. Conservation Areas containing very important buildings. Undesignated structures of clear national importance. Designated and undesignated historic landscapes of outstanding historic interest (including <i>Grade I and Grade II* Registered Parks and Gardens; Registered Battlefields</i>); undesignated landscapes of high quality and importance of demonstrable national value; and well preserved historic landscapes exhibiting considerable coherence, time depth or other critical factor(s).

Resource value	Description
	Assets that can contribute significantly to acknowledged national research objectives.
Medium ⁴	Designated or undesignated assets that contribute to regional research objectives <i>Grade II</i> (Scotland category B) Listed buildings. Historic (unlisted) buildings that can be shown to have exceptional qualities in their fabric or historical association. Conservation Areas containing important buildings that contribute significantly to their historic character. Historic townscapes or built up areas with important historic integrity in their buildings, or built settings (for example including street furniture or other structures). Designated landscapes of special historic interest (including <i>Grade II Registered Parks and Gardens</i>); undesignated landscapes that would justify such a designation; averagely well preserved historic landscapes with reasonable coherence, time depth or other critical factor(s); landscapes of regional value.
Low	Designated and undesignated assets of local importance including those compromised by poor preservation and/or poor survival of contextual associations. Assets of limited value, but with potential to contribute to local research objectives. Locally Listed buildings (Scotland category C(S) Listed Buildings) and historic (unlisted) buildings of modest quality in their fabric or historical association. Historic townscape or built-up areas of limited historic integrity in their buildings or built settings (for example including street furniture or other structures). Robust undesignated historic landscapes; historic landscapes with importance to local interest groups; and historic landscapes whose value is limited by poor preservation and/or poor survival of contextual associations.
Negligible	Assets with very little or no surviving archaeological interest. Buildings of no architectural or historical note and buildings of an intrusive character. Landscapes with little or no significant historical interest.
Uncertain	The importance of the resource has not been ascertained. Archaeological resources the importance of which cannot be ascertained. Buildings with some hidden (i.e. inaccessible) potential for historical significance.

4.3. Data sources

4.3.1. The data on all of the receptors has been utilised in GIS format, along with base mapping from the client.

4.4. Study area

4.4.1. The study area included the likely area of physical impact, and also those receptors adjacent to the proposed route which may be subject to non-physical effects (effects on setting, amenity value etc). HA 208/07 (para. 5.4) recommends a study corridor of 300m either side of the edge of the scheme footprint at the scoping (route evaluation) stage for a trunk road. Assuming a nominal land take of 100m for the track etc a corridor 700m wide (350m either side of the centre line) was considered.

4.5. Appraisal

4.5.1. The actual land take of the route marked on the engineering drawings, rather than the nominal 100m wide impact corridor assessed at the earlier stage, was considered for the proposed route. At the same time two additional data sources were examined.

Conservation Areas

4.5.2. Assessment was limited to a rapid appraisal of the historic character and importance of the Conservation Areas adjacent to Euston station and throat; and Curzon Street station and throat only. No consideration was given to Conservation Areas beyond these two route

⁴ While it is appropriate to classify Grade II Listed Buildings and Grade II Registered Parks and Gardens as receptors of Medium Cultural Heritage Value, they are national designations and all listed buildings and registered parks and gardens can be considered to be of national importance

sections. In assessing the historic importance of the Conservation Areas the following principal sources were consulted:

- Euston: a framework for change (LB Camden Supplementary Planning Document);
- Digbeth, Deritend and Bordesley High Street Conservation Area. Character Appraisal and Supplementary Planning Policies (Birmingham City Council); and
- Warwick Bar Conservation Area. Character Appraisal and Supplementary Planning Policies (Birmingham City Council).

Historic landscapes

4.5.3. There is no established rapid methodology or unified data source for identifying undesignated historic landscapes. The method employed by this rapid assessment comprises using information on the visible historic landscape from descriptions of Natural England (NE) Countryside Character Areas (CCA) to give an understanding of the rarity or importance of current historic landscape character. Such an approach is recognised as an appropriate initial approach in para 4.1.9 of *Assessing the Effect of Road Schemes on Historic Landscape Character: Draft for Discussion* (Highways Agency 2007).

4.6. Limitations

- 4.6.1. The appraisal of cultural heritage for the proposed route has occurred at a strategic level, and selection of the receptors considered has been required. A number of data sources which might provide information on further receptors of potentially Very High; High and Medium cultural heritage importance have therefore not been considered at this stage (see **Table 1**). Future stages of assessment should consider additional receptors to provide a more rigorous assessment. For instance, as stated in the table, not all archaeological sites of High cultural heritage value are scheduled.
- 4.6.2. The most time effective and consistent method of considering non-designated sites of schedulable quality would be via a rapid sieving of GIS-based monuments and events data obtained from the Archives and Monuments Information England (AMIE) database curated by the National Monuments Record of English Heritage (EH). This sieving would be undertaken using professional judgment and would allow a basic list to be made which could be termed “archaeological sites of potentially high value”. Greater detail could further be obtained by interrogation of data contained on the various Historic Environment Records which cover the route.
- 4.6.3. Field evaluation of the proposed route is likely to be required as part of the Environmental Statement. Further appraisal should also consider the historic importance of Conservation Areas along the whole route, and assess the impact of the scheme upon the historic integrity of these areas. Detailed assessment of the non-physical impacts of the scheme upon historic buildings would also be required.
- 4.6.4. Further consideration should also be given of the impact of the scheme upon the historic landscape. This could be assessed via interrogation of Historic Landscape Characterisation (HLC) data held in the various Historic Environment Records. HLC data does not in itself establish the importance of areas of historic landscape, however, and it is likely that a detailed study akin to that implemented around the M11 Strategic Expansion Area would be required.

ANNEX A – Landscape Data Sources

Landscape Character Areas Descriptions

Natural England website: <http://www.naturalengland.org.uk/>

Character Area Breakdown:

Inner London

http://www.naturalengland.org.uk/OURWORK/LANDSCAPE/ENGLANDS/CHARACTER/AREAS/INNER_LONDON.ASPX

Northern Thames Basin

http://www.naturalengland.org.uk/OURWORK/LANDSCAPE/ENGLANDS/CHARACTER/AREAS/NORTHERN_THAMES_BASIN.ASPX

Thames Valley

http://www.naturalengland.org.uk/OURWORK/LANDSCAPE/ENGLANDS/CHARACTER/AREAS/THAMES_VALLEY.ASPX

Chilterns

<http://www.naturalengland.org.uk/OURWORK/LANDSCAPE/ENGLANDS/CHARACTER/AREAS/CHILTERNES.ASPX>

Upper Thames Clay Vales

http://www.naturalengland.org.uk/OURWORK/LANDSCAPE/ENGLANDS/CHARACTER/AREAS/UPPER_THAMES_CLAY_VALES.ASPX

Yardley-Whittlewood Ridge

http://www.naturalengland.org.uk/OURWORK/LANDSCAPE/ENGLANDS/CHARACTER/AREAS/YARDLEY-WHITTLEWOOD_RIDGE.ASPX

Northamptonshire and Leicestershire Vales

http://www.naturalengland.org.uk/OURWORK/LANDSCAPE/ENGLANDS/CHARACTER/AREAS/NORTHAMPTONSHIRE_AND_LEICESTERSHIRE_VALES.ASPX

Bedfordshire and Cambridgeshire Claylands

http://www.naturalengland.org.uk/OURWORK/LANDSCAPE/ENGLANDS/CHARACTER/AREAS/BEDFORDSHIRE_AND_CAMBRIDGESHIRE_CLAYLANDS.ASPX

Cotswolds

<http://www.naturalengland.org.uk/OURWORK/LANDSCAPE/ENGLANDS/CHARACTER/AREAS/COTSWOLDS.ASPX>

Northamptonshire Uplands

http://www.naturalengland.org.uk/OURWORK/LANDSCAPE/ENGLANDS/CHARACTER/AREAS/NORTHAMPTONSHIRE_UPLANDS.ASPX

Severn and Avon Valley

http://www.naturalengland.org.uk/OURWORK/LANDSCAPE/ENGLANDS/CHARACTER/AREAS/SEVERN_AND_AVON_VALES.ASPX

Dunsmore and Feldon

http://www.naturalengland.org.uk/OURWORK/LANDSCAPE/ENGLANDS/CHARACTER/AREAS/DUNSMORE_AND_FELDON.ASPX

Arden

<http://www.naturalengland.org.uk/OURWORK/LANDSCAPE/ENGLANDS/CHARACTER/AREAS/ARDEN.ASPX>

Trent Valley Washlands

http://www.naturalengland.org.uk/OURWORK/LANDSCAPE/ENGLANDS/CHARACTER/AREAS/TRENT_VALLEY_WASHLANDS.ASPX

Cannock Chase and Cank Wood

http://www.naturalengland.org.uk/OURWORK/LANDSCAPE/ENGLANDS/CHARACTER/AREAS/CANNOCK_CHASE_AND_CANK_WOOD.ASPX

GIS data

Area of Outstanding Natural Beauty (AONB). Country Parks.

Joint Character Areas.

National Parks. Sites of Special Scientific Interest (SSSI).

ANNEX B – Townscape Data Sources

Policy Documents

Euston Planning Framework Supplementary Planning Document, London Borough of Camden (April 2009);

Euston Area Planning Guidance Supplementary Planning Document Sustainability Appraisal Report, London Borough of Camden (April 2009);

Euston Planning Framework Supplementary Planning Document, London Borough of Camden (April 2009);

Euston Area Planning Guidance Supplementary Planning Document Sustainability Appraisal Report, London Borough of Camden (April 2009);

Camden Town Conservation Area Appraisal and Management Strategy (October 2007);

Regents Canal Conservation Area Appraisal and Management Plan (September 2008);

Camden Unitary Development Plan (2006);

Hartwell Conservation Area Appraisal, Aylesbury Vale District Council (September 2008);

Quainton Conservation Area Appraisal, Aylesbury Vale District Council (December 2008);

Chetwode Conservation Area Appraisal, Aylesbury Vale District Council (February 2008);

Turweston Conservation Area Appraisal, Aylesbury Vale District Council (February 2008);

West Northamptonshire Joint Core Strategy, Issues and Options, West Northamptonshire Joint Planning Unit (September 2007);

Emergent Joint Core Strategy Final Exhibition Event Boards, West Northamptonshire Joint Planning Unit (August 2009);

Stoneleigh Conservation Area Leaflet, Warwick District Council (no date);

Norton Lindsey Conservation Area Leaflet, Warwick District Council (no date);

Coventry Development Plan, Core Strategy Proposed Submission, Coventry City Council (March 2009);

The Birmingham Unitary Development Plan and Proposals Map, Birmingham City Council (September 2005);

Warwick Bar Conservation Area Character Appraisal and Supplementary Planning Policies, Birmingham City Council (March 2008);

Digbeth, Deritend and Bordesley High Streets (Digbeth/Deritend) Conservation Area Character Appraisal and Supplementary Planning, Birmingham City Council (March 2009);

London View Management Framework (July 2007);

Draft Revised Supplementary Planning Guidance London View Management Framework, The London Plan (Spatial Development Strategy for Greater London) published for public consultation (May 2009);

King's Cross Central Environmental Statement Volume 1: Main Report, Parts 1 to 8, Prepared for Argent St George, London and Continental Railways and Exel (May 2004);

King's Cross Central Environmental Statement VOLUME 2: Specialist Reports, Part 9 Cultural Heritage and Townscape Specialist Report and Part 10 Archaeology Specialist Report, Prepared for Argent St George, London and Continental Railways and Exel (May 2004);

King's Cross Central Environmental Statement Volume 5: Supplement, Prepared by: RPS Planning Transport & Environment (September 2005);

King's Cross Central Heritage Baseline Study Part 4 Views, Argent St George, LCR and Exel (April 2004);

King's Cross Conservation Area Statement 22, London Borough of Camden (June 2004);

King's Cross Opportunity Area Planning & Development Brief, London Borough of Camden (January 2004);

Dacorum Urban Design Assessment, Kings Langley, Dacorum Borough Council (January 2006);

Whaddon Conservation Area Appraisal, Aylesbury Vale District Council (February 2007);

The Birmingham Big City Plan, Birmingham City Council (2009);

Haddenham Conservation Area, Aylesbury Vale District Council (2008);

Fritwell Conservation Area Appraisal, Cherwell District Council (January 2008);

Cherwell Local Development Framework - Options for Growth, Cherwell District Council (September 2008);

Newton Longville Conservation Area Appraisal, Aylesbury Vale District Council (2006);

Ilmer Conservation Area Character Survey, Wycombe District Council (1996);

Turville Conservation Area Character Survey, Wycombe District Council (1995);

Knowle Conservation Area Appraisal, Solihull Metropolitan Borough Council (September 2007);

Draft Conservation Area Appraisal for Chesterton, Cherwell District Council (2007).

Other information

Local Planning Authority websites;

Local Plan Proposals Maps (viewed on specific Local Authority websites);

Ground level, aerial and oblique photographs (<http://www.bing.com/maps/>).

ANNEX C – Summary of Landscape Character Areas Crossed

Inner London

Inner London lies on the banks of the Thames where the river valley widens out into a broad floodplain.

Alluvial gravels overlie the heavy London clay, and rise in gentle steps to form river terraces to the north and south.

In places, sand and gravel glacial deposits form more noticeable low hills, as at Hampstead.

The gently terraced landform is almost completely obscured by the dense urban development.

The central area of London comprises broad formal streets, lined by stone and brick buildings, with narrow streets in the commercial centre and planned layouts of streets and squares in the west end.

Surrounding the centre are extensive housing areas, of lines of terrace houses, blocks of flats or estates of semi-detached dwellings, focused around local shopping centres, offices and small manufacturing works.

Northern Thames Basin

A diverse landscape with a series of broad valleys containing the major rivers Ver, Colne and Lea and extensive areas of broadleaved woodlands being the principal features of the area.

The landform is varied with a wide plateau divided by the valleys.

Hertfordshire's large towns, the M25 and M1 motorways, railway line and prominent electricity pylons are also a major influence on character.

Floodplain land is commonly arable sub-divided by hedgerow-deficient field boundaries.

Open grazing land remains in certain areas.

Many river valleys have been extensively modified by reservoirs, current and reclaimed gravel pits, landfill sites, artificial wetlands, river realignments and canals.

Smaller, intimate tree-lined valleys supporting red brick villages provide a contrast to the more heavily developed major river valley floodplains.

Within these river valleys, organic field shapes are common, defined by water courses and the legacy of woodland clearances rather than formal enclosure patterns.

Broader plateau areas are mainly in agricultural use, with field patterns exhibiting the regular shape characteristic of 18th century enclosures.

Thames Valley

Hydrological floodplain of the river Thames as a landscape feature provides unity to the large areas of fragmented poor agricultural land.

The western Thames valley is wide and flat with the river barely discernible, occupying only a small part of the wider geological floodplain.

Woodlands characterise the north-western area, with the wooded character extending up to the southern edge of the Chiltern Hills.

To the south, the open Thames floodplain dominates with its associated flat grazing land, becoming characterised by a number of formal historic landscapes on higher ground such as Windsor Park.

Towards London in the east, the natural character of the area is overtaken by urban influences; a dense network of roads including the M25 corridor, Heathrow Airport, railway lines, golf courses, pylon lines, reservoirs, extensive mineral extraction and numerous flooded gravel pits.

Chilterns

Chalk hills and plateau with a prominent escarpment in many places, and extensive dip slope with numerous dry valleys.

Remnants of chalk downland on the escarpment and valley sides. Extensive areas of downland invaded by scrub.

The most extensive areas of beech woodland in the country on the plateau, and 'hanging' woodlands in the valleys.

Enclosed and intimate landscapes of the valleys contrasting with the more open plateau top and extensive views from the scarp to the clay vale below.

Small fields and dense network of ancient hedges, often on steep ground. The agricultural landscape often dominated by hedges, trees and small woodlands.

Many surviving areas of semi-open common land on the plateau.

Scattered villages and farmsteads, some of medieval origin, displaying consistent use of traditional building materials including flint, brick, and clay tiles.

Network of ancient green lanes and tracks including the Ridgeway which links numerous archaeological sites and settlements.

Frequent grand country houses and designed landscapes occupying prominent positions on sloping valley sides.

Upper Thames Clay Vales

Broad belt of open, gently undulating lowland farmland on Upper Jurassic clays containing a variety of contrasting landscapes. Includes the enclosed pastures of the claylands and the wet valley bottoms and the more settled open arable lands of the gravel.

The valley bottoms, with open floodplain landscapes displaying gravel workings and flooded pits, a regular and well-ordered field pattern, willow pollards and reedbeds along the water courses.

The Vales in Oxfordshire are dominated by 18th century enclosure landscapes of small woods and hawthorn/blackthorn hedges. Former and current gravel workings along the Thames floodplain also include open water features. The distinctive character of Otmoor with its patchwork pattern of small fields defined by healthy hedgerows of elm add interest and variety to this area.

In Buckinghamshire, the Vale is a predominantly pastoral landscape including regular fields within a well-defined network of trimmed hedgerows often with oak/ash hedgerow trees and some small blocks of woodland.

Brick-built buildings within the Vales reflect the widespread use of the local clay as a building material.

Midvale Ridge

Low irregular wooded limestone ridge giving way to a series of isolated steep-sided tabular hills in the east which rise from the surrounding clay vales.

Large geometrically spaced fields divided by regular pattern of hedgerows and trees supporting both arable and pastoral farming.

Villages, typically built of local limestone, perched high up on spurs, hilltops and along ridges giving extensive views across the open, gently undulating, clay vales to the north and south.

Visible archaeology dating from early Roman settlement of the area found on prominent areas of higher ground.

Spring-line settlements associated with blocks of ancient woodland along the ridge.

Contrast between the moderately elevated limestone hills and ridges and the surrounding low-lying clay vales.

Bedfordshire and Cambridgeshire Claylands

Gently undulating topography and plateau areas, divided by broad shallow valleys.

Predominantly an open and intensive arable landscape. Fields bounded by either open ditches or sparse closely trimmed hedges both containing variable number and quality of hedgerow trees.

River corridors of Great Ouse and Ivel compose cohesive sub-areas characterised by flood plain grassland, riverine willows and larger hedges.

Woodland cover variable. Clusters of ancient deciduous woods on higher plateau area to north-west between Salcey and Grafham Water. Smaller plantations and secondary woodland within river valleys.

Settlement pattern clusters around major road and rail corridors (A1 and M1) many with raw built edges. Smaller, dispersed settlements elsewhere. Village edge grasslands an important feature.

Generally a diversity of building materials, including brick, thatch and stone. Limestone villages on the upper Great Ouse.

Man-made reservoir at Grafham Water. Restored gravel working lakes adjacent to river Ouse, and water-bodies in Marston Vale resulting from clay extraction.

Brickfields of Marston Vale and Peterborough form a major industrial landscape. Mixed extraction, dereliction and landfill.

Medieval earthworks including deserted villages the major feature of visible archaeology.

Cotswolds

Defined by its underlying geology: a dramatic scarp rising above adjacent lowlands with steep combs, scarp foot villages and beech woodlands.

Rolling, open, high wold plateaux moulded by physical and human influences, with arable and large blocks of woodland, divided up by small, narrow valleys.

Incised landscapes with deep wide valleys.

Flat, open dip slope landscape with extensive arable farmland.

Prominent outliers within the lowlands.

Honey-coloured Cotswold stone in walls, houses and churches.

Attractive stone villages with a unity of design and materials.

Yardley-Whittlewood Ridge

Broad plateau with shallow soils elevated above adjacent vales.

A strong historic landscape character, largely due to the continued presence of extensive areas of ancient woodland.

Mixed land uses of pasture, arable and woodland.

Generally medium-sized fields with full hedges and hedgerow trees, mainly oak.

