E24-B

High Speed Rail (West Midlands - Crewe)

Environmental Statement

Volume 5: Technical appendices

Environmental Impact Assessment Scope and Methodology Report Addendum (CT-001-002) Part 2

July 2017

ES 3.5.0.1.3

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Department for Transport

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Contents

List of annexes

1 Introduction

1.1 Scope and Methodology Addendum – Part 2

1.1.1 This is Part 2 of the HS2 Phase 2a Scope and Methodology Report Addendum. It contains the following technical notes:

Part 2

- Annex F: Electromagnetic interference;
- Annex G: Health;
- Annex H: Land quality;
- Annex I: Landscape and visual;
- Annex J: Major accidents and natural disasters;
- Annex K: Socio-economics;
- Annex L: Traffic and transport;
- Annex M: Waste and material resources; and
- Annex N: Water resources and flood risk.

Annex F: Electromagnetic interference – technical note

The following technical note is contained in this Annex:

- Electromagnetic interference.

HS2 Phase 2a West Midlands - Crewe: Technical note - Electromagnetic interference (EMI)

Contents

List of figures

List of tables

1 Electromagnetic interference (EMI)

1.1 Introduction

1.1.1 The purpose of this technical note is to provide guidance to undertake the assessment of the likely effects of electromagnetic interference (EMI) generated by the construction and operation of the Proposed Scheme.

1.1.2 Electric and magnetic fields are produced wherever electricity is used. The electric field is produced by voltage and the magnetic field by current. Electromagnetic fields (EMF) cause two types of effect;

- interference to electric and electronic equipment. This is called electromagnetic interference (EMI) and is the disturbance that affects an electrical system due to magnetic and electric fields, electromagnetic induction or electromagnetic radiation emitted from an external source; and
- the potential to cause harmful effects in the human body through EMF.

1.1.3 Electromagnetic compatibility (EMC) is the ability of equipment to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbance to other equipment in that environment.

1.1.4 This technical note considers the principal sources of EMI and EMF from the Proposed Scheme that may have an effect on third parties along the route, in particular from the traction power supply system. Emissions from the rolling stock, signalling and communication systems, electrical and mechanical systems, generally only affect the internal railway operating system and are therefore not considered further as having a wider potential effect.

1.1.5 There is also a requirement to address the EMF exposure, and the possible risk from exposures of the general public and workers to electric fields, magnetic fields and electromagnetic fields generated by the Proposed Scheme, in line with current UK Government recommendations.

1.2 Legal context

1.2.1 The Electromagnetic Compatibility Directive[1] has been incorporated in the UK as a Statutory Instrument[2]. The UK regulations requires that equipment shall be so designed and manufactured, having regard to the state of the art[3], as to ensure that:

- the electromagnetic disturbance generated does not exceed the level above which radio and telecommunications equipment or other equipment cannot operate as intended; and

[1] Official Journal of the European Union, (2014), The Electromagnetic Compatibility Directive 2014/30/EU.
[2] Enacted in December 2016 as Statutory Instrument 2016 No. 1091 Electromagnetic Compatibility, The Electromagnetic Compatibility Regulations 2016.
[3] As the 2004 EMC Directive has been repealed, government guidance is that all new installations and products should now be declared compliant to the current EMC Directive 2014/30/EU.

- it has a level of immunity to the electromagnetic disturbance to be expected in its intended use which allows it to operate without unacceptable degradation of its intended use.

1.2.2 A fixed installation shall be installed applying good engineering practices and respecting the information on the intended use of its components. With regard to the Proposed Scheme, the scope of the assessment is concerned with emissions from the Proposed Scheme only and will be installed with a view to meeting the requirements set out in bullet point 1 of paragraph 1.2.1.

1.2.3 A fixed installation is defined as a particular combination of several types of apparatus and where applicable, other devices, which are assembled, installed and intended to be used permanently at a predefined location.

1.2.4 The railway network and its components (e.g. a signalling system) are considered to be a fixed installation under the terms of the regulations.

1.2.5 An electrified railway has the potential to introduce additional risks through the generation of EMF, which has the potential to affect human health and interfere with electronic equipment. In addition, the transmission of high voltage electricity can induce potentially harmful voltages into adjacent cables, metallic structures and the human body. It is these risks that may affect third parties external to the railway and are to be considered in producing the Environmental Statement (ES).

1.2.6 For EMF exposure of the general public and workers, the reference levels based on short-term effects are found within the International Commission on Non-Ionising Radiation Protection (ICNIRP) guidelines[4] for limiting exposure to time varying electric, magnetic, and electromagnetic fields (1Hz to 100kHz) 2010. The limits within these guidelines will consider:

- occupational exposure; applicable to non-residential premises; and
- public exposure; applicable to residential premises.

1.2.7 For the assessment, the generic immunity standards will be applied i.e. BS EN 61000-6-1:2007. Electromagnetic compatibility Part 6.1: Generic standards - immunity for residential, commercial and light industrial environments and BS EN 61000-6-2:2005. Electromagnetic compatibility Part 6.2: Generic standards - immunity for industrial environments.

1.2.8 Immunity for residential, commercial and light industrial environments will be referred to as 'residential' within this technical note.

1.2.9 The Proposed Scheme will be built to comply with the BS EN 50121 series of standards, Railway Applications, Electromagnetic Compatibility, which contains the following parts;

- BS EN 50121-1:2015 Part 1: General[5];

[4] ICNIRP, (2010), Guidelines for limiting exposure to time-varying electric, magnetic and electromagnetic fields (1Hz to 100 kHz).
[5] BSI, (2015), BS EN 50121-1:2015. Railway applications - Electromagnetic compatibility Part 2: Emissions of the whole railway system to the outside world.

- BS EN 50121-2:2015 Part 2: Emissions of the whole railway system to the outside world[6];
- BS EN 50121-3-1:2015 Part 3-1: Rolling stock - train and complete vehicle[7];
- BS EN 50121-3-2:2015 Part 3-2: Rolling stock – apparatus[8];
- BS EN 50121-4:2015 Part 4: Emissions and immunity of the signalling and telecommunications apparatus[9]; and
- BS EN 50121-5:2015 Part 5: Emissions and immunity of fixed power supply installations and apparatus[10].

1.2.10 The series of standards in paragraph 1.2.9 are intended to permit compliance with the EMC Directive, but also provides a means of prescribing compatibility between the internal parts of the railway. These standards identify maximum limits of electromagnetic disturbance at the railway boundary, which is defined as 10m from the centre of the nearest track (BS EN 50121-1).

1.2.11 The Proposed Scheme will also comply with the BS EN 50122 series of standards, Railway Applications - Fixed installations - Electrical safety, earthing and the return circuit, which consists of:

- BS EN 50122-1:2011 Part 1: Protective provisions against electric shock[11];
- BS EN 50122-2:2010 Part 2: Provisions against the effects of stray currents caused by d.c. traction systems[12]; and
- BS EN 50122-3:2010 Part 3: Mutual Interaction of a.c. and d.c. traction systems[13].

1.2.12 In addition, the following standards are applicable:

- BS EN 50499:2008 Procedure for the assessment of the exposure of workers to electromagnetic fields and covers the essential requirements of the proposed EMF Directive[14];

[6] BSI, (2015), BS EN 50121-2:2015. Railway applications - Electromagnetic compatibility Part 2: Emissions of the whole railway system to the outside world.
[7] BSI, (2015), BS EN 50121-3-1:2015. Railway applications - Electromagnetic compatibility Part 3-1: Rolling stock - train and complete vehicle.
[8] BSI, (2015), BS EN 50121-3-1:2015. Railway applications - Electromagnetic compatibility Part 3-2: Rolling stock – apparatus.
[9] BSI, (2015), BS EN 50121-4:2015. Railway applications - Electromagnetic compatibility Part 4: Emissions and immunity of the signalling and telecommunications apparatus.
[10] BSI, (2015), BS EN 50121-5-2015. Railway applications - Electromagnetic compatibility Part 5: Emissions and immunity of fixed power supply installations and apparatus.
[11] BSI, (2011), BS EN 50122-1:2011. Railway Applications - Fixed installations - Electrical safety, earthing and the return circuit. Part 1: Protective provisions against electric shock.
[12] BSI, (2006), BS EN 50122-2:2010 - Railway applications. Fixed installations. Electrical safety, earthing and the return circuit. Provisions against the effects of stray currents caused by d.c. traction systems.
[13] BSI, (2006), BS EN 50122-3:2010. Railway applications. Fixed installations. Electrical safety, earthing and the return circuit. Mutual Interaction of a.c. and d.c. traction systems.
[14] BSI, (2008), BS EN 50499:2008. Procedure for the assessment of the exposure of workers to electromagnetic fields.

- EC Recommendation 1999/519/EC on the limitation of exposure of the general public to electromagnetic fields (0Hz to 300GHz), provides levels for public exposure to EMF[15]; and
- The Railways (Interoperability) Regulations 2011[16].

1.2.13 Electromagnetic Field (EMF) limits are specified in the EU Directive 2013/35/EU[17] Electromagnetic Fields (EMF) limits, published in 2013 and enforceable in the UK from July 2016. Currently, the limits provided by the International Commission on Non-Ionizing Radiation Protection[18] (ICNIRP) are applicable and can be used during design and installation.

1.3 Requirements

1.3.1 The requirements for EMC will be met throughout the life of the Proposed Scheme by adhering to the guidelines, technical specifications and industry best practice at the design, installation, test and commissioning stages.

1.3.2 To assist with the environmental assessment, baseline data will be collected and evaluated to assess the vulnerability of the existing environment against the effects of the Proposed Scheme and its operation. This will be undertaken as a desk-top study.

2 Scope and methodology

2.1 Electromagnetic risk

2.1.1 An electrified railway has the potential to introduce additional EMI and EMF risks through the generation of electromagnetic fields, which have the potential to effect human health and interfere with electronic equipment. In addition, the transmission of high voltage electricity can induce potentially harmful voltages into adjacent cables, metallic structures and the human body.

2.1.2 Emissions from the signalling and communication systems, electrical and mechanical systems, generally only affect the internal railway operating system and are not considered in this analysis.

2.1.3 Power supplies used for construction are generally not sufficient to cause major EMI or EMF problems. Tunnel boring machines generally use a high voltage supply for their operation, typically 11kV three phase. The levels of EMF emissions are generally insufficient to cause any adverse effect.

2.1.4 Within the land required for the construction of the Proposed Scheme, most buildings that would be potentially at risk will be demolished. It is not therefore, anticipated that any electromagnetic impact on people would occur. Some buildings may remain close to the Proposed Scheme and hence there may be risk of interference for some

[15] Official Journal of the European Union, (1999), EC Recommendation 1999/519/EC on the limitation of exposure of the general public to electromagnetic fields (0Hz to 300GHz).
[16] The Railways (Interoperability) Regulations 2011. Her Majesty's Stationery Office.
[17] Official Journal of the European Union, Directive 2013/35/EU on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (electromagnetic fields)
[18] ICNIRP (2010) 'Guidelines for Limiting Exposure to Time-Varying Electric, Magnetic, and Electromagnetic Fields (1Hz to 100kHz)', Health Physics, 99 (6): pp. 818-836

sensitive electrical equipment or equipment in residential, commercial and industrial properties.

2.1.5 EMI and EMF issues during operation of the Proposed Scheme will be limited to those caused by the traction current within the overhead line electrification system. Emissions from rolling stock, signalling and other electrical infrastructure such as trackside non-traction electrical distribution, are not high enough to cause effects outside the railway boundary.

2.2 Areas at risk

2.2.1 An electrified railway has the potential to affect the operation of susceptible equipment adjacent the railway. Examples of potential sensitive sites that may be at risk and are to be considered as part of this assessment are:

- universities;
- schools;
- hospitals;
- military establishments;
- airports;
- emergency and commercial radio stations;
- residential properties; and
- industrial properties.

2.2.2 Magnetic fields generated by current flowing within the overhead line traction distribution system, have the potential to cause harmful effects in the human body.

2.2.3 Power lines and other aerial cable routes that run parallel to the railway for any significant distance may be affected by induced voltages from the overhead line electrification system if placed too close together.

2.2.4 Other services such as underground pipelines are susceptible to induced voltage, if they are metal and run parallel for any significant distance.

2.3 Secondary areas

2.3.1 Where overhead power lines and their supporting structures have to be moved to enable safe construction of the Proposed Scheme, an assessment of the effect of the relocated power line will be undertaken, to ensure that it does not introduce any EMI or EMF that is detrimental to its new surroundings.

2.3.2 The National Grid in its publication Development near overhead lines[19] indicates that magnetic fields generated by 275/400kV overhead power lines are in the order of 4 microTesla (μT) at 10m from the centreline. BS EN 61000-6-1 specifies residential

[19] National Grid, (2008), Development near overhead lines - Planning and amenity aspects of high voltage electricity transmission lines and substations.

immunity of 3 Amperes per metre (A/m), which is approximately 4μT. It is therefore unlikely that moving an existing power line will have any significant effect.

2.3.3 Any changes to the route of overhead lines will be undertaken in accordance with National Grid's environmental and planning standards and procedures.

2.4 Data collection

2.4.1 A desk-top survey of the route will be undertaken to identify any potentially sensitive sites within a 50m corridor either side of the centreline of the nearest HS2 Phase 2a track, or from the proposed power equipment, e.g. overhead lines and traction substations.

2.4.2 The primary sources of EMI and EMF will be the traction power distribution and overhead line electrification. The extent of any interference or harmful effects will be limited to only a short distance from the railway boundary or the boundary of any traction power substation or switching station. A 50m corridor either side of the nearest rail is to be selected to identify all potential receptors within that area and any receptor outside of the 50m corridor will not be affected. Sections 2.8.2 and 2.10.2 identify the process used to determine the 50m corridor.

2.4.3 Preliminary traction power modelling has been undertaken, which has identified potential electromagnetic emissions data throughout the route. This preliminary EMF data has formed the baseline against which to identify those receptors that may be at risk. The Proposed Scheme will comply with BS EN 50121, which limits the maximum EMF at the railway boundary.

2.4.4 The identification of possible third-party receptors to EMI and EMF will be undertaken by mapping and analysing the alignment route(s) using the construction drawings for the applicable area and the route alignment maps. From this information, third party receptors that fall within the 50m corridor either side of the centreline of the nearest track and also the proposed power equipment e.g. overhead lines and traction substations will be identified.

2.4.5 Typical receptors will include (but are not limited to); residential zones, industrial zones, schools, hospitals, emergency services, military establishments, radio transmitters, mobile phone masts, National Grid infrastructure and existing railways.

2.4.6 Potential receptors in buildings that are to be demolished to make way for the Proposed Scheme will no longer be receptors once the Proposed Scheme is operational and are therefore not included in the assessment.

2.4.7 Although a 50m corridor has been selected, the effects of EMI can extend further afield in cases of services up to a limit of 200m and running parallel for any significant distances, causing induced voltages. Any such services (National Grid overhead power lines, motorway telecommunication systems, oil and gas pipelines etc.) will be included in the data collected.

2.4.8 If construction drawings are not available i.e. individual track positions are not available, those third-party receptors that fall within a 60m corridor either side of the centreline of the route will be identified.

2.4.9 An element of professional judgement must be applied whether to include receptors that fall just outside of the 50m or 60m rule.

2.4.10 Other than items identified in paragraph 2.4.7, any receptor outside the 50m wide corridor should not be affected and need not be considered as part of this assessment.

2.4.11 Three types of potential receptors shall be recorded:

- locations that could contain electrical equipment that may be susceptible to EMI;
- locations where people are located that may be affected by EMF; and
- adjacent equipment that may be susceptible to induced currents for example; overhead cables, parallel telecommunications cables, pipelines or metal fencing.

2.4.12 Once each receptor has been identified, an assessment will be undertaken to categorise the perceived level of risk and to identify the potential mitigation for each receptor.

2.4.13 Data will be collected to identify potential receptors at risk. Not all data will be presented within the ES, only those deemed to be at risk. The data collected will be kept to demonstrate an extensive search. The data will be tabulated for each type of receptor at risk (example Tables contained in Appendix A), showing:

- an identification number;
- its location along the route, in kilometres;
- distance from the centre of the nearest track;
- the receptor; house, industrial unit, hospital, school etc.;
- the receptor type; industrial, residential, railway, overhead power line etc.;
- the reference that defines the immunity limit[20];
- immunity limits[21];
- estimated emission level[22];
- is there an EMI/EMF risk (yes or no);
- mitigation measures; and
- other comments.

2.4.14 From the information identified in paragraph 2.4.13, only significant risks will be listed within the ES, as many of the EMF/EMI risks will be mitigated through the design,

[20] This is a reference to the standards that indicate immunity limits used to evaluate the receptor.
[21] Immunity limits are the maximum Electromagnetic intensity values that can be tolerated by a receptor before degradation or harm. See tables in Appendix A for specific values for equipment and human health limits.
[22] These are estimated EMF emission values according to the preliminary traction modelling results, see Appendix B of this technical note for contour plots for values.

installation, operation and maintenance of the Proposed Scheme. Risks to be identified for the ES are:

- residential, commercial and light industrial receptors sufficiently close to the proposed scheme that may be susceptible to EMI. Where these are identified, they will be subject to further assessment at detailed design stage. Example Table A1 in Appendix A of this technical note will include EMI receptors within 20m of the centreline of the nearest track, although some of these may not be at risk due to their particular situation e.g. sufficiently below a viaduct such that the EMI is expected to be below 3 A/m;
- in exceptional cases, where receptors are sufficiently close to the Proposed Scheme such that the plots in Appendix B of this technical note do not provide sufficient resolution to conclude that there is no EMF risk to particular receptors (typically, within 10m from the centreline of the nearest track), Table A2 in Appendix A will include these receptors, which will be further assessed at detailed design stage; and
- infrastructure identified in 2.4.7 which runs parallel to the Proposed Scheme for over 2km and within 200m from either side of the centreline of the track. This infrastructure may be at risk of induced voltages, which can be mitigated through adherence to applicable standards at the design and installation stages. These receptors will be presented in the example Table A3 in Appendix A.

2.5 Emission levels

2.5.1 The preliminary results of the traction power modelling show anticipated levels of EMF as contour plots. These plots are reproduced within Appendix B of this document and show key points from the centreline of the railway. They represent notional feeding sections of the HS2 Phase One route and are still relevant to Phase 2a as the feeder station loads correspond to the maximum traction power supply load on the HS2 route.

2.5.2 The worst case values of EMF will be used in determining the level of risk, which will depend on the receptor location in relation to track level, i.e. in a cutting, on an embankment or viaduct, or in a tunnel.

2.5.3 In any case, the Proposed Scheme will comply with BS EN 50121, which limits the maximum EMF at the railway boundary to below ICNIRP levels.

2.5.4 Outside the railway boundary, the levels of radiated electric fields generated from the traction power will not exceed the 5kV/m threshold within the ICNIRP guidelines and will have no adverse effect on human health. It will not therefore be considered further in this assessment. This has been established from the preliminary traction power modelling.

2.5.5 Results from the preliminary modelling estimates a maximum induced voltage per unit length of approximately 30V/km at 20m from the centre of the nearest track.

From this data, there is therefore the potential for any electrical conductor[23] within 20m exceeding the 60V touch threshold[24] if it ran parallel to the Proposed Scheme for over 2km. Similarly, between 20m and 50m from the centre of the nearest track, there is risk of induced voltages of over 60V where parallel running is over 3km.

2.5.6 Motorways that run parallel for a significant distance, typically more than 2km and up to 500m separation, may have telecommunication lines that could be susceptible to induced voltages. The induced voltage limits for telecommunication lines are recorded in the International Telecommunication Union Directive ITU-T Volume VI[25].

2.6 Risk assessment

2.6.1 The risk assessment will consider the following potential risks against each establishment or location:

- health immunity from the effects of power frequency magnetic fields;
- equipment immunity from the effects of radio frequency electric fields and power frequency magnetic fields; and
- effects of induced voltages and other effects.

Health immunity

2.6.2 The effects of magnetic fields will be assessed against the limits in ICNIRP for electromagnetic exposure to workers and the general public. For exposure compliance, extrapolated magnetic fields will be compared with the ICNIRP reference levels. The magnetic field levels will be taken from the contour plots that are contained within Appendix B of this technical note.

2.6.3 The plots indicate less than 10μT level of EMF at distances of between 7-10m from the centreline of the nearest track. This level is significantly lower than the 200μT ICNIRP recommendation for general public exposure.

2.6.4 ICNIRP identifies the reference level for short term exposure to magnetic fields, which are the only guidelines set by the UK Government. There are no standards applicable to long term effects. The risk arising from long-term, low level of magnetic field exposure to children is not assessed here as although ICNIRP acknowledges research in this area, it concludes that "a causal relationship between magnetic fields and childhood leukaemia has not been established nor have any other long-term effects been established."

Electrical interference

2.6.5 The modelled contour plots (Appendix B) indicate a 4A/m (equivalent to 5μT) level of emissions at approximately 15m from the centre of the nearest track. This level is above the 3A/m limit for residential immunity specified in BS EN 61000-6-1[26].

[23] An electrical conductor is a material that allows electric current pass through it easily.
[24] Touch threshold is a safe voltage/current value above which electric shocks are experienced and it is typically around 60V.
[25] International Telecommunication Union, ITU-T Directives, concerning the protection of telecommunication lines against harmful effects from electric power and electrified railway lines: Volume IV Danger, damage and disturbance.
[26] BSI, (2007), BS EN 61000-6-1:2007. Electromagnetic compatibility Part 6.1: Generic standards- immunity for residential, commercial and light industrial environments.

Therefore, residential receptors within 20m of the centre of the nearest track are considered to be potentially at risk from EMI.

2.6.6 The 20m distance identified in paragraph 2.6.5 is dependent on the receptor being at the same level as the railway. If the Proposed Scheme is on a viaduct, embankment or in a cutting this would affect the level of risk and should be taken into account when identifying receptors at risk.

2.6.7 Exceeding the reference level does not necessarily mean that the prescribed basic restrictions have been exceeded. Where reference levels have been exceeded then mitigation measures will be provided. The prediction of potential interference at this point in time is based on the preliminary traction power modelling. Further models will be generated during detailed design to facilitate further assessment. In some cases, interference may not be known until the testing and commissioning stage, where further mitigation may be necessary. The preliminary modelling is based on worst case levels of generated EMF, which appear as peak levels that may be experienced for very short periods of time.

2.6.8 There may be residual effects for people with active medical implants, including pacemakers, where the EMC immunity performance of the active medical implant is less than the immunity performance specified in applicable harmonised standards.

2.6.9 The effects of EMI will be assessed against the limits in BS EN 61000-6-1 and BS EN 61000-6-2[27]. Table A4 in Appendix A summarises the limits for both magnetic and electric immunity.

Other effects

2.6.10 The effects of induced voltages are mitigated by adherence to British and European Standards and industry best practice throughout the design, installation, operation and maintenance phases.

2.6.11 Similarly, any effects on other railways will be mitigated through adherence to British and European Standards and industry best practice throughout the design, installation, operation and maintenance phases. Studies undertaken previously on similar railway projects, suggest that the risk posed by a new electrified railway is well within recommended limits and that the risk of EMI is only confined to the railway infrastructure.

Wildlife

2.6.12 The published studies as identified in the ICNIRP guidance addressing the risk of EMF to wildlife shows little or no evidence of a significant environmental impact. From current information, the exposure limits in the ICNIRP guidelines for protection of human health are also protective of wildlife.

[27] BSI, (2006), BS EN 61000-6-2:2005. Electromagnetic compatibility Part 6.2: Generic standards- immunity for industrial environments.

2.7 Mitigation

2.7.1 Management and control of EMI will be assured by following the process defined within those standards and by adopting best practice for design, installation, maintenance and operation. In particular:

- compliance with the EU Directive 2014/30/EU and UK Statutory Instrument when enacted is December 2016;
- application of harmonised standards BS EN 50121, BS EN 50122 and BS EN 61000 series of standards;
- comply with applicable Technical Specifications for Interoperability; and
- application guidance of Network Rail (NR) code of practice NR/L2/RSE/30041[28], which although is not applicable to the Proposed Scheme, is an example of best practice.

EMF and human health

2.7.2 It is extremely unlikely that the levels of EMF will exceed those recommended in ICNIRP; even the closest of receptors will be subjected to emissions below 5% of the acceptable ICNIRP levels.

2.7.3 For public access where bridges pass over or under the Proposed Scheme, the level of EMF exposure may be higher than that at ground level, however it is unlikely to reach maximum threshold. The level of exposure is also likely to be of a transient and short-term nature (e.g. crossing a bridge in a vehicle or on foot).

2.7.4 It is therefore expected that in most cases no mitigation against EMF will be required, as the ICNIRP threshold limits will not be exceeded.

2.7.5 There may be exceptional cases where receptors are sufficiently close to the Proposed Scheme such that the plots in Appendix B do not provide sufficient resolution to conclude that there is no EMF risk to particular receptors. These receptors will be included in Table A2 of the assessment in the ES and they will be further assessed at detailed design stage.

Electromagnetic interference

2.7.6 Potential mitigations against significant EMI issues for receptors affected by the Proposed Scheme include:

- relocation of the receptor to a location where the impact is reduced below accepted limits;
- emission control from the Proposed Scheme;
- screening; and

[28] Network Rail, (2012), NR/L2/RSE/30041 Electromagnetic Compatibility Assurance Process. Issue 2, dated 2 June 2012.

- increase the immunity of the receptor (replace equipment designed for residential immunity with that designed for industrial immunity).

2.7.7 It is expected that EMI risks may only affect residential receptors within 20m from the centreline of the nearest track or industrial receptors with very sensitive electrical or electronic equipment. Where identified, these receptors will be further evaluated during the detailed design stage of the project and further mitigation taken, which may be in the form of replacement of equipment with less sensitive equipment.

Induced voltages and other effects

2.7.8 In addressing the impact of the route running alongside, over or under an existing railway, mitigation will be met by meeting the requirements of both BS EN 50121 and BS EN 50122 suite of standards for design, construction, operation and maintenance. The design solutions will have to be agreed with the railway owner at the detailed design stage though consultation.

2.7.9 Induced voltages are mitigated by separation, screening or earthing and bonding. Metallic pipes and conduits that are within 60m from the railway and run parallel for more than 200m can be bonded to earth electrodes at intervals at no greater than 200m. This is in accordance with the NR standard NR/SP/ELP/21085[29], which although not applicable to the Proposed Scheme is an example of best practice. Such solutions will be discussed with the infrastructure owner at the design stage for agreement.

2.7.10 Where there is parallel operation with an existing motorway for a significant length, typically exceeding 2km, a review is required to be undertaken at the design stage and in discussion with the motorway owner to agree mitigation in accordance with existing British and European Standards and industry best practice.

Construction

2.7.11 Mitigation against any specific construction issues will be addressed during the design. It will be the responsibility of the installation contractor to manage these issues on site.

2.7.12 High voltage supplies for construction machinery, especially for tunnel boring machines will not emit EMF at harmful levels.

2.7.13 Construction machinery and plant, and associated communications (e.g. construction radios) will comply with the applicable standards for EMF and EMC, for example Machinery Directive 2006/42/EC[30]. Therefore, when installed, operated and maintained correctly, the risk of this apparatus producing EMF exceeding published limits for workers and the public or causing EMI is considered to be low.

2.7.14 All other electrical equipment used for construction will conform to the EMC Directive and should not cause any adverse effects.

2.7.15 It is therefore expected that no mitigation against EMF or EMI will be required for construction.

[29] NR/SP/ELP/21085 Electromagnetic compatibility (EMC) assurance process, Network Rail publication.
[30] European Commission, (2006), EU Directive 2006/42/EC on machinery.

2.8 Cumulative effects

2.8.1 The likely cumulative effects of the Proposed Scheme running alongside an existing railway electrified at 25kV are unknown at this point in time. The electrification design of the Proposed Scheme is not sufficiently developed to make an accurate prediction. In undertaking the assessment of likely receptors, the cumulative effects have assumed to be the addition of the respective EMF strengths at any particular point from the railway. The results from the preliminary traction modelling show that the maximum level of EMF at a point 20m from the centre of the nearest track is less than 1.5% of the ICNIRP limit for residential receptors. It is highly unlikely that any cumulative effect will come anywhere near to the ICNIRP level and will be discounted for this assessment.

2.8.2 The cumulative level of EMI resulting from running alongside an existing electrified railway may lead to exceeding the recommended 3A/m residential limit identified in BS EN 61000-6-1:2007. Interference at this level is not always certain; other factors can affect the outcome. Where this occurs, individual tests can be undertaken to assess the level of interference once the Proposed Scheme is energised. For the purpose of the risk assessment, those receptors that are within 20m of centreline of the nearest track, are to be considered at risk.

2.8.3 It is unlikely that any cumulative effect will exceed the 30A/m industrial limit identified in BS EN 61000-6-2:2005 and will be discounted for this assessment.

2.9 Climate change

2.9.1 The levels of generated EMF and EMI are dependent on the traction power, which has been calculated for a worst-case scenario based on the maximum trains running per hour. Any change in climate is unlikely to affect the output from the traction power and cause any significant increase in EMF or EMI and will be discounted for this assessment.

2.10 Significance

2.10.1 The ES must identify all likely significant risks and it is therefore necessary to describe the level of significance for each type of risk. The following sections describe the levels of significance for EMF and EMI.

2.10.2 The limit recommended by ICNIRP for short term effects of EMF general public exposure is 200 µT andfor occupational exposure the limit is 1000µT. According to the preliminary modelling results, the maximum level of EMF estimated outside of the railway boundary (i.e. between approximately 7-10m from the centre of the nearest track) is less than 10µT or 5% of the acceptable limit. The level of significance for EMF is therefore regarded as negligible.

2.10.3 The immunity level specified in BS EN 61000-6-1:2007 for significant electromagnetic interference to occur in residential properties is 3A/m. Any value above this is significant however, the effects of EMI on residential electrical or electronic equipment would be classed as moderate; defined as, "limited impact (by extent, duration or magnitude) which may be considered to be potentially significant".

2.10.4 From the preliminary modelling results, only residential properties up to 20m from the centreline of the nearest track are to be considered at risk from EMI.

2.10.5 Similarly, the immunity level specified in BS EN 61000-6-2:2005 for significant electromagnetic interference to occur in industrial properties is 30A/m. The preliminary modelling results show that this figure is unlikely to be exceeded and therefore the significance of EMI on industrial properties is therefore regarded as negligible.

2.10.6 Where there is an impact on an existing railway, overhead power line, motorway telecommunication systems or metallic services running parallel with the Proposed Scheme, all issues will be mitigated through design, installation, operation and maintenance to current British, European Standards and industry best practice. Such design solutions will be developed though consultation with the infrastructure owner. As a result, effects of EMF or EMI on these systems can be disregarded for the purpose of reporting in the ES.

2.11 Presentation of assessment results

2.11.1 Receptors at risk of EMI are to be included within the table of results, which will form part of the Volume 5 appendices of the ES. Such receptors will be limited to residential properties within 20m from the centreline of the nearest track.

2.11.2 Exceptional cases of receptors at risk of EMF will be included within the table of results.

2.11.3 Consideration will be given to the position of the receptor relative to the Proposed Scheme as this may affect the risk.

2.11.4 Where the Proposed Scheme runs in a tunnel, receptors within 20m are unlikely to be affected. Similarly, where the Proposed Scheme runs on a viaduct, embankment or in a cutting the level of EMI may be less than for an equivalent receptor at grade.

2.11.5 Infrastructure identified in paragraph 2.4.7 which runs parallel to the Proposed Scheme for over 2km and within 200m are to be included within the table of results.

2.11.6 Tabulated examples are shown in Tables A1, A2 and A3.

Appendix A: Tables

Table A1: Example of tabulated results (for EMI receptors that are within 20m from the centre of the nearest track)

Electromagnetic compatibility assessment (equipment immunity to traction power frequency magnetic fields)										
ID number	**Railway chainage km + m**	**Distance from nearest track centre (m)**	**Sensitive installation**	**Receptor**	**Reference**	**Immunity limit (A/m)**	**Estimated emission level**	**Is there an EMI risk? (Y/N)**	**Mitigation measures**	**Comments**
A1	148+250	10	School	Residential	BS EN 61000-6-1 BS EN 61000-6-2	3	>3A/m	Y	Replace with less sensitive equipment	Undertake another review once the Proposed Scheme is operational and replace equipment only then
A2	148+550	15	Machine factory	Heavy industrial	BS EN 61000-6-1 BS EN 61000-6-2	30	<30A/m	N	N/A below recommended levels	The Proposed Scheme in cutting
A3	149+050	20	House	Residential	BS EN 61000-6-1 BS EN 61000-6-2	3	<3A/m	N	N/A below recommended levels	The Proposed Scheme on embankment
A4	149+550	15	Retail unit	Light industrial	BS EN 61000-6-1 BS EN 61000-6-2	3	>3A/m	Y	Replace with less sensitive equipment	The Proposed Scheme on embankment. Undertake another review once the Proposed Scheme is operational and replace equipment only then

Table A2: Example of tabulated results (for EMI receptors that are within 10m from the centre of the nearest track)

Electromagnetic field exposure assessment (health immunity)										
ID number	**Railway chainage km + m**	**Distance from nearest track centre (m)**	**Sensitive installation**	**Receptor**	**Reference**	**Immunity limit (μT)**	**Estimated emission level**	**Is there an EMF risk? (Y/N)**	**Mitigation measures**	**Comments**
B1	1+250	5	House	Residential	ICNIRP	200	>7.47μT	unclear	Undertake further review at detailed design stage	The Proposed Scheme on existing viaduct
B2	1+650	5	House	Residential	ICNIRP	200	>7.47μT	unclear	Undertake further review at detailed design stage	The Proposed Scheme on existing viaduct

Table A3: Example of tabulated results (for other receptors that run parallel to the proposed scheme for over 2km and within 200m)

Electromagnetic compatibility assessment (induced voltages and other effects)										
ID number	**Railway chainage km + m**	**Distance from nearest track centre (m)**	**Sensitive installation**	**Receptor**	**Reference**	**Immunity limit (μT)**	**Estimated emission level**	**Is there an EMI risk? (Y/N)**	**Mitigation measures**	**Comments**
C1	147+900 to 149+180	200	275/400kV Grid overhead line route	Power line	Potential induced voltages. HS2 EMC Strategy Document			N	Earthing and bonding to current standards	Unlikely to cause significant induced voltages, distance from track centre too great.
C2	148+800 to 152+000	50	The Proposed Scheme runs parallel to existing Birmingham Coventry 25kV electrified railway	Railway	BS EN 50121 suite of standards apply as does BS EN 50122			Y	Earthing and bonding to current standards	Design solutions to be agreed with the asset owner.

Electromagnetic compatibility assessment (induced voltages and other effects)										
ID number	**Railway chainage km + m**	**Distance from nearest track centre (m)**	**Sensitive installation**	**Receptor**	**Reference**	**Immunity limit (μT)**	**Estimated emission level**	**Is there an EMI risk? (Y/N)**	**Mitigation measures**	**Comments**
C3	166+300 to 168+900	50-150	Buried BP Pipeline	Metal pipe line	Potential induced voltages. HS2 EMC Strategy Document			Y	Earthing and bonding to current standards	Design solutions to be agreed with the asset owner.
C3	166+310 to 168+320	100-200	The Proposed Scheme runs parallel to M42 motorway	Motorway telecoms cables	Potential induced voltages. HS2 EMC Strategy Document			N	Earthing and bonding to current standards	Unlikely to cause significant induced voltages, length of parallelism below limit.

Table A4: Assessment limits at 50Hz, taken from ICNIRP, BS EN 61000-6-1 and BS EN 61000-6-2

Basis of limit	**Units**	**Public Limit**	**Occupational Limit**
Electric fields, limit based on public health considerations	kV/m	5	10
Magnetic fields, limit based on public health considerations	μT	200	1000
EMC recommendations. Magnetic interference with any electronic equipment:			
Residential, commercial and light industrial limits	A/m	3	
Industrial limits	A/m	30	

Appendix B: EMF contour plots

The following plots have been produced from the preliminary traction power modelling undertaken by HS2 Ltd. which used a theoretical feeding section for computer simulation. They show worst case values of EMF along the route of the Proposed Scheme. The data cursors indicate the magnetic flux density at distances of about 10 m, 15 m, 20 m and 30 m from the centre line of the nearest track and are measured in microTesla (µT). The different plots represent the train positions (traction loads) in an auto-transformer feeder section. The trains are placed 20km apart on the basis of a headway which corresponds to the interval between consecutive trains at 360kph.

Figure B1: EMF Contour Plot -Line km 17.5

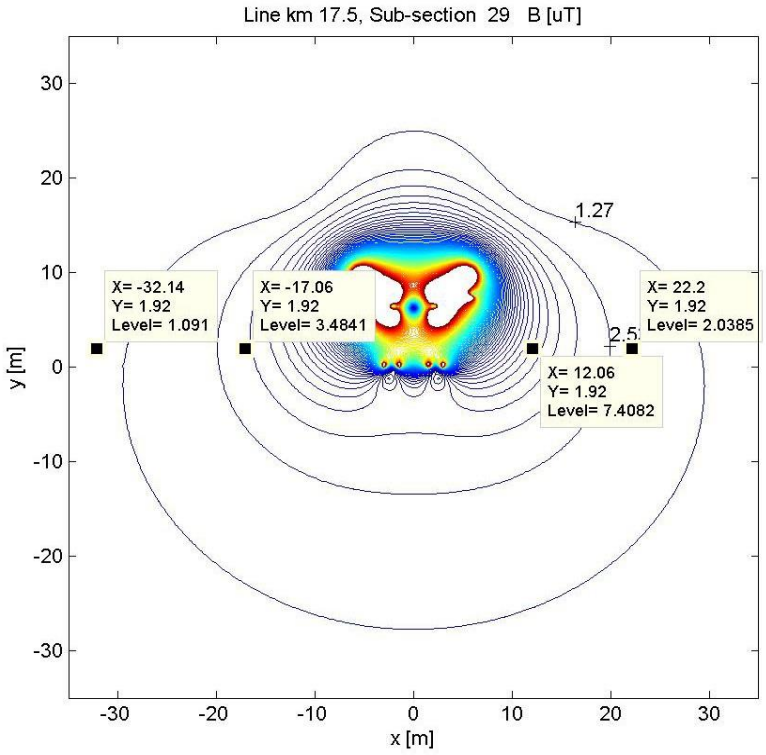


Figure B2: EMF Contour Plot -Line km 17.5

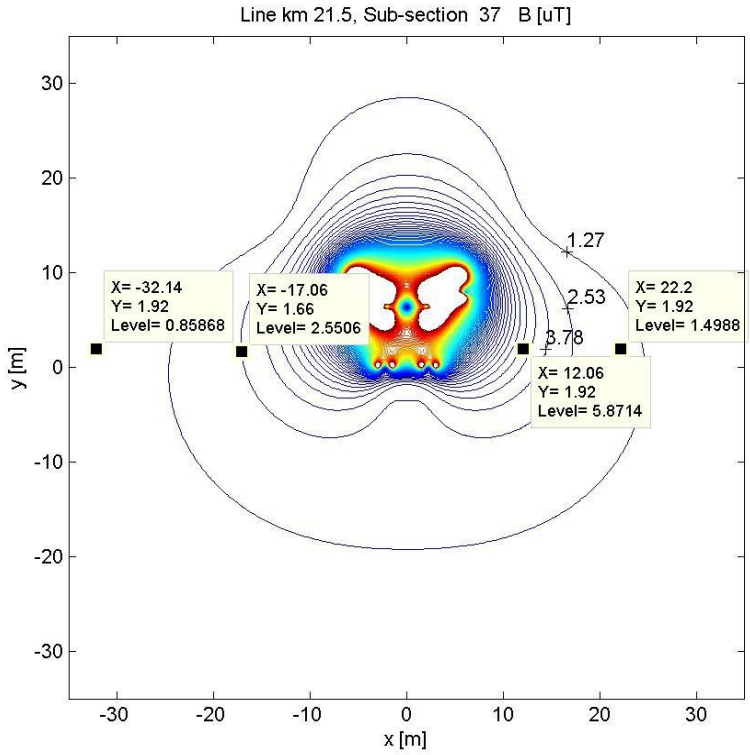


Figure B3: EMF Contour Plot -Line km 24

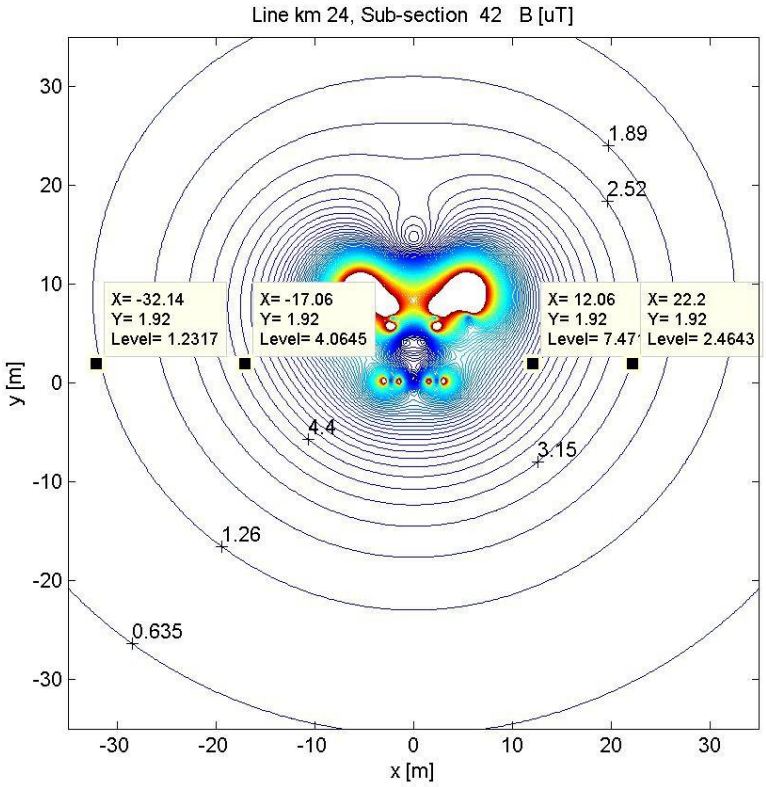


Figure B4: EMF Contour Plot -Line km 27.5

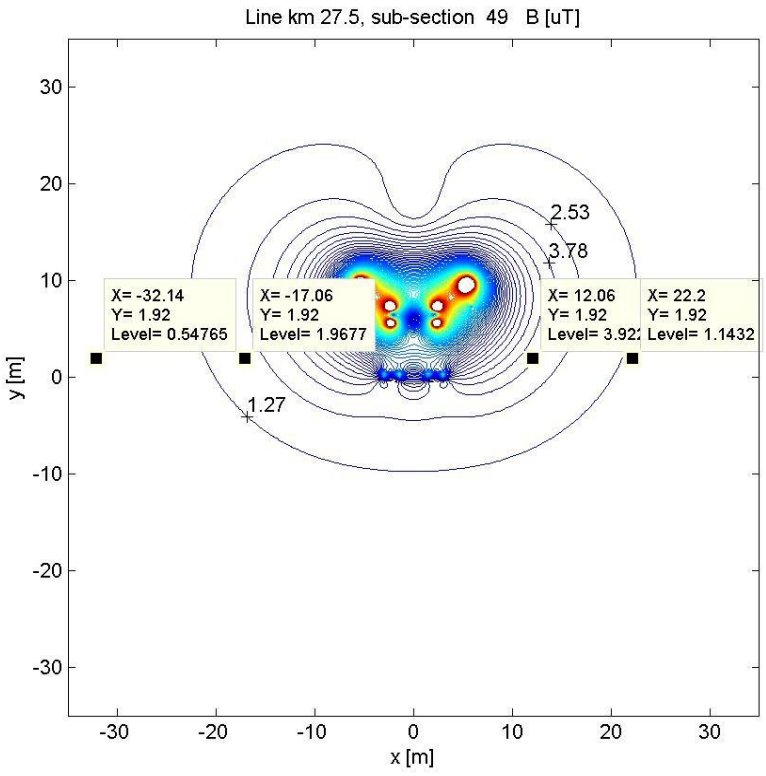


Figure B5: EMF Contour Plot -Line km 32.5

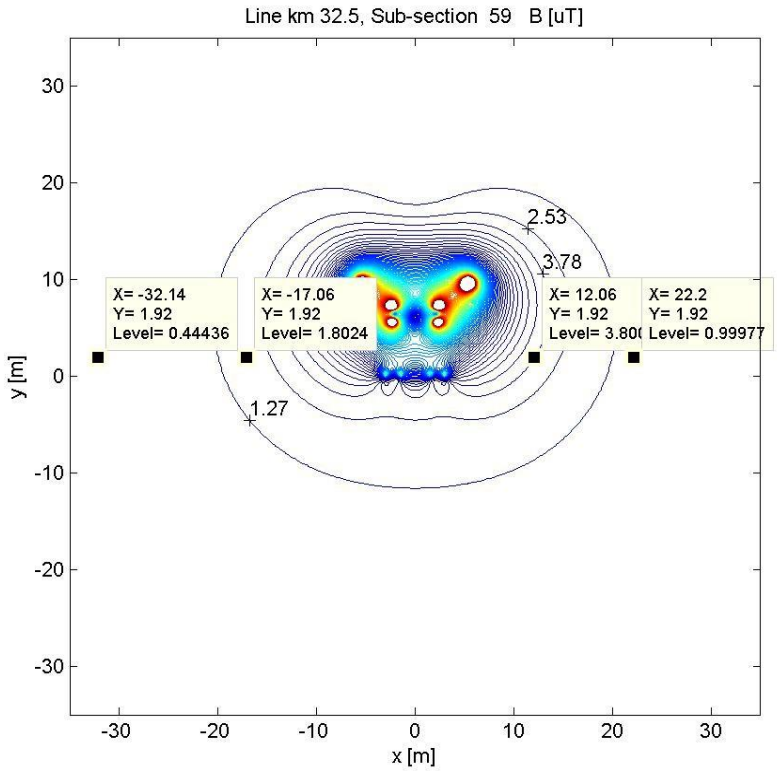


Figure B6: EMF Contour Plot -Line km 41.5

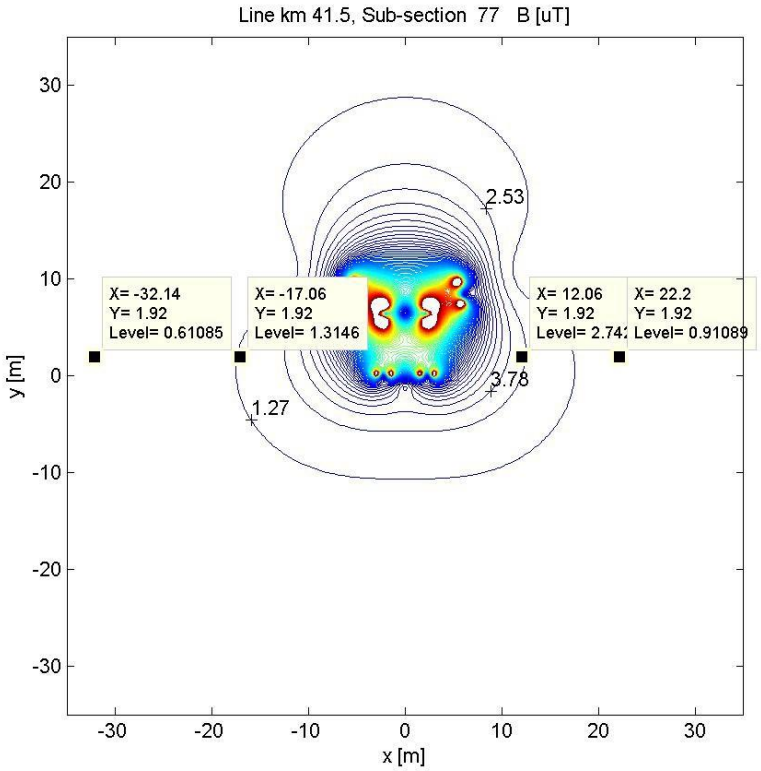
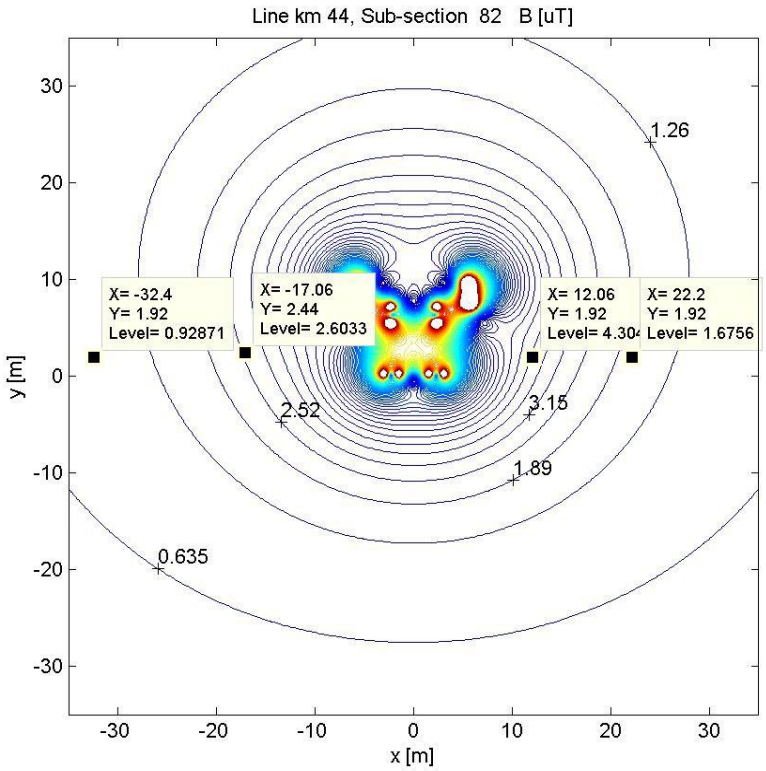


Figure B7: EMF Contour Plot -Line km 44



Annex G: Health – technical notes

The following technical notes are contained in this Annex:

- Guide to health data gathering;
- Assessment of social capital;
- Qualitative health assessment methodology;
- Quantitative health assessment methodology; and
- Health assessment literature review.

HS2 Phase 2a West Midlands - Crewe: Technical note - Health assessment - Guide to health data gathering

Contents

List of tables

1 Introduction

1.1 Purpose of this report

1.1.1 This technical note provides guidance on the data gathering exercise to be undertaken to inform the assessment of health impacts arising from the construction and operation of High Speed Two (HS2) Phase 2a (West Midlands - Crewe).

1.1.2 The technical note builds upon and should be read alongside the Environmental Impact Assessment (EIA) Scope and Methodology Report[1].

1.1.3 The objectives of this guide are as follows:

- to detail the data and information to be assembled to inform the assessment of health effects;
- to outline the relationship with other environmental assessment topics;
- to define the spatial and temporal extent of data gathering; and
- to outline how the baseline data will be presented.