Low density of settlement and consequently few local roads; cut through by major north-south canal, rail and road routes.

Northamptonshire Uplands

Rounded, undulating hills with many long, low ridgelines.

Abundant and prominent ridge and furrow with frequent deserted and shrunken settlements.

Sparse settlement of nucleated villages on hilltops or valley heads.

Mixed farming: open arable contrasts with pasture enclosed by good hedges with frequent hedgerow trees.

Wide views from the edges and across the ridgetops.

Straight, wide, enclosure roads, often following ridges.

Little woodland, but prominent coverts on higher ground.

Ironstone and limestone older buildings with a transition across the area. Brick buildings in some villages.

Great variety of landform with distinctive local features like Hemplow Hills.

Large and nationally-important historic parks.

Northamptonshire and Leicestershire Vales

Gentle clay ridges and valleys with little woodland and strong patterns of Tudor and parliamentary enclosure.

Distinctive river valleys of Soar, Welland and Nene with flat floodplains and gravel terraces.

Large towns of Leicester and Northampton dominate much of the landscape.

Frequent small towns and large villages, often characterised by red brick buildings.

Prominent parks and country houses.

Frequent imposing, spired churches.

Attractive stone buildings in older village centres and eastern towns and villages.

Great diversity of landscape and settlement pattern with many sub units, e.g. Nene Valley and Welland Valley.

Dunsmore and Feldon

Farmland with large geometric fields divided by straight hedges with many hedgerow trees.

Generally well-wooded appearance but also extensive open arable farmland.

Heathland character still evident in woodland clearings and roadsides.

Plateau landscape of open, flat, rather empty character, with long views.

Plateau fringes more enclosed, with rolling landform and woodland more dominant.

Large ancient woodlands of high nature-conservation value in the west.

Strong urban influence in some areas.

Arden

Well-wooded farmland landscape with rolling landform.

Ancient landscape pattern of small fields, winding lanes and dispersed, isolated hamlets.

Contrasting patterns of well-hedged, irregular fields and small woodlands interspersed with larger semi-regular fields on former deer parks and estates, and a geometric pattern on former commons.

Numerous areas of former wood-pasture with large, old, oak trees, often associated with heathland remnants.

Narrow, meandering river valleys with long river meadows.

North-eastern industrial area based around former Warwickshire coalfield, with distinctive colliery settlements.

North-western area dominated by urban development and associated urban edge landscapes.

ANNEX D – Conservation Areas: Historic Importance

Introduction

- 4.6.5. Conservation Areas have been identified within the physical impact corridor and the 350m buffer area along the line of route for the proposed route although these have been identified in the AoS Frameworks (Volume 2). More detail have been provided on Conservation Areas impacted at station locations below.

Euston station and throat

- 4.6.6. The Euston Station and throat area is bounded by three Conservation Areas designated by LB Camden.

Bloomsbury Conservation Area

- 4.6.7. The boundary of Bloomsbury Conservation Area runs along the southern edge of the forecourt of Euston Station. In general, the buildings along Euston Road have an architecturally classical theme and the majority were constructed in first half of the 20th century.
- 4.6.8. On the north side of the road, the Fire Station (Grade II listed) is part of a group with the four storey bow-fronted houses to the north which are the only remaining indication of the domestic scale of the earlier buildings surrounding Euston Square.
- 4.6.9. Euston Square was part of the planned development of the Bloomsbury area in the 18th and 19th centuries. It was originally a large square bisected by Euston Road. The square is predominantly grassed with mature trees and railings defining the frontage, and subdivided by a central access to the station. The Grade II listed Portland stone lodges flanking the central access are the sole remnants of the Victorian station buildings. The 1921 War Memorial in front of the station is listed, as are the statue of Robert Stephenson in Euston Station forecourt; the railings along Euston Square Gardens, and 163-203 Eversholt Street; All are Grade II listed.
- 4.6.10. Nos.194-200 Euston Road and Nos.1-9 Melton Street, on the north side of Euston Road, and the Wellcome Institute, on the south side, form a group of classically-styled Portland stone buildings. 194a Euston Road (Dept of Health and Social Security and attached railings; EH ref: 477509) is Grade II* listed, whilst the attached building No 9 Melton Street and attached railings (EH ref: 477510) is Grade II listed. 194a Euston Road was built in 1906-8 by Arthur Beresford Pite for the London, Edinburgh and Glasgow Assurance Company which was connected with the Trade Union movement and provided insurance to the working classes. No. 9 is an office block extension, slightly lower in height to 194a Euston Road. It was built in 1932 by Josiah Gunton. Both buildings were formerly listed as one structure known as 30 Euston Square, the last amendment to the listing description for No. 9 Melton Street being in 1999.
- 4.6.11. Opposite Euston Square on the south side of Euston Road is the Grade II listed Friends House and Nos.161-167 Euston Road (not listed), both of Portland stone and brick.

Camden Town Conservation Area

- 4.6.12. Camden Town Conservation Area lies on the eastern side of the existing line between the station platforms and the start of the existing tunnel. The residential parts of the Conservation Area adjacent to the line were laid out between 1820 and 1850. This part of the Conservation Area comprises long residential terraces running in a north-south direction on a planned rectilinear grid (Mornington Terrace, Albert Street and Arlington Road) intersected by shorter terraces (Delancey Street and Mornington Street). The area contains a large number of good examples of early/mid 19th-century terraced houses,

generally of a uniform appearance, and many statutorily listed. The rectilinear pattern is broken to the south by Mornington Crescent which was developed as a formal piece of early 19th-century town planning, comprising three curved terraces of sizeable townhouses grouped in a crescent around communal gardens, with views across open country to the front and rear. The large Greater London House (originally the Carreras Tobacco Factory) was erected on the site of the gardens in the 1920s. Adjoining the southernmost terrace of Mornington Crescent are No's 261-263 Hampstead Road, the only remaining houses of a terrace c. 1830, shortened by the widening of the railway cutting.

Regents Park Conservation Area

4.6.13. Regents Park Conservation Area lies to the west of the lines before they go into tunnel. Its boundary is on the western side of Park Village East, north of no. 36. The Conservation Area is characterised by detached villas, designed by John Nash, built in neoclassical and gothic styles set in landscaped gardens. These villas are Grade II listed. A pair of stone piers with lamp standards at the western end of Mornington Street Railway Bridge are also Grade II listed.

St James Gardens and Euston Square

4.6.14. While St James Gardens and Euston Square are not formally designated as Conservation Areas, St James Gardens, to the west of Euston station, is the former burial ground of St James church. It contains three listed structures: a monument to the Christie family, an Obelisk to Baron Southampton and a drinking fountain.

4.6.15. The new design of Euston Station would bring about a significant change to the setting of Euston Square and surrounding parts of Bloomsbury Conservation Area. The scheme may require the re-siting of a small number of listed statues/railings. The physical impacts on the Grade II Listed Buildings No 9 Melton Street and No's 14/15 Melton Street require careful consideration and further assessment, as does the proposal to preserve the Grade II* 194a Euston Road in isolation from 9 Melton Street. There would be a physical impact on structures within the Conservation Area adjacent to 194a Euston Road. The only potential physical impacts on Camden Town and Regents Park Conservation Areas would come from construction activities and non-physical impacts from any enhanced levels of noise and vibration generated by the scheme. It is proposed that replacement open space to compensate for the partial loss of St James Gardens would be provided at a new site above the station concourse and the three Grade II Listed Monuments currently located within St James Gardens would be relocated there.

Curzon Street station and throat

4.6.16. Curzon Street station lies on opposite side of railway tracks to the two Conservation Areas of Warwick Bar and Digbeth/Deritend designated by Birmingham City Council. A small strip of land within the Warwick Bar Conservation Area crosses the line to the east of the platforms and is therefore slightly impinged upon by the construction area.

Warwick Bar

4.6.17. Most of the Conservation Area was undeveloped until the construction of the Digbeth Branch Canal (1790) and the Warwick and Birmingham Canal (1799) triggered development which included houses and industrial works laid out on a grid of new streets. By the mid 19th century high density housing was interspersed with industrial works and infrastructure.

4.6.18. The railway from Manchester and Liverpool reached Birmingham in 1837 and that from London in 1838. The two lines terminated in a shared station at Curzon Street (the extant Goods Office is Grade I listed). The project involved the construction of a substantial bridge (Curzon Street Railway Bridge; Grade II listed) across the Digbeth Branch Canal. The line from Oxford was completed in 1848 and work was started on a viaduct (unfinished) from

Bordesley Station to the proposed junction. The opening of New Street Station in 1854 required a second bridge over the Digbeth Branch Canal, to the south of Curzon Street Railway Bridge. New lines were taken into Curzon Street for the Midlands Railway in 1851 on a southern extension of Curzon Street Railway Bridge.

- 4.6.19. The built character of the Conservation Area is defined through a range of warehouses and purpose-built manufactories dating from the mid 19th to the mid 20th century. The Gun Barrel Proof House (built 1813 with later additions; Grade II* listed), set slightly apart on Banbury Street, is the sole example of an early 19th-century works.
- 4.6.20. In addition to statutory listed structures, the Conservation Area also contains a number of locally listed structures. Locally listed structures are defined as being of Low Cultural Heritage Value in this assessment. No locally listed structures would be physically impacted upon by the scheme.

Digbeth/Deritend

- 4.6.21. A small amount of pottery was recovered during excavations at Park Street and Moor Street, indicating the possible presence of a Roman farmstead at the west end of the Conservation Area.
- 4.6.22. Moor Street Station was opened in 1906 to take extra traffic and relieve the pressure on Snow Hill Station when a line was opened to Stratford. The viaduct across the Rea valley was widened in 1910. The station buildings were constructed from 1911 to 1916 with warehousing and stabling beneath the platforms and large warehouses nearby. Moor Street station was closed in 1986 but has been refurbished and the buildings reopened in 2002-2003. The built character of the Conservation Area encompasses a variety of building types which date mostly from the mid-19th to the mid-20th century.
- 4.6.23. In addition to listed structures, the Conservation Area also contains a number of locally listed structures. None of these structures would be physically impacted by the scheme.
- 4.6.24. Overall the scheme would have a negative visual impact on the historic fabric of the two Conservation Areas, although to a lesser degree than the Warwick Wharf station option. There is conceivably a physical impact on the 1838 railway bridge (Grade II listed) within the Warwick Bar Conservation Area.

ANNEX E – Historic Landscape Descriptions by Countryside Character Areas

4.6.25. The following section discusses the visible historic landscape character within the Natural England (NE) Countryside Character Areas (CCA) crossed by the proposed route. Area reference numbers, as defined by Natural England, are provided for each Character Area.

Cannock Chase and Cank Wood (Area 67)

4.6.26. Historic time depth is readily visible in the current landscape of this area, although the proposed route does not cross a significant historic element, Cannock Chase, or the historic area of industrial activity to the south relating to the South Staffordshire Coalfield. The Berkswell Station to WCML (Lichfield) section of the proposed route crosses land more agricultural in character, with large arable fields resulting from the removal of hedgerows, although its heathland origins are visible in vegetation in the hedgerows and small woodlands.

Trent Valley Washlands (Area 69)

4.6.27. Modern development is now a large part of the historic landscape of this CCA, including recently-restored gravel pits in the Tame valley and major transport routes. The establishment of the transport network of railways and canals and the proximity of coal sources led to the growth of textile and engineering industry in these areas. In the 20th century, the availability of water and coal led to the construction of coal-fired power stations in the CCA. The line of the proposed route (Berkswell Station to WCML), and part of the Birmingham Spur) would cross the south-westernmost part of this CCA.

Arden (Area 97)

4.6.28. The main character of this area is of a small-scale landscape of low, rounded hills, but the historic landscape pattern is a mixture of enclosed river valleys, wooded landscapes, small hedged fields and former industrial landscapes. The area was historically a region of woodlands and heaths: Extensive woodland cover probably was present until the Anglo-Saxon period, and much woodland remains. Many commons were wooded and were previously wood-pasture. Many deer parks were established in the medieval period, and the proposed route (Brackley to Kenilworth/Coventry Gap) passes through an area with a distinctively parkland character, including Stoneleigh Abbey Grade II* Registered Park. Birmingham developed from a medieval centre of industry, with suburbs following the arrival of the railways, and growth continuing through the 20th-century.

4.6.29. Several elements of the proposed route (the Birmingham Spur; the Birmingham Interchange Station; the Kenilworth/Coventry Gap Berkswell Station; rolling stock Depot (Washwood Heath); Curzon Street Station and Approach; Warwick Wharf Station and Approach; Brackley to Kenilworth/Coventry Gap), pass through this CCA, mainly in the area between Coventry and Birmingham, as well as extending into the central area of Birmingham. As the route crosses Stoneleigh Abbey Park without passing through a tunnel (passing through a cutting in the central area and over viaducts at the edges of the park), it would impact upon a historic landscape of national importance.

Dunsmore and Feldon (Area 96)

4.6.30. Dunsmore and Feldon is a transitional area between more distinctive character areas. It is primarily a late, formally enclosed landscape of large geometric fields, many of which originated from the enclosure of former heathland, and small villages. Woodlands, including ancient woodland areas, are common. The line of the proposed route (Brackley to Kenilworth/Coventry Gap) crosses the central northern area of this CCA.

Northamptonshire Uplands (Area 95)

4.6.31. This area comprises a long range of clay hills, which in the southern area where the proposed route (Brackley to Kenilworth/Coventry Gap) crosses is undulating in nature. Here, the fields are small and settlements frequent. Time depth is visible in the historic landscape through the survival of ridge and furrow and deserted medieval settlement earthworks. Large manor houses within formal parkland and extensive estates are also present, resulting from the accumulation of large areas of land for grazing following the depopulation that resulted in the abandonment of the villages. However, no Registered Parks and Gardens are crossed by the proposed route. The field pattern predominantly reflects parliamentary enclosure, with a rectilinear pattern and wide, straight enclosure roads. This is potentially an area of historic landscape of national importance which would be impacted upon by the proposed route (Brackley to Kenilworth/Coventry Gap). Further assessment of historic landscape character data for this area would be necessary to refine the assessment of impact.

Yardley-Whittlewood Ridge (Area 95)

4.6.32. This area is predominantly agricultural in character, although the thin soils have constrained development resulting in the survival of some historic woodland. A number of historic parks are present and the Grand Union Canal crosses the area. The line of the proposed route (comprising part of Brackley to Kenilworth/Coventry Gap) crosses a very small area of this CCA.

The Cotswolds (Area 107)

4.6.33. The Cotswolds have significant visible time depth in the historic landscape, ranging from extant prehistoric monuments, large estates created after the dissolution of the monasteries, and evidence of the cloth industry. However, the proposed route (comprising part of Brackley to Kenilworth/Coventry Gap) only just encroaches into this area, on the outskirts of Brackley.

Bedfordshire and Cambridgeshire Claylands (Area 88)

4.6.34. This is an area of predominantly open and intensive arable landscape, with time depth visible through moated sites, deserted medieval villages and ruined and isolated churches. The clay geology resulted in the area being exploited for brick production in the 20th century, and airfields were sited on the plateaux of the area in the Second World War. The proposed route (comprising part of Brackley to Kenilworth/Coventry Gap and part of Aylesbury to Brackley) crosses a very small area at the extreme west of this area.

Upper Thames Clay Vales (Area 108)

4.6.35. The Vale of Buckinghamshire, which the proposed route (Aylesbury to Brackley and Colne Valley Junction to Aylesbury) crosses, is predominantly pastoral, with regular fields within hedgerows, and small blocks of woodland. The straight-sided fields of the vales are typical of a planned countryside. The settlement pattern was historically sparse, compared to the Upper Thames Valley. Evidence of ancient settlement sites more commonly occurs on the gravel terraces in river valleys. The Vale of Aylesbury, through which the proposed route also passes, has a geometric field pattern of formal parliamentary enclosure, with sizeable farms set amongst large hedged fields. Roman road lines are still visible in the modern network. Deserted medieval villages frequently occur in this area. Formal landscapes are also present, including Hartwell House Grade II* Registered Garden, which the proposed route crosses (Colne Valley Junction to Aylesbury) in a cutting and across a viaduct, and Waddesdon Manor Grade I Registered Park (Aylesbury to Brackley), to which the proposed route passes close. Hence, the proposed route would impact upon historic landscapes of national importance.

Midvale Ridge (Area 109)

4.6.36. The characteristic field pattern of this area is geometrically shaped with a regular pattern of hedgerows and trees. Field sizes in the eastern area, through which the proposed route (Aylesbury to Brackley) passes were generally smaller than in the western area. Reference is made in the Domesday Book to the good cover of forests in the area but the eastern area of the ridge, on Portland Limestone, has fewer large woods.

The Chilterns (Area 110)

4.6.37. The area of the Chilterns comprises the chalk hills and plateau, with a prominent escarpment in many places. Significant historic time depth is visible in the current landscape. The Ickneild Way, which was in use in the Bronze Age, runs along the scarp of the Chilterns, and is associated with still-visible burial mounds. The Iron Age is represented by hillfort earthworks and dykes along the scarp. Many towns and roads in this area are of Roman origin, and the area was used for agriculture and charcoal production. Farming returned to subsistence in the Saxon period, and marginal fields on the plateau were abandoned, and woodland cover increased, and remains high today. Towns and villages of medieval origin are found throughout the Chilterns, with the oldest located in valleys with reliable water supplies. As the population increased, pressure on land led to an expansion in agriculture, shown by the creation of strip lynchets on steeper slopes. New farms and settlements were established on the plateau. Designed parklands and large gardens associated with historic houses are characteristic of the area. Large scale development has taken place along major road and rail corridors in the 20th-century.

4.6.38. The proposed route (Colne Valley to Aylesbury) crosses the south-eastern part of the area in two tunnels, but would cross Shardeloes Grade II* Registered Park in a cutting between these. The Chilterns is considered to be a historic landscape of potentially national importance that would be impacted upon by the proposed route. Consideration of historic landscape characterisation data would refine the assessment of impact upon the Chilterns.

Thames Valley (Area 115)

4.6.39. The eastern part of this area has a strong urban character, having been altered by the spread of outer London over the last century. The field pattern was previously regular and suggestive of later enclosure. More recent, highly-visible elements of the modern landscape include transport links, golf courses, reservoirs, mineral workings and flooded former gravel pits. The proposed route (Colne Valley Junction to Aylesbury and Old Oak Common to Colne Valley Junction) crosses the north-eastern part of this CCA.

Northern Thames Basin (Area 111)

4.6.40. Although the proposed route (Old Oak Common to Colne Valley Junction) passes through the south-easternmost area of this CCA, it would lie within the suburbs of London including Northolt and Perivale. Hence, the area has a strongly urban character.

Inner London (Area 112)

4.6.41. Significant time depth is obviously visible in Inner London. The proposed route runs in a tunnel through central London (in tunnel from Euston Station to Old Oak Common), although open construction works would occur at Euston Station (and throat). Before there it would run through suburbs (Old Oak Common Box to Colne Valley Junction, and Old Oak Common Box and Station), along an existing transport corridor. The tunnel would pass under Kensal Green Grade II* Registered Cemetery.

Appendix 5.2 Biodiversity

Biodiversity

1. Introduction

1.1. Scope of appraisal

- 1.1.1. The Ecology Consultancy was commissioned to assist Booz-Temple in undertaking an appraisal of sustainability (AoS) of a proposed new high speed railway termed High Speed Two (HS2) between London the West Midlands. ECL carried out the appraisal of the ecological resources present in the areas through which the route alternatives passed and assisted with the sifting of options from which the proposed route and main alternatives were identified. Further assessment of this alternative was then carried out. This appendix describes the methods applied for the input on ecological matters to the AoS.
- 1.1.2. As the proposals are at present strategic in nature, consideration was given to the national and regional characteristics and potential impacts of the route proposals on the landscape, townscape and heritage resources.
- 1.1.3. A separate screening report to determine the need for Appropriate Assessment of impacts on European sites is presented at Appendix 4 – the HRA Screening Report.