1.1.4 This guide may be amended or updated should new issues evolve during the assessment processes.

2 Data requirements

2.1 Introduction

2.1.1 Baseline data will be gathered from a variety of sources and will be used to construct:

- a community profile;
- a health profile including information on potential health inequalities; and
- baseline data for the social determinants of health.

2.2 Community profile

2.2.1 Baseline data will be collected from a variety of sources and will be used to construct a community profile, providing an overview of the prevailing socio-economic status of the existing population and highlighting issues such as population trends and levels of deprivation.

2.2.2 Over the timescale of the Proposed Scheme's construction and operation, the profile and situation of affected communities is likely to change, influenced by wider economic and policy change as well as demographic trends. Where data and forecasts are available, the likely future community profile will be considered.

[1] Environmental Impact Assessment Scope and Methodology Report, Volume 5: Appendix CT-001-001

2.3 Health profile and health inequalities

2.3.1 A health profile of the existing community will be constructed to provide an indication of current levels of health and wellbeing. This will include data on both physical and mental health and wellbeing.

2.3.2 Some individuals or groups experience systematically better or worse health than others and this is referred to as health inequalities. Such inequalities in health are a result of differential exposure across a life span to different risks associated with their socio-economic circumstances.

2.3.3 Data will be collated to assist in identifying receptors/sub-groups that are more vulnerable to health inequalities. These may include people on low incomes or subject to high levels of social deprivation, people with existing health problems such as long-term illness sufferers, young families, disabled people and older people. Data will be drawn from the datasets used within the community and health profile.

2.4 Baseline profiles for the determinants of health

2.4.1 The health of a community is determined by genetic, lifestyle, economic, social and environmental influences. A social model, as opposed to a clinical model of health, forms the basis of the approach to health assessments.

2.4.2 Factors such as age and gender are not directly affected by development, although development can alter the age and gender distribution of communities, thereby affecting the health profile of an area. Principally, the Proposed Scheme has the potential to affect the social and economic circumstances, the environment as well as lifestyle factors such as opportunities for physical exercise and accessibility of services. As a result, the health assessment will assess the potential outcomes for the determinants of health including, but not limited to, the following:

- education, employment and income;
- transport including traveller stress and road safety;
- housing;
- social capital;
- noise and vibration;
- air quality;
- neighbourhood quality including greenspace and contact with nature, landscape and visual, crime and safety;
- opportunities for physical activity; and
- access to services, health and social care.

2.4.3 Data will be collected to profile the existing and future baseline for the above determinants to provide a benchmark against which to assess the potential outcomes resulting from the construction and operation of the Proposed Scheme.

2.4.4 Reference will also be made to environmental baseline information collated by other Environmental Statement (ES) topics, including environmental characteristics (e.g. background noise, air quality and landscape character), and the presence of key features and resources used by the community.

2.5 Policies, plans and programmes

2.5.1 A review of relevant health, wellbeing and community related policies, plans, programmes and strategies will be undertaken for the Local Authority areas within the study area to construct an appreciation of the existing health and wellbeing profile of target communities and the vision/programmed interventions such as regeneration activities, new retail, housing or public open space measures etc.

2.5.2 The following types of documents are to be reviewed where relevant to the anticipated health effects (i.e. for those areas where an impact on the strategies' aims and objectives are considered likely):

- core strategy policies/objectives related to:
  - housing allocations and regeneration;
  - employment site allocations;
  - public open space strategies;
  - equalities/health strategies and objectives;
- open space and allotments strategies;
- Supplementary Planning Guidance (SPG) and Supplementary Planning Documents (SPDs) addressing community health and wellbeing;
- SPGs and SPDs addressing open space or housing;
- sustainable community strategies;
- children and young people's plans and older people strategies;
- housing strategies;
- sports, recreation and physical activity strategies' SPGs and SPDs;
- community safety/crime reports;
- neighbourhood plans;
- last two years' Annual Reports of the Director of Public Health;
- latest Joint Strategic Needs Assessment and supporting evidence; and
- other evidence based reports on the local health agenda.

2.5.3 The review will be co-ordinated with other disciplines to avoid duplication of effort.

2.6 Data gathering process

2.6.1 The process of gathering baseline data will be undertaken in collaboration with related assessment topics including community, socio-economics and equalities.

2.6.2 The principal sources of data will include desk study information, information from field surveys and stakeholder feedback.

Desk study

2.6.3 Spatial and non-spatial data will be obtained from a variety of publicly accessible sources.

2.6.4 The principal sources of data will include:

- national datasets such as those from the Office of National Statistics, Local Authorities, Public Health Observatories, Public Health England (PHE), Sport England (Active People Survey), Joint Strategic Needs Assessment and other sources;
- local public health reports;
- information from local strategies and policies relating to health and wellbeing;
- data obtained through consultation with public health authorities;
- feedback received through joint public consultations; and
- output from the ES baseline assessments (e.g. sound, noise and vibration; air quality; and landscape and visual baselines).

2.6.5 The source, definition and date of all reported data will be provided.

Field surveys

2.6.6 No field surveys are proposed for the health assessment. The baseline will draw on information from field surveys undertaken by other topics including surveys of community facilities (from the Community assessment).

2.7 Data obtained through consultation

2.7.1 Health sector stakeholders will be consulted through written correspondence and meetings. Stakeholders will be asked to provide information that is relevant and useful to the assessment, based on their local knowledge. The type of information obtained is likely to include:

- key local health issues and challenges;
- key opportunities for local health improvement;
- data or anecdotal evidence for levels of social capital in the affected communities;
- information about vulnerable communities and health inequalities;
- key policy objectives related to health and health improvement agendas; and

- new sources of baseline data to inform the baseline health profiles.

2.8 Relationship with other assessments

2.8.1 The health assessment will assess the health effects of issues also covered under other ES topics. Therefore, data from other topics will be relevant to the health assessment and the data gathering process will be integrated across topics.

2.8.2 The table below lists the baseline data gathered by other topics that will be used in the health assessment, as well as data specific to the health assessment only.

Table 1: Health baseline data - relationship to other ES topics

Data set	Health assessment only	Data collected by other topics to be used in health assessment						
		Equality	Community	Socio-economic	Transport	Landscape and visual	Noise	Air quality
Spatial data								
Residential properties			✓					
Health and social care facilities including GP practices and health centres, hospitals, hospices, residential care facilities, sure start centres, social work centres, health-related emergency services and dentists			✓					
Educational facilities including day nurseries, primary schools, secondary schools, colleges, universities, other organised learning environments and education resource centres			✓					
Community centres, youth centres and other relevant facilities used for local community meetings and activities			✓					
Institutional uses defined as Government Local Authority and emergency services open to the public			✓					
Local high streets and local centres which provide local services including convenience retail and services such as post offices and hairdressers			✓					

Data set	Health assessment only	Data collected by other topics to be used in health assessment						
		Equality	Community	Socio-economic	Transport	Landscape and visual	Noise	Air quality
Places of worship (with some potential overlap with open space e.g. burial grounds, cemeteries)			✓					
Open space, Public Rights of Way (PRoW) and play space			✓					
Recreational infrastructure including leisure centres, pubs, and sports and social clubs			✓					
Index of Multiple Deprivation (IMD) data including data for all seven domains (income; employment; health; education, skills and training; barriers to housing and services; crime; and living environment)		✓						
Bus routes					✓			
Landscape Character Areas						✓		
Key visual receptors along the route						✓		
Main sources of background emission concentrations								✓
Air quality management areas								✓
Sensitive receptors that may be impacted by poor air quality								✓

Data set	Health assessment only	Data collected by other topics to be used in health assessment						
		Equality	Community	Socio-economic	Transport	Landscape and visual	Noise	Air quality
Non-spatial data								
General review of health needs/trends from local plans and strategies	✓							
Association of Public Health Observatories (APHO) health profiles	✓							
Office for National Statistics (ONS) annual population survey	✓							
ONS mid-year population estimates	✓							
ONS age structure profiles		✓						
ONS ethnic group		✓						
ONS social grade	✓							
ONS life expectancy	✓							
ONS sector of employment				✓				
ONS unemployment				✓				
ONS education				✓				
ONS population density								
ONS sex								

Data set	Health assessment only	Data collected by other topics to be used in health assessment						
		Equality	Community	Socio-economic	Transport	Landscape and visual	Noise	Air quality
ONS disability								
Local Authority housing waiting lists	✓							
Department for Communities and Local Government (DCLG) dwellings by tenure and district		✓						
Description of background air quality by community area								✓
Description of background noise environment by community area							✓	
Other quantitative noise baseline data to be provided by the sound, noise and vibration topic team							✓	
Non-motorised user surveys for each community area for PRoW usage					✓			
Accidents and safety data					✓			
Pedestrian, cycle and equestrian facilities for each settlement					✓			

2.9 Spatial/temporal extent of data gathering

2.9.1 This section defines the geographical area within which data is to be collected.

2.9.2 Data will be collected for the area within 1km of the route of the Proposed Scheme.

2.9.3 The granularity of data varies between different data sets used, ranging from regional level data and ward level data to small localised areas (Lower Super Output Areas (LSOA)). LSOA are small geographical areas with populations of between 1,000 and 1,500 which are used to report small area statistics in England and Wales. Table 2 outlines the different geographical areas at which data will be collected.

Table 2: Local Authorities, Wards and LSOA within the study area

Local Authority	Ward	LSOA Code
Lichfield District	Alrewas and Fradley	E01029479 E01029477
	Armitage and Handsacre	E01029509 E01029480
	Colton and Mavesyn Ridware	E01029498
	Kings Bromley	E01029509
Stafford Borough Council	Haywood and Hixon	E01029711 E010129710 E01029713 E01029712
	Milwich	E01029732 E01029687
	Seighford	E01029743
	Church Eaton	E01029688
	Milford	E01029730 E01029732 E01029732
	Walton	E01029754 E01029755 E01029753 E01029756

Local Authority	Ward	LSOA Code
	Eccleshall	E01029695
	Swynnerton	E01029747 E01029683 E01029749 E01029748
	Barlaston and Oulton	E01029682
Newcastle-under-Lyme District	Loggerheads and Whitmore	E01029570
	Madeley	E01029574 E01029575
	Halmerend	E01029557
Cheshire East	Wybunbury	E01018515 E01018516
	Haslington	E01018465
	Shavington	E01018494
	Crewe South	E01018445 E01018446 E01018448 E01018447 E01018486
	Crewe East	E01018501 E01018502

3 Presentation of data

3.1 Non-spatial data

3.1.1 The baseline data will be reported in the ES.

3.1.2 Non-spatial data will be presented in the form of tables and diagrams with accompanying analysis. Regional and England level data will be provided for comparison.

3.2 Spatial data

3.2.1 Spatial data will be presented in the form of GIS based maps with accompanying analysis.

3.3 Policies, plans and programmes

3.3.1 A summary of relevant policies, plans and programmes will be presented in the form of a table with analysis provided that highlights how the Proposed Scheme will contribute towards local health policies and strategies.

HS2 Phase 2a West Midlands - Crewe: Technical note – Health assessment - Health assessment of social capital

Contents

1 Introduction

1.1 Purpose of this technical note

1.1.1 An assessment of health effects will be included in the High Speed Two (HS2) Phase 2a (West Midlands - Crewe) Environmental Statement (ES). This will consider how community health and wellbeing may be influenced by changes to 'health determinants' (environmental and social factors that can influence health) resulting from the Proposed Scheme. This technical note provides guidance on the assessment of health effects related to changes in 'social capital'. It provides a definition of social capital, describes how social capital is linked to health and describes how the effects of the Proposed Scheme will be assessed.

1.1.2 A number of ES topics will assess issues relating to social capital, most notably the community topic. This technical note also describes the interface between the health and community assessments.

1.1.3 The technical note builds upon and should be read alongside:

- the Environmental Impact Assessment (EIA) Scope and Methodology Report (SMR)[1]; and
- the HS2 Phase 2a technical note: Qualitative health assessment methodology.

1.2 Definition of social capital

1.2.1 The term 'social capital' refers to social networks and the value of these networks to individuals and society. The concept of social capital acknowledges the contribution made by social networks in a range of areas such as health and wellbeing, educational attainment, productivity and crime rates.

1.2.2 The Office for National Statistics (ONS)[2] provides the following definition of social capital:

"In general terms, social capital represents social connections and all the benefits they generate. Social capital is also associated with civic participation, civic-minded attitudes and values which are important for people to cooperate, such as tolerance or trust."

1.2.3 The ONS identifies four main dimensions of social capital:

- civic participation: individual involvement in local and national affairs and perceptions of ability to influence them;
- social networks and support: contact with, and support from, family and friends;
- social participation: involvement in, and volunteering for, organised groups; and

[1] Environmental Impact Assessment Scope and Methodology Report, Volume 5: Appendix CT-001-001.
[2] Office for National Statistics (2015), *Measuring national wellbeing: An analysis of social capital in the UK.*

- reciprocity and trust: the amount of trust individuals have in others, those they know and do not know, as well as trust in formal institutions.

1.3 Links to health and wellbeing

1.3.1 A review of evidence linking social capital with health outcomes was undertaken for the HS2 Phase One Health Impact Assessment[3] and the key findings are summarised below. The literature review is currently being updated and will be reported in the ES.

1.3.2 Social networks are important to people's quality of life and play an important role in improving health and wellbeing. Social connections provide emotional support that can help people to cope with stressful life events. This type of support has also been shown to exert positive physiological effects on the body's hormonal and immune systems, and reduce susceptibility to mental and physical illness.

1.3.3 An evidence review undertaken by the ONS identified a range of beneficial effects associated with increased social capital including:

- improved personal wellbeing and health;
- improved functioning of communities; and
- economic benefits, for example the value of informal care, more effective running of institutions and reduced crime rates.

2 Approach to assessing social capital

2.1 Baseline

2.1.1 The likely levels of social capital within the existing communities along the route of the Proposed Scheme will be evaluated using the following information:

- the density and distribution of communities and size of settlements;
- demographic information including age profile, unemployment levels, ethnic diversity and Index of Multiple Deprivation (IMD) data on access to services;
- public transport links, levels of private car ownership and journey times between communities and facilities; and
- The presence of formal and informal facilities and spaces where communities meet, for example:
  - local centres where shops, post offices and banks are located;
  - community facilities such as libraries and leisure centres;
  - places of worship;
  - restaurants, pubs, cinemas, theatres etc.;

[3] HS2 Ltd (2013), *High Speed Rail (London -West Midlands) Health Impact Assessment*, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/378711/Health_impact_assessment.pdf

- private members clubs and organisations;
- local community groups, residents' associations etc.; and
- local parks and public spaces where people meet.

2.1.2 This information will be largely drawn from the data gathered by the community, socio-economic and transport assessments.

2.1.3 Additional information about social capital will be taken from a review of responses to consultation on the working draft EIA Report, and through discussion with health sector stakeholders. This will aim to further increase understanding of issues such as:

- barriers to accessing community facilities and social networks;
- levels of participation in cultural and leisure activities and membership of social groups;
- levels of community cohesion and perceived safety of neighbourhoods; and
- how well-informed people feel about local affairs (including the Proposed Scheme), levels of trust in the authorities and perceptions of their ability to influence events.

2.2 Assessing how the Proposed Scheme affects social capital

2.2.1 The assessment will identify those aspects of the Proposed Scheme that have the potential to increase or reduce levels of social capital, either permanently or temporarily, and examine the potential pathways through which these effects may occur.

2.2.2 Aspects of the Proposed Scheme with the potential to affect social capital will include:

- removal of people from the community through residential relocations;
- impacts on community facilities and spaces that support social capital through demolition/partial removal/relocation of community facilities, parks etc.;
- impacts on the amenity value of community facilities and spaces that support social capital due to proximity to construction activities or the operation of the Scheme;
- effects on movement within and between communities due to road and footpath closures and diversions; and
- introduction of new people into the community e.g. the construction workforce.

2.2.3 The health assessment will assess the potential social capital impacts on the people directly affected by these changes and on the community as a whole.

2.2.4 Combinations of individual impacts that, when combined, could lead to changes in social capital will be assessed for each community area and, where relevant, for specific settlements or defined areas within community areas. The assessment will

consider whether the Proposed Scheme has the potential to affect levels of social capital in the community by:

- changing the availability, accessibility and/or attractiveness of places in which people meet and socialise;
- affecting levels of participation in cultural and leisure activities and membership of social groups;
- affecting people's ability to travel to visit friends and family;
- changing levels of community cohesion, trust and perceived safety of neighbourhoods; and/or
- influencing the demographic profile of the community.

2.3 Assessing health outcomes

2.3.1 The assessment of health effects associated with changes in social capital will be qualitative. Where a likely impact on social capital is identified, it is considered that there would be a corresponding effect on health and wellbeing. This is based upon evidence showing associations between levels of social capital and health and wellbeing (to be reported in the Health Literature Review in ES Volume 5, Appendices). The assessment will not define specific health outcomes, since the available evidence does not allow for this.

2.3.2 Other ES topics will assess the impacts of the Proposed Scheme on the physical environment and socio-economic conditions in the study area, using numerical criteria (e.g. number of properties demolished) to identify significant effects. The health assessment will use reasoned judgement to assess the potential effects on social capital and consequent effects on health and wellbeing at community level.

2.3.3 The potential for health effects to occur will be assessed using the criteria set out in the HS2 Phase 2a technical note: Qualitative health assessment methodology.

2.4 Relationship with other topic assessments

2.4.1 Impacts of the Proposed Scheme that have the potential to influence social capital will be assessed within other sections of the ES including air quality; community; landscape; socio-economics; sound, noise and vibration; and traffic and transport. Information will be obtained through discussion with these topics during the assessment process.

2.4.2 The health and community assessments will both use information from the air quality; landscape; sound, noise and vibration; and traffic and transport assessments. The community assessment will identify the in-combination effects on community resources and receptors associated with the significant effects from other topics. The health assessment will identify the potential effects on social capital arising from the in-combination effects from other topics. This will include the effects of perceptions about the potential impacts of the Proposed Scheme, which may include issues identified as 'non-significant' in the ES.

HS2 Phase 2a West Midlands - Crewe: Technical note – Health assessment - Qualitative health assessment methodology

Contents

List of tables

1 Introduction

1.1.1 This technical note provides guidance on the qualitative assessment of potential health effects arising from the construction and operation of High Speed Two (HS2) Phase 2a (West Midlands – Crewe). The technical note builds upon and should be read alongside:

- The Environmental Impact Assessment (EIA) Scope and Methodology Report (SMR)[1], which provides an outline methodology for the qualitative assessment of health effects; and
- The HS2 Phase 2a technical note: Quantitative assessment of health effects, which describes the methodology for the quantitative assessment of health effects associated with noise and air quality.

1.1.2 In most cases, the available evidence does not provide sufficient information on exposure-response relationships to enable the magnitude of health effects to be quantitatively assessed. Therefore, the health assessment will be largely qualitative.

1.1.3 This technical note may be amended or updated in response to issues arising during the consultation and assessment processes.

2 Scope of assessment

2.1.1 The assessment will not be based on a single 'study area' since the geographic extent of effects will vary between the different health determinants considered. For example, effects associated with construction traffic may occur in areas remote from the route of the Proposed Scheme, whereas effects arising from land requirements will occur within the boundaries of the Proposed Scheme.

2.1.2 Many of the health effects will be local and some will be specific to individual community areas. However, other effects can only be assessed at a broader, route-wide level. The health assessment will therefore be reported both at community area level (within Volume 2 of the Environmental Statement (ES) and at route-wide level within Volume 3). Table 1 identifies those health determinants that will be reported at local and route-wide level.

Table 1: Health determinants assessed at local and route-wide level

Health determinant	Scope of assessment
Education, employment and income	route-wide (Volume 3)
Transport effects	route-wide (Volume 3)
Housing relocations	route-wide (Volume 3)
Social capital	community area (Volume 2)

[1] Environmental Impact Assessment Scope and Methodology Report, Volume 5: Appendix CT-001-001

Health determinant	Scope of assessment
Noise and vibration (quantitative assessment of train noise)	route-wide (Volume 3)
Air quality (quantitative)	route-wide (Volume 3)
Neighbourhood quality (local traffic, noise, dust and visual effects and perceived environmental quality)	community area (Volume 2)
Access to green space, recreation and physical activity	community area (Volume 2)
Access to services, health and social care	community area (Volume 2)

3 Qualitative health assessment criteria

3.1 Introduction

3.1.1 Criteria for the qualitative assessment of health effects are set out below. Their purpose is to ensure consistency in the assessment of potential health and wellbeing effects and to provide clear definitions for the terminology used in the assessment. The criteria are based on the HS2 Phase One Health Impact Assessment (HIA)[2] assessment criteria and the amended criteria used in the subsequent HIA Addendum (Euston Station and approach area)[3], and have been updated following a review by HIA practitioners.

3.1.2 There is no general consensus on what constitutes a 'significant' health effect from a development project and the definition of significance is not generally included in HIAs in the UK. The health assessment criteria will enable the potential health effects of the Proposed Scheme to be assessed without reference to 'significant'/'non-significant' effects.

3.2 Strength of evidence

3.2.1 The strength of evidence for a link (or 'association') between an environmental or community factor (or 'health determinant') and a health outcome may be defined as:

- strong: a wide range of peer-reviewed research studies showing similar associations. The association is widely accepted by the public health community and there is consensus on the specific causal factors, the mechanism of effect and the strength of association;
- moderate: a range of peer-reviewed research studies showing similar associations. The association is widely accepted by the public health

[2] HS2 Ltd (2013), *High Speed Rail (London -West Midlands) Health Impact Assessment*, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/378711/Health_impact_assessment.pdf
[3] HS2 Ltd (2015), *High Speed Rail (London - West Midlands) Health Impact Assessment Addendum: Euston station and approach area,* https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/460717/Health_impact_assessment_addendum_-_Euston_station_and_approach_area.pdf

community, though there may be debate about the specific causal factors, the mechanism of effect and/or the strength of association;

- weak: a few peer-reviewed/non-peer-reviewed research studies to suggest an association, or studies showing conflicting findings; and
- anecdotal: based on the opinions or experiences of members of the public and other stakeholders consulted during the assessment process.

3.2.2 It should be noted that weak evidence does not necessarily indicate an absence of association between a health determinant and a health outcome, but shows that there is uncertainty in the assessment of the likely effect.

3.3 Nature of change

3.3.1 The nature of the change in health determinant resulting from the Proposed Scheme will be described including:

- the aspect of the Proposed Scheme causing the change;
- the nature of the receptor(s);
- the direction of change (beneficial or adverse);
- the perceptions of the community, which may influence the way in which people experience or react to a change; and
- the extent to which the change can be reduced or controlled in order to minimise adverse health effects or enhance beneficial effects.

3.4 Duration of change

3.4.1 Operational effects are assumed to be permanent in most cases. Construction effects will generally be defined as 'short term' if under six months, 'medium term' if six months to two years, or 'long term' if more than two years in duration. Very short-term effects, such as those lasting less than one month, will be scoped out.

3.5 Intensity of change

3.5.1 The intensity of the change to a health determinant will be judged as 'low', 'medium' or 'high' taking into account factors such as the magnitude, frequency and duration of the effect, and/or the value and how replaceable the affected resource(s) is.

3.5.2 The intensity of change may be expressed as a range (e.g. 'low to medium') to take account of the different levels of intensity experienced by different groups and individuals within the population.

3.6 Extent of exposure to change

3.6.1 The size of the population exposed to the change will be described as 'low', 'medium' or 'high'. The following examples provide guidance on how the extent of exposure will be judged in the assessment:

'Low' extent of exposure to change:

- the change affects the occupiers of a few residential properties;
- the change affects a community resource that is used sporadically or by a small group of people; or
- the change is likely to affect a small number of individuals within the local/wider population.

'Medium' extent of exposure to change:

- the change affects a moderate number of residential properties;
- the change affects a well-used local community resource; or
- the change affects a small to moderate proportion of the local/wider population.

'High' extent of exposure to change:

- the change affects a moderate to large number of residential properties;
- the change affects a well-used community resource serving the wider population (e.g. borough or regional level); or
- the change affects a moderate to large proportion of the local/wider community.

3.6.2 Professional judgement will be used in the application of the above terms on a case-by-case basis, taking into account the local context. The judgement will consider the proportion of the community exposed to a change, as well as the absolute number of people exposed. For example, for a given number of properties affected in a rural village the level of exposure may be considered 'high', whereas the same number of properties within an urban area could be 'moderate' or 'low'. In many instances, the extent to which a change will be experienced by the population cannot be accurately determined, and a reasonable assumption will need to be made.

3.7 Sensitivity of the affected population

3.7.1 The sensitivity of the affected population will be considered, based on information contained in the community profile and feedback received through community engagement. This will include, where appropriate, an assessment of effects on sections of the community with particular characteristics that may make them more vulnerable to adverse effects, or more likely to benefit from positive effects.

4 Interfaces with other assessment topics

4.1.1 The health assessment will be undertaken through an integrated assessment process, working closely with other assessment topics to share information and coordinate the assessment process. The key interfaces are shown in Table 2.

Table 2: Health assessment topic interfaces

Health topic	**Other assessments**						
	Equality	**Community**	**Socio-economics**	**Traffic and transport**	**Landscape and visual assessment**	**Sound, noise and vibration**	**Air quality**
Education, employment and income	✓	✓	✓				
Transport	✓	✓		✓			
Housing	✓	✓					
Social capital	✓	✓		✓			
Noise and vibration	✓					✓	
Air quality	✓						✓
Neighbourhood quality	✓	✓			✓	✓	✓
Opportunities for physical activity	✓	✓		✓			
Access to services, health and social care	✓	✓		✓			

HS2 Phase 2a West Midlands to Crewe: Technical Note - Health assessment - Quantitative assessment of health effects

Contents

List of tables

1 Introduction

1.1.1 This technical note provides information on the quantitative assessment of health effects arising from the construction and operation of High Speed Two (HS2) Phase 2a (the Proposed Scheme). Quantitative assessment may be undertaken where established assessment methodologies exist, namely in relation to air quality and sound, noise and vibration.

1.1.2 The technical note should be read alongside:

- The HS2 Phase 2a West Midlands to Crewe Scope and Methodology Report (SMR)[1] which provides an outline methodology for the quantitative assessment of health effects in relation to HS2;
- The HS2 Phase 2a West Midlands to Crewe Technical note: Qualitative health assessment methodology, which provides a detailed methodology for the assessment of health effects in relation to HS2; and
- WebTAG Unit A3 – environmental impact appraisal[2].

1.1.3 The objective of this technical note is to provide further detail on the approach to quantitative assessment of the health effects arising from air quality and sound, noise and vibration.

2 Quantifying the effects of noise and vibration on health and wellbeing

1.2 Health evidence base

1.2.1 Health and wellbeing effects caused by sound, noise and vibration from the construction and operation of the Proposed Scheme will be assessed in the Environmental Statement (ES). Evidence shows that exposure to noise and/or vibration has an effect on health and wellbeing. The assessment criteria in the sound, noise and vibration assessment is used to determine the effect that noise and vibration from the Proposed Scheme has on health and wellbeing.

1.2.2 The evidence base for the health and wellbeing assessment will be set out in the ES. This will include consideration of the following effects:

- amenity – including sleep disturbance and annoyance; and
- health – including heart attacks, strokes and dementia.

[1] Scope and Methodology Report, Volume 5: Appendix CT-001-001.
[2] TAG unit A3 environmental impact appraisal, Department for Transport, December 2015. https://www.gov.uk/government/publications/webtag-tag-unit-a3-environmental-impact-appraisal-december-2015

1.3 Approach to sound, noise and vibration assessment

Receptor-level assessment

1.3.1 A receptor-level assessment will be reported in Volume 2 of the ES. This will include text that indicates the significant effects on health and quality of life. This follows Government policy aims and uses levels that were first chosen for Phase One using UK legislation and World Health Organisation (WHO) targets. The spatial scope of the sound, noise and vibration study area will be defined using the assessment criteria in the HS2 Phase 2a SMR.

1.3.2 The assessment criteria will apply to residential receptors as well as categories of noise sensitive non-residential receptors along the route. LOAEL and SOAEL[3] thresholds are set for residential receptors, based on evidence linking noise exposure with observable effects on health and quality of life. The LOAEL and SOAEL values for the assessment will be informed by:

- the health evidence reviewed;
- any unique features of the Proposed Scheme's sound or impacts in the area being considered; and
- the UK Noise Insulation Regulations[4] and WHO guidelines.

1.3.3 This approach is consistent with HS2 Phase One Environment Statement and HS2 Information Papers.

1.3.4 The significance criteria for non-residential receptors are based on WHO guidelines, guidelines developed for the design of good buildings as well as levels set by previous Hybrid Bill projects including HS1, Crossrail and HS2 Phase One.

Population-level assessment

1.3.5 In addition to the receptor-based assessment of construction and operational SNV impacts, a population-level assessment of the effects of operational railway noise will be undertaken using Defra guidance[5] and reported in Volume 3 of the ES. This assessment will quantify the expected number of people affected and then value this impact in terms of Disability-Adjusted Life Years (DALYs). This value is comprised of a number of components:

- Amenity (annoyance);
- sleep disturbance;
- acute myocardial infarction (AMI);
- stroke; and
- dementia.

[3] Lowest Observed Adverse Effect Levels and Significant Observed Adverse Effect Levels.
[4] Statutory Instrument 1996 No. 428. The Noise Insulation (Railways and Other Guided Transport Systems) Regulations 1996. HMSO.
[5] Defra (2014). Environmental Noise: Valuing impacts on: sleep disturbance, annoyance, hypertension, productivity and quiet

1.3.6 The sound, noise and vibration assessment will provide the overall net present value of noise incorporating all of the above components.

1.4 Approach to health assessment

1.4.1 As described above, health and wellbeing effects are integral to the Volume 2 receptor-based sound, noise and vibration assessment. Quantitative data from the SNV assessments will be used to inform a judgement-based assessment of the effects on 'neighbourhood quality' arising from a consideration of impacts on a range of health determinants, including noise and vibration, affecting the communities along the route. This will constitute a subjective conclusion based on objective data. The health sections of the ES will signpost the reader to the individual and community based information within the sound, noise and vibration sections.

1.4.2 The population-level sound, noise and vibration assessment will quantify the health and wellbeing effects of noise and combine these to give a total value for the entire Proposed Scheme. The Volume 3 Health section will provide a breakdown and summary of each component health effect.

1.4.3 Table 1 below shows how the effects of sound, noise and vibration on health and wellbeing will be reported in the ES. This includes both qualitative and quantitative assessment of effects during the construction and operational phases.

Table 1: Reporting health and wellbeing effects of SNV in the ES

Receptors	Construction / operational	Assessment criteria	Wellbeing effects	Reporting			
				Sound, noise and vibration assessment (Volume 2 of the ES)	Sound, noise and vibration assessment (Volume 3 of the ES)	Health (Volume 2 of the ES)	Health (Volume 3 of the ES)
Individual residential properties	Construction and operational	SOAEL	Significant effect on health and wellbeing identified for individual residential properties	✓		Neighbourhood quality – qualitative assessment using quantitative SNV assessment along with other health determinants Sign-post individual and community assessments in sound, noise and vibration section (Volume 2 of the ES).	N/A
Individual residential properties	Construction and operational	LOAEL	Significant effect on health and wellbeing identified for residential communities	✓			
Noise sensitive non-	Construction and operational	Impact Levels	Significant effect on health and	✓			

Receptors	Construction / operational	Assessment criteria	Wellbeing effects	Reporting			
				Sound, noise and vibration assessment (Volume 2 of the ES)	Sound, noise and vibration assessment (Volume 3 of the ES)	Health (Volume 2 of the ES)	Health (Volume 3 of the ES)
residential properties e.g. schools, places of worship, external amenity spaces			wellbeing identified for noise sensitive non-residential properties			Summarise specific health effects for sensitive receptors e.g. cognitive impairment in schools and sign-post sound, noise and vibration (Volume 2 of the ES)	
Population level – route wide residential properties	Operational	WebTAG guidance	Net present value broken down into components: - amenity - sleep disturbance - AMI - stroke - dementia		✓ Total net present value of change in noise		Net present value of impact on components and cross refer to total value in sound, noise and vibration (Volume 3 of the ES)

2 Quantifying the effects of air quality on health and wellbeing

2.1 Background and evidence

2.1.1 Since the 1990s, scientific evidence has steadily accumulated showing the association between exposure to air pollutants and several adverse health outcomes, most notably premature mortality and hospital admissions. This strong body of evidence can be used to quantify the health effect of a change in exposure experienced by a large population, an exercise that has been undertaken at a national level by the Committee on the Medical Effects of Air Pollutants (COMEAP), for example. Public Health England (PHE) has also produced a report showing the mortality burden of exposure to PM2.5 at the local authority level[6].

2.1.2 Relationships describing the change in health outcome for a given change in pollutant concentration have been proposed as a result of many hundreds of epidemiological studies and the majority of these provide a strong consensus as to the magnitude of

[6] Gowers AM, Miller BG and Stedman JR (2014) Estimating Local Mortality Burdens associated with Particulate Pollution. A report prepared for Public Health England PHE Publications gateway number 2014016.

the effect. Typically, most of the studies have examined the effects of air pollution on urban populations, either as cross-sectional studies, cohort studies, or as time series studies. Effects have been demonstrated for short term, peak exposures and as long term, cumulative exposures. The effect of greatest magnitude appears to be long term exposure to PM2.5 and also NO2, which are now both thought to have an adverse effect on premature mortality.

2.1.3 For example, long term exposure to PM2.5 was considered by the COMEAP in its report of 2010[7] to have an effect on mortality (in 2008) in the total UK population equivalent to 29,000 deaths. This is a deliberately precise expression of the burden on mortality and should not be interpreted as meaning that there are 29,000 individuals who die prematurely each year as a consequence of exposure to PM2.5. The reality is that this pollutant is a contributory factor in a number of deaths that cannot be directly quantified. It is, however, a 'shorthand' means of presenting the results that is more accessible than expressing the mortality burden in 'lost life years.' The shortening of life implied by the figure of 29,000 'deaths' would be about 12 years in each case or a total of 340,000 'life years' for the UK population.

2.1.4 The current estimate of premature mortality in the UK population through long term exposure to NO2 is 23,000 according to Defra[8], based on the recommendations of COMEAP[9]. There are several complicating factors in making these national estimates, one of which is the uncertainty in the degree to which the two pollutants are independently responsible for the observed mortality burden. It is extremely difficult to disentangle their separate roles though epidemiological studies. COMEAP estimates that about 30% of the observed effect attributable to NO2 is in fact caused by PM2.5 and allows for this degree of overlap in making a quantitative estimate.

2.1.5 This point illustrates the danger of being overly precise when using the evidence to make quantitative estimates of health outcomes. Although the evidence that air pollutants exert a health effect is strong, uncertainties remain and any estimates can only be regarded as being accurate to within an order of magnitude.

2.1.6 Perhaps the most difficult part of applying the knowledge gained through epidemiological studies is the validity of this approach for smaller populations. Since the evidence base has been established for large populations, typically measured in tens of thousands, it would seem appropriate that any quantification should similarly apply to similar sized populations. For many developments, however, the change of exposure is confined to a population of a much smaller size and therefore the approach becomes less robust. No guidance exists that is applicable to this problem and it is a matter of judgement as to the confidence that can be attached to quantification in the case of individual projects, as distinct from national policies. On the other hand, the strength of evidence relating to air quality and health effects is much greater than for many health determinants and especially so in the context of quantification.

[7] COMEAP (2010). The Mortality Effects of Long-Term Exposure to Particulate Air Pollution in the United Kingdom.
[8] Defra (2015) Improving Air Quality in the UK *Tackling nitrogen dioxide in our towns and cities* UK overview document December 2015.
[9] COMEAP (2015). Interim statement on quantifying the association of long-term average concentrations of nitrogen dioxide and mortality.

2.2 Methodology

2.2.1 For air quality related health effects of the Proposed Scheme, quantification is a possible option that could be used to support any conclusions. In circumstances where any air quality changes are obviously very small and/or the exposed population is also small, then the knowledge gained elsewhere with quantification would lead to a justifiable conclusion that the health effects are inconsequential. The findings from the air quality assessment will be reviewed to determine whether quantitative assessment of health effects is justified. Where the health effects might reasonably be considered to be at a level that it is meaningful to report, then quantification will be undertaken, following the methodology set out below. This judgement will reflect the magnitude of the air quality impacts and the size of the population exposed to these impacts.

2.2.2 The air quality impacts to be considered in this context are those that arise from changes in vehicle flows, sufficient to change exposure for some thousands of people living alongside the affected road network. The scale of change required to exert a health effect of consequence is such that the assessment is route wide in nature and not confined to individual communities.

2.2.3 As described above, evidence shows that long-term exposure to NO2 and PM2.5 is associated with adverse health effects, which are defined in terms of premature mortality and morbidity at the population level. The techniques for quantifying these effects have been applied at the national level by COMEAP and others. These techniques can be adapted to quantify the effect that a change in NO2 or PM2.5 resulting from a development proposal is likely to have on health outcomes. This requires:

- knowledge of a reliable 'concentration response function' (CRF)[10] (as recommended by the WHO, for example);
- knowledge of the baseline rates of certain health outcomes in the population, e.g. mortality;
- air quality dispersion modelling output, defining the change in exposure of PM2.5, PM10 or NO2 at all locations; and
- the population numbers within the affected area.

2.2.4 These elements are used to calculate the attributable fraction (AF, %) and the number of pollutant-related health outcomes in the exposed population. The AF is derived from the CRF and the level of exposure. The pollutant-related deaths are estimated from the size of the population exposed and background health outcome rate. This method provides estimates for the number of attributable cases of the health outcome under assessment, e.g. for a given population exposed to a given concentration of an air pollutant multiplied by the number of deaths that can be attributable to the exposure.

[10] The concentration-response function (CRF) defines the association between a certain level of exposure to an air pollutant and its effect on certain health outcomes within the exposed population, as identified in the scientific research literature and based on epidemiological studies.

2.2.5 It is important to understand that while this quantification of mortality is expressed as a number of deaths, e.g. two deaths, this does not correspond to a discrete number of individuals, e.g. two people, dying as a result of exposure to air pollution. This is highlighted by COMEAP and PHE, which both report that while the number of deaths is a metric widely used in communicating public health impacts from exposure to air pollution, the estimated number of attributable deaths does not represent the number of individuals whose length of life has been shortened by air pollution. It is that air pollution contributes a small amount to the deaths of a larger number of exposed individuals rather than being solely responsible for a number of deaths equivalent to the calculated figure of attributable deaths. This is because exposure to air pollution is a contributory factor to deaths from respiratory and, particularly, cardiovascular disease, i.e. there are other factors such as diet, the amount of tobacco smoking or alcohol drinking and the level of physical activity an individual undertakes. One limitation of this approach is that the specific distribution of the impact within the exposed population cannot be identified.

2.2.6 The population data can be estimated by the number of properties existing at each receptor location where air quality changes are expected to occur. Properties falling within a local authority or some smaller unit of demographic information, an assumption can be made that the residents living in these properties follow a certain age profile. This age profile can be obtained from the Office for National Statistics. The average household size from the 2011 census can be applied to these receptors to estimate the size of the population under exposure.

2.2.7 The population data should be averaged for over three years or more to provide representative values for the existing baseline year. This is because the size of the population within each single year age group can vary from calendar year to calendar year quite significantly; averaging across three calendar years can smooth these variations out. The population is summed by gender and for 5-year age group intervals. For some calculations, only those aged 30 and above are considered, because the data from which some CRFs have been derived are for this age group only. This age span is recommended for long-term mortality impacts from PM2.5 and NO_2.

2.2.8 For the future assessment years, the population living within the geographical area of interest may increase. Population projections for future years may be needed to capture this likely increase in population exposed to changes in air quality.

2.2.9 Mortality data (deaths) will be obtained from the Office of National Statistics (ONS) by single year age and sex for local authority areas.

2.2.10 Morbidity data (hospital admissions) will be obtained from the Health and Social Care Information Centre, Hospital Episode Statistics. Emergency respiratory hospital admissions for all ages (ICD 10 J00-J99) and emergency cardiovascular hospital admissions for all ages (ICD 10 I00-I99), for England for will be used to derive hospital admission rates.

2.2.11 Exposure to pollutant concentrations will be obtained from additional analysis carried out on the air quality assessment. Annual average PM2.5 and NO_2 concentrations are modelled at each receptor location where changes to traffic flows are expected to occur as a result of construction and operation of the Proposed Scheme. The

modelled concentration for NO2 or PM2.5 is taken from the dispersion modelling for every assessment year and at each receptor location. This value is then multiplied by the population at each receptor location (based on the average household size). The result of this multiplication is then summed over all receptor locations and divided by the total population to give the population-weighted average concentration (PWAC).

2.2.12 The baseline year and future assessment years are considered in the assessment. These will be 2014 (existing baseline), one or more construction scenario years and possibly an operational scenario year.

2.2.13 The four components described above in paragraph 2.2.3 represent the input data for the calculation, taken from external sources and the air quality assessment. They are shown as hypothetical values below for a fictitious scheme, although they represent values that might be expected for a population of the size that makes the calculation meaningful.

Table 2: Example tabulation of inputs to calculation

	2014	**Construction year**		**Operational year**	
	Baseline	**Without scheme**	**With scheme**	**Without scheme**	**With scheme**
Population under exposure, all ages	180,500	190,600		200,100	
Baseline deaths, all ages	850	890		910	
Baseline cardiovascular hospital admissions	1,500	1,570		1,590	
Baseline respiratory hospital admissions	2,010	2,100		2,150	
PM2.5 PWAC	15.1	14.5	14.6	14.1	14.1
NO2 PWAC	34.2	32.1	32.0	30.5	30.5

2.2.14 The relative risks (on which the CRF taken is based) for both short-term and long-term effects of PM2.5 and NO2 used in this assessment are presented in Table 2.2 below, along with the relevant sources.

Table 3: CRFs used for quantification

Impact Pathway	**Pollutant**	**Relative risks (RR) (a)**	**Source**	**Pollutant Threshold**	**Other**
Chronic Mortality (Attributable deaths at typical ages)	PM2.5	1.06 (1.01 – 1.12)	COMEAP	N/A	Ages 30+
Short-term mortality (Deaths brought forward)	PM2.5	1.0123 (1.0045–1.0201)	HRAPIE	N/A	All ages
Cardiovascular hospital admissions	PM2.5	1.0091 (1.0017–1.0166)	HRAPIE	N/A	All ages
Respiratory hospital admissions	PM2.5	1.0190 (0.9982–1.0402)	HRAPIE	N/A	All ages
Short-term mortality (Deaths brought	NO2	1.0027	HRAPIE	N/A	All ages

Impact Pathway	Pollutant	Relative risks (RR) (a)	Source	Pollutant Threshold	Other
forward)		(1.0016–1.0038)			
Respiratory hospital admissions	NO2	1.0015 (0.9992–1.0038)	HRAPIE	N/A	All ages
Chronic Mortality (Attributable deaths at typical ages)	NO2	1.055 (1.031–1.080) / 1.039 (1.022–1.056)	HRAPIE - Full and assuming 30% overlap with effect from PM2.5	Assumed zero (b)	Ages 30+

(a) Relative risks given for a 10 µg/m3 change in pollutant concentrations. For example, a relative risk of 1.06 represents a 6% change in risk rate per 10 µg/m3 change in pollutant concentrations

2.2.15 The calculation is described below for the example of premature mortality associated with exposure to PM2.5. The relative risk (RR) per 10 µg/m3 is scaled to a new relative risk for the appropriate population-weighted average concentration for the exposed population. The equation used (for the example CRF of 1.06) is:

RR(x) = 1.06x/10,

where x is the population-weighted average concentration (PWAC) of interest (weighted by the relevant gender and 5-year age group aged above 30).

2.2.16 The new RR(x) is then converted to the attributable fraction (AF) using the following formula:

AF = (RR-1)/RR,

multiplied by 100 to give a percentage.

2.2.17 The attributable fraction (AF) is then multiplied by the number of baseline deaths in the relevant gender and 5-year age group aged 30+ within the exposed population to give the number of attributable deaths over the year.

2.2.18 The attributable deaths are summed across the 5-year age groups aged above 30, for both males and females, to give a total number of attributable deaths for the exposed population.

2.2.19 To calculate the loss of life years associated with these deaths, the deaths and population data ate used as input into a Life Expectancy Calculator[11]. This calculator provides the expected remaining life expectancy for specified 5-year age groups. This is calculated separately for males and females. This is the baseline life expectancy, representing how much an average person of that age group would be expected to live, were it not for the attributable deaths. The relevant values for expected remaining life expectancy in an age group are then multiplied by the number of attributable deaths for each age group and sex to estimate the total life years lost.

[11] For example, see http://www.sepho.org.uk/viewResource.aspx?id=8943

2.2.20 A similar method can be used for the premature mortality associated with long term exposure to NO2. The methodology and specific methods used in calculating the mortality and morbidity impacts from short-term exposure to both PM2.5 and NO2 are the same as for the calculation of attributable deaths from long-term exposure, described above. Input data are the same except for the relative risks used, i.e. the CRFs. The calculation uses the same PWAC based on annual mean concentrations, as performing the calculation in this way is identical to performing the calculations for every day of the year and then summing.

2.2.21 It is highly likely, if not almost certain, that the outputs for any calculation in respect of the HS2 scheme will be such that the magnitude of health effects in these terms will be small. As noted previously, the changes in air quality result from traffic changes, which means that the people exposed are those living adjacent to the roads affected. The spatial extent of these changes to pollutant concentrations is small, limited largely to within 50 m of the roadside, a fact that restricts the size of the population experiencing any change. The changes in traffic flows have to be large in order to produce changes in NO2 and PM2.5 concentrations that are substantial enough to translate into consequential health impacts. Large in this context means changes in traffic flows of many hundreds of vehicles (as a daily average).

2.2.22 The changes may not only be adverse. With road closures and/or diversions, some roads may experience a reduction in traffic flows, which would have beneficial effects for health. In these circumstances, the calculation for adverse effects is made separately to that for beneficial effects. These opposing effects would be experienced by different parts of the overall population and need to be recorded separately, as they could be felt by different groups of people with differences in demographic, socio-economic and health characteristics.

2.2.23 The impacts associated with the changes in air quality aggregate over all the construction and operation periods, although the calculation is made for selected years. The year assessed for construction will be the one that generates the greatest change in traffic flows, so is the worst case year. Any aggregation of health effects for the entire construction period based on this year is therefore an overestimate of health effects. In fact, over-estimation is built into the calculation, as the air quality modelling is based on peak construction traffic flows, which will only represent part of a year.

2.2.24 The estimates of attributable deaths or deaths brought forward do not represent individuals dying due to air pollution. They represent an increased risk of dying to the local population, as a whole, associated with the likely changes to levels of air pollution.

2.2.25 The quantification places an emphasis on those health outcomes that are most important, i.e. premature mortality and hospital admission, for which the evidence is strongest in relation to the CRFs. The rates for other health outcomes may also be affected by the air quality changes, such as asthmatic symptoms and chronic bronchitis. These too could be quantified, if the major outcomes proved to be sufficiently consequential.

2.2.26 Placing the calculated health effects, i.e. premature mortality and hospital admissions, in context is not straightforward. There is no accepted methodology for

this. Understanding the magnitude of the effects in relation to the baseline rates is helpful, as is comparing the effects to other public health burdens, such as obesity and passive smoking. Neither approach is completely satisfactory, but these comparisons are the only ones that can be made that have any meaning. In most circumstances, it is likely that the magnitude of the health effects is so obviously small that further discussion on this point is not merited.

HS2 Phase 2a West Midlands - Crewe: Technical note – Health assessment - Health assessment literature review

Contents

1 Introduction

1.1.1 This technical note provides guidance on updating the HS2 Phase One Health Literature Review to inform the assessment of health effects arising from the construction and operation of High Speed Two (HS2) Phase 2a (West Midlands - Crewe).

1.1.2 The technical note builds upon and should be read alongside the Environmental Impact Assessment Scope and Methodology Report (SMR)[1].

1.1.3 This technical note responds to issues raised by Public Health England (PHE) in response to the HS2 Phase One London to West Midlands Health Impact Assessment (HIA) where they stated that:

"An up-to-date and systematic search for relevant health studies should be described in the Health Assessment i.e. search terms, time period. This strategy should then be implemented for reference during the Health Assessment. In relation to this issue, the scope of case studies of High Speed Rail projects should be broadened to include those beyond English-speaking countries."

1.1.4 This technical note sets out the purpose, structure and scope of the Phase 2a health assessment literature review. It outlines the process for ensuring that an up-to-date and systematic search for relevant health studies is undertaken to inform the health assessment and limitations of the review.

1.1.5 This technical note may be amended or updated in response to issues arising during the consultation and assessment stages.

2 Scope and approach

2.1 Purpose of the literature review

2.1.1 The purpose of the literature review is to provide a summary of key research evidence demonstrating the links between health determinants and potential health outcomes. This information will underpin the assessment of health effects.

2.1.2 The HS2 Phase One Health Literature Review was undertaken in 2013, using articles and publications publically available online. The updated review will include evidence published since 2013 and will also identify evidence from journal articles available through bibliographic database searches that could not be identified through online searches.

2.1.3 The review will focus on two key areas:

- a wide-ranging review of evidence linking changes in health determinants with health outcomes, using mainly secondary sources such as literature reviews; and

[1] Environmental Impact Assessment Scope and Methodology Report, Volume 5: Appendix CT-001-001

- a review of evidence relating specifically to high speed rail, conventional rail, road and other major infrastructure projects, using both primary and secondary sources.

2.1.4 This literature review will not include evidence relating to noise and health. This will be covered in a separate literature review undertaken by the sound, noise and vibration topic team, to be reported in the Environmental Statement (ES).

2.2 Type of health outcome

2.2.1 The literature review will cover the following types of public health outcomes:

- communicable diseases;
- non-communicable diseases (including obesity);[2]
- injuries; and
- mental health and wellbeing.

2.3 Geographical scope

2.3.1 The review will analyse and summarise evidence from the UK and high income/developed countries internationally (e.g. Europe, North America, Australia, New Zealand, Japan, South Korea and Taiwan)[3]. This is because these countries are likely to have the most comparable public and environmental health legislative and regulatory context and have implemented major rail or similar linear projects.

2.3.2 Documents published in English from any high income/developed country will be included. Where possible, key findings from non-English literature may also be identified through discussions with international HIA experts.

2.4 Temporal scope

2.4.1 Peer reviewed and non-peer reviewed literature from the year 2005 to the present will be searched and reviewed.

2.5 Review of evidence on health determinants

Type of health determinant

2.5.1 The literature review will gather evidence on the health and wellbeing effects associated with the following determinants, based on the determinants set out in the SMR:

- education;
- employment;
- income;

[2] In the context of the UK, nutritional disorders e.g. under and mal nutrition as well as micronutrient deficiencies are not relevant. The main nutritional disorder that is relevant is obesity. Obesity is discussed under non-communicable diseases.
[3] The World Bank defines high income economies as those with a Gross National Income (GNI) per capita of $12,736 or more (http://data.worldbank.org/about/country-and-lending-groups#High_income)

- transport;
- road safety;
- housing;
- social capital;
- air quality;
- green space/open space;
- landscape and visual amenity;
- crime and safety;
- physical activity; and
- access to services, health and social care.