1.2. Methodology

- 1.2.1. The Ecology Consultancy assessed the ecological features along the route, describing the key features of national and regional importance that could potentially be affected by the presence of the proposed route. The appraisal was broadly based upon WebTAG, the Department for Transport's Guidance for appraising transport projects and in particular, the methodologies provided in TAG Unit 3.3.10 *Biodiversity Sub-objective* & TAG Unit 3.3.6.
- 1.2.2. The appraisal was commensurate with the strategic nature of the proposals, the route length and the extent of information available to undertake the appraisal. The appraisal was undertaken largely from GIS data, plan and written information at this stage as it was unfeasible to conduct detailed site visits along each line section. The specific method relating to each environmental element is described in the sections below.

2. Approach to Assessment

In carrying out this assessment the following types of sites were considered:

- European Sites – SPA, SAC, Ramsar;
- National Sites – NNR, SSSI; and
- Regional Sites – LNR, BAP, ancient woodlands, SNCIs, natural areas.

2.1. European sites

Special Areas of Conservation, Special Protection Areas

- 2.1.1. Sites of European importance for nature conservation (referred to collectively as Natura 2000 Sites) within 10 kilometres⁵ of any route segment were identified using Proximity Analysis in Arc GIS. A total of eleven sites were identified of which nine (9) were Special Areas of Conservation (SACs) and two (2) were Special Protection Areas (SPAs)/Ramsar Sites.

⁵ The rationale for this is described in the HRA Screening Report, Appendix 7-1.

- 2.1.2. SACs are strictly protected sites designated under the EC Directive 92/43/EC on the conservation of natural habitats and wild fauna and flora (the EU “Habitats Directive”) as areas identified as best representing the range and variety of habitats and (non-bird) species listed in Annexes I and II. Article 3 of the Habitats Directive requires the establishment of a European network of important high-quality conservation sites that would make a significant contribution to conserving the 189 habitat types and 788 species identified in Annexes I and II of the Directive (as amended). The listed habitat types and species are those considered to be most in need of conservation at a European level (excluding birds).
- 2.1.3. SPAs are strictly protected sites classified in accordance with Article 4 of the EC Directive 79/409/EEC on the conservation of wild birds (the EU “Birds Directive”), which came into force in April 1979. They are classified for rare and vulnerable birds (as listed on Annex I of the Directive), and for regularly occurring migratory species.

Ramsar

- 2.1.4. Ramsar sites are designated under the Convention on Wetlands of International Importance, developed and adopted by participating nations at a meeting in Ramsar on February 2 1971, coming into force on December 21 1975. It now includes 1,847 sites covering around 1,810,000 km², up from 1,021 sites in 2000. The nation with the highest number of sites is the United Kingdom at 166.

2.2. National sites

National Nature Reserves (NNR)

- 2.2.1. NNRs were initially established to protect sensitive features and to provide ‘outdoor laboratories’ for research. Their purpose has widened since those early days. As well as managing some of our most pristine habitats, they contain examples of some of the most important natural and semi-natural terrestrial and coastal ecosystems, our rarest species and our most significant geology in Great Britain. Most NNRs now offer great opportunities to the public as well as schools and specialist audiences to experience England’s natural heritage. Natural England is the body empowered to declare NNRs in England, with the NNRs being a selection of the very best parts of England’s Sites of Special Scientific Interest. It is this underlying designation which gives NNRs their strong legal protection. The majority also have European nature conservation designations. They are protected through the same legislation as SSSIs (below). There were five NNRs within 2.5km of the routes considered after Gate 3.

Sites of Special Scientific Interest (SSSI)

- 2.2.2. SSSI’s are legally protected from damaging development on account of its flora, fauna, geological and/or physiological features under the Wildlife and Countryside Act 1981, as amended by the Countryside and Rights of Way (CROW) Act 2000 and the Natural Environment and Rural Communities (NERC) Act 2006. This legislation gives Natural England powers to ensure better protection and management of SSSIs and safeguard their existence into the future. The Government's Public Service Agreement target is for 95% of SSSI land to be in ‘favourable’ or ‘recovering’ condition by 2010. These sites are also used to underpin other national and international nature conservation designations.

2.3. Regional and local sites

Local Nature Reserves (LNR)

- 2.3.1. A Local Nature Reserve or LNR is a statutory designation made under Section 21 of the National Parks and Access to the Countryside Act 1949 by principal local authorities in England, Scotland and Wales.

- 2.3.2. LNRs are of local, but not necessarily national, importance. LNRs are almost always owned by local authorities, who often pass the management of the LNR onto County Wildlife trusts or other local environmental bodies. LNRs also often have good public access and facilities. An LNR may be given protection through design and construction controls. It also has certain protection against development on and around it. This protection is usually given via the Local Plan, (produced by the planning authority), and often supplemented by local by-laws. However there is no national legal protection specifically for LNRs.

Biodiversity Action Plan (BAP) habitats and species

- 2.3.3. The UK Biodiversity Action Plan, published in 1994, was the UK Government's response to signing the Convention on Biological Diversity (CBD) at the 1992 Rio Earth Summit. The plan set out a programme for conserving the UK's biodiversity. It also led to the production of 436 action plans between 1995 and 1999 to help many of the UK's most threatened species and habitats to recover. A review of the UK BAP priority list in 2007 led to the identification of 1,150 species and 65 habitats that meet the BAP criteria at UK level. BAP habitats (and species) are protected through their inclusion as habitats of principal importance for the conservation of biodiversity in England. The list of habitats are used to guide decision-makers such as public bodies, including local and regional authorities, in implementing their duties under section 40 of the Natural Environment and Rural Communities Act 2006, to have regard to the conservation of biodiversity in England, when carrying out their normal functions.
- 2.3.4. The national GIS data set for BAP habitats covers a proportion of the habitats covered in the UK BAP as a whole.

Ancient Woodland

- 2.3.5. Ancient woodland is usually described as that which has been in existence since 1600. It is an important and effectively irreplaceable wildlife habitat. Ancient woodland is specifically mentioned in Planning Policy Guidance 9 Biodiversity and Geological Conservation which states: *"Ancient woodland is a valuable biodiversity resource both for its diversity of species and for its longevity as woodland. Once lost, it cannot be recreated. Local planning authorities should identify any areas of ancient woodland in their areas that do not have statutory protection (e.g. as a SSSI). They should not grant planning permission for any development that would result in its loss or deterioration unless the need for, and benefits of, the development in that location outweigh the loss of the woodland habitat."*

Sites of Nature Conservation Importance, SNCIs

- 2.3.6. These sites are a non-statutory designation generally identified at the county or metropolitan level and according to locally developed criteria. They protect sites of significant ecological value that helps to maintain wildlife away from designated sites. Planning Policy Statement 9: Biodiversity and Geological Conservation provides a statement of national planning policy for biodiversity and geological conservation in England. It recognises that Local Sites have a fundamental role to play in helping to meet overall national biodiversity targets, contributing to the quality of life and the well-being of the community and in supporting research and education. It states that Local Development Frameworks should identify all local nature conservation areas on the proposals map.
- 2.3.7. For both London and Birmingham, the data covers different grades of sites. In London sites may be of Metropolitan, Borough (Grade I or II) or Local Importance, while in Birmingham there are Sites of Importance and Sites of Local Importance for Nature Conservation.

Natural Areas

- 2.3.8. Natural Area boundaries are based on the distribution of wildlife and natural features, and on the land use pattern and human history of each area. They therefore offer a more effective framework for the planning and achievement of nature conservation objectives

than do administrative boundaries. There are 120 designated terrestrial and marine Natural Areas in the UK, which describe the wildlife and natural features of each area, and what makes them distinctive. They are not designations rather a tool for landscape planning at the landscape level, and are of value in characterising the likely ecological interest of route options away from designated areas.

3. Data Sources

3.1. Mapped data

3.1.1. The GIS Digital Boundary Datasets held by Natural England are available for downloading via the Internet. These covers all the principal statutory terrestrial nature conservation in the UK as well as some relevant non-statutory data such as ancient woodland, Natural Areas and some Biodiversity Action Plan habitats. The data was down loaded from Natural England's website⁶ in September 2009 from. GIS data for SNCIs (where requested) was provided by local authorities or local biological records centres.

3.2. Citations

3.2.1. Information on statutory and non-statutory nature conservation sites was obtained from the following sources, most being accessed on a number of occasions between September and November 2009:

- Joint Nature Conservation Committee or information on European sites including candidate sites from: <http://www.jncc.gov.uk/page-4>. Information was updated on 31 August 2009 for all designations.
- Information on boundaries and citations for NNRs, SSSIs and was obtained from Nature on the Map hosted by the Natural England website at: <http://www.natureonthemap.org.uk/>.
- Information on citations for LNRs was obtained from the Natural England website: <http://www.english-nature.org.uk/Special/lnr/office.htm> and from local authority websites.
- Citations and boundaries for SNCIs in London was obtained from London Wildweb at: <http://wildweb.london.gov.uk/wildweb/Welcome.do>. Information on Birmingham sites was obtained from a general web search.
- Information on Natural Areas was obtained from the Natural England website at: <http://www.english-nature.org.uk/Science/natural/role.htm>.

4. Limitations

4.1.1. The appraisal was carried out at the strategic level and focused on sites of international, national and regional importance (and in some places where data was readily available, local importance) for which there is a complete data set, detailing the sites, their interest, condition and trends. The appraisal assessed the potential impacts of the proposed HS2 options on these sites at varying distances, with 10km selected for international sites and 2.5km for national sites, based on current guidance (e.g. Design Manual for Roads and Bridges 2009 <http://www.standardsforhighways.co.uk/dmrb/index.htm>). Direct effects such as habitat loss or habitat fragmentation were obvious in some respects. The prediction of indirect effects such as changes in ground water flows, population fragmentation, or the off-site effects of pollution could not be judged accurately based on the information provided. Rather, these impacts have been considered in terms of the risk of an effect. In order to

⁶ http://www.gis.naturalengland.org.uk/pubs/gis/GIS_register.asp

differentiate between different route options, the number of sites affected and the likely severity of effects (in very broad terms) were also considered.

- 4.1.2. With the exception of information on LNRs, the information on regional and local sites is not complete. Due to the level of the assessment, SNCIs were only considered for the London and Birmingham areas where there are too few sites with a higher level of designation to distinguish between quite similar route options. The available data provided a partial list of BAP habitats. While the available information is sufficient to carry out a strategic assessment it does not fully represent the ecological interest of the areas being considered but is considered appropriate at this stage of appraisal.

Appendix 5.3 Water and Flood Risk

Water and Flood Risk

1. Introduction

1.1.1. Water Environment Ltd were commissioned by Booz-Temple (on behalf of HS2 Ltd) to undertake the analysis for water-related categories of the Appraisal of Sustainability (AoS). The purpose of this study is to identify the likely impacts on surface and groundwater resources. The method is outlined below.

2. Approach to assessment

2.1.1. As a major transport and infrastructure project, the assessment has been carried out having cognisance of the Department for Transport's WebTAG methodology. This approach attempts to quantify both the strategic importance of a national resource and the severity of an impact on the resource in order to arrive at an overall assessment of the impact. WebTAG suggests that we should be considering the impacts of the scheme at an area level against identified environmental capital and other policy objectives; however the proposed route would involve:

- construction in Flood Zones 2, 3a and 3b, which could result in adverse flooding effects for neighbouring properties. This is in conflict with Environment Agency (EA) national objectives as stated in PPS25;
- some tunnelling and below-ground work within designated Source Protection Zones 1 and 2, which could have adverse effects on the productivity and quality of the aquifers. This is in conflict with EA national objectives to protect groundwater resources;
- tunnelling and cutting through high-yield, good-quality aquifers which are considered to be an important national resource (even if they are not designated Source Protection Zones), and this is in conflict with the objectives set out in the Water Framework Directive (WFD) which applies across the EU;
- crossing of rivers, which would lead to interference with the river corridor (and in some cases destruction) of riparian habitat with resulting adverse effects on riparian and water-based flora and fauna, and a corresponding adverse impact on the water quality as classified in the WFD;
- interfere with catchment hydrology by cutting off parts of the catchment and in some cases concentration of discharge to the water course at points upstream of the line which would result in a change in fluvial morphology and a possible increase in erosion of the catchment; and
- the construction of hard-standing areas and an increase in surface-water runoff volume resulting in heavier loads on the sewerage infrastructure and ultimately increased discharge to the rivers with resulting influences on flooding, erosion and water quality which is in conflict with the WFD and the EA national objectives.

As a result, this level of information is not useful for comparison of routes, even at the highest strategic level of assessment. It is therefore necessary to consider more specific issues and thereby to provide a means of measuring, and ultimately minimising the conflicts with the national and regional objectives identified above.

The water-related categories in the AoS were divided into the following issues:

- Issue 1 – Climatic factors and adaptability;
- Issue 6 – Water Resources; and
- Issue 7 – Flood Risk.

2.1.2. Each issue was then broken down into core sustainability objectives with associated evaluation criteria which could be measured for comparison between the routes and used to influence the evolving route options. The water-related issues, core sustainability objectives and evaluation criteria considered were:

Table 1 - Relevant objectives and evaluation criteria

Issue	Core Sustainability Objective	Evaluation Criteria
1. Climatic factors and adaptability	1a. Improve resilience of rail network against extreme weather events	Length of line at risk of flooding in Flood Zone 2 and 3, with focus on the land most likely to become impacted by flooding more frequently than 1 in 100 years as a result of climate change.
6. Water Resources	6a. Protect surface water resources	Impacts on river catchments. (Area of catchment upstream of river crossing points, Number of major river crossings, number of minor river crossings).
		Impacts on surface water bodies. (Number of major river diversions, number of minor river diversions, impacts on artificial water bodies, impacts on reservoirs).
	6b. Protect groundwater resources	Impacts on groundwater Source Protection Zones (SPZs). (Length of cut or tunnel through SPZ1 and/or SPZ2).
		Impacts on groundwater flow in strategic aquifers. (Length of cut or tunnel through aquifers classified as "good yield" and/or "good quality" under the WFD).
7. Flood Risk	7a. Conserve and enhance the capacity of floodplains	Extent of infrastructure within 1 in 100 year flood zones (Flood Zone 3)
		Extent of infrastructure within 1 in 1000 year flood zones (Flood Zone 2).

2.1.3. Evaluation criteria were based on the following way:

- 1a (i) Length of line at risk of flooding in Flood Zone 2. Measured as length (metres) of proposed line in Flood Zone 2; also identifies the length of scheme outside Flood Zone 3, but within Flood Zone 2;
- 6a (i) Impacts on river catchments. Measured as area of catchment (km²) upstream of river crossing points, number of major river crossings, number of minor river crossings;
- 6a (ii) Impacts on surface waterbodies. Measured as number of major river diversions, number of minor river diversions, impacts on artificial water bodies, impacts on reservoirs;
- 6b (i) Impacts on groundwater Source Protection Zones. Measured as length of cut (metres) or tunnel through SPZ1 and/or SPZ2;
- 6b (ii) Impacts on groundwater flow in strategic aquifers. Measured as length of cut (metres) or tunnel through aquifers classified as "good yield" and/or "good quality" under the WFD;
- 7a (i) Extent of infrastructure within 1 in 100 year flood zones. Measured as length of line (metres) in Flood Zone 3; and

- 7a (ii) Extent of infrastructure within 1 in 1000 year flood zones. Measured as length of line (metres) in Flood Zone 2.

2.2. Methods of measurement

2.2.1. For surface-water related criteria, the locations of all river crossings were identified by comparing the GIS centrelines provided by Arup with Ordnance Survey 1:25,000 raster mapping, and subsequently with the Environment Agency Detailed River Network (DRN) dataset (Release 1). The DRN components used were primary, secondary and tertiary river alignments, extended culverts, canals and underground rivers. WFD protections, along with ecological and chemical water quality status were added to the DRN dataset by cross-referencing the id with the WFD data provided by the Environment Agency (version 1). The following data were extracted for each crossing:

- Potential need for diversion: assessed by visual comparison of watercourse alignment with centreline and buffer;
- Length of line in flood zones: measured using MapINFO measurement tool as the centreline length crossing the GIS flood zone mapping provided by the Environment Agency;
- Catchment size: taken at location of centreline intersection, catchment sizes were extracted from the FEH CD-ROM version 2.0;
- Ecological quality, Chemical quality and WFD protections: taken as the cross-referenced WFD data attached to the watercourse at the crossing location;
- Crossing type: taken directly from vertical alignments provided by Arup; and
- Lakes, canals and other artificial waterbodies were identified using the Ordnance Survey raster mapping. Where available, WFD data was extracted from the EA dataset, however the majority of these waterbodies (with the exception of canals) are not large enough to be included in the dataset.

2.2.2. For groundwater related criteria, both Source Protection Zone (SPZ) and Strategic Aquifer datasets, the vertical alignment provided by Arup was used as the starting point. Source Protection Zone location data was provided in GIS format by the Environment Agency and lengths of line, along with the type of vertical alignment, in each SPZ was extracted by identifying the intersection points in the GIS. The same approach was applied to the Strategic Aquifer assessment, however the dataset used in this case was extracted from data obtained from the Environment Agency website. Since no shapefiles were available, the images downloaded from the EA website were scaled into MapINFO and the outlines traced. Consequently, there may be minor errors in the dataset as a result of tracing error and limitations of data resolution.

2.2.3. The abstraction dataset is based on the abstraction database provided by the Environment Agency. Further data on each relevant abstraction were obtained via radial searches undertaken by the Environment Agency. More detail on the hydrogeology such as the aquifer depth and depth to groundwater were manually extracted using the Hydrogeological map of the South West Chilterns obtained from the British Geological Survey (BGS). The resolution of the data and lack of available detail means that the hydrogeological data is an estimate, which would need to be confirmed by obtaining detailed borehole information from the BGS and/or Environment Agency.

3. Assumptions and Limitations

3.1. Issue 1 - Climatic factors and adaptability

Length of line at risk of flooding in Flood Zone 2

- 3.1.1. The adaptability to climatic factors is related to the length of line in the flood plain, although as a strategic infrastructure the final design would allow for rare flood events and current best-practice assumptions for climate change to ensure that the line remains unaffected by the 100-year flood, including an allowance for climate change for which flood zone 2 levels have been used as a proxy. Mitigation (and resilience to flooding) is achieved by design - subject to cost and other constraints. It is theoretically possible to virtually eliminate the risk of flooding through change in vertical alignment or tunnelling, although this is not always practical given other sustainability constraints. Practical considerations may be to allow sections of the line to flood for given flood events (for example, greater than a 100-year flood event plus a 20% allowance for Climate Change), but on critical sections where the consequences of flooding are particularly severe, to raise the standard of protection to reduce any residual risk to an acceptable level. A neutral evaluation has been assigned to this category in the AoS assessment since the measurement of track within the flood plain is repeated in the Flood Risk issue.

3.2. Issue 6 – Water resources

Impacts on river catchments

- 3.2.1. The impact on river catchment hydrology is assessed as area (km²) of diverted catchment runoff, which is assumed to be proportional to the measured area (km²) of catchment upstream of the proposed line, as well as the number of major river crossings and the number of minor river crossings. It is impractical to mitigate the effects on the catchment hydrology completely and it is inevitable that overland flow would be collected adjacent to the track by filter drain and piped to convenient crossing points such as culverts and bridges. This would have a local effect on river catchment hydrology, concentrating the rate of discharge into rivers at selected points (with a likely increase in erosion) and altering the characteristics of river morphology with a possible adverse effect on river quality. It is important to be aware of the current ecological and chemical status of the rivers for future design reasons. For the purposes of the AoS assessment, route sections which only cross minor rivers (catchments less than 50km²) are assigned a neutral evaluation since the effects would be only local, route sections which cross major rivers are assigned a minor negative evaluation due to the cumulative effects of diversions of minor tributaries.

Impacts on surface-water bodies

- 3.2.2. Diversion of any main river would have significant effects on river morphology and riparian habitat, and hence the quality of the river as specified in the WFD. Assuming crossings of artificial water bodies are constructed using responsible methods, they should not have a direct effect on the water resource; however they may adversely affect the use of these waterbodies for recreation. Crossing of a canal is not considered to be a significant impact provided that it does not interfere with the navigation of the canal. For the purposes of AoS assessment, diversion of a major river is assigned a major negative evaluation, diversion of a minor main river is assigned a minor negative evaluation and crossing of a lake or reservoir is assigned a minor negative evaluation.

Impacts on Groundwater Source Protection Zones (SPZ)

- 3.2.3. A significant proportion of the UK drinking water is obtained through the abstraction of ground water and this process is licensed by the Environment Agency. Each abstraction licence is associated with a corresponding SPZ to prevent pollution of the ground water

subject to abstraction. Cutting or tunnelling through source protection zones is likely to have significant detrimental effects on the quality of the water and on the flow within the aquifer. Where Source Protection Zones are affected, it would be necessary to employ specialised boring and construction techniques to minimise the risk of pollution and to mitigate the effects of obstructing the ground water flow regime. For the purposes of the AoS assessment, route sections which cut or tunnel through SPZ1 are assigned a major negative evaluation and routes which cut or tunnel through SPZ2 are assigned a minor negative evaluation.

Impacts on groundwater flow in Strategic Aquifers

- 3.2.4. The WFD classifies groundwater resources in terms of the potential yield of the aquifer and the chemical quality. In both cases, classifications are either good or poor. Aquifers of poor yield potential or poor chemical quality are unlikely to be of strategic importance as a water resource, however if the aquifer can provide large volumes of good chemical quality, it is likely to be of strategic importance. Tunnelling or cutting through a strategic aquifer would have a significant detrimental effect on the water resource and must be carefully controlled. Specialist excavation and construction techniques would be required in these cases, in order to protect the aquifer and to ensure that the natural flow of groundwater is maintained. Cut or tunnel passing through aquifers with both "Good Yield" and "Good Chemical Quality" is considered to be a major detrimental impact on an important resource. For the purposes of the AoS assessment, cut or tunnel passing through aquifers with both "Good Yield" and "Good Chemical Quality" is assigned a major negative evaluation, while cut or tunnel through an aquifer with only "good quality" or only "good yield" is assigned a minor negative evaluation.

3.3. Issue 7 – Flood risk

Extent of infrastructure within 1 in 100 year flood zones

- 3.3.1. Under the terms of Planning Policy Statement 25 (PPS25), any development must be designed to avoid placing people at risk of flooding, and to ensure that there is no increase in the risk of flooding on other properties as a result of the proposed development. PPS25 requires a sequential risk-based approach to determining the suitability of land for development, consisting two tests:
- The Sequential Test is used to discourage development within flood prone areas where alternative land is reasonably available. A linear development such as HS2 must traverse all flood zones at some stage, and transport infrastructure is not exempt from any flood zones; and
 - The Exception Test is used to manage flood risk where development is necessary in land of higher flood risk, as determined through the Sequential Test. It should be applied as early as possible in the planning process.

The principles of these two tests have been used to sift options and identify the proposed route options.

- 3.3.2. For a strategic level analysis, including option selection and identification of the proposed route options, the Environment Agency Flood Zones provide sufficient guidance on the likely impacts of development. As with any country-wide study, the Flood Zones are occasionally subject to error, but they provide a robust level of detail for the scale of assessment required in this strategic study. Should the scheme progress to the next stage, extant Strategic Flood Risk Assessments for the areas crossed by the scheme would be examined in greater detail to inform preparation of a Flood Risk Assessment for the scheme itself.
- 3.3.3. From a sustainability perspective, it is obviously preferable to avoid any development within the floodplain, however within the context of this type of development, crossing of floodplains is inevitable. Crossing of Flood Zone 3 has the potential to have a significant

adverse impact, however in most cases, it should be possible to mitigate the flood risk issues through design, adjusting vertical track alignment and designing river crossings so that they have a minimal effect on flood flow. It may also be possible, in cases where the consequences of occasional flooding are relatively low such as fields, parks or rural areas, to accept a small increase in the risk of flooding at the local scale to avoid disproportionate costs of mitigation. As such, and in contrast to major river diversions, viaduct crossings of Flood Zone 3 is assigned a minor adverse evaluation in the AoS assessment.

Extent of infrastructure within 1 in 1000 year flood zones

- 3.3.4. Flood Zone 2 represents land which is expected to flood more frequently than once in 1000 years, but not as frequently as once in 100 years. A 1000 year return period is usually far in excess of the flood design criteria for this type of infrastructure. Consequently, the extent of track in Flood Zone 2 represents a measure of the residual risk in the design where it becomes more economic or sustainable to accept the consequences of such rare events than to mitigate against them in design. This also serves as a measure of resilience to the effects of climate change. For critical components of the track where the consequences of flooding could be particularly severe such as at the entrance to tunnel sections, it may prove more sustainable to design these sections to a higher standard. As for Flood Zone 3, it is obviously more sustainable to avoid Flood Zone 2 altogether, however in the context of this development it is impractical to do so. For the purposes of the AoS assessment, a neutral evaluation is assigned to crossing of Flood Zone 2 for minor rivers and a minor negative evaluation is assigned for crossing of Flood Zone 2 for a major river.

4. Data sources

- 4.1.1. The following is a list of the relevant data sources used to carry out these assessments:

Table 2 - Data sources

Data	Source
Maps showing Flood Zone extents for Flood Zone 2 and 3	Provided by Environment Agency as a GIS dataset
Maps showing Source Protection Zone extents (SPZ1 and SPZ2)	Provided by Environment Agency as a GIS dataset
Groundwater abstraction data corresponding to source protection zones	Provided by Environment Agency in spreadsheet form
Maps showing extent of Good Yield Aquifers as classified in the Water Framework Directive	Maps taken from Environment Agency website
Maps showing extent of Good Chemical Quality Aquifers as classified in the Water Framework Directive	Maps taken from Environment Agency website
Proposed track alignment and vertical profiles	Provided as GIS data files and PDF drawings from project engineers Arup
1:25,000 Ordnance survey raster images	Provided by Ordnance Survey
Quality classification of surface-water bodies under the Water Framework directive	Provided as cross-referenced spreadsheet and taken from Environment Agency website
Excerpts from the Water Framework Directive	As published on the Environment Agency website
Hydrogeological map of the South-West Chilterns	British Geological Survey

Appendix 5.4 Noise and Vibration

Noise and Vibration

1. Introduction

1.1.1. This chapter presents the noise and vibration appraisal that has been carried out. The current strategic appraisal has primarily concentrated on operational airborne noise at residential areas; other issues such as airborne noise at other sensitive locations, construction noise, vibration and ground-borne noise have been appraised on either a qualitative basis or at commentary level. All of these matters would be considered in greater detail at the Environmental Impact Assessment (EIA) stage of the project should the scheme be progressed.

1.2. How Railway Noise is Assessed

1.2.1. There are a number of indices that can be used to measure noise from the operation of a railway. It is important to identify which of these correlate with people's response when exposed to that noise. The consensus of many worldwide studies, and consequently legislation, standards and guidance, is that annoyance correlates best with the measure equivalent continuous sound level L_{Aeq} . This is the sound level, which, if kept constant over the assessment period, would give the same noise energy as is received from the fluctuating noise (in this case noise from the new railway).

1.2.2. Its use is widespread, with the 18 hour daytime L_{Aeq} and 6 hour night-time L_{Aeq} used in the assessment of eligibility for sound insulation for new, additional or altered railway schemes under the England and Wales "Noise Insulation (Railways and other Guided Transport Systems) Regulations 1996". $L_{Aeq, 18hr}$ is also one of the noise indices that forms the basis for noise mapping under "The Environmental Noise (England) Regulations 2006".

1.2.3. In order to predict L_{Aeq} from a railway service it is necessary to sum the received noise energy from each train event in the assessment period. Therefore, to determine the total noise energy from a railway, one needs to know the type of train, train length, train speed and the number of trains over the assessment period. Also, to predict railway noise at a particular location, one also needs to take account of the distance, any screening, surrounding topography and type of ground absorption (i.e. soft or hard ground), between the receiver and the railway.

1.3. Noise Action Plans in England

1.3.1. The recent Defra Noise Mapping in England for aircraft, road, rail and industrial noise sources have been produced to help fulfil the requirements of The Environmental Noise (England) Regulations 2006. The maps use L_{den} [the day, evening (with 5 dB penalty), night (with 10dB penalty) noise level] and L_{night} , as required by the EU Environmental Noise Directive, and also a number of L_{eq} values for different periods within the day.

1.3.2. From the results of the mapping it was a requirement that Action Plans would be drawn up to determine locations which should be investigated to see what measures, if any, might be taken in order to improve the noise management. Each Member State was free to determine the manner in which it determined these Important Areas.

1.3.3. In England, Defra concluded for railways that Important Areas were those where 1% of the population are affected by the highest noise from major railways and 'First Priority Locations' (those to be looked at first) would be where the mapped noise level exceeded 73 dB L_{Aeq} for the period 06.00 – 24.00. Consistent with the mapping requirements this was a free field noise level (no effect from the building façade) for a receiver 4m above the ground.

- 1.3.4. In developing this criterion it was stated that “implementing many of the potential actions available to manage noise issues and effects would not only address the noise as measured by the $L_{Aeq,18hr}$ indicator but also the noise that occurs at night.”

1.4. Department of Transport WebTAG

- 1.4.1. The Department for Transport has recently introduced a method for a common assessment of different transport proposals (“Transport Analysis Guidance”) which is particularly valuable in the context of route optioneering and selection. This method identifies notional costs against proposals based on residents’ perceived willingness to pay, relative to impacts. In the case of noise this places a value on changes in noise levels in terms of a value people would be willing to pay to avoid that noise. The guidance contains tables of annoyance vs. noise level, including a table of monetary valuation, per household, for a 1 dB change in noise level as a function of base noise level. Again, this assessment uses the noise indicator L_{Aeq} measured over an 18 hour day 0600 – 2400.

1.5. Time Period of Assessment

- 1.5.1. For consistency with WebTAG and Noise Action Plans in England, the noise from the operation of HS2 has been appraised, for the purpose of the AoS, in terms of the equivalent continuous sound level L_{Aeq} for the 18hr period from 0600 to 2400. This approach is considered appropriate due to the predominantly daytime operation of HS2. Night-time noise has been qualitatively appraised in Section 8.2.

1.6. Appraisal Criteria

- 1.6.1. In addition to the WebTAG appraisal that has been carried out, this appraisal has considered three noise criteria which are discussed further in Section 6.

2. Background

- 2.1.1. The following specific sources contribute to the noise and vibration at railway wayside locations:

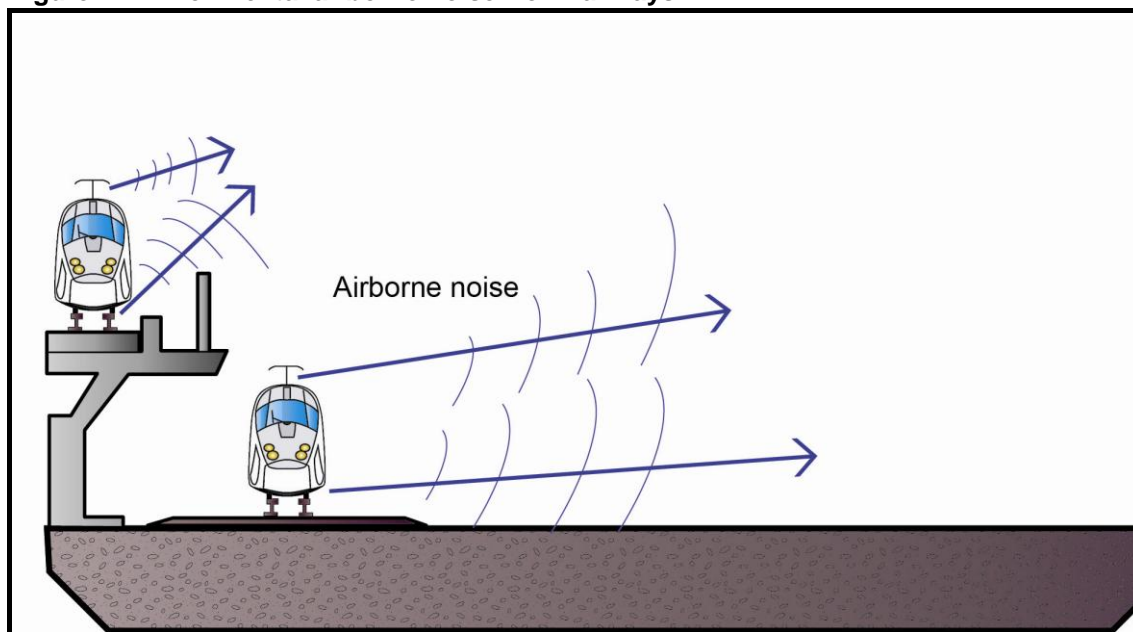
2.2. ‘Direct’ Airborne Noise

- 2.2.1. Direct airborne noise includes the following:

- mechanical noise from motors, fans and ancillary equipment on the train; this tends to be the dominant source at low speeds;
- ‘rolling’ noise from wheels passing along the rails; this usually dominates between low speed and higher speeds up to 300km/h; and
- aerodynamic noise from general air flow around the train body, pantograph and bogie areas that starts to become prevalent at the highest speeds (over 300km/h).

- 2.2.2. **Figure 1**, illustrates typical propagation paths of airborne noise associated with railway operation as described above.

Figure 1 Environmental airborne noise from railways



2.2.3. Airborne noise from railways can be mitigated in the following ways:

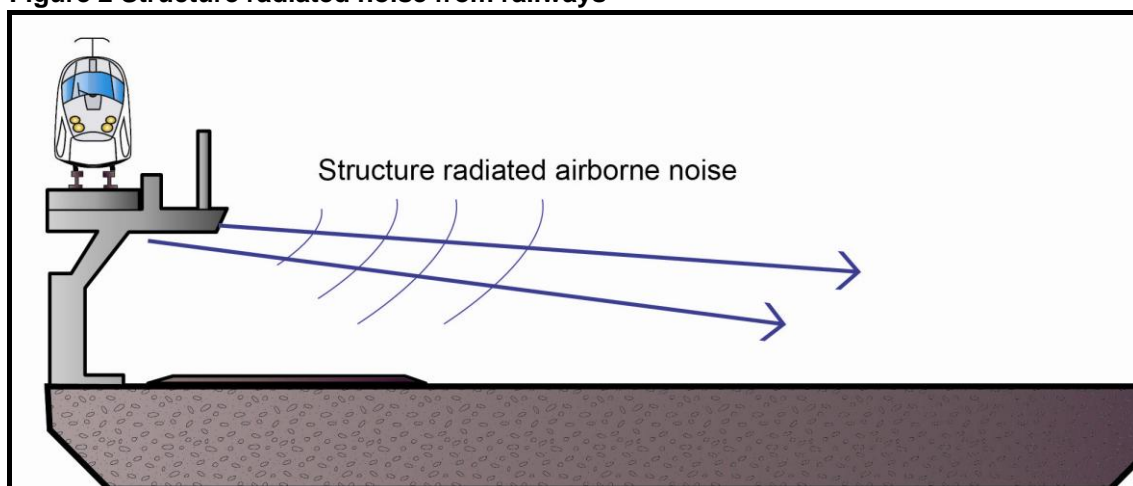
- at the source, through advanced rolling stock and track design,
- at the propagation pathway, by using barriers and earth bunds; and
- at the receptor by using noise insulation.

2.3. Structure Radiated Airborne Noise

2.3.1. Airborne noise also includes structure radiated noise, for example from viaducts.

2.3.2. **Figure 2** illustrates typical propagation paths of structure radiated noise associated with railway operation as described above.

Figure 2 Structure radiated noise from railways



2.3.3. Structure radiated noise from railways can be mitigated by damping the track structure, using resilient baseplates, resiliently supported ties or floating slab track.

2.4. Ground-borne Noise and Vibration

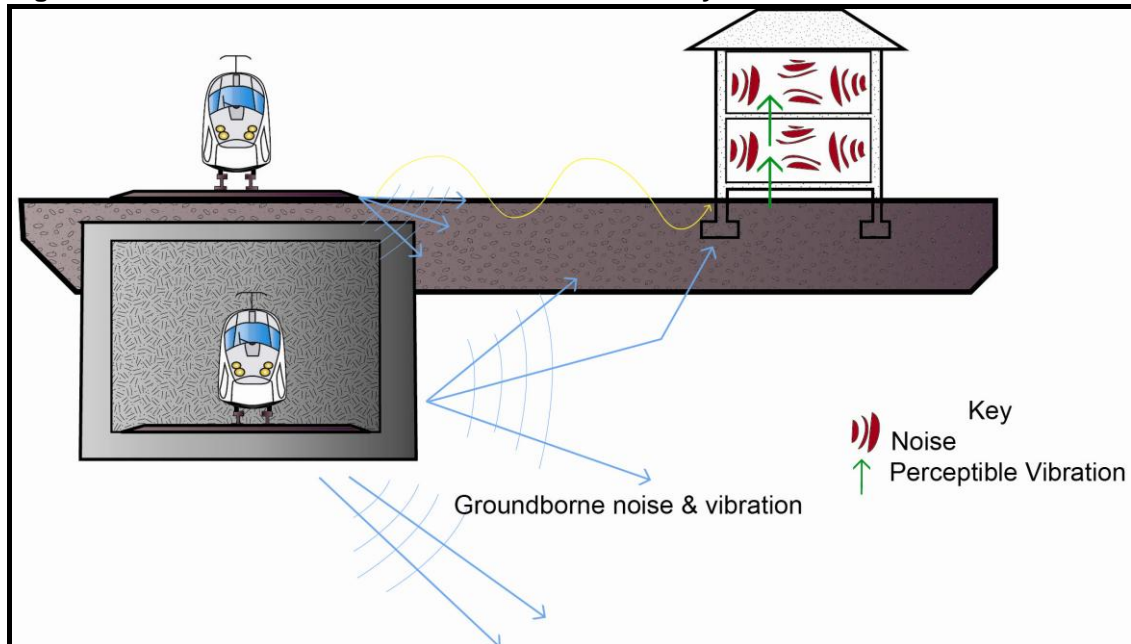
2.4.1. Ground-borne noise and vibration consists of:

- Ground-borne vibration (tactile vibration); and

- Ground-borne noise (audible low frequency ‘rumbling’ sound generated inside rooms by low amplitude vibration on walls, floors and ceilings).

2.4.2. **Figure 3** illustrates typical propagation paths of ground-borne noise and vibration associated with railway operation as described above.

Figure 3 Ground-borne noise and vibration from railways



2.4.3. Ground-borne noise and vibration from railways can be mitigated by incorporating vibration isolating track forms, for example floating slab track or booted sleepers.