2.5.2 It is important to recognise that the majority of literature in these areas is not explicitly related to linear infrastructure projects, but is part of a general evidence base related to all types of physical, social and economic conditions and interventions.

2.5.3 This literature review will not include evidence relating to noise and health. This will be covered in a separate literature review by the sound, noise and vibration topic team, to be reported in the ES.

Type of evidence

2.5.4 The amount of research on links to health outcomes varies between the determinants. However, in total, this amounts to a wealth of primary evidence, a comprehensive review of which would be beyond the scope of this health assessment. Therefore, this part of the literature review will focus on secondary sources including literature reviews that reflect a scientific consensus on the available evidence. This will comprise peer reviewed journal articles on systematic reviews relating to health determinants.

2.5.5 For those determinants that have not been subject to a large amount of research, there may be insufficient evidence available from secondary sources. In these cases, the search will be widened to include primary sources.

2.6 Review of evidence on infrastructure projects

Type of project

2.6.1 The literature review will search for evidence on the health and wellbeing effects associated with major infrastructure projects in the UK and high income/developed countries internationally (e.g. Europe, North America, Australia, New Zealand, Japan, South Korea and Taiwan).

2.6.2 The review will prioritise evidence relating to the health and wellbeing effects of high speed rail projects. However, in recognition of the lack of studies with particular focus on high speed rail, the review will also encompass conventional rail, major roads and other linear infrastructure projects. Depending on the level of findings, the search may be broadened further to encompass other types of major development project.

Type of evidence

2.6.3 Previous literature reviews have indicated that there is a lack of research focused on the health and wellbeing effects of major infrastructure projects. In order to capture all of the available evidence, the review will cover a wide range of sources including:

- journal articles (peer reviewed and non-peer reviewed) on primary scientific studies relevant to high speed or conventional rail projects or linear projects of a similar scale and nature e.g. epidemiological or qualitative including studies of potential, estimated or modelled effects;
- journal articles (peer reviewed and non-peer reviewed) on systematic reviews relevant to high speed or conventional rail projects or linear projects of a similar scale and nature;
- other journal articles/case studies of monitored impacts on determinants of health relevant to high speed or conventional rail projects or linear projects of a similar scale and nature;
- anecdotal case studies e.g. community complaints feedback, structured accounts of experiences by communities or local professionals; and
- evidence based editorials, opinion or perspectives pieces discussing issues relevant to high speed rail projects or conventional rail projects or linear projects of a similar scale and nature.

2.6.4 These articles will be reviewed for relevance. For those that are identified as relevant, a review of their references will be undertaken to identify other relevant articles that were not picked up in the databases searches.

3 Search strategy and review methods

3.1 Bibliographic database search

3.1.1 The review team will search key databases including for example:

- Biomed Central;
- CAB Abstracts;
- CINAHL;
- Cochrane Database of Systematic Reviews;
- Database of Abstracts of Reviews of Effects;
- Global Health;
- Google Scholar;
- JSTOR;
- NICE Evidence search;
- Ovid online (includes Embase);

- ProQuest central;
- PsychINFO;
- Pubmed;
- ScienceDirect;
- Scopus;
- Web of Science (Includes SCIE and SSCI); and
- ZETOC Search.

3.2 Search strategy

Health determinants

3.2.1 The search terms used for the literature review in relation to broad determinants of health will include (health OR wellbeing OR well-being) AND ([determinant] – see list in Section 2.5).

Infrastructure projects

3.2.2 The search strategy will start with a narrow search which will then be broadened.

3.2.3 Narrow search for health impacts of high speed and conventional railway projects:

- (health OR wellbeing OR well-being) AND high speed rail;
- (health OR wellbeing OR well-being) AND rail AND operation;
- (health OR wellbeing OR well-being) AND rail AND construction; and
- (health OR wellbeing OR well-being) AND rail.

3.2.4 Broader search on similar infrastructure development projects:

- health AND (linear infrastructure OR linear project);
- health AND (large scale infrastructure OR large-scale project);
- health AND (highway OR motorway); and
- above search terms AND (construction OR operation).

3.3 Exclusion criteria

3.3.1 The review will focus on impacts that were identified as important by two or more evidence reviews, reports or journal articles, or which had already been identified in the HS2 Phase One HIA[4] and HIA Addendum[5] evidence reviews.

[4] HS2 Ltd (2013), *High Speed Rail (London -West Midlands) Health Impact Assessment,* https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/378711/Health_impact_assessment.pdf

[5] HS2 Ltd (2015), *High Speed Rail (London - West Midlands) Health Impact Assessment Addendum: Euston station and approach area*, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/460717/Health_impact_assessment_addendum_-_Euston_station_and_approach_area.pdf

3.3.2 Across the body of the literature the titles and abstracts will be reviewed for relevance, applying the following exclusion criteria:

- no abstract available;
- no paper available;
- did not focus on a high-income country;
- human health included as variable for measurement but not discussed in a relevant way;
- focus on: hospital workers or practices in hospitals; health information infrastructure; occupational health and safety; 'health' of the actual infrastructure, i.e. not community health;
- assessment of health impacts of high speed rail policies or other similar types of policies;
- scope too tight or not relevant; or
- scope too diffuse e.g. global impacts from climate change.

3.4 Limitations

3.4.1 The health assessment literature review will use the most up-to-date and credible sources available. The strength of evidence is in some cases well supported by research evidence and in other cases weak or non-existent. Consequently, professional judgement will be necessary in the health assessment concerning the likely way in which potential health impacts may occur.

3.4.2 There is limited published evidence of the effects of large scale infrastructure projects on human health, with a recent review by Arup and Public Health by Design[6] indicating that specific monitoring of health impacts of development projects is not being undertaken at the present time.

3.4.3 The review will generally be limited to English-language literature. This is in keeping with good practice for literature reviews including major Government evidence reviews. Where possible, key findings from non-English literature may be identified through discussions with international HIA experts.

[6] Arup and Public Health by Design (2015), *Draft Review of Evidence for Community Health Impacts of Major Infrastructure Projects.*

Annex H: Land quality – technical notes

The following technical notes are contained in this Annex:

- Introduction to land quality assessments;
- Mining, mineral and geological resources;
- Detailed methodology for land contamination assessment;
- Land quality operational effects; and
- Potential mitigation measures.

HS2 Phase 2a West Midlands - Crewe: Technical note – Land quality - Introduction to land quality

Contents

List of tables

1 Introduction

1.1.1 This technical note presents the introduction to land quality assessment for the HS2 Phase 2a Proposed Scheme. It is based on the methodology utilised on HS2 Phase One London - West Midlands which is described in the HS2 Phase One Land quality technical note – Introduction to land quality (contained in HS2 Phase One Scope and Methodology Report (SMR) addendum[1] and also the Phase 2a SMR[2].

1.1.2 The land quality assessment considers the quality of the land that the Proposed Scheme will pass over or through, and the resources that the soil or rocks contain. It is predominantly a desk based assessment which considers the following principal issues, including:

- the presence of existing contamination along or close to the Proposed Scheme that may be disturbed by the construction or operation of the Proposed Scheme;
- the presence of mining or mineral resources that may be sterilised or otherwise adversely affected; and
- the presence of geo-conservation resources that may be destroyed or their integrity otherwise affected.

1.1.3 In addition, the construction and operation of the Proposed Scheme may give rise to potential contaminative effects. For example, from activities at construction sites during the construction of the Proposed Scheme and track and train maintenance work at the main depot sites during the operational period.

1.1.4 The land quality assessment identifies those areas or sites along or near to the Proposed Scheme that may have existing contamination present on them. It assesses the potential significance of the contamination, with respect to construction of the Proposed Scheme, and indicates whether specific mitigation may be required during the construction period to contain or remediate the contamination to allow safe construction, and to bring post construction risks to an acceptable level. It outlines the types of remedial works that may be necessary at certain locations.

1.1.5 The assessment also identifies the scale of any impacts on geological, geomorphological, mineral and mining resources, and estimates the significance of the effects that the construction and operation of the Proposed Scheme may have on these resources in the future.

1.1.6 Finally, it identifies the potential for contamination arising from the construction and operation of the Proposed Scheme, and sets out the operational mitigation measures that will be undertaken to minimise this risk.

[1] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/260153/Vol5_Scope_and_methodology_report_addendum_CT-001-000.2.pdf
[2] Volume 5: Appendix CT-001-001, Environmental Impact Assessment Scope and Methodology Report.

2 National policy and guidance

2.1 National EIA guidance on land quality issues

2.1.1 There is no national legislation or policy specifically for the assessment of land quality within an Environmental Impact Assessment (EIA). However, within the UK, the assessment of land or groundwater in general is underpinned by Part IIA of the Environmental Protection Act[3] and subsequent guidance that has been issued to support the Act.

2.1.2 There are a number of national policy and guidance documents on EIA which refer to land quality issues, such as:

- Environmental Impact assessment - A handbook for Scoping Projects[4]; and
- Assessment and Management of Environmental Effects. Highways Agency Design Manual for Roads and Bridges[5].

2.2 Contaminated land

Planning guidance

2.2.1 In April 2012, the National Planning Policy Framework[6] (NPPF) came into being. Previously, the principal guidance document relating to land quality was PPS23 Land Contamination and Pollution[7], in particular Annex 2 which dealt with contaminated land.

2.2.2 One of the NPPF core planning principles encourages the effective use of land by promoting reuse of previously developed (brownfield) land, provided that it is not of high environmental value. Therefore, the NPPF envisages that the planning system should contribute to conserving and enhancing the natural environment by remediating and mitigating despoiled, degraded, derelict, contaminated and unstable ground where appropriate. However, to prevent unacceptable risks to human health and the environment, a new development should be appropriate for its location and, after treatment where necessary, suitable for its new use. After remediation, land should not be capable of being determined as 'contaminated land' under Part IIA of the Environmental Protection Act (1990).

2.2.3 In order to assess risks from contamination, site investigation data needs to be presented during the planning stage. These data should as a minimum contain desk study information and a site reconnaissance. This procedure will be followed as far as possible in this assessment.

[3] Her Majesty's Stationery Office, London, (1990), Environmental Protection Act (1990).
[4] Environmental Agency, (2012), Environmental Impact Assessment; A Handbook for Scoping Projects.
[5] Highways Agency, (2008), Design Manual for Roads and Bridges, Assessment and Management of Environmental Effects. HA205/08 Volume 11, Section 2, Part 5.
[6] Department for Communities and Local Government (2012), *National Planning Policy Framework.*
[7] HMSO (2004), Planning Policy Statement 23: Planning and Pollution Control.

Contamination Risk Assessment guidance

2.2.4 There are two complementary systems in the UK for dealing with issues of land contamination. Part IIA of the Environmental Protection Act of 1990 set up a system of control by regulators (either the local authority in the case of human health risks and/or the Environment Agency, which in any case deals separately with controlled water risks). These regulators deal with issues of ongoing contamination of sites within their boundaries by determining land as 'contaminated land' and, if necessary, by issuing a 'remediation notice' to the responsible person (usually the owner or occupier of the site in the absence of the original polluter) to enforce investigation and remediation.

2.2.5 Secondly, for those sites that enter the planning and redevelopment process, the regulator will normally require the developer to undertake sufficient assessment of the site to show whether the site is contaminated or not, and if so, to design, undertake and to verify adequate remediation as part of the development. Each stage of the process needs to be agreed with the regulator(s). It is worth noting that 2016 has seen a change in the planning process[8], in that some brownfield sites will no longer require planning permission before development. Although untested, it is envisaged that this new approach will still require rigorous investigation, assessment and regulatory consultation, prior to development proceeding.

2.2.6 With respect to the identification, assessment and remediation of contaminated land and groundwater there is a considerable body of knowledge that has been built up over the last 30 or so years, principally by the Environment Agency, the Department for environment, food and rural affairs (Defra), Construction Industry Research and Information Association (CIRIA) and Contaminated Land: Applications in Real Environment (CL:AIRE), together with other organisations. The most relevant documentation to support the assessment and management of contaminated land is CLR11 Model Procedures for the Management of Contaminated Land[9] which sets out the procedures to be undertaken at various stages of a project on land affected by contamination. A key activity is the development of an initial conceptual site model identifying potential contaminant linkages between sources and receptors.

2.2.7 Detailed guidance is given within various Environment Agency and Defra documents, which deal with the detailed risk assessment of sites once direct intrusive ground investigation has been undertaken and the detailed scope and nature of contaminants and the immediate environment is understood. Direct intrusive ground investigation would be completed post EIA phase.

2.2.8 The primary method by which contaminants in soil are assessed is the Contaminated Land Exposure Assessment (CLEA) methodology[10]. This methodology has been prepared by the Environment Agency and sets out the science and assumptions by which critical criteria for contaminants can be estimated for different end-scenarios and in different soils. A set of criteria, using the most onerous assumptions, are

[8] 2015 Productivity Plan and Budget 2016 (HM Treasury, July 2016).
[9] Environment Agency (2004), *Model Procedures for the Management of Land Contamination. CLR11.*
[10] Environment Agency (2009), Updated technical background to the CLEA Model. Science Report SC050021/SR3.

encapsulated within the Soil Guideline Values[11] (SGVs) by the Environment Agency. In 2012, Defra published new guidance documents concerning contaminated land assessment[12]. This was followed in 2014 by the publication of Category 4 Screening Levels (C4SLs) policy companion document[13].

2.2.9 The primary method by which contaminants in controlled waters are assessed is the methodology published within the Environment Agency document Remedial Targets Methodology 2014[14].

2.2.10 The primary method of assessing the risks to designated ecological receptors from contaminants is based upon CLR11. It sets out a three-tiered risk assessment process that is designed to establish whether contaminant linkages between contamination and ecological receptors exist, and to gather sufficient information for making decisions on whether harm to those receptors could occur.

2.2.11 Where more complex/sensitive ecological contaminant linkages are identified, the CLR11 qualitative risk assessment processes will be augmented by utilising the 'Ecological risk assessment framework for contaminants in soil (2008)[15]' guidance document as published by the Environment Agency. Quantitative risk assessment of ecological impacts is outside the scope of the land quality assessment.

2.2.12 The primary method by which ground gases are assessed is the CIRIA report C665[16] and BS8485:2015 Code of practice for the characterisation and remediation from ground gas of affected developments[17]assessing risks posed by hazardous ground gasses to buildings. The methodology includes information on how best to monitor ground gases over an interval of time, how to interpret the results and what mitigation measures to design to prevent ground gases entering buildings. Additional information is contained in BS8485:2015.

2.2.13 Below ground concrete (e.g. building foundations) are at risk from various chemical species within the ground, primarily types of sulphates. The sulphates are often naturally occurring, but can also be present as a result of pollution. The assessment and mitigation of this risk is considered as part of the geotechnical engineering assessment of the Proposed Scheme, and will not be considered within the Environmental Statement (ES).

2.2.14 Applying a risk based approach will identify relevant contaminant linkages within the study area and whether they pose a significant risk to receptors as a result of the construction of the Proposed Scheme. Rational decisions can then be made on the detailed extent and type of mitigation and/or remediation methods that could be applied.

[11] Environment Agency (2009), Using Soil Guideline Values. Science Report SC050021/SGV Introduction.
[12] DEFRA (2012), Contaminated Land Statutory Guidance. [online] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/223705/pb13735cont-land-guidance.pdf
[13] Department for Environment, Food and Rural Affairs (DEFRA) (2014), *SP1010: Development of Category 4 Screening Levels for Assessment of Land affected by Contamination – Policy Companion Document.*
[14] Environment Agency (2014), *Remedial Targets Methodology.*
[15] Environment Agency (2008). *An ecological risk assessment framework for contaminants in soil'.* Science Report SC07009/SR1.
[16] CIRIA, (2007,) *Assessing risks posed by hazardous gasses to buildings. Report C665.*
[17] British Standards BS8485, (2007 and 2015), *Code of practice for the characterisation and remediation from ground gas affected developments.*

2.2.15 In choosing particular remediation methods, a number of factors are relevant including:

- the type or types of contamination;
- their extent;
- the types of soils they are contained within;
- the time period for remediation;
- the site size and other logistical constraints; and
- the sustainability of the various remedial options.

2.2.16 An options appraisal in line with CLR11 and the Sustainable Remediation Forum (SURF)[18] is usually undertaken as part of the pre-construction works to identify the option or options that would be most appropriate. This appraisal process would include GI data which would facilitate the development of a remedial strategy for the site.

2.3 Mining, Mineral and geological resources

2.3.1 Guidance on the approach to be adopted in the land quality section of ES for minerals and geological resources is set out in Section 11 of the NPPF 'Conserving and enhancing the natural environment' and in HS2 Phase 2a Land quality technical note 'Mining and Mineral Resources and Geology'.[19]

3 Assessment methodology

3.1 Introduction

3.1.1 The land quality topic contains several differing strands of assessment. There is not a single assessment methodology that can be used for the varying sub-topics. Therefore, detailed methodologies have been developed for each sub-topic, based on current best practice and guidance. A summary of these assessment methodologies is set out in this section. They are given in detail in other HS2 Phase 2a Land quality technical notes - 'Detailed methodology for land contamination assessments' and 'Mining and Mineral Resources and Geology'.

3.1.2 The contaminated land assessment methodology is based on the source-pathway-receptor concept, whereby in order to have an environmental effect, there needs to be:

- a source (e.g. of contamination) which can impact a receptor;
- a pathway (between the source and receptor); and

[18] http://www.sustainableremediation.org/remediation-resources/

[19] Hs2 Phase 2a West Midlands - Crewe: Land Quality Technical Note – Mining and Mineral Resources Geology, Volume 5, SMR Addendum (CT-001-002).

- a receptor or receptors (which may have a varying sensitivity to the impacts from the source).

3.1.3 The mining, mineral resources and geology assessment methodology considers the sensitivity or value of the resource and the magnitude of the impact on the resource from the construction and operation of the Proposed Scheme. These two elements are then combined in a matrix to provide an estimate of the significance of the effects on the resource.

3.2 Scope

3.2.1 The study area used in the assessment of land quality is the area of land required to construct the Proposed Scheme together with a buffer extending out for a minimum of 250m, but in the case of groundwater data up to 1km. Areas of land required for the Proposed Scheme which will only entail minimal ground disturbance (e.g. utility diversions within highways and existing remote train stabling areas) will not be assessed.

3.2.2 The impact of existing and known land contamination during the construction stage will be considered. Any significant existing contamination intercepted by the Proposed Scheme will be remediated during the construction process therefore, it is not considered further during assessment of the operational stage of the project.

3.3 Sources of Information

3.3.1 Sources of information for contamination issues, mining and mineral issues, and geological conservation issues are shown in Tables 1, 2 and 3.

Table 1: Sources of information for contamination issues

Source of information	Type of information
Envirocheck/ Groundsure Report	Historical mapping, landfill and other waste management activities, surface and groundwater data, pollution control data, Radioactive Substance Act data, previous and current industrial land uses, and hazardous substances planning data.
Local authorities	Supplementary information on landfills and other waste management activities, underground petrol tanks, previous investigation data, potential and/or determined contaminated land sites.
Environment Agency	Supplementary information on landfills, and surface water/groundwater data.
Defra/Food and Environment Research Agency (FERA)	Animal burial sites.
British Geological Survey (BGS)	Basic geological mapping (1:10,000 and 1:50,000), specialist mapping, memoirs, borehole logs from BGS borehole database.
Network Rail	Previous ground investigation data.
Ministry of Defence (MoD)	Information on current and former Ministry of Defence land.
Other archive resources	For example, available third-party data in house investigation data, information from waste disposal companies.
Current/historical aerial photography	Where required, to supplement historical mapping.

Table 2: Sources of information for mining and mineral issues

Source of Information	Type of Information
Coal Authority	Details of previous, current and potential future opencast and underground coal mining.
Local authorities	Planning designations regarding mineral extraction.
Mineral extraction companies	Supplementary information.

Table 3: Sources of information for geological conservation issues

Source of Information	Type of Information
Natural England	Data on geological or geomorphological Sites of Special Scientific Interest (SSSI).
Local authorities	Data on Local Geological Sites or other local geological conservation sites.
Geo-Conservation UK	Data on Local Geological Sites or other local geological conservation sites.

3.4 Site Inspections

3.4.1 In addition to 'familiarisation visits', following collection of data, site visits will be required to confirm some of the data collected (particularly from key sites). Such visits may require:

- access to private land for which access permission will be required; and/or
- access to public land (e.g. highways, public footpaths, amenity land etc.).

3.4.2 Because access to private land requires permission, which may not always be granted, access to certain areas may not be available during the preparation of the ES.

3.5 Existing land contamination

3.5.1 The methodology for assessing existing potential land contamination along the Proposed Scheme is set out in detail in the technical note HS2 Phase 2a Land quality technical note 'Detailed Methodology for contaminated land assessment'. Part of HS2's strategy for contaminated land investigations is also encapsulated in the draft Code of Construction Practice (CoCP)[20].

3.5.2 Essentially the process consists of three stages:

- a screening process whereby all potential areas of land contamination identified from the data collected, are assessed against criteria including current and historical land use, the proximity of receptors (e.g. aquifers and watercourses), the proximity of the potential land contamination to the Proposed Scheme and the nature of construction etc. A scoring system for the

[20] Volume 5: Appendix CT-003-000, Draft Code of Construction Practice.

screening process identifies those areas that potentially pose a contaminative risk for the Proposed Scheme;

- a more detailed risk assessment process will be undertaken for areas that potentially pose a contaminative risk. This is to be done to assess the risks of potential contamination and the degree of risk they are likely to pose; and
- consideration is given to the effects that remediation or mitigation of the contamination could have on areas that potentially pose a contaminative risk, and whether this will lead to a longer term beneficial effect (because of containment or removal of contamination).

3.5.3 During the screening process and the risk assessment process, where potentially contaminated sites are likely to give rise to the same types of risks, they can be grouped and considered together, where appropriate.

3.5.4 The screening processes for the assessment of potential areas of land contamination is to be carried out after ground investigation operations have been undertaken.

3.5.5 Potential mitigation measures (including contamination remediation) are described in the Hs2 Phase 2a Land quality technical note 'Potential mitigation measures'. It is the intention to treat and re-use as much contaminated soil as possible within the Proposed Scheme. The potential mitigation measures for contaminated soils could include the following methodologies as either a single approach or as part of a 'treatment train', but are not limited to:

- bio-remediation: excavation and placing of hydrocarbon impacted soils in bio-piles or windrows, followed by aeration, and where required, addition of composting materials, nutrients and microbial inocula[21]. Treatability studies are generally required and remediated soil can be usually re-used on site following treatment;
- chemical treatment systems: controlled and in situ injection of contaminant specific oxidising or reducing agents to destroy or immobilise contaminants, followed by confirmatory monitoring. This technique is useful for sites with limited access or groundwater hydrocarbon contaminant plumes beneath buildings etc;
- soil stabilisation: excavation and batch treatment of soil with additives such as lime, cement and other proprietary materials to alter the physico-chemical characteristics of the soil, to reduce the leachability of contaminants within the soil and/or reduce the permeability of the soil. Stabilisation is useful for a wide range of contaminants, both organic and inorganic, but significant areas are required for stockpiling of untreated soils. Treatability studies are generally required and remediated soil can be re-used on site following treatment. Stabilisation may be required independently for geotechnical purposes;

[21] A substance used/usually injected into the ground under controlled conditions to make an inoculation.

- soil washing: excavation and batch or continuous treatment of soils to remove contaminants (or the soil matrix that contains the contaminants). In practice the finer particles (clays and silts) with contaminants adhered to them are separated from the coarser particles (sands and gravels) which can then be re-used. Wash water can be recycled, but contaminated residues may need to be disposed of at a landfill site. It can be used on soils with a wide range of contaminants, but the soils themselves need to have a reasonably high proportion of re-usable granular materials (>70%) for the process to be economic;

- cover systems and vertical cut-offs: contaminated soils are left in the ground and the contaminant linkage is broken by placing a cover system on top of the contaminated soil and/or providing a cut-off around the contaminated soil. Cover systems most often comprise clay systems sometimes accompanied by geotextiles, capillary break systems etc. Alternative geo-synthetic clay systems are also used. Vertical cut-offs can include bentonite, concrete or sheet steel barriers. No remediation trials are generally necessary and they can be installed quickly. However, contaminants are not removed or destroyed and long-term maintenance requirements are associated with this type of approach, including leachate, gas, ground or surface water monitoring. Some contaminated materials are not amenable to treatment and re-use and will need to be disposed of off-site. Such materials may include asbestos containing materials (ACM), radioactive materials and recent domestic waste;

- ground gas control: ground gas migration can be controlled by vertical and/or horizontal cut-offs together with controlled venting to the atmosphere. In some cases, the removal of gas generating material (e.g. recent domestic waste) may also be required; and

- groundwater remediation: There are a wide number of groundwater remediation methodologies. Where groundwater receptors are not immediately at risk monitored natural attenuation (MNA) can be undertaken, whereby the contaminated groundwater is monitored on a regular basis to confirm that natural processes are acting to degrade and disperse the contaminants within the groundwater. Where receptors are at risk, contaminants in the groundwater can be treated using a variety of methods including injection, pump and treat and vacuum extraction based techniques.