3. Approach

- 3.1.1. The noise approach for option development and selection was based on Department for Transport's (DfT's) guidance provided in WebTAG Noise Sub-Objective Unit 3.3.2 and Supplementary Guidance documentation. The results of the WebTAG appraisal of route options, completed in March 2010, can be found in the AoS Framework tables located in Appendix 6.
- 3.1.2. In addition, a WebTAG appraisal was carried out for the proposed route, which is presented in Section 7.
- 3.1.3. Once the proposed route emerged, the appraisal criteria described in Section 6 were used to help inform the design process and identify the potential noise effects at a community level. The effect of indicative additional mitigation was also appraised and this is discussed later in the chapter.
- 3.1.4. Operational noise at non-residential noise sensitive receivers has not been assessed to a similar level of detail at this stage.
- 3.1.5. Construction noise has not been appraised as it is not appropriate at this stage of the Project, however such matters would be addressed as part of the HS2 Code of Construction Practice (CoP).
- 3.1.6. Ground-borne noise and vibration have been appraised at a strategically high level to determine the potential impacts to sensitive properties (residential and non-residential) and indicative mitigation measures have been considered.

- 3.1.7. All potential noise and vibration impacts including construction noise, operational noise at non-residential receivers, ground-borne noise and vibration would be fully assessed at EIA stage should the scheme be progressed.

4. HS2 Noise and Vibration Working Group

- 4.1.1. The HS2 noise and vibration working group has been established to provide:

- scrutiny and advice;
- direction on the application and relevance of emerging noise/vibration legislation/guidance; new research findings; and
- peer review of the appraisal method.

- 4.1.2. External members, in addition to HS2 and B-T personnel, and whose contributions in this respect are acknowledged include⁷:

- Brian Hemsworth – advisor to Temple
- Rick Jones – advisor to HS2
- Richard Greer – Arup

5. Computer Noise Modelling Methodology

- 5.1.1. The approach developed to perform the airborne noise appraisal of the proposed route includes predicting noise levels at receivers and undertaking statistical calculations of the results such as calculating the numbers of dwellings which meet the appraisal criteria. The HS2 noise model has been developed using the CadnaA⁸ noise prediction software which involves modelling a three dimensional approximation of the study area and implements the railway noise calculation methodology (Calculation of Railway Noise 1995). ArcView GIS (geographic information system) software⁹ has been used to perform the statistical calculations on the resulting receiver noise levels.

5.2. Study Areas

- 5.2.1. A study area 3km either side of the proposed route has been used as it is considered sufficient to encompass all areas subject to potential HS2 residential airborne noise impacts.
- 5.2.2. Predictions of the noise level at dwellings¹⁰ have been calculated, using the computer modelling approach described below, for ‘with scheme’ and ‘without scheme’ for operational year 15 (15 years after the opening of the scheme).

5.3. Mixed Noise Sources

- 5.3.1. For the purposes of this document, mixed noise is defined as noise which contains contributions from more than one type of noise source, e.g. rail and road noise. The perception and potential effect of different noise sources is related not only to the noise level (or ‘volume’) of the source, but also its characteristics (tonality, intermittency etc.)
- 5.3.2. The perception and potential effect of mixed noise is not easily predicted, and it should be recognised at the outset that there is currently no established method or professional

⁷ Stephen Turner – Defra is also acknowledged to be involved with the working group, though did not attend working group meetings.

⁸ CadnaA (Computer Aided Noise Abatement) software version 3.72.129 (64bit) - DataKustik GmbH.

⁹ Esri ArcMap 10 Build 2414

⁹ Dwellings extracted from 2009 ordnance survey data provided by HS2 Ltd. Dwellings likely to be demolished have been removed from all results. However those at risk of demolition have not been excluded nor does the data consider any future dwelling developments.

¹⁰ This level is used as the cut-off for both annoyance and valuation calculations in WebTAG

consensus on this topic, and genuine uncertainties remain on how best to assess mixed noise. As a result, a range of appraisal methodologies may be considered.

- 5.3.3. The approach described below has, therefore, predicted potential impacts based on a comparison of HS2 and other existing rail noise only, subject to a minimum value of 45dB(A). It should be noted that the consideration of other sources of existing noise, namely road, aircraft and industrial, could alter the identified potential impacts, and in general impacts are likely to be lower than identified at this stage.

5.4. 'With Scheme' Noise Levels

- 5.4.1. The predictions of 'with scheme' noise impacts were carried out by calculating noise levels at receiver points representative of residential dwellings using the HS2 Noise Model. Noise sources 'with scheme' consisted of the proposed HS2 railway as well as existing railways.

5.5. 'Without Scheme' Noise Levels

- 5.5.1. The prediction of 'without scheme' noise impacts was carried out calculating noise levels at receiver points representative of residential dwellings using the HS2 Noise Model. Noise sources 'without scheme' consisted of the existing railways only.

5.6. HS2 Source Noise levels

- 5.6.1. The HS2 source noise level used in the Noise Model relies upon:

- assumed noise levels of HS2 trains are based on the noise levels of currently operating high speed trains¹¹ together with noise level requirements for new trains from European specifications¹² (Technical Specification for Interoperability [TSI]);
- operating speeds for different sections of the route, as supplied by the HS2 Ltd engineering team;
- the number and length of the trains;
- details on the proposed route alignment, including proposed embankments, cuttings, tunnels and viaducts, within the context of the surrounding landscape; and
- a defined time period.

- 5.6.2. Noise levels have been predicted as 18 hour daytime L_{Aeq} ¹³ values (06:00-24:00) which can be thought of as a type of 'average' or 'typical equivalent' value.

Source Noise Level

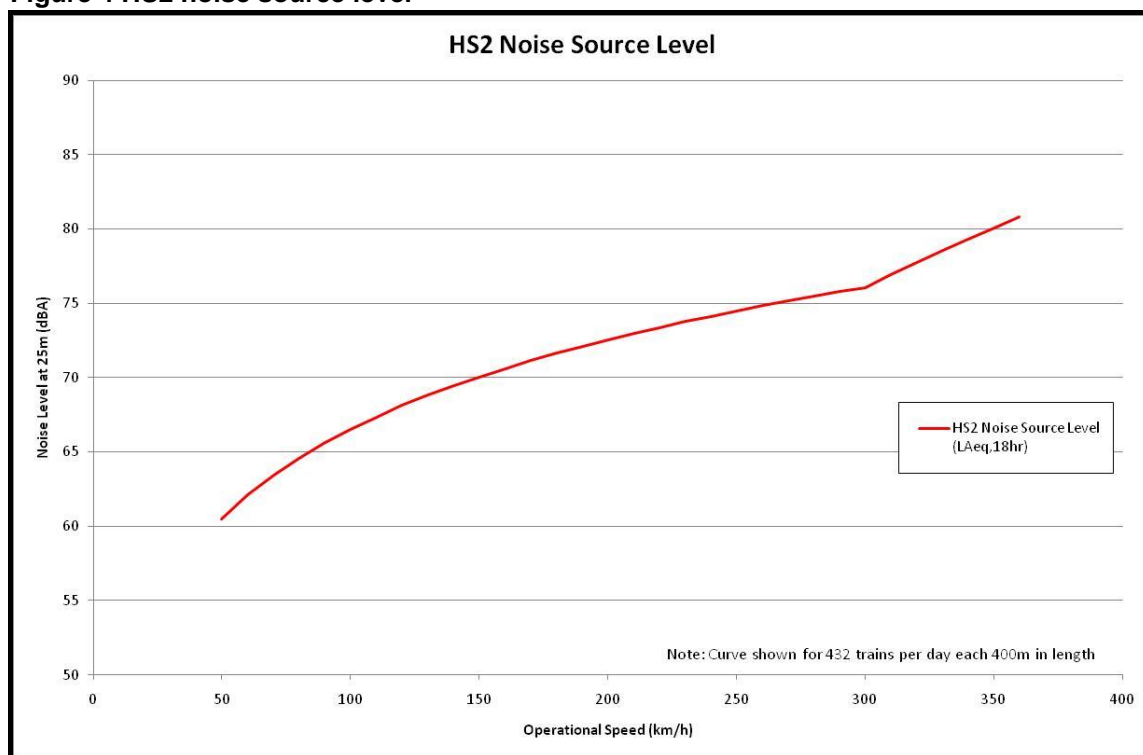
- 5.6.3. HS2 source levels were derived using both 2008 measurement data of TGV trains at 350 km/h and high speed TSI requirements. **Figure 4** below shows the $L_{Aeq,18hr}$ HS2 source noise level at 25m for various operational speeds; for a specific number of trains with no mitigation and hard flat ground.

¹¹ Gautier, P.-E., Létourneaux, F., & Poisson, F. (2007). High Speed Trains External Noise: A Review of Measurements and Source Models for the TGV Case up to 360km/h. SNCF, Innovation and Research Department, France.

¹² COMMISSION DECISION of 21 February 2008 concerning a technical specification for interoperability relating to the 'rolling stock' sub-system of the trans-European high-speed rail system (notified under document number C(2008) 648) (2008/232/CE).

¹³ The L_{Aeq} is the A-weighted sound level, which, if kept constant over the assessment period, would give the same noise energy as is received from the fluctuating noise (in this case noise from the new railway)

Figure 4 HS2 noise source level



Operational Speeds

5.6.4. Operational speed data within the HS2 noise model is the design speed provided by HS2 Ltd in the HS2 shapefiles; where design speeds are over 360km/h, a maximum of 360 km/h is used as listed in the HS2 Project Specification.

Operational Service Patterns

5.6.5. Operational characteristics have been provided by HS2 Ltd including the number of trains and length of trains on each route segment, and track speeds. Service patterns have been provided for two scenarios; a scheme with High Speed Rail from London-West Midlands only (without “Y”) and a scheme which extends further north via Leeds and Manchester (with “Y”). These are provided in **Table 1** below.

Table 1 – Two-way HS2 train movements

	Operational Year 15 (trains per period)		
	Standard Hour	Peak hour**	Day (18hr)***
London to West Midlands only (without “Y”)			
Birmingham to London	6	8	120*
Birmingham to north	0	0	9*
North to London (i.e. bypass Birmingham)	16	20	312*
With operational pattern to service Northern Extension (With “Y”)			
Birmingham to London	6	8	120*
Birmingham to north	12	12	225*
North to London (i.e. bypass Birmingham)	24	28	456*

* Includes empty stock trains to and from Washwood Heath depot
 ** Peak hours assumed to be 07.00 - 10.00 and 16.00 - 19.00;
 ***Daytime Hours from 06:00 to 24:00

Route Alignment

5.6.6. The HS2 Proposed Route alignment was provided as a three dimensional shapefile, the height of which is the rail head height. Only a single centreline was modelled, which was considered reasonable for the strategic level appraisal.

Noise Source Height of High Speed Trains

5.6.7. HS2 noise predictions have used the UK modelling methodology Calculation of Railway Noise 1995 (CRN). This is the official model for assessing eligibility for sound insulation under England and Wales Noise Insulation Regulations for Railways and the model typically used for the environmental impact assessment of railway projects.

5.6.8. In its general form, this model assumes there are three possible noise source heights:

1. at the head of the nearest rail (of the relevant track); to model rolling noise and
2. at 2m or 4m above rail head:
 - a. to model diesel locomotive power noise, the source is located 4m above the head of the nearest rail (of the relevant track); or
 - b. for fan noise from Eurostar high speed train locomotives the source is located 2m above the head of the nearest rail (of the relevant track).

5.6.9. For very high speed rail, i.e. above 300km/h it is likely that CRN would need to be adapted to have sources at two or more heights above rail: for example rolling noise and the second for aerodynamic noise, however the research basis for this change in calculation methodology is not currently available.

5.6.10. It was decided that some modification to the base CRN calculation should be included to account for aerodynamic noise. The best option at this stage was to retain a single noise source but alter the source height.

5.6.11. A source located 1.0m above the head of the near rail was used as a series of comparative calculations indicated that this gave the most consistent results when compared with SNCF¹⁴ data for speeds in excess of 300km/h. For train speeds less than 300km/h the rolling noise source location of CRN was used (rail head height).

5.6.12. Following a review of 3m high barriers, the acoustic barrier effect, for these or higher barriers, expected from high speed rail at above 300km/h was simulated for modelling purposes by reducing the actual barrier height by 1m for calculation purposes only and retaining a source 1m above the head of the rail.

5.7. Existing Rail Source Noise Levels

5.7.1. The existing rail noise levels at dwellings have been calculated within the HS2 CadnaA Noise Model. Existing railway source noise levels have been based on published Defra railway noise contour maps¹⁵. The Defra railway noise maps are strategic in nature, and therefore do not give accurate noise levels at specific locations, however, this was considered sufficient for the strategic level appraisal. At EIA stage, should the scheme be progressed, a baseline noise measurement study would be carried out.

5.7.2. The location of existing railways within the vicinity of the study area was input to the model. The source noise level attributed to these railways was calibrated so that the noise contour they produced was reasonably consistent with those provided in the Defra railway noise contour maps.

¹⁴ Experimental study of noise barriers for high-speed trains; P. Belingard, F. Poisson, S. Bellaj (2010); IWRN10; SNCF

¹⁵ Department for Environment, Food and Rural Affairs: London. Noise Mapping England. [Online] Accessed on 29 June 2009 <http://www.Defra.gov.uk/environment/quality/noise/mapping/index.htm>

- 5.7.3. Where predicted rail noise levels are low, a minimum value of 45dB $L_{Aeq,18hr}$ has been chosen and this has also been taken as the assumed level in areas where railway noise is not present.

5.8. Noise Model

- 5.8.1. For the appraisal, the following inputs were included in the HS2 CadnaA Noise Model to provide an adequate level of precision in the calculated noise levels.

Digital Terrain Model

- 5.8.2. The existing digital terrain model is based on 5m interval contour lines extracted from ordnance survey data provided by HS2 Ltd.
- 5.8.3. To model the terrain changes due to the alignment of the HS2 proposed route, the three dimensional shapefile lines provided by HS2 Ltd (i.e. embankments, cuttings and viaducts for example) were converted to contour lines to define the ground terrain.

Built up Areas

- 5.8.4. The effect of acoustic shielding from buildings has been approximated by calculating the noise attenuation at dwellings located in areas of densely populated buildings. The attenuation of built-up areas is based on the guidance within the ISO 9613-2 standard¹⁶ for noise propagation with a relative height of 8m above ground level assigned to all built up areas. Other detailed built up areas have not been incorporated into the HS2 noise model.

Ground Absorption

- 5.8.5. The calculations have been carried out with a default ground absorption assuming hard ground in built up areas and soft ground elsewhere.

Receivers

- 5.8.6. Calculations of noise exposure have been completed at receiver locations which represent either individual dwelling address points close to the route or clusters of dwellings further from the route. All receivers are represented in the HS2 Noise Model as points located 4m above the existing ground height.
- 5.8.7. Within 300m of the route centreline (i.e. 600m corridor), individual address points from the postal address points data¹⁷ provided by HS2 Ltd (this can represent more than one dwelling). This was done to provide a higher level of detail to receivers near the line of route which are more noise sensitive to the precise geometry of the source-to-receiver sound propagation path.
- 5.8.8. To represent dwellings further than 300m from the route centreline, point receivers have been used, each representing a group of all the dwellings located in the postal address point data in a 50m square surrounding the point.
- 5.8.9. All airborne noise levels calculated and reported are free field (see glossary for further explanation) with the exception of those used to represent noise insulation criteria. In this case, a facade correction of 3 dB has been used to convert free field noise levels to facade noise levels.

¹⁶ ISO 9613-2: 1996 Attenuation of sound during propagation outdoors – Part 2 General method of calculation

¹⁷ Dwellings extracted from 2009 ordnance survey data provided by HS2 Ltd. Dwellings likely to be demolished have been removed from all results. However, those at risk of demolition have not been excluded nor does the data consider any future dwelling developments.

- 5.8.10. Calculations have been carried out using the noise exposure results at receiver points calculated in the HS2 Noise Model, using GIS software.
- 5.8.11. Results are broken down into route segments. However, in the case of the Birmingham Delta Junction results have been grouped to reflect the close proximity and associated combined noise of two or more route segments.

Barriers

- 5.8.12. Barriers are included in the HS2 Noise Model as part of the calculation of the predicted noise levels due to the HS2 Proposed Route with indicative additional mitigation. Barriers have been included where an area has been identified as a preliminary Candidate Area for Mitigation (which is based on the base case engineered route noise model results) although barriers may not necessarily be employed in the final form of mitigation in any given location. Further information regarding the height of the barriers is discussed below in Section 6.

6. HS2 Proposed Route Airborne Noise Appraisal

6.1. HS2 noise appraisal criteria

High HS2 Noise Levels

- 6.1.1. To indicate potential noise impacts associated with the HS2 proposed scheme option, the number of dwellings that could potentially experience high HS2 noise levels have been reported. The proposed criterion for a high noise level exposure is defined as a free field noise level greater than or equal to 73 dB $L_{Aeq,18hr}$ ¹⁸.

Noise Insulation

- 6.1.2. The Noise Insulation (Railway) Regulations (NIRR 1996) are England and Wales legislation that applies to works on new, altered or additional railway systems such as HS2. The regulations set the daytime criterion for noise insulation of residential buildings at:
- greater than or equal to 68 dB $L_{Aeq,18hr}$ at the building façade (i.e. a facade noise level);
 - the new altered or additional railway must make a contribution of at least 1 dB $L_{Aeq,18hr}$ to the total railway noise;
 - at least 1dB $L_{Aeq,18hr}$ increase in total railway noise level; and
 - within 300m of the new, altered or additional railway.

Noticeable Noise Increase

- 6.1.3. The noise level criteria above, i.e. High HS2 Noise Levels and Noise Insulation levels, have been identified at National level, however neither represents an acceptable design aim and should be viewed as an upper limit when no further reduction of noise is possible having regard to all reasonably practicable mitigation measures.
- 6.1.4. It follows that other design criteria need to be developed to inform the design process in order to minimise the noise impacts on the local community. To this end, it should be noted that there is no universally accepted approach but there is general acceptance that it is appropriate to evaluate rail noise impact in terms of noise change, as evidenced by noise impact assessments on recent railway schemes e.g. HS1 Channel Tunnel Rail Link, (CTRL), West Coast Main Line (WCML) and Crossrail. This is also the approach for roads

¹⁸ This criterion for railway noise exposure has been used in the past by Defra, to identify First Priority Locations for Noise Action Planning as part of The Environmental Noise (England) Regulations 2006.

as set out in the Design Manual for Roads and Bridges. Additional criteria (referred to as “assessment criteria”) would be developed at the EIA stage should the scheme be progressed, to provide further guidance on the community impacts and to inform the design process.

- 6.1.5. In terms of a railway noise change, 3 dB L_{Aeq} or more is generally considered as a noticeable change. For the AoS study, this has been taken as the difference in railway noise, with and without the presence of HS2; this approach is consistent with the approach taken for HS1 (CTRL), Crossrail and WCML.
- 6.1.6. The World Health Organisation, in its 1999 Noise Guidelines¹⁹ report in 2000 on states “to protect the majority of people from being moderately annoyed during the daytime, the outdoor sound level should not exceed 50 dB L_{Aeq} ”.
- 6.1.7. This has been taken as an indicator of the onset of annoyance and, therefore, a Noticeable Noise Increase for HS2 AoS purposes is defined as having a total rail noise level of greater than or equal to 50 dB L_{Aeq} 06:00 – 24:00 with an increase in rail noise of at least 3 dB L_{Aeq} 06:00 – 24:00. At receiver locations where predicted existing rail noise levels are low or there is no rail traffic (assumed at 45 dB $L_{Aeq,18hr}$), a predicted HS2 noise level of 50 dB $L_{Aeq,18hr}$ or above would result in a noticeable noise increase as per this definition.

6.2. Preliminary Candidate Areas for Additional Mitigation

- 6.2.1. The development of HS2 Ltd’s proposed route has resulted in a number of changes to the route alignment to reduce environmental and community impacts. These have already been described elsewhere, but in summary they include green bridges and new or deeper cuttings, as well as re-alignments away from certain settlements, such as Mixbury, Brackley, Greatworth and Ladbroke.
- 6.2.2. In addition to this incorporated mitigation, other locations were identified as candidate areas for additional mitigation. Such locations were identified with regard to the number of dwellings impacted in any one area according to the aforementioned criteria, i.e. High Noise Levels, Noise Insulation Levels and Noticeable Noise Increase and using professional judgement as to the likely effectiveness of potential mitigation measures. Due to the strategic nature of this study, these locations should be seen as preliminary at this stage.
- 6.2.3. These locations have been highlighted on the Residential Airborne Noise Appraisal Maps (see **Main Report Volume 2**).

6.3. Noise Mitigation Options

- 6.3.1. The consideration of mitigation at this stage of the scheme’s development is necessarily strategic. The airborne noise mitigation hierarchy consists of mitigation at the source, including the rolling stock and track, before mitigation of the propagation pathway, including barriers and earth bunds. Mitigation at the receiver, including noise insulation, should only be considered for residual effects, and as a last resort.
- 6.3.2. The preliminary candidate areas for mitigation have been selected based on the service pattern expected if the future High Speed services were to extend further North via Leeds and Manchester. The potential benefit derived from the mitigation has been appraised based on the service pattern for London-West Midlands only. In this way, mitigation of the scheme is future-proofed in the sense that provision has been made for the possible extension of High Speed services further North. Should the Northern extension not materialise, the mitigation provided would still result in benefits.

¹⁹ World Health Organisation 1999 Guidelines for Community Noise

- 6.3.3. To mitigate potential impacts in areas of high operating speeds, there is a need to control aerodynamic noise through advanced rolling stock design. Without first mitigating the source of aerodynamic noise, wayside noise barriers are not likely to be as effective or feasible, due to the required increase in barrier height, to provide shielding to the entire train.
- 6.3.4. The assumptions used in the additional indicative mitigation scenario drew on the knowledge and experience of the engineers and acoustic specialists.
- 6.3.5. The principal assumptions used to model this scenario are set out below.
- At operation, there would be a 3 dB reduction in noise emissions at source based on the anticipated noise control improvements in the next generation of high speed rolling stock.
 - Noise reduction would be equivalent to that achieved by use of 3m high²⁰ noise barriers (or bund) at all the preliminary candidate areas for mitigation or, at viaducts, by 2m high barriers; noise-absorbent materials would be used throughout. In total, approximately 100km of noise barriers have been broadly applied in the noise model at preliminary candidate areas for mitigation. The actual mitigation technique employed at each location may not be a barrier, and local conditions would be considered to decide which technology would be most appropriate at a later stage.
- 6.3.6. The way in which noise would eventually be mitigated would depend on various considerations, such as engineering feasibility and effectiveness, and may use any of the techniques set out in Section 2, either independently or in combination, and these would be developed further as part of the EIA should the scheme be progressed.

7. Findings

7.1. WebTAG

- 7.1.1. WebTAG results for the proposed route with the indicative additional mitigation applied are reported in the AoS Framework Tables and summarised in **Table 2** below.
- 7.1.2. Given the strategic nature of the study, reported numbers have been rounded.²¹

Table 2: HS2 airborne noise impacts from WebTAG appraisal

WebTAG Appraisal of HS2 Proposed Route with Indicative Additional Mitigation		
Criteria	Description of Criteria	HS2 Engineered Route
WebTAG Annoyance	Change in Annoyance	850 people*
WebTAG Monetary Cost	Residents' willingness to pay for the change in noise	~£41 million*
300m Buffer (either side of LoR)	Non-Residential Noise Sensitive Buffer Area	250 properties*
*Estimated numbers exclude dwellings likely to be demolished, but include those potentially at risk of being demolished. Note: Depots, Stations, and Station Approaches not reported in these numbers due to limited information		

- 7.1.3. The 'change in noise annoyance' figure is assessed in WebTAG by calculating the difference in the population who would be annoyed by the predicted noise levels, comparing the 'with scheme' and 'without scheme' scenarios.
- 7.1.4. The monetary values are national average values per household per year at 2002 prices. These are increased in line with forecasts of GDP per household and discounted over the

²⁰ Barrier height quoted is the height above ground level; suitable barrier locations were chosen to give the greatest screening effect; based on the location.

²¹ See Section 10 for details of rounding methodology

appraisal period to give a present value of noise, representing peoples' expected willingness to pay to avoid such effects.

- 7.1.5. The number of potentially impacted non-residential noise sensitive receivers has been identified by counting the number of educational, health, community and recreational properties located within 300 metres of the route centreline, which are considered to be those potentially at risk of airborne operational noise impacts, i.e. a total of 250 properties in this case.

7.2. HS2 Proposed Route Airborne Noise Appraisal

- 7.2.1. **Table 3** shows the estimated number of dwellings potentially impacted by operational noise from the London to West Midlands Proposed Route according to the HS2 appraisal criteria with and without additional indicative mitigation broken down on a regional basis. This table should be read in conjunction with the residential airborne noise appraisal maps (**Main Report Volume 2**). These results are based on the operational service patterns for the London to West Midlands High Speed Rail Network (i.e. without "Y").

Table 3 – HS2 Proposed Route Airborne Noise Appraisal Findings – Without "Y"

	High noise levels ¹		Noise Insulation Regulations ²		Noticeable noise increase ³	
	Including Additional Indicative Mitigation	Without Additional Mitigation	Including Additional Indicative Mitigation	Without Additional Mitigation	Including Additional Indicative Mitigation	Without Additional Mitigation
Old Oak Common to West Ruislip	<5	<50	~80	~1,300	~650	~6,700
West Ruislip to Aylesbury	<5	<5	<20	<30	~1,450	~8,700
Aylesbury to Brackley	<5	<10	<20	<20	~350	~1,300
Brackley to Kenilworth-Coventry gap	<5	<10	<20	<20	~350	~1,100
Kenilworth-Coventry gap to Berkswell rail station, and the Birmingham spur	<5	<5	<10	<20	~70	~200
Berkswell rail station to Middleton	<5	<10	<20	<40	~1,700	~5,700
Middleton to WCML	<5	<10	<10	<20	~200	~750
Total	~10	~70	~150	~1,400	~4,700	~24,300
¹ Dwellings potentially exposed to high HS2 noise levels, greater than 73dBL _{Aeq18hr} ² Dwellings potentially qualifying for noise insulation under the Noise Insulation Regulations ³ Dwellings potentially exposed to a noticeable noise increase						

- 7.2.2. Findings given in **Table 4** are those for the London to West Midlands Proposed Route based on the operational service patterns for the wider High Speed Rail Network (i.e. with "Y") with and without additional indicative mitigation.

Table 4 – HS2 Proposed Route Airborne Noise Appraisal Findings – With “Y”

	High noise levels ¹		Noise Insulation Regulations ²		Noticeable noise increase ³	
	Including Additional Indicative Mitigation	Without Additional Mitigation	Including Additional Indicative Mitigation	Without Additional Mitigation	Including Additional Indicative Mitigation	Without Additional Mitigation
Total	<20	<210	<200	<1650	~6600	~33600
¹ Dwellings potentially exposed to high HS2 noise levels, greater than 73dB _{L_{Aeq}18hr} ² Dwellings potentially qualifying for noise insulation under the Noise Insulation Regulations ³ Dwellings potentially exposed to a noticeable noise increase						

7.3. HS1 Connection

- 7.3.1. The HS1 Connection links HS2 to HS1. The Connection consists of a new tunnelled section of line from Old Oak Common to Camden. Where the line comes out of tunnel in Camden, it connects to the existing North London Line for a small section of track between Camden and Kings Cross St Pancras Station. It is anticipated that three trains per day in each direction would run on this connection.
- 7.3.2. For the new section of tunnel, it is likely that operation noise and vibration impacts can be avoided; HS2 Ltd is committed to ensuring that no significant effects arise. Section 9 for further information on ground-borne noise and vibration from tunnels.
- 7.3.3. The current service pattern for the section of track above ground is approximately 108 trains in each direction. The addition of three HS2 trains per day would have a negligible effect on daytime noise exposure $L_{Aeq,18hr}$ from this section of line, and consequently no noise or vibration impacts are predicted using the aforementioned criteria.

8. Additional Potential Noise Issues

- 8.1.1. Due to the strategic nature of this appraisal, not all potential noise issues have been addressed quantitatively. This section identifies these further issues at commentary level. These issues would be assessed, in detail, at the EIA stage should the scheme be progressed.

8.2. Night Noise

- 8.2.1. The noise appraisal has identified preliminary candidate areas for mitigation. The application of this mitigation would also benefit those who may experience night noise effects since:
- It is likely that all the properties which would be identified as eligible for noise insulation under the night time noise insulation criteria within the Noise Insulation Regulations have already been identified in the AoS as being eligible under the daytime noise insulation criteria; and
 - It is unlikely that any further candidate areas for mitigation would arise as a result of a night time noise assessment using a high maximum noise level (e.g. 85 dB L_{Amax}).

8.3. Stations and Depots

- 8.3.1. The following sources of noise from HS2 stations and depots have the potential to cause impacts at sensitive locations in proximity to the proposed stations and depots:
- Passenger and maintenance trains accessing stations or depots;
 - Fixed plant installations at stations or depots e.g. wheel lathes, CET (Controlled Emissions Tanking) units, wash plant etc;
 - Mobile plant and maintenance activities not considered a constant noise source e.g. forklift trucks, hand tools etc;

- Local road traffic accessing stations and depots, and changes to local road infrastructure; and
- Public Address (PA) systems.

8.3.2. However, past experience has shown that the majority of these impacts can be avoided or minimised to a large degree through the use of effective planning/design and other noise mitigation measures.

8.4. Tunnel Ventilation Shafts

8.4.1. Tunnel Ventilation Shafts (TVS) are required to provide:

- natural ventilation, which also acts as pressure relief;
- forced, mechanical ventilation, to operate during maintenance or emergency situations; and
- access and egress for emergency services.

8.4.2. The forced ventilation system would not operate continuously but only in the event of severely disrupted operation, an emergency or testing. When the ventilation system is not operating, the main noise source from the tunnel would be associated with the passage of trains, that is pressure relief and train pass-by noise.

8.4.3. HS1 and the Jubilee Line Extension experience indicates that impacts can be avoided if vent shafts are built with appropriate mitigation. Crossrail will also feature noise-controlled vent shafts. The approach to HS2 TVS noise would adopt best practice for noise control. Past experience has shown that the majority of potential noise impacts can be avoided through the use of effective planning/design and other noise mitigation measures.

8.5. Tranquillity and Quiet Areas

8.5.1. The WebTAG noise sub-objective states that tranquillity is to be taken into account in the assessment of impact under the Landscape sub-objective. A tranquillity map has been produced by the CPRE (Campaign to Protect Rural England), and Northumbria University, where noise is one of a number of considerations. Identification of England's quiet areas within agglomerations is currently under investigation by Defra.

8.5.2. A mitigation strategy that takes into account the relative importance of different factors affecting relative tranquillity, as identified in the CPRE/NU study and mapping, could help to reduce the potential impacts.

8.5.3. The Environmental Noise Regulations (England) 2006 must identify quiet areas for agglomerations. This requirement relates only to identifying quiet areas in large agglomerations (urban areas) and as such, do not provide any protection for quiet areas in open country or smaller populated areas.

8.6. Tunnel Boom Noise Levels

8.6.1. The HS2 Project Specification assumes the use of slab track in tunnelled route sections. Pressure waves created as a high speed train enters a tunnel portal can result in micropressure waves that cause a boom or bursting noise at the exit of long tunnels comprising a slab track rail formation. Mitigation measures undertaken outside the tunnel exit, such as a noise barrier, have not been found to be effective. Instead, mitigation must be undertaken at the stage of generation of the pressure wave or at the stage of wave propagation through the tunnel. Widening the tunnel entrance and providing a more aerodynamic noise profile of the train are the primary options for mitigation at the stage of pressure generation. Ways to mitigate the boom noise at the stage of propagation of the pressure waves within the tunnel include providing ballasted track, acoustic track absorbers, or pressure relief shafts along the length of the tunnel.

- 8.6.2. If unmitigated, the boom noise associated with high speed rail in tunnels can create a significant environmental impact at the exit of the tunnel. However, with the incorporation of reasonable mitigation options, it is possible to reduce or avoid this effect. Consequently, it should be possible for trains entering a tunnel with a cross section of 100m² at a speed of 320km/h to operate without restrictions.

8.7. Cumulative Effects from Road and Aircraft Noise

- 8.7.1. WebTAG does not provide guidance for the appraisal of impacts from mixed noise environment. Locations where possible cumulative effects of aircraft or road noise with HS2 railway noise could occur can be seen on noise maps shown in **Figures 5-7**. The locations of potential cumulative effects of road noise with HS2 railway noise have been defined as the overlapping areas of 300m from Motorway and A-Road centrelines within 1500m of the HS2 route centreline. The locations of potential cumulative effects of aircraft noise with HS2 railway noise have been defined as the overlapping areas of the 55 dB L_{den} aircraft noise contour from 2006 Defra Noise Maps of Heathrow Airport and Birmingham International Airport within 1500m of the HS2 route centreline.

8.8. Potential Benefits

- 8.8.1. Preliminary demand model outputs indicate that there is the potential for some modal shift from road to rail on both HS2 and the WCML. However, the reduction in the number of road trips is not expected to be significant when considering overall traffic flows on the wider motorway network. The resultant shift may however produce a small reduction in traffic numbers, although it is unlikely that this effect would result in any perceived benefit in terms of reduced overall noise levels.
- 8.8.2. In some instances noise barriers or earth bunds may be implemented as part of a noise mitigation strategy. These also have the potential to provide acoustic screening of noise from existing roads and/or railways as has been the case with other schemes.
- 8.8.3. In these areas, some properties may experience a noticeable reduction in overall noise level (existing sources and HS2 combined), due to the attenuation effect of such noise barriers or bunds. The specific locations where this benefit may arise would be explored further as part of the EIA should the scheme be progressed.
- 8.8.4. The implementation of noise insulation under the Noise Insulation Regulations at some properties may also benefit some residents who live near an existing transport corridor and are already exposed to high existing noise levels, and the implementation of such noise insulation could reduce internal noise levels from existing noise sources.

9. Vibration and Ground-borne Noise

9.1. Introduction

- 9.1.1. Vibration and ground-borne noise is dependent upon numerous factors at the source, during ground propagation and at receivers. The design at this early stage of a development provides insufficient detail to undertake a quantitative assessment, however, substantial experience from other projects, particularly HS1, enables a robust qualitative assessment to be made.

9.2. Background

- 9.2.1. Experience from HS1 and international guidance²² suggests that, without any mitigation, ground-borne noise and vibration impacts from HS2 could occur up to 100m from London

²² U. S. Department of Transportation Federal Railroad Administration HMMH Report No. 293630-4:High-Speed Ground Transportation Noise and Vibration Impact Assessment (Harris Miller Miller & Hanson Inc., October 2005)

tunnels and up to 200m from country tunnels, the difference reflecting the attenuating effects of London Clay and the relatively slower line speeds through London. However, HS1 and other international high speed rail experience suggest that potential vibration and ground-borne noise impacts could be avoided.

9.3. Approach and Findings

- 9.3.1. Whilst later more detailed assessments would need to consider potential ground-borne noise and vibration impacts arising from all sections of the line, this strategic appraisal has been based on the overarching conclusion of HS1 and the majority of high-speed lines in Europe: that airborne noise is the dominant issue for surface sections of line; and ground-borne noise is the key issue for tunnelled sections.
- 9.3.2. Receivers considered for the vibration and ground-borne noise appraisal consisted of geo-referenced postal address point data. Both residential dwellings and a small number of non-residential noise sensitive receivers are included within this address point data.
- 9.3.3. Assuming 260km/h operational speeds in twin bore London tunnels and use of slab track, optimised to mitigate ground-borne noise and vibration, HS1 has shown that high speed rail can operate under densely populated residential areas with no adverse effects.
- 9.3.4. An initial search of non-residential receivers considered particularly sensitive to noise and vibration around the proposed tunnel alignment has identified some potentially affected uses such as research and media facilities. These locations would require further consideration as the project progresses.
- 9.3.5. Assuming 320 km/h operational speeds, with the provision of slab track and the alignment of the single bore tunnels under the Chilterns through chalk, there is a risk of adverse ground-borne noise and vibration effects to both residential and other noise sensitive resources located within 200m of the HS2 proposed alignment.
- 9.3.6. Where properties may experience adverse effects based on the above, mitigation would first be assessed by further optimisation of the track design e.g. HS1 substantially extended the level of ground-borne noise and vibration mitigation possible for underground high speed train operations, and further mitigation may be achieved by provision of ballast track with under ballast mats or floating slab track, although there is limited available data for high speed operation. Where this is not practicable, further consideration would be given to the tunnel alignment or alternatively mitigation may be provided at the receiver.
- 9.3.7. Such mitigation could avoid potential adverse effects over the tunnels. HS2 Ltd is committed to ensuring that no significant effects arise.
- 9.3.8. The degree of ground-borne noise and vibration mitigation that is reasonably practicable during the construction of railway tunnels is constrained and hence it is likely that some level of short term adverse effect would arise during construction.

10. Assumptions and Limitations

- 10.1.1. **Tables 5- 8** set out key assumptions and limitations for the airborne noise appraisal, and should be read in conjunction with those already discussed in this chapter.

Table 5 - Assumptions - WebTAG Airborne Noise Appraisal

The limited strategic level data available on 'with scheme' and 'without scheme' scenarios is sufficient to provide a plan level WebTAG appraisal of route.
Annoyance levels and monetary valuation provided in WebTAG can be used to assess noise from high speed railways.
Only Daytime 18hr (06:00-24:00 hrs) operational noise levels ($L_{Aeq,18hr}$) between 45 dB $L_{Aeq,18hr}$ and 81 dB $L_{Aeq,18hr}$ are appropriate for the WebTAG appraisal.
Change in annoyance has been based on the 'with scheme' and 'without scheme' noise levels during

operational year 15.
The difference between the 'with scheme' and 'without scheme' noise levels is considered to be constant throughout the life of the 60 year appraisal period.
Dwellings located in areas with noise levels over 81 dB $L_{Aeq,18hr}$ have been considered to be relocated to an area experiencing the same noise level as the predicted existing noise level.
Monetary values have been based on 2002 data with no adjustment for income levels, property values, deprivation or demographic.
Monetary values based on operational year 15 noise levels with GDP growth and discounting applied as per WebTAG supplementary guidance.
Habituation to noise has not been considered in annoyance or monetary value calculations.
Population has been calculated as a national average of 2.36 people per dwelling.
Reported numbers of dwellings have been rounded. Generally, those in the hundreds have all been rounded to the nearest fifty, in the thousands to the nearest hundred and less than 100 have been reported as "less than". Reported monetary costs have all been rounded to the nearest half a million.