3.6 Construction issues

3.6.1 At construction compounds, there will be a variety of materials and liquids being stored, handled and used during the construction period. Therefore, there is a risk that such materials could give rise to soil and/or groundwater contamination through spillage or leakage.

3.6.2 In these locations, consideration will be given to the types of construction activities that will be undertaken, the types of contaminative materials or liquids that will be used or stored (for example fuel oils), and the types of safeguards (mitigation measures) that will be required in order that such materials or liquids would not give rise to significant soil or groundwater contamination. This process has informed the

development of environmental management protocols for construction compounds (for example, specific measures within the draft CoCP).

3.7 Operational issues

3.7.1 The main potential operational sources of contamination will be derived from maintenance works at the Infrastructure Maintenance Base-Rail (IMBR).

3.7.2 Consideration will be given to the types of operations that will be undertaken, the types and volumes of contaminative materials or liquids that will be used or stored (for example fuel oils), and the types of safeguards (mitigation measures) that will be required in order that such materials or liquids will not give rise to significant soil or groundwater contamination.

3.8 Mining, mineral and geological resources

3.8.1 Existing mining and/or mineral sites, together with the areas or sites that are likely to be considered as future mining or mineral areas will be identified through review of desk study data as set out in Tables 1-3. These are usually designated as mineral safeguarding areas in county council or unitary authority mineral plans, and indicate that for any planning applications submitted within those areas, there is a need to consider conflicts with the mineral extraction requirements for the county.

3.8.2 The methodology for assessing the effects of the Proposed Scheme on current and future mining and mineral resources is contained in detail in the HS2 Land quality technical note 'Mining and Mineral Resources and Geology', which sets out a method to assess the value of a resource and the magnitude of impact that it will experience, to determine whether there are significant effects.

3.8.3 Where significant effects are determined, then mitigation measures will be required to reduce or offset the impacts. Such measures for mineral resources may include, for example, prior use of the resource before construction of the Proposed Scheme or, in the case of severance or isolation, providing additional or alternatives accesses to working sites.

3.8.4 In the case of a geo-conservation resource, mitigation may include the creation of a similar geo-conservation site in the near vicinity which replicates the geological features of interest.

3.8.5 Further details regarding mitigation measures are contained within the HS2 Phase 2a Land quality technical note 'Potential mitigation measures'.

3.9 Assumptions and limitations

3.9.1 The assessment will primarily be based on existing documentation (such as historical mapping, geological mapping and a variety of reports) supplemented by site visits. In some areas, previous ground investigation data may also be available to assist in the assessments. Project specific ground investigation will not be undertaken.

3.9.2 Considerable use is made of historical Ordnance Survey mapping to identify previous uses of land. There is the possibility that short term contaminative land uses may not be shown on mapping if it only occurred for a brief period between two subsequent mapping editions.

HS2 Phase 2a West Midlands - Crewe: Technical note - Land quality – Mining, mineral and geological resources

Contents

List of tables

1 Introduction

1.1 Introduction

1.1.1 This technical note presents the basis of the mining, minerals and geological resources assessment of the Environmental Statement (ES) for the HS2 Phase 2a Proposed Scheme. It is based on the HS2 Phase One methodology (HS2 London - West Midlands Land Quality Technical Note –Mining and Minerals Resources and Geology HS2 Doc ref: CT-001-000/2).[1]

1.1.2 This technical note explains the basis for the assessment of significance with regard to a number of geological issues, other than existing contaminated land (which is dealt with in a separate technical note - Detailed methodology for contaminated land assessment. It is pertinent to note that this guidance document applies only to Phase 2a of the Proposed Scheme). The issues considered here include:

- geological conservation resources; and
- mining and mineral resources.

1.1.3 Geological conservation resources include geological and geomorphological Sites of Special Scientific Interest (SSSI) and Local Geological Sites (LGS) (previously known as Regionally Important Geological Sites).

1.1.4 Mining and mineral resources include both deep and opencast coal mining, sand and gravel production, building stone and aggregate production from quarries, and the exploitation of other identified geological materials (e.g. coal bed methane).

1.1.5 Historical mining activities will be assessed with regard to remnant contamination (e.g. the possibility of contamination within backfilled quarries and pits) and the absence of the associated mineral resource. Issues associated with ground settlement will not be assessed. Assessment of contamination will be undertaken in accordance with HS2 Phase 2a Land quality technical note – Detailed methodology for contaminated land assessment.

1.1.6 Sources of information for mining, minerals and geological conservation resources are provided in the technical note entitled 'HS2 Phase 2a Land quality technical note- Introduction to Land quality'.

1.1.7 Groundwater (hydrogeological) resources and flooding are dealt with in a Water resources and flood risk technical note entitled HS2 Phase 2a Water resources and flood risk technical note - Groundwater assessment method.

[1] London to West Midlands Environmental Statement. Volume 5 Technical Appendices (Scope and Methodology Report Addendum November 2013), Available at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/260153/Vol5_Scope_and_methodology_report_addendum_CT-001-000.2.pdf

2 Proposed methodology

2.1 General

2.1.1 Geological conservation resources and mining/mineral resources will be assessed by considering the sensitivity or value of the resource and the magnitude of the impact on the resource from the construction and operation of the Proposed Scheme. These two elements are then combined in a matrix to provide an estimate of the significance of the effects on the resource.

2.1.2 As a guide to the significance of the effects, the following definitions in Table 1 are based on those provided in the introduction to the Phase 2a Environmental Impact Assessment Scope and Methodology Report (SMR)[2].

Table 1: Significance of effects

Term	Description
Major adverse	Considerable detrimental or negative impact (by extent, duration or magnitude) of more than local importance or in breach of recognised standards, policy or legislation. Always considered significant.
Moderate adverse	Limited detrimental or negative impact (by extent, duration or magnitude) which may be considered to be significant.
Slight adverse	Slight, very short or highly localised detrimental or negative impact without a significant consequence.
Negligible	Imperceptible impact to an environmental resource or receptor.
Slight beneficial	Slight, very short or highly localised advantageous or positive impact without a significant consequence.
Moderate beneficial	Limited advantageous or positive impact (by extent, duration or magnitude) which may be considered to be significant.
Major beneficial	Considerable advantageous or positive impact (by extent, duration or magnitude) of more than local importance or exceeds beneficially the minimum requirements of recognized standards, policy or legislation. Always considered significant.

2.2 Geological conservation resources

2.2.1 This section presents the sensitivity/value and impact magnitude tables for geological conservation resources, together with the significance matrix.

[2] Scope and Methodology Report, Volume 5: Appendix CT-001-001.

Table 2: Sensitivity/value of geological resources

Sensitivity/value	Description
Very high	Geological or geomorphological SSSI of international importance.
High	Geological or geomorphological SSSI.
Medium	LGS.
Low	Other local geological conservation resource.

Table 3: Impact on geological resources

Magnitude	Description
Major	Complete loss of resource.
Moderate	Partial loss of feature/resource or a significant impact on its setting, and/or accessibility.
Minor	Slight loss of feature/resource, or a slight impact on its setting and/or accessibility.
Negligible	No significant impact.
Positive	Creation of a new feature/resource (e.g. a new permanently accessible geological exposure) or a new geological understanding (e.g. through ground investigation).

Table 4: Significance of effects on geological resources

	Sensitivity/Value			
Magnitude	**Very high**	**High**	**Medium**	**Low**
Major	Major adverse effect	Major adverse effect	Moderate adverse effect	Minor adverse effect
Moderate	Moderate adverse effect	Moderate adverse effect	Minor adverse effect	Minor adverse effect
Minor	Minor adverse effect	Minor adverse effect	Negligible effect	Negligible effect
Negligible	Negligible effect	Negligible effect	Negligible effect	Negligible effect
Positive	Major beneficial effect	Moderate beneficial effect	Minor beneficial effect	Negligible effect

2.3 Mining and mineral resources

2.3.1 This section presents the sensitivity/value and impact magnitude tables for mining and mineral resources, together with the significance matrix.

Table 5: Sensitivity/value of current mining or mineral resources

Sensitivity/value	Description
Very high	Mining or mineral resource of national importance (strategic) currently being worked.
High	Non-strategic mining or mineral resource currently being worked, or Specific Sites/Preferred Area for mining mineral works within a Mineral Planning Authority's (MPA) Local Plan.
Medium	Mineral Safeguarding Areas within a MPA Local Plan.
Low	Mineral Consultation Areas within a MPA Local Plan.

Table 6: Impact on current mining or mineral resources

Magnitude	Description
Major	Complete loss of resource.
Moderate	Major loss of resource or significant severance of a resource.
Minor	Minor loss of resource with no severance.
Negligible	No significant impact.
Positive	Project allows definition/exploration/sustainable working of resource, thereby reducing impact (e.g. traffic).

Table 7: Significance of effects on mining or mineral resources

	Sensitivity/Value			
Magnitude	**Very High**	**High**	**Medium**	**Low**
Major	Major adverse effect	Moderate adverse effect	Moderate adverse effect	Minor adverse effect
Moderate	Moderate adverse effect	Moderate adverse effect	Minor adverse effect	Minor adverse effect
Minor	Minor adverse effect	Minor adverse effect	Negligible effect	Negligible effect
Negligible	Negligible effect	Negligible effect	Negligible effect	Negligible effect
Positive	Major beneficial effect	Moderate beneficial effect	Minor beneficial effect	Negligible effect

HS2 Phase 2a West Midlands - Crewe: Technical note - Land quality -Detailed methodology for contaminated land assessment

Contents

List of tables

1 Introduction

1.1 General

1.1.1 This technical note presents the detailed methodology for the assessment of existing potentially contaminated sites along the length of the route of the HS2 Phase 2a Proposed Scheme. It is based on the HS2 Phase One methodology (HS2 London - West Midlands Land quality technical note – detailed methodology for contaminated land assessment).

1.1.2 The methodology is based primarily on the assessment of potential sources of contamination identified from current and historical mapping, site inspections where possible and other documentary data made available (for example, information held by local authorities). It includes:

- categorisation of sources;
- categorisation of potential receptors as defined in the HS2 Phase 2a Environmental Impact Assessment (EIA) Scope and Methodology Report (SMR) (Table 23)[1];
- presentation/identification of pathways;
- assessment of potential impacts on sensitive receptors;
- assessment of environmental effects; and
- identification of high risk sites in terms of construction risk and/or long term liability risk.

1.1.3 These terms are further defined in Tables 1 to 4 and appendices referenced therein.

1.1.4 The methodology essentially comprises four parts; an initial screening process referred to as Stages A and B; followed by a more detailed assessment for those sites which were not screened out at Stages A and B, referred to as Stages C and D.

1.1.5 This technical note deals with the assessment of existing land contamination including where land quality may affect controlled waters. It does not deal with any contamination potentially arising from the operation of the railways (see HS2 Phase 2a Land quality technical note 'Operational effects'), nor with other land quality issues, such as geo-conservation or mineral issues (see HS2 Phase 2a Land quality technical note – 'Mining and mineral resources and geology'). It does however deal with contamination aspects of landfills and mining.

1.1.6 The process used is based on the procedures outlined in the Environment Agency Report CLR 11: Model Procedures for the Management of Land Contamination. Report CLR 11 applies as guidance to Statutory Contaminated Land as defined in Part 2A of Environment Protection Act (EPA) 1990 and land affected by contamination, i.e.

[1] Scope and Methodology Report, Volume 5: Appendix CT-001-001.

land that may have contamination present which may, or may not, meet the statutory definition of contaminated land.

1.2 Layout of the report

1.2.1 Section 2 of this technical note details the screening methodology proposed (Stages A and B). The screening aims to identify those sites with potential sources of contamination, which could be impacted by the construction of the Proposed Scheme, and in turn cause a significant effect on the surrounding population and environment. These sites will be taken through to a more detailed assessment (Stages C and D), taking into account the potential for complete contaminant-pathway-receptor linkages.

1.2.2 Section 3 of this technical note describes the more detailed assessment (Stages C and D) for these higher risk sites. It is essentially a preliminary risk assessment employing a conceptual site model (CSM) to identify the various types of risk present at the site. The more detailed assessment will be undertaken for baseline (i.e. pre-construction), construction and post construction stages. The construction stage assessment assumes that normal construction mitigation measures will be applied during the construction work, as set out in the draft Phase 2a Code of Construction Practice (CoCP). The post-construction assessment assumes that appropriate remedial measures have been undertaken during the construction phase and essentially addresses the status of contamination identified pre-operation.

1.2.3 Contamination risks at baseline and construction stages are then compared to estimate the temporary effects of dealing with land contamination during the construction stage.

1.2.4 Contamination risks at baseline and post-construction stages are also compared to estimate the long term (permanent) effects following appropriate remediation as part of the construction stage. Where significant remediation of contaminated land has taken place, a beneficial effect will be recorded at the post-construction stage (even when risks during the construction stage may be temporarily higher).

1.3 Coverage, Constraints and Data Limitations

1.3.1 For the purposes of undertaking the land quality contamination assessment, information on potentially contaminated sites will be collected for a 250m wide buffer around the earthworks line /construction footprint of the Proposed Scheme including:

- line of route;
- road/rail alterations and realignments;
- infrastructure maintenance base-rail (IMB-R); and
- temporary construction sites, where known.

1.3.2 For the purposes of considering receptors at groundwater abstraction points, the buffer shall extend to 1km where appropriate, in accordance with normal practice and professional judgement.

1.3.3 At each relevant assessment stage the data and information required to support the assessment process is outlined. However, it should be noted that not all the desired data will necessarily be in the possession of HS2 Ltd and may not be made available for inclusion within the relevant reporting period. In such instances assessments will be made based on information available at the time of drafting/preparation of the assessment.

2 Screening

2.1 Stage A

2.1.1 The screening process is divided into two stages (A and B). Six steps are involved in Stage A:

- divide the route into lengths showing similar vertical alignment (see Table A1 in Appendix A);
- divide the area either side of the route into proximity zones (see Table A2 In Appendix A);
- review mapping and other data sources and identify potentially contaminative land uses and categorisation (see Table A3 in Appendix A), giving each a unique reference number;
- review landfill information and other land use information and identify any additional potentially contaminative land uses and categorisation, giving each a unique reference number;
- apply impact potential scoring (see Table A4 in Appendix A); and
- determine, from scoring, which sites to take through to Stage B.

2.1.2 Professional judgement may be required for determining proximity zones for sites identified near to side roads, compound areas and other areas of non-invasive construction activity.

2.1.3 Table A3 in Appendix A provides a list of the more common contaminative land uses but is not exhaustive. Where potentially contaminative land uses are identified but not listed, professional judgement will be used to agree the contaminative use terminology and Class, and the use recorded as 'other' (with clarification or justification of what that is) in the listing.

2.1.4 Where sites present a similar contamination risk, they may be grouped and considered together. This may be the case in the more urban areas where, for example, a light industrial estate may be considered as one site, rather than a number of individual sites. Similarly, in rural areas, small historical backfilled ponds and pits might be grouped together.

2.1.5 Where a site may have more than one contaminative land use for the purposes of the screening process, the highest class category for type of contamination as set out in Table A3 in Appendix A will be used.

2.1.6 The scoring system assigns a score of between 0 and 5 to each site based on the type of potentially contaminative land use, the proximity of the site to the Proposed Scheme and the vertical alignment.

2.1.7 Scores of 0 to 1 require no further action. Scores of 3 and above automatically will go through to Stage B. For scores of 2, a sense check will be undertaken to decide whether further assessment is necessary. It is recommended that where a value of 2 is associated with bored tunnels, they all proceed to Stage C to establish whether they are located within a sensitive groundwater environment or a non-aquifer.

2.2 Stage B

2.2.1 There are three further steps in Stage B:

- identify sensitive land use locations (receptors) in the construction footprint and 250m buffer zone (see table A5 in Appendix A);
- identify sensitive receptors, e.g.: controlled waters in the construction footprint and 250m buffer zone and for groundwater abstractions up to 1km (see table A5 in Appendix A); and
- based on impact potential scoring, apply receptor proximity assessment as shown below to determine which sites should proceed to Stage C.

Sensitive receptors included are those identified as 'High Sensitivity' as stipulated in the SMR Table 23.

2.2.2 All sites with an impact potential score of 5 will go forward for a detailed assessment, irrespective of receptor sensitivity. For sites with an impact potential score of 4, if the potentially contaminative land use is within 50m of a sensitive land use and/or overlies a Principal or Secondary A aquifer, then the site goes forward for detailed assessment. For sites with an impact potential score of 3 or 2, if the potentially contaminative land use immediately adjoins a sensitive land use and/or overlies a Principal or Secondary A aquifer, then the site goes forward to a more detailed assessment (Stage C).

2.2.3 At each of the above stages professional judgement will need to be used to check that the screening system is highlighting the most significant sites.

2.2.4 The output from this stage will be the completion of a set of drawings showing the location of land contamination sites identified by the screening process.

3 Contamination risk assessment

3.1 Stage C

3.1.1 There are two stages (C and D) to the more detailed assessment. The first stage has two steps:

- for each site, develop three (baseline, construction and post-construction) CSMs; and
- estimate the risk magnitude of the contaminant linkages that are considered to exist by assessing the probability (likelihood) of pollution/harm occurring

and the consequence of that pollution/harm, through a qualitative risk assessment (see Tables 1 - 3). This is undertaken for the baseline, construction and post construction phases. The estimation of risk is undertaken using the matrix presented in Table A6 in Appendix A together with the associated definitions in Tables A7 and A8.

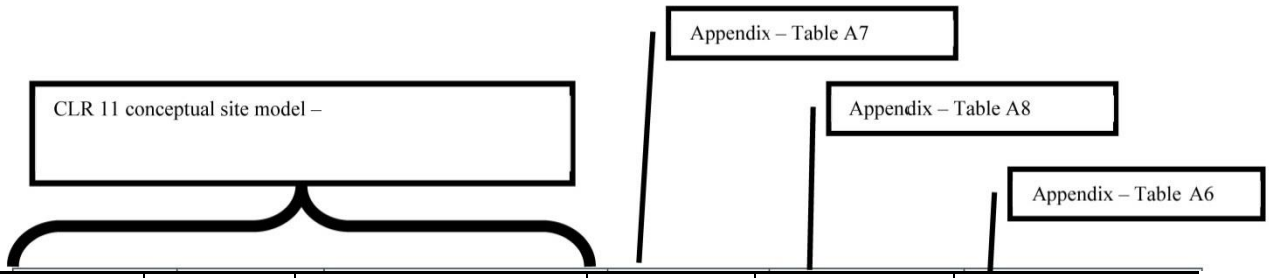
3.1.2 All receptors need to be considered at the CSM stage, not just those that were instrumental at the screening stage in identifying the site as requiring a CSM.

3.1.3 Receptor sensitivity for the CSMs are described in the SMR, Table 23 and the sensitive receptors are listed in Table A5 of this technical note.

3.1.4 The results of Stage C are presented in three CSMs as qualitative risk assessments (baseline, construction and post-construction). The construction and post construction risk assessments assume that appropriate mitigation has been undertaken and that the operation of the railway is in accordance with appropriate environmental legislation.

3.1.5 Where sites have been grouped together, only one CSM is prepared for the grouped sites.

Table 1: Baseline CSM and qualitative risk assessment



Source (incl Unique Site ref)	Receptor	Pathway	Probability	Consequence	Risk at baseline without mitigation
Contaminant linkages					

Table 2: Construction CSM and qualitative risk assessment

Source (incl Unique Site ID)	Receptor	Pathway	Probability	Consequence	Risk with construction stage mitigation
Contaminant linkages					

3.1.6 Table 2 assumes standard construction mitigation practices presented in CoCP. Assumes construction includes remediation where required.

Table 3: Post construction CSM and Qualitative Risk Assessment

Source (incl Unique Site ID)	Receptor	Pathway	Probability	Consequence	Risk with permanent works mitigation
Contaminant linkages					

3.1.7 Table 3 assumes remediation has been undertaken and construction works completed.

4 Stage D

4.1.1 During Stage D, the significance of the effects of the land contamination is assessed by comparing the difference in risk of each contaminant linkage at baseline to those at construction and at post construction stages. This provides a way of assessing both the adverse and beneficial effects during construction and the post construction period. Table 4 provides a template of how this may be presented using the definitions in Table A9 in Appendix A. Where there has been a decrease in environmental risk, the Proposed Scheme is having a beneficial effect on the environment in the long term.

Table 4: Significance of impact during construction and post construction

Contaminant Linkage	Baseline	Construction	Post-construction	Construction impact	Post-construction impact
	Risk	Risk	Risk	Significance	Significance
Overall Significance					

4.1.2 Overall impact significance should be reported as a range (e.g. neutral to minor beneficial impact). The effect of the impact should be reported as either being significant or not significant. All impacts with a rating of minor or neutral, whether beneficial or adverse, are not significant.

Appendix A

Table A1: Classes of vertical alignment

Code	Definition
V	A Viaduct where main intrusion into ground will be from localised foundations of structures
E/S	Embankment > +1m assumed constructed of chemically suitable material, extent of interaction will dependent on ground conditions but as a minimum will comprise strip and removal of soft/hard spots but could include more intrusive works such as overdig and/or sort/treat and replace or installation of land drains or structural support installation of piles, stone columns etc. Near surface pathway for non-leachable or non- volatile contamination will be removed. At Grade -1m to +1m the extent of interaction will depend on ground conditions
C	Cuttings >-1m, cut and cover tunnels, tunnel shafts, tunnel portals. These earthworks solutions are likely to interact with contamination located within the construction footprint and migrating contamination from sites located outside the construction footprint. They are likely to remove primary contamination as a result of the works but may complete a contaminant linkage by introducing a new receptor to contamination migrating from outside the construction footprint.
T	Bored tunnels, with no disturbance of surface are considered to be below the level of primary soil contamination but depending on permeability of the surrounding geology may interact with contaminated groundwater or migrating ground gases and may complete a contaminant linkage by introducing a new receptor to contamination outside the construction footprint. This can be mitigated by design.

Table A2: Proximity zone definition

Zone no	Definition
Zone 1	All land on or within the footprint of the line and including a 10m margin either side of the Proposed Scheme, and including side shoots such as road realignments, spoil borrow or storage areas etc.
Zone 2	All land within 50m of the edge of Zone 1 land
Zone 3	All land from between 50 and 250m from the edge of Zone 1 land

Table A3: Potentially contaminative land uses

Class	Generic description	Typical land-uses
Class 1	Low risk of potential contamination, or less hazardous chemicals in use	Farms (i.e. ancillary buildings and areas for storing chemicals, fuel etc.)
		Warehouses
		Goods yards
		Hospitals

Class	Generic description	Typical land-uses
		Builders' yards
		Retail and Business Parks
		Light commercial industries, small businesses
		Infilled ponds
		Borrow Pits
		Localised shallow mineral extraction
		Infilled Brick works/marl pits, quarries and claypits (not listed as landfills)
		Other
Class 2	Medium risk of potential contamination, more hazardous chemicals in possible use	Engineering workshops
		Railways/disused Railway lines
		Rail goods yards, Engine sheds and workshops
		Airports
		Dry cleaners (retail)
		Sewage works
		Cement/asphalt works
		Car breakers
		Garage workshops
		Waste transfer facilities
		Paper works
		Power stations
		Glass works
		Timber treatment works
		Foot and mouth and Anthrax burial sites

Class	Generic description	Typical land-uses
		Metal manufacturing and plating
		Depots
		Scrap yards
		Coal mining pit heads and spoil mounds
		Industrial estates
		Cemeteries
		Mine entries - coal shafts; air shafts
		Marshland/Ppeat deposits
		Other (as detailed)
Class 3	High risk of potential contamination, hazardous chemicals likely to be present	Gas and cokeworks
		Active landfills and historical landfills
		Metal mining and spoil heaps
		Petrol filling stations
		Oil depots
		Iron and steel works
		Historical foundries
		Chemical works
		Tanneries
		Asbestos works
		Textiles and dye works
		Animal processing and abattoirs
		Printers
		Evidence of fuel/storage tanks

Class	Generic description	Typical land-uses
		Dry cleaners (industrial)
		Printers (industrial)
		MoD land/explosives/chemical weapons
		Combination of heavy industrial sites
		Other (as detailed)

Table A4: Impact potential scoring method

Potentially contaminative land-use class (see Table A3)	Proximity to route (see Table A2 and below)	Vertical alignment (see Table A1 and below)	Impact potential score
Class 1 Low risk	Zone 1	E/S	1
		V	2
		C	3
		T	0
	Zone 2	E/S	1
		V	1
		C	2
		T	0
	Zone 3	E/S	0
		V	1
		C	1
		T	0
Class 2 Medium risk	Zone 1	E/S	2
		V	3
		C	4
		T	2

Potentially contaminative land-use class (see Table A3)	Proximity to route (see Table A2 and below)	Vertical alignment (see Table A1 and below)	Impact potential score
	Zone 2	E/S	2
		V	2
		C	3
		T	2
	Zone 3	E/S	1
		V	2
		C	3
		T	1
Class 3 High risk	Zone 1	E/S	3
		V	4
		C	5
		T	3
	Zone 2	E/S	3
		V	3
		C	4
		T	3
	Zone 3	E/S	2
		V	3
		C	4
		T	2

Table A5: Sensitive receptors

List of land uses deemed sensitive	Sensitive water resources	Geological or ecological designations	Property
Housing	Principal	SSSI	Agricultural land Grade
Schools	Secondary A	Ramsar	Building structures and foundations
Public parks	Secondary B	SPA and pSPA	Crops, domestically grown produce, livestock, and Part 2A protected species
Playgrounds/POS/sports grounds	SPZ	SAC and cSAC	Major, regional or local mineral resource areas and mineral consultation areas. Strategic underground storage spaces.
Allotments	Watercourses	NNR	

Table A6: Estimation of risk magnitude

		Consequence			
		Severe	Medium	Minor	Negligible
Probability	High likelihood	6	5	4	3
	Likely	5	4	3	2
	Low likelihood	4	3	2	1
	Unlikely	3	2	1	1

The descriptions of the classified risks are as follows:

6 (Very high risk)

There is a high probability that a contaminant linkage could exist between a source and a designated receptor resulting in detriment to the receptor. Investigation and remediation will be required prior to (or as part of) construction. During construction further mitigation and monitoring measures (in accordance with the CoCP) are likely to be required. Such sites are considered significant.