Table 6 - Assumptions - Airborne Noise Source Level

Existing aircraft noise has not been considered in calculations
Existing road traffic noise has not been considered in calculations
Noise levels 'without scheme' are considered to be existing railway noise levels only, subject to a minimum 45 dB(A).
Existing railway source levels have been calculated using the HS2 CadnaA noise model. Published Defra railway noise contour maps have been used to calibrate existing railway source noise levels for use in the model.
Noise levels 'with scheme' are considered to be existing railway noise levels combined logarithmically with future HS2 noise levels
HS2 source levels have been based on TGV measured data up to 360 km/h and further extrapolated to higher speeds.
Aerodynamic noise contribution starts to influence overall levels at 300 km/h
Maximum operational speed for HS2 is 360 km/h.
Operational characteristics such as service patterns, train length and design speed were provided by HS2 Ltd. with peak periods considered to be 07:00 to 10:00 and 16:00 to 19:00.
Speed used to calculate HS2 sources noise level is 360 km/h where design speed is above 360 km/h and design speed where design speed is below 360 km/h
Capacity modelled for the case without a wider high speed network in place for operational year 15.
3dB reduction in HS2 source noise level for the mitigated scenario irrespective of speed or numbers of trains. *

*this assumption is only valid for the proposed route with additional indicative mitigation

Table 7 - Assumptions - Airborne Noise Model

HS2 and existing rail receiver noise levels have been calculated using CRN prediction methods combined with ISO 9613-2 prediction methods for shielding from buildings
Shielding from residential and commercial buildings has been approximated by built up areas (8m relative height at edges) using ISO 9613-2 prediction methods with an attenuation of 15dB per 100m.
Receiver heights have been set at 4m relative to ground.
Dwellings within 300m of route centreline have been spatially located from postal address point data.
All dwellings outside of 300m from route centreline have been spatially located from postal address point data and grouped to 50m x 50m grid squares.
Estimated numbers exclude dwellings likely to be demolished, but include those potentially at risk of being demolished.
3D route alignment shapefile provided has been modelled as 3D
3D earthworks shapefile (cuttings and embankments) provided has been modelled as 3D
Existing Digital terrain model is based on 5m ground contours.
Built up areas assumed to be hard ground; elsewhere assumed to be soft ground.
Barrier locations within the model based on preliminary candidate areas for mitigation. These are groups of 5 or more dwellings which experience HS2 noise levels over 45 dB(A) within 300m of route centreline; additional areas were introduced following discussion and professional judgment.*

Indicative barriers applied as 2m barriers at the top of cuttings and embankments where speed is over 300km/h; 3m barriers where speed is below 300km/h and 2m on all viaducts. *
Source height has been assumed as 1m above rail head for speeds over 300Km/ and Rail head height for speeds below 300km/h
Attenuation from barriers has been calculated using CRN method, except, where speeds are above 300km/h, and barrier height is 3m, barrier height has been reduced by 1m. *

*this assumption is only valid for the proposed route with additional indicative mitigation

Table 8 - Limitations - Airborne Noise

Noise model accurate as a community level appraisal.
'With scheme' and 'without scheme' noise levels do not consider released capacity or future changes to traffic volumes of road or rail.
Noise levels do not consider stationary environmental noise sources (e.g., industrial, commercial sources).
Noise bands or intermediate WebTAG tabulation have been prepared. Calculations have been applied directly to receiver noise levels using GIS software.
The influence of detailed variations in ground attenuation and meteorological conditions are not considered in sound propagation.
The feasibility of additional indicative mitigation options has only been examined at a strategic level.
Limited research available on dose response relationship of high speed rail noise. The appraisal, therefore has assumed a traditional railway dose response.
No site surveys or baseline surveys have been carried out at the time of the noise appraisal.

Glossary

Aerodynamic Noise	Acoustic noise caused by turbulent airflow over the surface of the train body, pantograph and bogie areas.
Defra Noise Maps	Noise maps produced by Defra to meet the requirements of the Environmental Noise (England) Regulations 2006, and are intended to inform the production of noise action plans for large urban areas, major transport sources, and significant industrial sites in England.
dB	Decibel. The unit used to describe the magnitude of sound. The decibel scale is logarithmic and it ascribes equal values to proportional changes in sound pressure.
dBA	The unit of sound pressure level, weighted according to the A scale, which takes into account the increased sensitivity of the human ear at some frequencies.
Free Field	An environment in which there are no sound reflections other than from the ground. A façade correction of 3 dB is commonly used to convert free field noise levels to façade noise levels.
HGV	Heavy Goods Vehicle (a lorry/ truck weighing more than 3.5 tonnes)
$L_{Aeq,18h}$	The A-weighted equivalent continuous sounds pressure level over the 18 hour daytime period (06:00 to 24:00).
$L_{Aeq,Tp}$	The A-weighted equivalent continuous sounds pressure level of a train passby normalised to the passby duration (buffer to buffer).
L_{den}	The day, evening, night level, L_{den} is a logarithmic composite of the L_{day} , $L_{evening}$, and L_{night} levels but with 5 dBA being added to the $L_{evening}$ value and 10 dBA being added to the L_{night} value

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Figure 5 – Potential Locations of Cumulative Noise Effects – London Approach

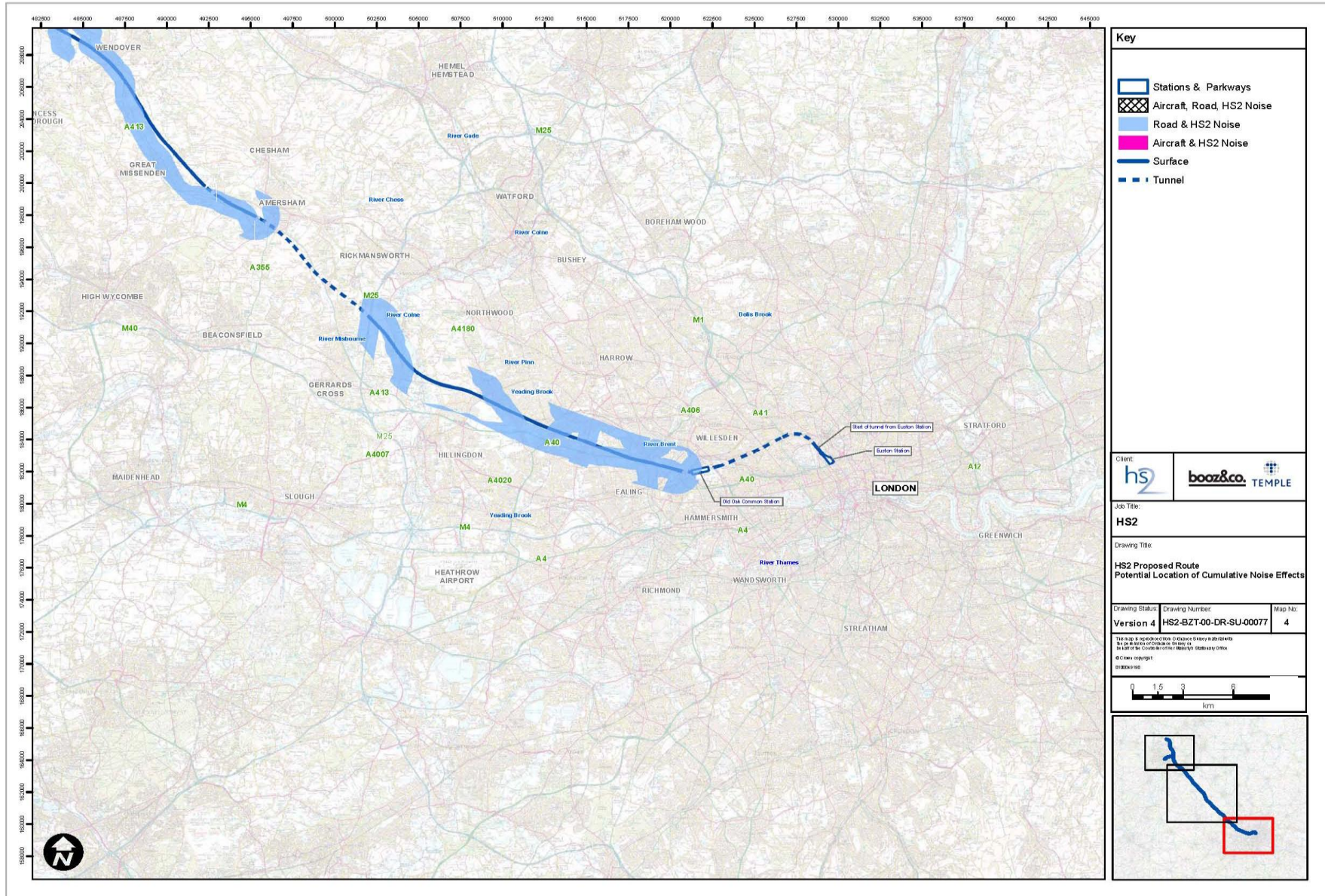


Figure 6 – Potential Location of Cumulative Noise Effects – Central Section

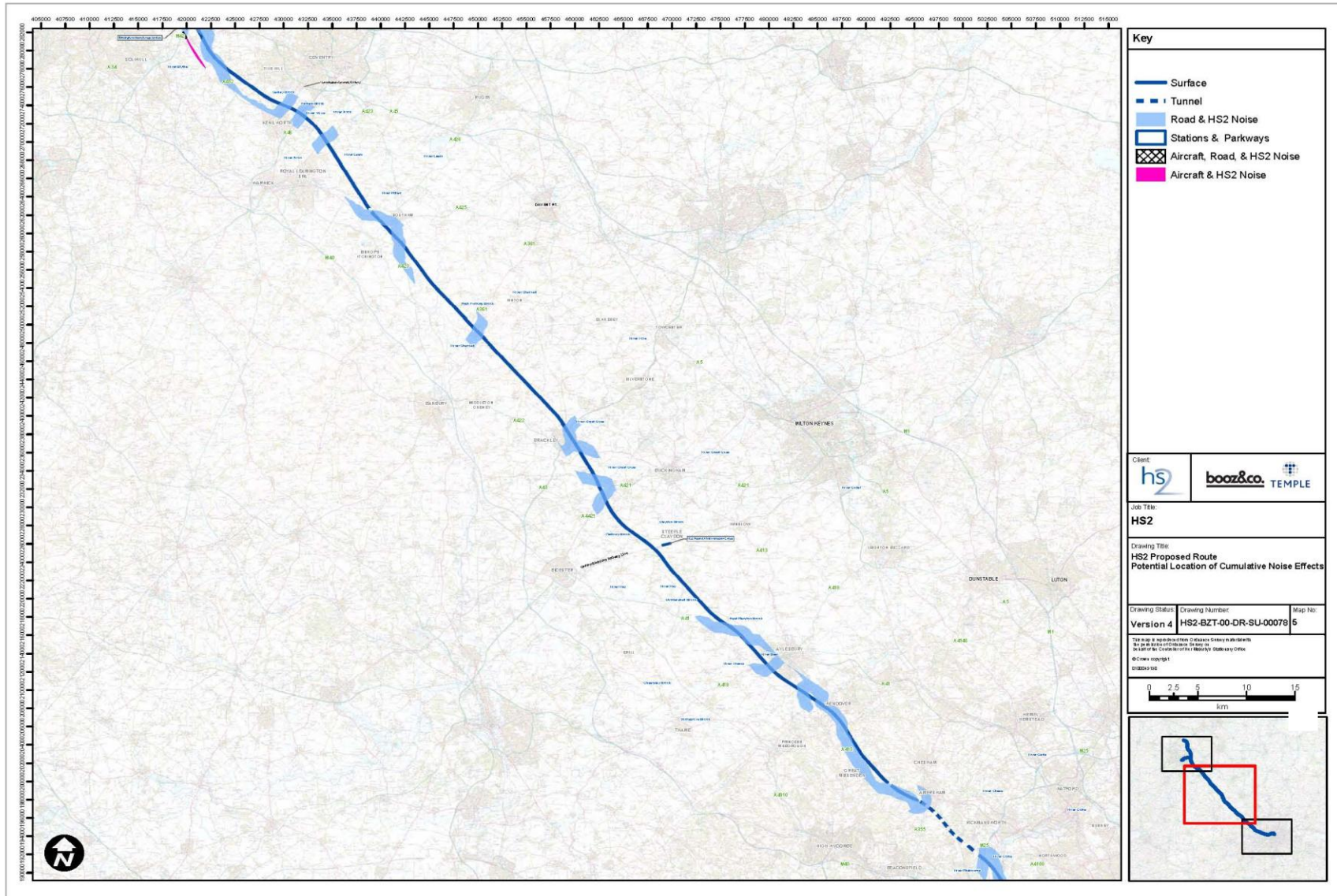
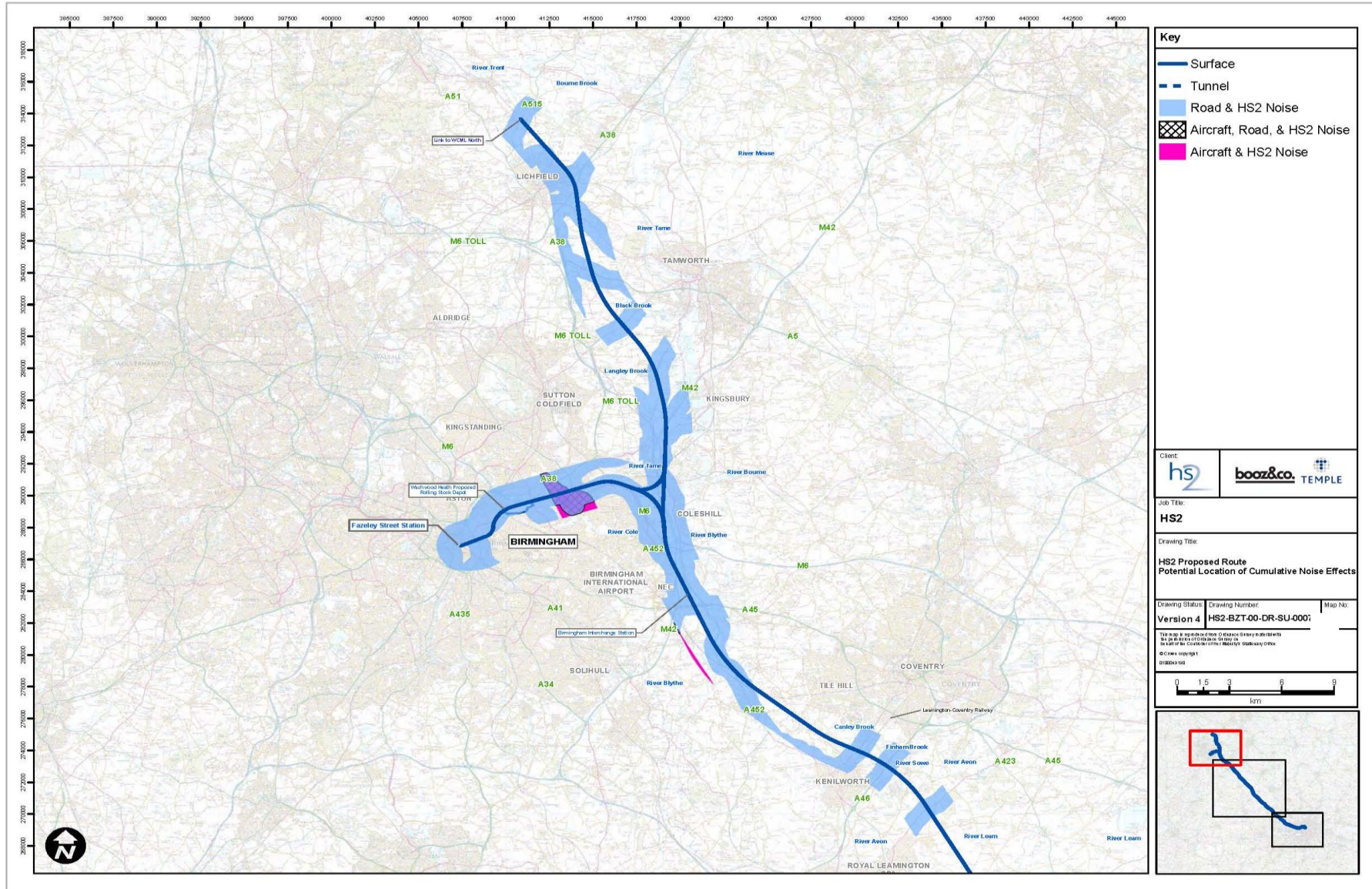


Figure 7 – Potential Location of Cumulative Noise Effects – Birmingham



Appendix 5.5

Community Integrity and Accessibility

Community Integrity and Accessibility

1. Introduction – community integrity

1.1.1. This appendix summarises the scope and methodology that has been used to appraise the potential impacts on the integrity of communities along the proposed route. It also provides an overview on the data sources used for the appendix, and a brief summary of results. This appendix describes the methods applied for the appraisal of community integrity and accessibility matters as part of the AoS.

1.2. Scope of appraisal

1.2.1. The approach taken to the appraisal of potential impacts on the AoS framework objective ‘to maintain and enhance community integrity’ (core sustainability objective 10a) has focused on four key evaluation criteria:

- Number of properties demolished²³ or affected by landtake: where the potential loss of ten or more properties in any one location is considered to be a significant adverse effect;
- Number of properties at a high risk of isolation: as a result of the introduction of a new physical barrier in the local environment. This criterion is designed to provide an indicator of both physical severance and the potential severance of social networks and interactions (see figures within this appendix);
- Properties in the 20% most deprived areas demolished or at high risk of isolation; and
- Properties with disproportionately high numbers of equality groups demolished or at high risk of isolation where known; from publicly available information sources.

1.3. Methodology and data sources

1.3.1. **Numbers of properties likely to be demolished.** The area of direct landtake associated with the route alignment, plus a 25 metre buffer zone either side of the proposed centre line reviewed against address point data and OS base maps in order to identify properties that would be physically affected by the route. Properties were counted initially using GIS mapping and were categorised into residential, commercial, industrial and community classifications. The GIS counts were refined further by reviewing hard copy maps and plans to obtain a more accurate interpretation of potential demolition effects. Where the alignment passed through urban areas and alongside existing rail infrastructure the demolition buffer was reduced to 15m and these identified properties were then reviewed in further detail in conjunction with the plans. In some areas, particularly in urban locations and around existing stations (e.g. Euston and surrounds), more detailed information was obtained through a review of planning documentation to understand possible future projects, and in some cases through site visits to determine current land use and type occupancy.

1.3.2. **Numbers of properties at high risk of isolation.** The route alignment was studied to identify any potential areas that appeared to be at most direct risk of isolation as a result of the introduction of a new physical barrier in the environment. In particular, areas of land were identified that appeared to be ‘islanded’ between the new route alignment and other existing features, including existing railways, motorways, A-roads (dual carriageway), rivers or other physical obstacles. The number of residential dwellings potentially affected within each of the identified ‘areas’ was counted using recent OS Address Point data.

²³ This has been counted using address point data from GIS

- 1.3.3. **Properties in the 20% most deprived areas demolished or at high risk of isolation.** Areas of 20% most deprived (in accordance with the Governments 2007 Indices of Multiple Deprivation) have been overlaid with areas identified as being at high risk of isolation and locations of potential demolitions to identify if there is a disproportionate impact on communities already affected by deprivation. Consideration has also been given to community facilities or places of worship within these areas.
- 1.3.4. **Properties with disproportionately high numbers of equality groups demolished or at high risk of isolation, where known.** For the length of the route, data on ethnic origin and age group has been analysed, categorised into White, Asian, Mixed, Black, Chinese and other, based on 2001 census data. An age profile has also been developed, categorised into 0-4, 5-17, 18-25, 25-45, 45-60 and 60+ based on census 2001 data. These age categories have also been chosen based on best practice from other known Equality assessments²⁴. This National data has been broken down at Ward level in order to compare against the average levels for the boroughs, and in some cases (e.g. London Euston and the Birmingham stations), this data has also been analysed at Super Output Area level. Consideration has also been given to community facilities or places of worship. It should be noted that the findings of this aspect of the appraisal have been recorded in the Framework and also in the EqIA screening report (See also *Appendix 4-2*).