5 (High risk)

It is likely that a contaminant linkage exists and could be realised affecting a receptor. Investigation and remediation is very likely to be required. Such sites are considered significant.

4 (Moderate risk)

It is possible that an effect could arise to a designated receptor through a contaminant linkage. However, it is either relatively unlikely that the effect would be severe, and more likely for it to be moderate to minor. Further investigative work is likely to be required to clarify the risk. Some remediation works may be required. Such sites may be considered significant.

3 (Moderate/low risk)

It is possible that a contaminant linkage could exist but it is likely at worst, that if this linkage is realised the effect to the receptor would normally be minor. Further investigative work (which is likely to be limited) to clarify the risk may be required. Any subsequent remediation works are likely to be relatively limited.

2 (Low risk)

It is a low possibility that a contaminant linkage could exist. However, should this be realised the effect to the receptor (with regards to controlled waters) would normally be minor or negligible and the effect on human health would be negligible. No investigation or remedial works are likely to be required.

1 (Very low risk)

It is unlikely that a contaminant linkage could exist between a source and a designated receptor.

Table A7: Classification of probability

Classification	Definition of the probability of harm/pollution occurring
High likelihood	The contaminant linkage exists and it is very likely to be realised in the short term, and/or will almost inevitably be realised in the long term and/or there is current evidence of it being realised.
Likely	The source, pathway and receptor exist for the contaminant linkage and it is probable that this linkage will be realised. Circumstances are such that realisation of the linkage is not inevitable but possible in the short term and likely over the long term.
Low likelihood	The source, pathway and receptor exist and it is possible that it could be realised. Circumstances are such that realisation of the linkage is by no means certain in the long term and less likely in the short term.
Unlikely	The source, pathway and receptor exist for the contaminant linkage but it is improbable that it will be realised even in the long term.

Table A8: Classification of consequence

Classification	Definition of consequence
Human health receptors – site end users	
Severe	Acute damage to human health based on the potential effects on the critical human health receptor.
Medium	Chronic damage to human health based on the potential effects on the critical human health receptor.
Minor	Minimal short- term effects on human health based on the potential effects on the critical human health receptor.
Negligible	No appreciable impact on human health based on the potential effects on the critical human health receptor.
Controlled water receptors	
Severe	Pollution of a Principal aquifer within a source protection zone (inner and outer) or potable supply characterised by a breach of drinking water standards. Pollution of a surface watercourse characterised

Classification	Definition of consequence
	by a breach of an Environmental Quality Standard (EQS) at a statutory monitoring location or resulting in a change in General Quality Assessment (GQA) grade of river reach. Discharge of a hazardous or polluting substance to groundwater.
Medium	Pollution of a Principal aquifer outside a source protection zone (inner and outer) or a Secondary A aquifer characterised by a breach of drinking water standards. Pollution of an industrial groundwater abstraction or irrigation supply that impairs its function. Substantial pollution but insufficient to result in a change in the GQA grade of river reach.
Minor	Low levels of pollution of a Principal aquifer outside a source protection zone or an industrial abstraction, or pollution of a Secondary A or B aquifer. Low levels of pollution insufficient to result in a change in the GQA grade of river reach, pollution of a surface watercourse without a quality classification.
Negligible	No appreciable pollution, or pollution of a low sensitivity receptor such as a secondary (undifferentiated) aquifer or a surface watercourse without a quality classification.
Ecosystem receptors	
Severe	For sites with designations as follows – Site of Special Scientific Interest, National Nature Reserve, Special Protection Area (and potential sites), Special Area of Conservation (and candidate sites) or Ramsar. Irreversible adverse change in the functioning of the ecological system or any species of special interest that forms part of that system.
Medium	For sites with designations as follows – Site of Special Scientific Interest, National Nature Reserve, Special Protection Area (and potential sites), Special Area of Conservation (and candidate sites) or Ramsar. Substantial adverse change in the functioning of the ecological system or any species of special interest that forms part of that system.
Minor	Harm to ecosystems of a low sensitivity such as sites of local importance. No appreciable harm to ecosystems with statutory designations.
Negligible	Limited harm to ecosystems of low sensitivity such as sites of local importance.
Property receptors – buildings, foundations and services including the operational Proposed Scheme	
Severe	Collapse of a building or structure including the services infrastructure.
Medium	Significant damage to a building or structure including the services infrastructure impairing their function.
Minor	Damage to buildings/structures and foundations but not resulting in them being unsafe for occupation. Damage to services but not sufficient to impair their function.
Negligible	No appreciable damage to buildings/structures, foundations and services.
Property receptors – Agricultural land, Part 2A receptors	
Severe	Substantial loss in the value of crops or domestically-grown produce resulting from disease, death or other physical damage. Death to livestock, domesticated animals or wild animals subject to shooting or fishing rights.
Medium	Substantial diminution in yield of crops or domestically-grown produce resulting from disease, death or other physical damage. Serious disease or other serious physical damage to livestock, domesticated animals or wild animals subject to shooting or fishing rights.

Classification	Definition of consequence
Minor	Harm to crops but not resulting in a substantial loss in value or diminution in yield. Limited harm in terms of disease or other physical damage to livestock, domesticated animals or wild animals subject to shooting or fishing rights.
Negligible	No appreciable harm, or harm to a low sensitivity receptor.

Table A9: Significance criteria

Significance Criteria	Definition
Major adverse effect	An increase in contamination risk of 4 or 5 risk levels in the risk matrix, e.g. from land that has a very low contamination risk in the baseline becomes a high or very high risk.
Moderate adverse effect	An increase in contamination risk of 2 or 3 risk levels in the risk matrix, e.g. land that has a low contamination risk in the baseline becomes a moderate or high risk.
Minor adverse effect	An increase in contamination risk of 1 risk level in the risk matrix, e.g. land that has a low contamination risk in the baseline becomes a moderate/low risk.
Neutral effect	No change in contaminated land risks.
Minor beneficial effect	A reduction in contamination risk of 1 risk level in the risk matrix, e.g. land that has a moderate/low contamination risk in the baseline becomes a low risk.
Moderate beneficial effect	A reduction in contamination risk of 2 or 3 risk levels in the risk matrix, e.g. land that has a high contamination risk in the baseline becomes a moderate/low or low risk.
Major beneficial effect	A reduction in contamination risk of 4 or 5 risk levels in the risk matrix, e.g. land that has a very high contamination risk in the baseline becomes a low or very low risk.

HS2 Phase 2a West Midlands - Crewe: Technical note - Land quality – Operational effects

Contents

1 Introduction

1.1.1 The purpose of this technical note is to set out the scope of the land quality assessment for the operational phase of the HS2 Phase 2a Proposed Scheme.

1.1.2 There are several strands to the land quality assessment of operational issues:

- contamination at depots;
- contamination from other buildings/areas (e.g. stations, auto-transformer station sites);
- contamination on track areas;
- contamination from the operation of high speed trains on the tracks; and
- continued sterilisation of minerals located within influencing distance of the railway.

1.1.3 These issues will be addressed in turn in this technical note.

1.1.4 The methodology of assessment of existing contamination on depot sites, railway stations and the track area is covered within a separate technical note HS2 Phase 2a Land quality technical note - Detailed methodology for land contamination assessments.

2 Operational issues

2.1 Infrastructure Maintenance Base-Rail

2.1.1 There is an Infrastructure Maintenance Base-Rail (IMB-R) proposed as part of the Proposed Scheme.

2.1.2 The proposed Stone IMB-R would cover a significant area of land, and would house plant and materials that are required for rail maintenance. The facilities located in the IMB-R are likely to include the following:

- workshop;
- stabling roads, e.g., for ballast trains;
- welfare facilities;
- car park;
- material storage areas;
- a re-fuelling siding; and
- administration offices.

2.1.3 As such the Stone IMB-R site will store, handle and use a variety of potentially contaminative materials which will be used in these operations. Such materials will potentially include:

- clean and used ballast and sub-ballast materials;
- temporary handling and storage of materials, before consignment of waste;
- fuels, including petrol;
- cleaning fluids; fuel oils;
- metals;
- paints;
- solvents and degreasers;
- grease, lubricating and hydraulic oils;
- herbicide/pesticide storage;
- miscellaneous construction materials;
- waste water/train sewage, including chemical toilet reagents;
- switches and crossovers motors and gearboxes; and
- gas cylinders.

2.1.4 Because of their proposed use, an assessment of the contaminative materials to be used will be undertaken within the land quality section, of their potential for contaminative releases. The operation of the sites will be governed by environmental regulations and good practice however, the assessment will note any particular safeguards (mitigation measures) that may also be required.

2.2 Stations and other buildings/areas

2.2.1 There are no stations planned for the Phase 2a route.

2.2.2 Other buildings or areas which could present a risk of contamination are auto-transformer stations, auto-transformer feeder stations and package substations. The only contamination risk with transformer station sites is the small potential for ground contamination from accidental spillage of coolants (which could be synthetic or oil-based). Where necessary, the transformers will incorporate secondary containment appropriate to the level of risk and to minimise external leakage/spillage. Therefore, it is considered that the risk of significant contamination of ground or groundwater in the vicinity of auto-transformer stations is very low and can therefore be scoped out of the assessment.

2.3 Track and trackside area maintenance

2.3.1 Contamination from the maintenance of track and trackside areas will be limited. Track switch locations will require maintenance and lubrication. The quantities of lubricants required are low, and the lubricants themselves are water repellent and can be bio-degradable, such that any effects on the underlying ground, groundwater and drainage system would be reduced. Sleepers will be predominantly concrete (not wooden) and therefore not subject to protection by wood preservatives. Vegetation maintenance will be required possibly with the use of herbicides to keep vegetation

under control. There will be track side parking areas at track access locations and these may be subject to small amounts of oil contamination from vehicle fuel or oil leaks.

2.3.2 Track and trackside maintenance will be subject to environmental controls and management systems. Overall, the degree of contamination from track and trackside maintenance is not expected to be significant and can therefore be scoped out of the assessment.

2.3.3 During operation of the railway, the risk of pollution resulting from criminal activities (e.g. trespassing and/or vandalism) would be limited by conventional rail security measures. Such criminal activities could cause contamination for example, if equipment is stolen or damaged or if fly tipping were to occur.

2.4 Operations

2.4.1 The operational trains are powered through overhead electric conductors. The operation of the trains on the tracks will give rise to local generation of potential contaminants through wear and tear of contact areas causing mainly metal release from the overhead conductors. There is also the possibility of leakage of hydraulic or lubricating oils from the gear boxes and axle boxes of trains or from points machines but this is not expected to be significant.

2.4.2 Maintenance trains will be powered by the overhead electrical system, but will also have diesel engines (for motive power whilst the overhead electrical system is switched off) and other ancillary uses.

2.4.3 There will be no release of sewage on the track from on-board toilets as these will be sealed systems.

2.4.4 The main releases from contact wear issues are:

- wear of the (mainly) copper contact wire;
- abrasive losses from brake wear (i.e., brake pads and wheel linings); and
- wheel to rail contact and abrasion wear generating iron and carbon.

2.4.5 Some studies have been undertaken on these wear issues. The most widespread study was undertaken in Switzerland on its 7,200km rail network. Abrasion losses of operating components across that network was estimated, and the data presented both as annual losses of various metals and oils, and as mass/km length of track. Of the common contaminative metals the greatest losses (and therefore the highest potential for contamination) were from copper which abrades from the contact wire, losses from which were estimated at 5,280 grams/kilometre/year. Because abrasion occurs at a high level (above the train), there is a greater propensity for copper particles to be distributed outside the railway corridor through wind dispersal, in comparison with abrasion losses at track level (e.g. from brakes). Abrasion at track level is predominantly of iron with some carbon (from wheel and rail contact and brake wear) and neither is considered to be a contaminative material.

2.4.6 Dutch railways have also estimated copper losses from contact wire abrasion and have estimated a loss of 0.15 grams/train/kilometre. Assuming 360 trains per day, this would give a rate of loss of 9,860 grams/kilometre/year per conductor.

2.4.7 In the UK, copper losses have been estimated from typical replacement times for contact wire. The contact wire needs replacement when the abrasion losses on the underside of the wire reduce the wire diameter to two thirds of its original diameter. It is estimated that this occurs after 50 years of use. Based on a contact wire diameter of 13.2mm, this loss equates to 7,120 grams/kilometre/year.

2.4.8 The above three estimates, although not identical, are of the same order of magnitude. Differences between estimates would be expected given that there will be a number of variables which contribute to copper losses on the contact wire which may differ between countries and railway operators.

2.4.9 Based on the above figures an estimate has been made of the potential copper pollution from the operation of the Proposed Scheme. The copper particles abraded from the contact wire are very small and are likely to be spread over a considerable width both on the track and adjacent to the track. Assuming that the width of deposition is 20m either side of the track centreline and that over a period of time the additional copper becomes mixed with the topsoil to a depth of 300mm, the additional copper load within the topsoil would be between about 0.2 and 0.4mg/kg copper/year. This is not considered to be significant.

2.4.10 It should be noted that, given the limited data available for high speed lines, the figures above were generated, in the main, by low speed lines with higher levels of braking and turning which would arguably lead to greater abrasion losses.

2.4.11 It should also be noted that trackside drainage systems will be required to cope with all/any contamination in surface run-off to comply with environmental permitting regulations.

2.4.12 Taking the above into consideration, the scale of loss of copper from abrasion of the contact wire will lead only to small increases in copper concentrations in near surface topsoil adjacent to the railway. Therefore, contamination from abrasion losses will be scoped out of the assessment.

3 Summary

3.1.1 Given the nature of the materials used and stored at the IMB-R site it is considered that there is a low risk of operational contamination. This site will therefore be considered within the land quality assessment.

3.1.2 There is a minimal risk of contamination from auto-transformers stations, feeder stations and the package substations and therefore they will be scoped out of the land quality assessment.

3.1.3 It is unlikely that track and trackside maintenance will give rise to a risk of significant contamination effects and will be scoped out.

3.1.4 The biggest of the operational abrasion losses are likely to be those of copper from abrasion of the contact wire. Abrasive losses from carbon and iron are considered to be low and not significant. Data from a number of railway operators indicate that the

scale of loss of copper from abrasion of the contact wire would lead at most to only small increases in copper concentrations in near surface topsoils adjacent to the railway. Therefore, contamination from abrasion losses will be scoped out of the assessment.

HS2 Phase 2a West Midlands - Crewe: Technical note - Land quality – Potential mitigation measures

Contents

List of tables

1 Introduction

1.1.1 The purpose of this technical note is to provide guidance with regard to potential approaches that could be followed when specifying mitigation measures, in particular remediation, in the Land quality assessment of the Environmental Statement (ES) for the Phase 2a Proposed Scheme the approaches presented are not necessarily comprehensive, or applicable to every circumstance and may need to be applied in combination. The Land quality assessment includes three strands: land contamination, mining (including mineral resources) and geo-conservation resources. This technical note explains how mitigation measures will be considered in the ES for each.

1.1.2 In terms of land contamination, this note supports the general principle that, in the case of the expected forms of contamination (wherever it is found in the Proposed Scheme and when it has been fully defined), it will be mostly amenable to remediation using established technologies in preference to off-site disposal.

1.1.3 The mitigation of significant effects for mining/mineral resources principally relate to consultation and negotiations regarding prior extraction, where practicable, which would occur with site and mineral owners and the mineral planning authority.

1.1.4 For geo-conservation resources, mitigation will involve measures to protect or replace the identified resource.

1.1.5 In all three cases, the mitigation measures anticipated will be described in the ES, together with the significant effects remaining after mitigation (termed the residual significant effects). Where the Proposed Scheme is likely to improve environmental conditions (over and above the baseline), these beneficial effects will be identified. Mitigation measures for construction and operational effects will be described separately.

1.1.6 In the case of land contamination, the contamination in the ground is often already present. The amount of remediation required need be no more than to allow safe development of the site suitable both for its proposed use and for the wider environment. Once remediated (which may include systems of ongoing management and control) there should be no significant adverse residual impacts and there may well be a beneficial effect on the surrounding environment through the severance of existing contaminant linkage(s).

2 Land contamination

2.1 Legal basis

2.1.1 With regard to contamination, HS2 Ltd may need to remediate land over which the Proposed Scheme passes, where:

- the Proposed Scheme exacerbates any existing contaminant linkage(s), where these linkages are not the responsibility of HS2;
- HS2 Ltd is liable for addressing a particular contaminant linkage(s);

- the Proposed Scheme causes a pollutant linkage(s) to be put in place; and/or
- the Proposed Scheme compromises permanently the ability to remediate existing contamination (within the land required temporarily or non-operationally) at some later date.

2.1.2 Any remediation or other mitigation undertaken would need to be sufficient such that the land could not be identified currently as 'contaminated land' under the Environmental Protection Act 1990.[1]

2.2 Guidance

2.2.1 Guidance on the management of investigation, assessment and remediation of contaminated land is contained within the Environment Agency publication CLR11 Model Procedures for the Management of Land Contamination[2]. Detailed guidance on examples of various remediation methodologies is contained within numerous publications produced by the Environment Agency, Construction Industry Research and Information Association (CIRIA), Building Research Establishment (BRE) and other organisations:

- Remedial Treatment Data Sheets[3];
- Selection of Remedial Treatments for Contaminated Land. A Guide to Good Practice[4];
- Remedial Treatment of Contaminated Land Vol I – XII[5];
- Technical Options for Managing Contaminated Land[6];
- Definition of Waste: Development Industry Code of Practice[7]; and
- Guidance on the Assessment and Monitoring of Natural Attenuation of Contaminants in Groundwater[8].

2.2.2 This is not an exhaustive list and there are many other documents which describe methodologies and the basis for choosing between them.

2.3 Development of remedial strategies

2.3.1 It is assumed that prior to a remedial strategy being formulated, sufficient investigation, monitoring and risk assessment will be undertaken in order to identify the nature and extent of contamination that needs to be remediated. The remedial strategy chosen will then address the risks to all receptors affected.

2.3.2 Contamination remediation methodologies for soil will be chosen following the hierarchy given below:

[1] Environmental Protection Act (1990).
[2] Environment Agency (2004), *CLR11 Model Procedures for the Management of Land Contamination.*
[3] Environment Agency *Remedial Treatment Data Sheets.*
[4] CIRIA (2004), *Selection of Remedial Treatments for Contaminated Land. A Guide to Good Practice.*
[5] CIRIA (2005), *Remedial Treatment of Contaminated Land Vol I – XII.*
[6] Safegrounds/CIRIA (2004), *Technical Options for Managing Contaminated Land.*
[7] Contaminated Land: Applications in Real Environments (CL:AIRE) (2011), *Definition of Waste: Development Industry Code of Practice.*
[8] Environment Agency (2000), *Guidance on the assessment and monitoring of natural attenuation of contaminants in groundwater.*

- on-site treatment and subsequent reuse on site;
- nearby off-site treatment and re-importation to site and reuse (e.g. use of a hub and cluster approach or a soil treatment centre);
- off-site treatment (possibly at a treatment hub or cluster) and reuse on other projects; and
- off-site disposal (with or without treatment).

2.3.3 The last option may be appropriate for materials that cannot be suitably treated (e.g. recently deposited domestic waste) or for material for which there is no suitable use (even after treatment) in the vicinity of its source area (i.e. it is not economically feasible to treat).

2.3.4 The choice of contamination remediation methodologies for groundwater will depend on a number of factors including:

- the nature of the contaminants, their variability and extent;
- the nature of the aquifer including depth to groundwater table;
- access to all relevant areas at the ground surface;
- the time allowed for remediation (which may include monitored natural attenuation (MNA), see paragraph 2.4.9); and
- the target remediation criteria to be used.

2.3.5 The choice of remediation methodologies for ground gases may include any or a combination of the following:

- vertical or horizontal gas cut-offs;
- gas membranes within building floor slabs;
- active or passive gas venting; and
- monitoring systems.

2.3.6 Sustainability factors will be taken into account in the choice and application of a methodology. A framework for sustainable remediation options is obtainable from the Sustainable Remediation Forum- UK (SURF-UK), a non-profit organisation which aims to develop and disseminate best practice in sustainable remediation.

2.3.7 It is envisaged that there will be no requirement for land contamination mitigation during the operational stage. However, it is likely that where mitigation works have been carried out during the construction stage, there may be a requirement for on-going monitoring (e.g. of groundwater and/or gas) extending into the operational stage.

2.3.8 A number of treatment technologies may be used at any one site in order to treat one or more contaminants in one or more media (e.g. in soils and in groundwater).

2.4 Remedial methodologies

2.4.1 There are a wide variety of potential treatment methodologies; those that are most likely to be used for the Proposed Scheme are given in this section. This is not an exhaustive list, and other technologies may be considered where appropriate. These methods may require procurement of planning permission and/or an Environmental Permit, prior to commencement.

Soil remediation technologies

Reuse

2.4.2 Contaminated soils may be reused, whether treated or not, as long as a risk assessment shows that they are suitable for use in the area in which they are to be used. Rules governing the reuse of soils are contained within the 'The Definition of Waste; Development Industry Code of Practice'[9].

Bio-remediation

2.4.3 Excavation and placing of contaminated soils in bio-piles or windrows, followed by aeration, and where required, addition of composting materials, nutrients and microbial inocula (microbes introduced into the soil). This technique is useful for remediation of certain types of hydrocarbon contamination. Treatability studies are generally required and remediated soil can be usually reused on site following treatment.

Soil stabilisation

2.4.4 Excavation and batch treatment of soil with additives such as lime, cement and other proprietary materials to alter the physico-chemical characteristics of the soil, to reduce the leachability of contaminants within the soil and/or reduce the permeability of the soil. Useful for a wide range of contaminants, both organic and inorganic.

Soil washing

2.4.5 Excavation and batch or continuous treatment of soils to remove contaminants (or the soil matrix that contains the contaminants). In practice the finer particles (clays and silts) with contaminants adhered to them are separated from the coarser particles (sands and gravels) which can then be reused. Wash water can be recycled, but contaminated residues may need to be disposed of at a landfill site. It can be used on soils with a wide range of contaminants, but the soils themselves need to have a reasonably high proportion of re-usable granular materials (>70%) for the process to be economic.

Thermal desorption

2.4.6 Contaminated soils are heated up to increase the volatility of contaminants such that they can be removed from the solid residues and collected/treated. It is generally used for complex organic compounds (such as pesticides) which are not amenable to bio-remediation as well as long chain hydrocarbons.

[9] CL:AIRE (2011), *The Definition of Waste: Development Industry Code of Practice Version 2*.

Cover systems and vertical cut-offs

2.4.7 Contaminated soils are left in the ground and the pollutant linkage broken by placing a cover system on top of the contaminated soil and/or providing a cut-off around the contaminated soil. Cover systems most often comprise clay systems sometimes accompanied by geotextiles, capillary break systems etc. Alternative geo-synthetic clay systems are also used. Vertical cut-offs comprise bentonite, concrete or sheet steel barriers. No remediation trials are generally necessary and they can be installed quickly if required. However, contaminants are not removed or destroyed and aftercare maintenance and monitoring may be necessary.

Off-site disposal

2.4.8 Some contaminated materials, classified by HS2 Ltd as "U2: hazardous, unacceptable and untreatable materials" are not amenable to treatment and reuse, and will need to be disposed of off-site in appropriately licensed landfill sites. Such materials may include asbestos containing materials (ACM) and recent domestic waste.

Groundwater remediation technologies

Monitored natural attenuation (MNA)

2.4.9 MNA consists of the monitoring of groundwater to confirm whether natural attenuation processes (physical, chemical and biological) are acting at a sufficient rate to ensure that the wider environment (external to the immediate area of the contamination plume) is essentially unaffected (i.e. within agreed remedial targets) such that remedial objectives will be achieved within a reasonable timescale, typically less than 30 years.

Impermeable and permeable reactive barriers

2.4.10 Installation of a (generally) vertical barrier system to either control groundwater flow or to channel contaminated groundwater (a contaminant plume) through one or more permeable parts of a treatment "wall" where contaminants will be removed or deactivated by chemical and/or biological means, by constituents of the wall (such as zero valent iron).

In situ groundwater remediation

2.4.11 Groundwater may be treated in situ by a number of different methods which may be used in combination. Typically such methods will involve one or more of the following:

- soil flushing (to remove hydrocarbon contaminants from the unsaturated zone);
- vacuum extraction of vapours in the unsaturated zone;
- removal of floating product (non-aqueous phase liquids (NAPL)) by pumping, vacuum extraction etc.;
- introduction of compressed air into the groundwater to volatilize dissolved organics (air-sparging), followed by vacuum extraction;

- introduction of reducing and/or oxidising chemicals into the water to promote breakdown of hydrocarbon contamination (e.g. reductive dechlorination); and
- introduction of additional microbes into the unsaturated zone or groundwater to promote breakdown of hydrocarbon contamination.

Pump and treat

2.4.12 This technique involves pumping and removal of contaminated groundwater from the ground, ex situ treatment (e.g. air-stripping, carbon adsorption) and re-injection or discharge of the treated water. The distribution of the pumping and re-injection wells can be used to create a hydraulic control of the aquifer to prevent further migration of the contaminated groundwater.