1.4. Assumptions and limitations

- 1.4.1. It has been assumed that all properties located within the areas of land required for the route alignment would be demolished and all properties within the 50 metre buffer zone are at risk of demolition. It is anticipated, however, that the numbers of properties demolished or at risk of demolition would be reduced as design development becomes more detailed.
- 1.4.2. While recent OS address point data has been used in the appraisal (2009), it is possible that some of the properties have since been altered (change of use) or demolished, or that new properties have been, or are in the process of, being developed.
- 1.4.3. Ordnance Survey Address Layer 2 data (2009) was used within a GIS in order to identify properties at risk within the 50m route corridor. Whilst the data used is the most up to date available, there is the possibility that since the information was last made available the use and/or existence of some properties may have changed and this therefore must be noted as a limitation to this approach. A further limitation of using the Address Point data is that each property is represented by a single point, so it is possible that whilst the point of property would lie outside the 50m corridor, part of the actual spatial extent of the property may lie within this line but this would not be acknowledged at this stage.
- 1.4.4. The identification of pockets of land at a high risk of isolation has relied on the current level of design detail and on professional judgement. As a consequence, they should only be viewed as a general indicator of potential impacts on community integrity. At this stage, it is not feasible to map the direction or extent of the various social networks that characterise the various communities along the line of the route.

2. Introduction – accessibility

2.1. Scope of appraisal

- 2.1.1. The approach taken to the appraisal of potential impacts on the AoS objectives to maintain and enhance (a) pedestrian access, (b) access to public transport, and (c) public transport interchange (Core sustainability objectives 11a-c) has focused on seven key evaluation criteria:

²⁴ Scott Wilson (2009) Heathrow Airport: Equalities Impact Assessment

- Numbers of strategic footpaths, bridleways, nature trails and cycle paths severed and/or requiring diversion;
- Impacts on areas of open access, including common land and greens;
- Potential for improved access to public transport for non car users;
- Potential to improve option values;
- Population in the 20% most deprived areas with better access to public transport services;
- Potential to improve transport interchanges as a result of option; and
- Ability to accommodate mobility impaired access with option.

2.2. Methodology and data sources

- 2.2.1. This section summarises data sources and the methodology used for the appraisal of the first and second evaluation criteria listed in the previous section. Data sources and methodology for the remaining evaluation criteria are provided in Appendix 3 – Socio-economic Assessment. Numbers of strategic footpaths, bridleways, nature trails and cycle paths severed and/or requiring diversion: access routes that are intersected by the scheme have been assessed using available OS layers or other relevant mapping, including National Trails, Local, National and Regional cycle routes. While a footpath layer is not available, information has been gathered from the GIS OS base, which has allowed the identification and classification of pedestrian routes, including those categorised as ‘National Trail, European Long distance path, Long distance route or selected recreational routes’. Bridleways have not been assessed as this information is not available on GIS as a National Layer.
- 2.2.2. To appraise impacts on areas of open access, including Common Land and greens, Community Forests, Millennium Greens, Doorstep Greens, Forestry Commission Woodland and Countryside and Rights of Way (CROW) have been mapped. The CROW information has been categorised into Open Country, Common Land, and Section 16 Dedicated Land. These areas have been noted where the route alignment intersects or isolates any of the above categories.

2.3. Assumptions and limitations

- 2.3.1. While impacts to open space and other access routes have been identified at a broad level, the impact of changes on the users of these EIA routes would be the subject of assessment at a later stage of design detail i.e. during the EIA process, should HS2 be progressed further.

Figure 1 Areas of severance identified for the proposed route and main alternatives: London and London approaches

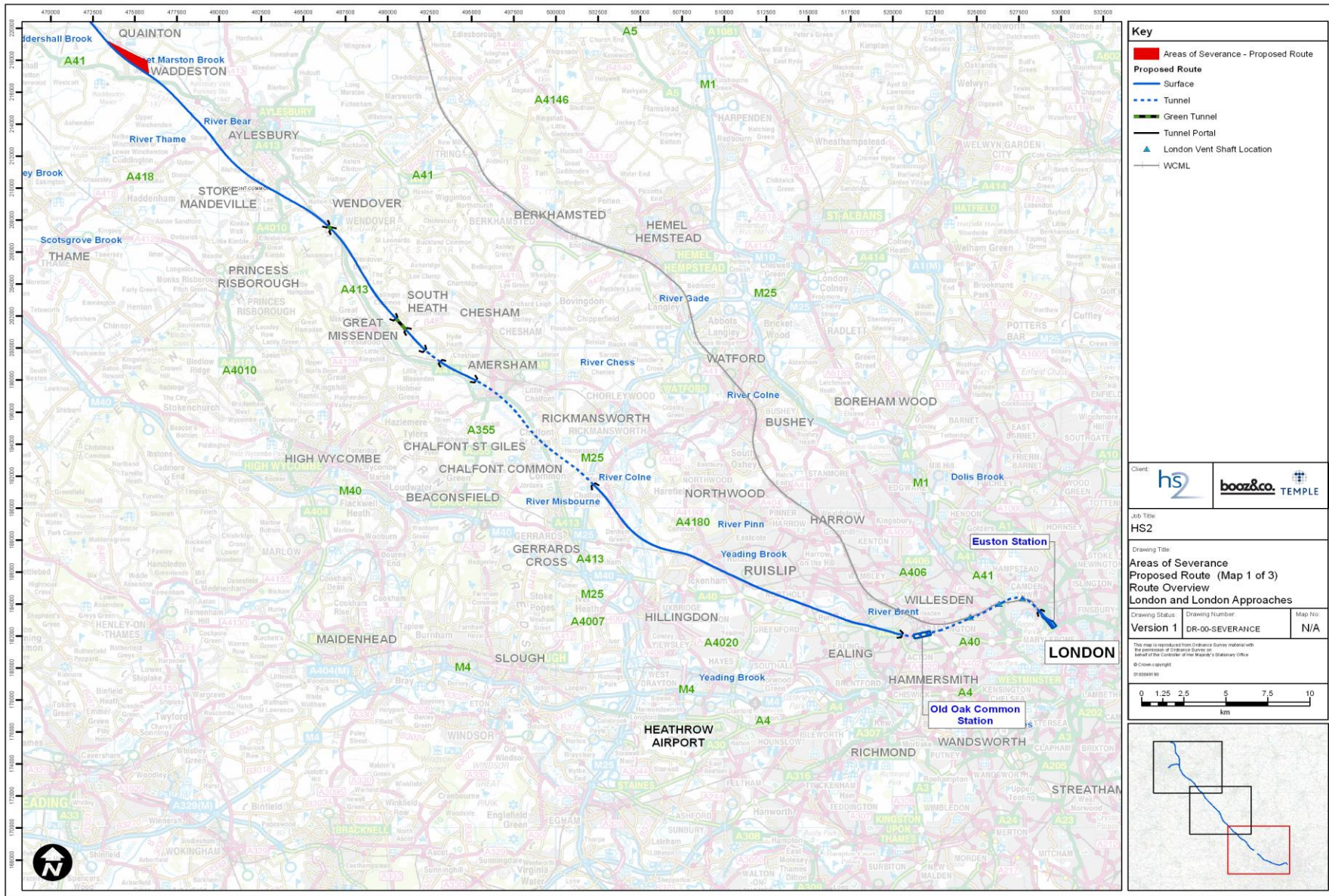


Figure 2 Areas of severance identified for the proposed route and main alternatives: section between Aylesbury and Ladbroke

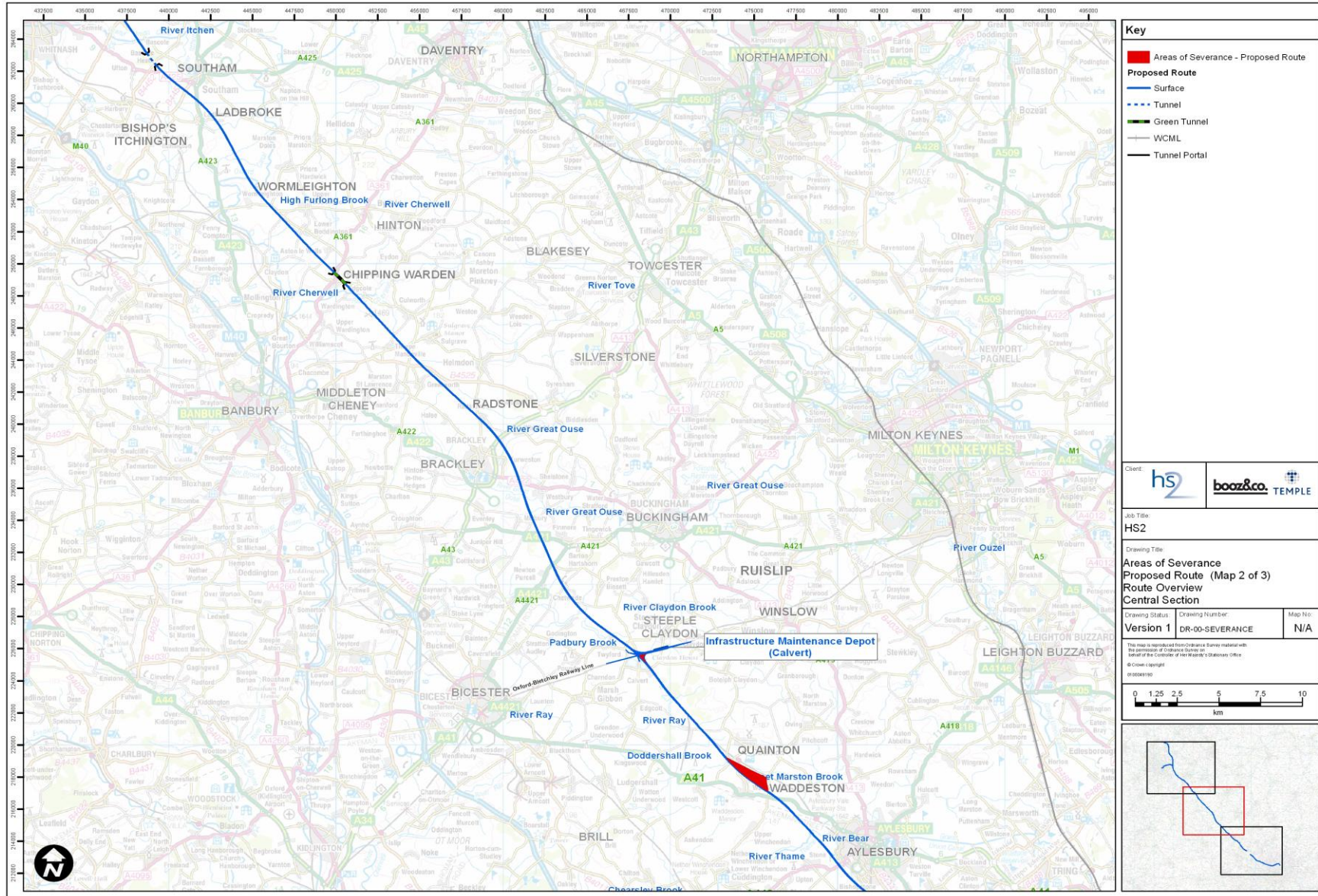
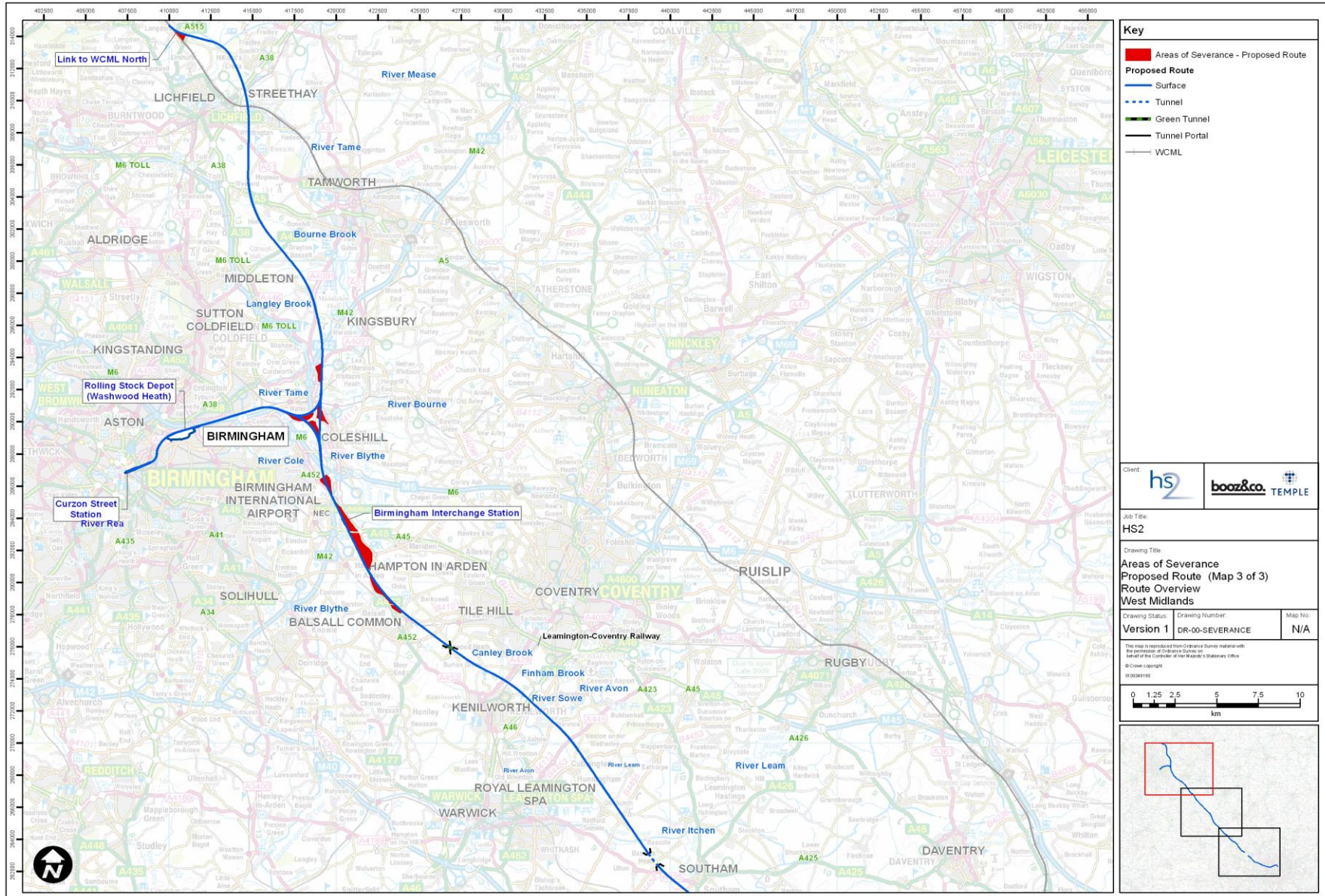


Figure 3 Areas of severance identified for the proposed route and main alternatives: West Midlands



Appendix 5.6

Initial Health Analysis

1. Initial Health Analysis

1.1. Introduction

1.1.1. This appendix summarises the scope and approach that has been used in appraising the potential impacts on the health and well being of people potentially affected along the proposed route. It also gives an overview of the information that was used and a brief summary of the results.

1.2. Scope of appraisal

1.2.1. The approach taken to potential impacts on the AoS framework objectives: to maintain and improve mental health; to maintain and improve physical health; and to reduce health inequalities (core sustainability objectives 12a, 12b and 12c) has focused on six key evaluation criteria:

- Impacts on the key determinants of mental well being (12a);
- No. of residential dwellings within 100m of the surface section of the line (which has the potential to generate impacts during construction) (12a);
- Impacts on areas with the highest 20% of tranquillity scores (12a);
- Potential to encourage a more healthy lifestyle e.g. through more active travel options) when accessing the network (12b);
- Impacts on the key determinants of physical health (12b); and
- Impacts on the key determinants of health inequality (12c).

1.2.2. A review of the effects on human health is a requirement of SEA and has been incorporated into the AoS process. Health and well-being are determined by a range of social factors, including access to transport, housing, employment, education and leisure, as well as the environmental factors more traditionally associated with the key determinants of health.

1.2.3. Transport has several features that contribute positively to the determinants of health by providing improved access to a range of services, facilities and amenities, and by providing the opportunity for social contact and interaction²⁵. Equally, the environmental impacts of transport projects during construction and operation can sometimes give rise to health effects.

1.2.4. The AoS Framework developed for HS2 Ltd addresses a number of health issues explicitly through its consideration of mental well-being, physical health and health inequalities as noted above. Other health issues are also considered as integral components of other core sustainability objectives.

1.2.5. These are summarised in **Table 1** of this appendix with reference to that part of the AoS framework in which they are captured.

²⁵ Paragraph 6.1 in Cave et al (2004) Healthy sustainable communities: What works? Milton Keynes/South Midlands Sub-Region Health and Social Care Project Team

Table 1 - Potential health effects of transport proposals

Direct effects	AoS ref	Indirect effects on a determinant of health	AoS ref
Impacts on the key determinants of mental well-being.	Issue 12	Indirect effects on physical health (e.g. physical exercise, severance, exposure to airborne contaminants)	Issue 12
Potential to encourage a more healthy lifestyle.	Issue 12	Indirect effects on mental well-being (see list below)	Issue 12
Impacts on the key determinants of physical health	Issue 12	Indirect effects on health inequalities (see list below)	Issue 12
Impacts on the key determinants of health inequality	Issue 12	Noise and vibration	Issue 9
		Congestion (n.b.: local issue)	No reference
		Physical activity and exercise	Issue 12
		Community or social networks/severance	Issue 10 and 11
		Social exclusion/inclusion	Issues 10 - 12
		Social contact and support ²⁶	Issue 10
		Social capital	Issue 13-15
		Employment opportunities	Issue 14 and 15
		Retention of money in the local economy	Issue 14
		Access to public transport	Issue 11
		Access to healthcare and social services	Issue 10 and 11
		Access to employment opportunities	Issue 14 and 15
		Access to leisure and recreation opportunities	Issue 10 and 11
		Built environment	Issue 3 and 4
		Natural environment	Issue 3, 5 and 6
		Biodiversity and habitats	Issue 5
		Planning blight	Issue 15
		Crime and disorder	Issue 13
		Fear of crime and disorder	Issue 13
		Personal safety	Issue 13
		Public safety	Issue 13
		Perceptions of safety	Issue 13
		Mobility	Issue 11
		Global climate change	Issue 2

1.3. Approach

- 1.3.1. The appraisal at this stage of design detail relied on a review of the potential positive and negative impacts on mental well being, physical health and health equality in respect of each of the sustainability issues that formed the foundations of the AoS framework.
- 1.3.2. This was recorded in the framework at commentary level and would provide input to a full Health Impact Assessment (HIA) that would be undertaken if HS2 is progressed further.
- 1.3.3. The number of residential dwellings within 100m of the surface sections of the proposed line were recorded as an indicator of those most likely to be affected by construction activities and therefore by extension at the greatest risk of experiencing temporary health

²⁶ Social support comprises three facets: emotional, practical and technical support.

impacts. In reality, mitigation and normal construction management techniques would ameliorate or reduce such effects to a practicable minimum but the appraisal of health impacts and the later HIA would guide the main focus of mitigation.

- 1.3.4. Data to enable quantified analysis of tranquillity impacts was not available when the AoS was undertaken and thus this criterion was not addressed in the framework at this stage. However, commentary on tranquillity generally is provided in Volume 1 of the Main Report under noise and landscape.
- 1.3.5. The results of this element of the appraisal are recorded under issue 12 in the Appraisal of Sustainability Framework (Volume 2).

1.4. Assumptions and limitations

- 1.4.1. The health appraisal has not been informed by consultation at this stage. As a consequence, the perceptions of potentially affected communities towards possible health issues are as yet unknown. It should also be noted that the appraisal has relied on Indices of Multiple Deprivation (IMD) data to provide an indicator of potential health inequalities. Detailed community profiles have not been prepared at this stage, and accordingly, impacts on particular groups within the community have not been appraised.
- 1.4.2. The level of design detail has not allowed for the consideration of design features that could encourage a healthier lifestyle. It is nevertheless recognised that such measures should be given further consideration at a more detailed design stage. In particular, consideration could be given to design options around stations that encourage people to access the network by modes of transport other than private vehicles.