Ground gas remediation and management

Ground gas cut-offs

2.4.13 Cut-offs to prevent ground gas migration may be either vertical or horizontal and typically comprise an impermeable membrane (such as high density polyethylene HDPE) through which the gases cannot penetrate. The biggest issue in using such systems is ensuring that during placement (and subsequently) the membrane is not damaged or torn, such as to allow migration pathway. Cut-offs are often used in conjunction with venting layers.

Ground gas venting

2.4.14 Ground gas venting controls the migration of ground gases such that they can vent to atmosphere in a location which does not cause any significant risks. Venting materials include natural soils (gravel, aggregates) and man-made materials (such as polystyrene vent formers). Often used in conjunction with cut-offs.

Removal

2.4.15 Gas generating material (such as domestic waste, peats) may be excavated and removed. This is often undertaken when the gas generating material also causes other problems such as intolerable settlement.

Monitoring

2.4.16 Gas monitoring may be used when gas concentrations are generally low enough not to cause an issue, but occasional high concentrations may occur. The monitoring needs to be linked to a management plan. Within buildings, such systems monitor gases on a semi-continuous basis and can sound alarms when concentrations rise above pre-set criteria.

3 Mining and minerals

3.1.1 Mitigation of mining and mineral effects will depend on the type of impacts suffered by the mining or mineral resource. These are:

- complete or partial sterilisation of the resource;
- severance[10] and/or isolation of the resource; and
- constraint on use of the resource (e.g. cutting an access road).

3.1.2 The mitigation measures to be considered are therefore likely to include:

- use of the resource prior to or during construction of the Proposed Scheme (e.g. use of sands and gravels within the construction of the Proposed Scheme by excavating and stockpiling the resource for later use). Over-excavation may be required in order to remove all the usable resource, followed by infilling with suitable materials;
- provision of additional access to a site (in the case of severance); and
- provision of alternative access to a site.

3.1.3 Whilst the Proposed Scheme, being a national infrastructure project, could be used to justify the sterilisation of the mineral resources along and adjacent to the route, such an approach would conflict with the principle of the National Planning Policy Framework[11] and would be expected to inhibit synergies and opportunities for reduction of transport movement.

4 Geo-conservation

4.1.1 Mitigation of geo-conservation effects will depend on the type of impacts suffered by the geo-conservation resource. These are:

- complete or partial loss of the resource;
- severance or isolation of the resource; and
- constraints on access to the resource (e.g. cutting an access road).

4.1.2 The mitigation measures to be considered are therefore likely to include:

- partial or full replacement of a geological resource at the same stratigraphical horizon but in a geographically different area (could be either adjacent to the scheme or remote from it);
- if an alternative location cannot be found then intensive investigation and recording of the site before it is constructed upon, including removal of rock and fossil specimens; and

[10] In this context, severance refers to the Proposed Scheme splitting an actual or proposed mining/mineral site into two or more areas, such that separate accesses would be required to work the whole site.
[11] Department for Communities and Local Government (2012), *National Planning Policy Framework.*

- providing alternative or additional access to sites where the access or the site has been severed.

5 Mitigation interactions

5.1.1 Use of in situ remediation measures are usually overwhelmingly beneficial in term of potential environmental effects. However, an important aspect in the identification of mitigation measures is that there is appropriate consideration of the effects that the selected mitigation measures may have on the environment.

5.1.2 Table 1 presents some of these potential effects, taking examples from the mitigation measures described above.

Table 1: Examples of other effects arising from mitigation measures

Mitigation/remediation method	Effects
Bio-remediation, soil washing, soil stabilisation	Typically these require large areas for stockpiling and equipment, which may require additional temporary land–use and effects on ecology, agricultural land, landscape etc.
Off-site disposal	Would increase total required amount of soil to be landfilled (to be taken into account in waste topic) and traffic impacts/air quality impacts.
All groundwater methods	Effects on groundwater, such as changes to levels and yields at springs or wells.
Replacement of geological resources	Would require additional land and therefore may have effects on ecology, agriculture, landscape.

Annex I: Landscape and visual – technical notes

The following technical notes are contained in this Annex:

- Approach to photography;
- Zone of theoretical visibility production methodology;
- Approach to landscape sensitivity;
- Approach to night time 'darkness' surveys; and
- Approach to verifiable photomontages.

HS2 Phase 2a West Midlands - Crewe: Technical note - Landscape and visual assessment - Approach to photography

Contents

List of figures

1 Introduction

1.1.1 This note has been prepared to provide guidance on the methodology for undertaking all photography associated with the Landscape and Visual Impact assessment (LVIA) for the Phase 2a Environmental Statement (ES)[1].

1.1.2 The landscape and visual section of the ES will require photographs to be taken for three main purposes:

1. Photographs to help illustrate the character of each landscape character area (LCA) and to inform the landscape impact assessment;
2. Photographs to illustrate the winter and summer view from each selected viewpoint and to inform the visual impact assessment; and
3. Verifiable photographs from some viewpoints from which verifiable photomontages are to be prepared.

1.1.3 A separate technical note has been prepared to provide guidance on verifiable photography and verifiable photomontages[2]. This technical note covers items 1 and 2 on the list above – photography which will be used within Volume 5 of the ES.

1.1.4 All photography will be taken using high quality Digital single-lens reflex (DSLR) cameras with a minimum resolution of 6 megapixels and taking account of the following:

- photographs will be taken in suitable weather and light conditions and periods of poor light, heavy rain, fog, mist or snow will be avoided; and
- photographs will be taken at a typical viewing height of approximately 1.6m above ground level.

2 Landscape character baseline

2.1.1 Photographs will be taken to help illustrate the character of each LCA within the HS2 Phase 2a study area. A selection of annotated images will be presented within Volume 5 of the ES to support the baseline descriptions of each LCA. Photographs will be chosen to illustrate representative aspects of each character area. It is not possible to include photographs of every part of the landscape and so photographs will be taken to illustrate representative aspects of each LCA. The specific requirements for character area photography are:

- all photographs will be taken in landscape orientation (as opposed to portrait);
- all photographs will be taken using an appropriate focal length which assists the character description;

[1] Landscape Institute Advice Note 01/11: Photography and photomontage in landscape and visual impact assessment.
[2] Technical Note – Approach to verifiable photomontages.

- a single image will be used (avoiding the use of stitching images together);
- a number of photographs will be taken for each LCA to represent key landscape value and susceptibility characteristics; and
- the approximate location of each photograph will be recorded.

Figure 1: Screen shot of LCA photo location on software application

Photograph location, with LCA reference, shown on digital map

Imagery © 2017 Google. Map data ©2017 Google

3 Visual baseline

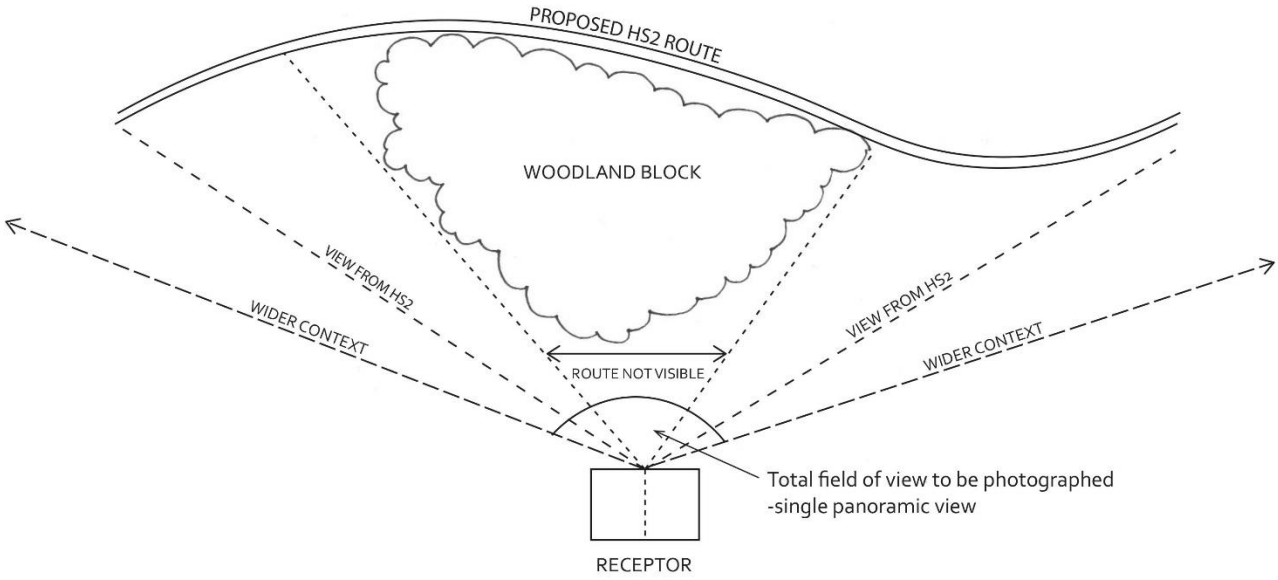
3.1 Introduction

3.1.1 Photographs will be taken to illustrate a representative view from each of the visual receptor locations identified and agreed with stakeholders. Photographs will be taken during both winter and summer to illustrate how the view changes seasonally (or to confirm that the view does not change substantially between winter and summer). The winter and summer photographs will match as closely as possible in terms of precise viewpoint location, field of view and focal length. (Where a verifiable photomontage is required for a viewpoint a different methodology is used for obtaining verifiable photography, as defined in the Technical note – Approach to verifiable photomontages). The specific requirements for viewpoint photography are:

- an appropriate horizontal field of view for each viewpoint. For the majority of locations, this will require multiple photographs to be taken and for these to then be stitched together (Section 3.3 below); and

- the field of view must, as a minimum, fully capture the extent of any part of the Proposed Scheme (during either construction or operation) visible from each location. There may be cases where two different elements of the Proposed Scheme would be visible in different locations when viewed from a specific location. In this instance, a single panoramic view (comprising multiple photographs stitched together) will be taken (see Figure 2).

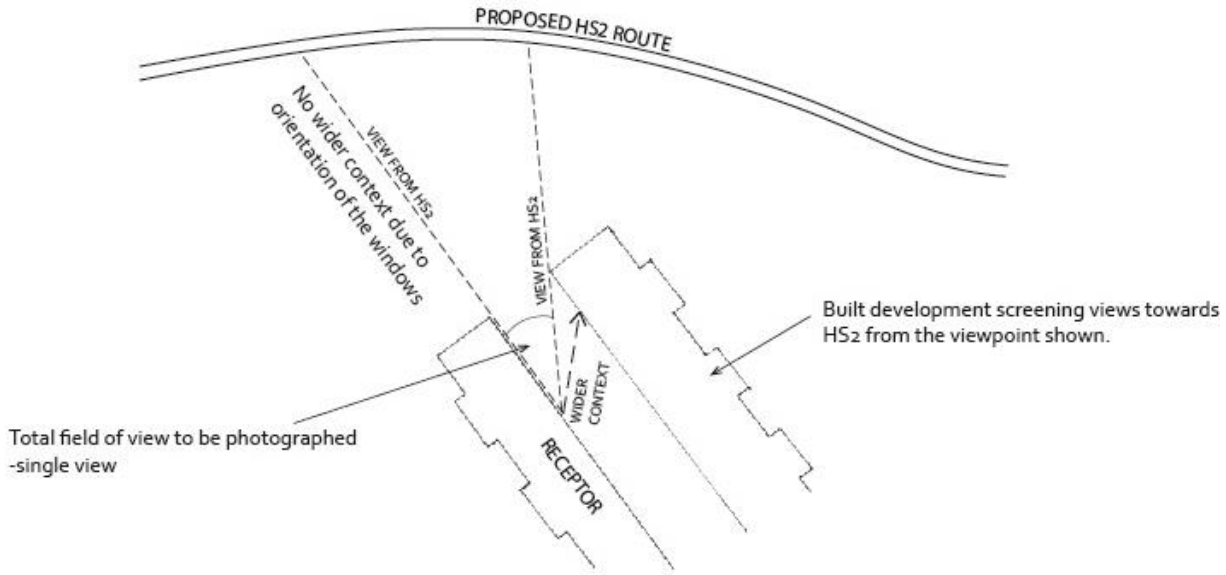
Figure 2: Wide field of view



- the final image[3] must illustrate the context of the view towards the Proposed Scheme (i.e. a wider field of view than just the extent in which the Proposed Scheme would be visible).
- lastly, if the viewpoint is representative of the view from a building (residential, hotels, employment, schools etc.), this should restrict the field of view (see Figure 3).

[3] The use of the term 'image' within this technical note relates to a 'photograph' that has been manipulated.

Figure 3: Restricted field of view



3.1.2 The purpose of winter photography is to illustrate the view when there are no leaves on deciduous trees. Therefore, winter photographs will generally only be taken between the start of December and the end of March.

3.1.3 Conversely, the purpose of summer photography is to demonstrate the screening effect leaves may have. Therefore, summer photos will be taken between the start of June and the end of September.

3.1.4 All viewpoints will be uniquely named and labelled as specified by HS2.

3.1.5 All viewpoints will be stored in GIS feature classes and have attribute data as specified by HS2.

3.2 Recording the location of photographic viewpoints

3.2.1 For all viewpoints the information listed below will be captured by a surveyor, using a software application (an 'app'), to ensure the identity of the correct location on site:

- the viewpoint number, date and time of the visit;
- sub 5m accuracy coordinates for each camera position using a handheld GPS unit;
- photographic evidence of the exact camera position;
- notes to describe the exact camera position where necessary. It would be advisable to identify the exact camera positions in relation to a feature (joint in paving slabs, manhole cover, distance from a fence post etc.) which can be later identified by the verifiable photographer and verifiable surveyors;
- the GPS coordinates, aerial imagery and OS mapping will be used to confirm the latitude and longitude and National Grid Easting and Northing position of each viewpoint; and

- field notes will be compiled and the GIS feature classes will be populated with the key attributes as specified by HS2.

3.3 Taking panoramic photography

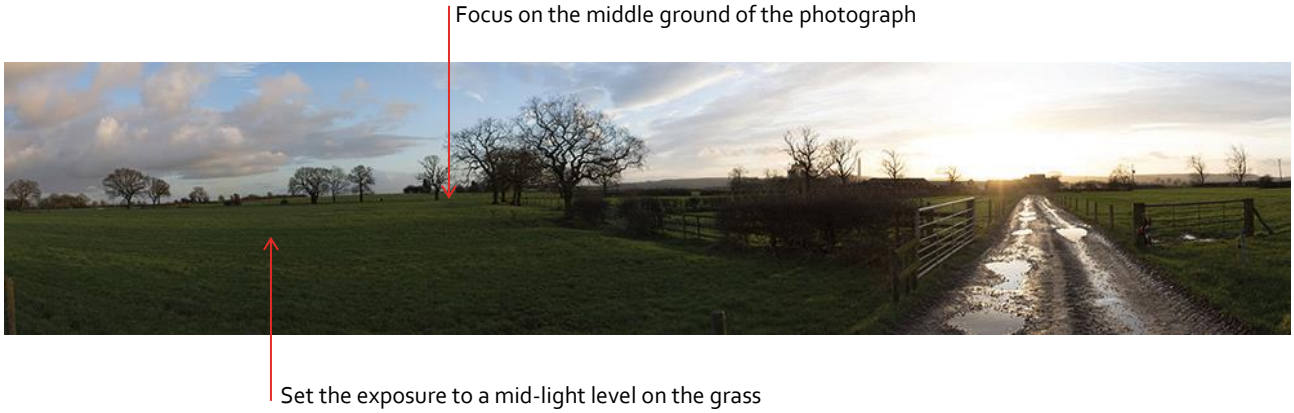
3.3.1 The following methodology will be followed for all panoramic photography for viewpoints:

- widest possible lens setting (typically 18mm on a crop camera) will be used in order to take as much of the landscape as possible for subsequent stitching into panoramic views;
- an overlap of 25-33% between shots;
- full 360 degree site photography will be taken where possible;
- when taking photographs, the photographer will turn the camera round with the lens directly over their left foot in portrait orientation. Refer to Figure 4. This is regarded as best practice for taking panoramic photography in the field without a tripod; and

Figure 4: Standing position for taking handheld panoramas

- the camera will be focused once to the middle distance and then set to manual focus to ensure all shots are consistent in focus distance. Refer to Figure 5 below.

Figure 5: Technique for photography



3.4 Stitching multiple photographs for viewpoints

3.4.1 As noted above, there are likely to be occasions when the view from a visual receptor will need to be made up of a series of overlapping photographs due to the extent of the site that needs to be recorded. See Figure 6.

Figure 6: Series of 24 overlapping photographs

3.4.2 Panoramas will be produced by stitching multiple site photographs into single panoramic images (using PTGui stitching software). See Figure 7.

Figure 7:A stitched panorama

3.4.3 As panoramic images are inherently distorted when projected on to flat media, the panoramic images we will be adjusted back into a series of more conventional rectilinear photographs (based around the field of view of the 50mm focal length more commonly associated with LVIA photography). See Figure 8.

Figure 8: A stitched panorama showing guides where the four images are to be taken from

3.4.4 A series of four extracted images will create a horizontal field of view of just over 158 degrees. See Figure 9.

Figure 9: The four rectilinear images extracted for to represent the panoramic view, based on 50mm field of view

Hs2 Phase 2a West Midlands - Crewe: Technical note - Landscape and visual -

Zone of theoretical visibility production methodology

Contents

List of figures

1 Introduction

1.1.1 This note has been prepared to describe the methodology used to produce the zones of theoretical visibility (ZTV) of the Proposed Scheme.

1.1.2 The broad methodology for producing the ZTV is described in Section 12.5 of the HS2 Phase 2a Environmental Impact Assessment (EIA) Scope and Methodology Report (SMR)[1]. ZTV have been produced to indicate the extent of the theoretical visibility of the Proposed Scheme during both construction and operation. The ZTV have been produced using one model for the whole route to ensure route-wide consistency.

1.1.3 ZTV have been prepared to show:

- the theoretical visibility of the Proposed Scheme during construction. This excludes cranes on the basis that these would indicate widespread visibility and take emphasis away from understanding the potential extent of significant effects. Cranes have been considered, where relevant, in the assessment of effects (see paragraph 3.1.3);
- the theoretical visibility of the Proposed Scheme in year 1 of operation. Overhead line equipment (OLE) has also been excluded due to its potential to take emphasis away from the understanding of significant effects; and
- the theoretical visibility of the Proposed Scheme in year 15 of operation, taking into account the benefit maturing vegetation may have on restricting visibility.

1.1.4 The ZTV are based on the Proposed Scheme used for the assessment of effects which will be presented in the Environmental Statement.

2 Production of the base model

2.1 Baseline construction surface

2.1.1 The creation of a baseline model, on which to run the construction phase visual analysis, is a multiple step process and is wholly reliant on the datasets available.

2.1.2 To reflect actual conditions of topography along with buildings and large belts of vegetation, which may act as visual barriers, it is necessary to build a model that takes these into account but removes any unwanted barriers from a surface model that may not truly reflect the surface. For example, in a DSM (Digital Surface Model), a bridge or an elevated walkway would be interpreted as a visual barrier whereas in fact an observer would be able to see under the element.

2.1.3 The datasets used to produce the ZTV of the Proposed Scheme are as shown in Figure 1 and Figure 2:

[1] Volume 5: Appendix CT-001-001, Scope and Methodology Report.

Figure 1: 5m Digital Terrain Model in gdb raster format and 2m Digital Surface Model in .gdb raster format. Source DEFRA

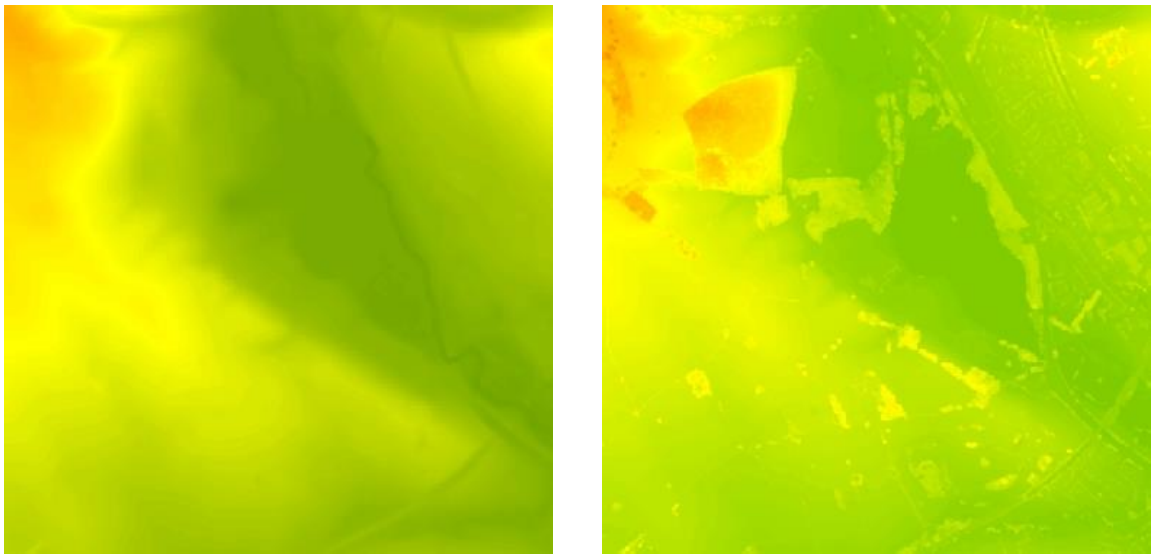
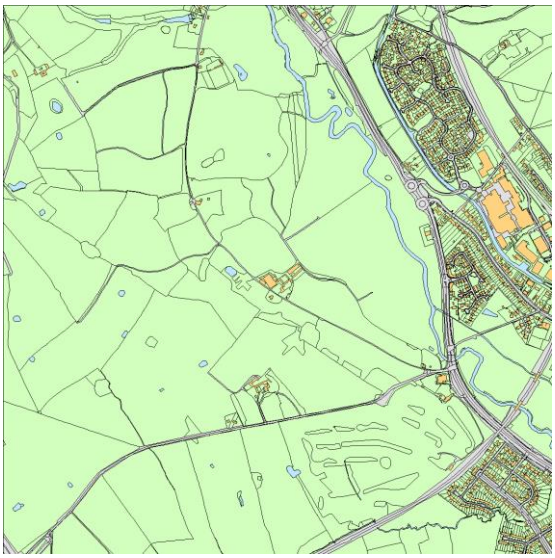


Figure 2: Ordnance Survey MasterMap



2.1.4 The above data was chosen due to the extent of coverage offered. (Two datasets of higher accuracy were available to the project (200mm as opposed to 2m and 5m) however, these datasets only covered a 500m corridor either side of the line of route of the Proposed Scheme, and a coverage of 5000m corridor was required for this study.)

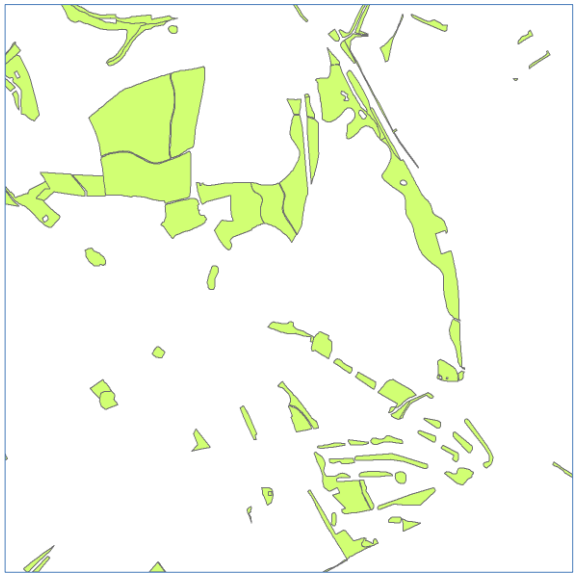
2.1.5 The decision was made not to use these datasets because the height values in the higher and lower resolution datasets varied to such an extent in places that 'steps' were created in the terrain when the two data were merged.

2.1.6 In essence, the following process takes elements such as buildings and large tree belts from a Digital Surface Model (Figure 3) and adds them to a Digital Terrain Model.

Figure 3: Definition query used in ArcGIS to extract buildings from the Ordnance Survey MasterMap. Legend = '0321 Building'.

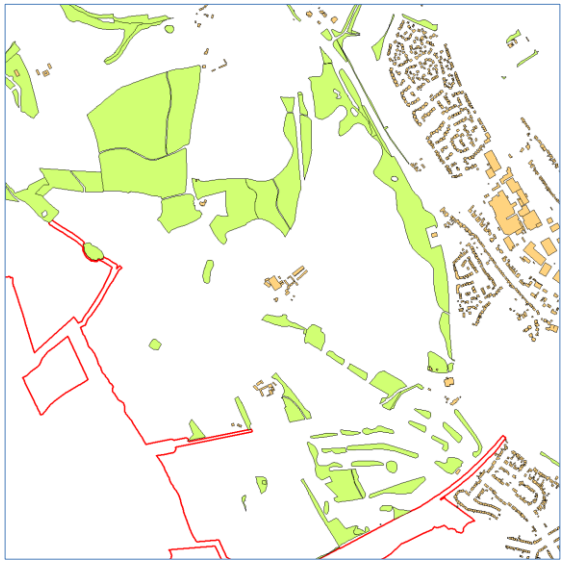
2.1.7 This query ensures that any overhead structures such as bridges or elevated walkways are removed from the buildings theme and only buildings are left. A feature class can then be exported for later use (Figure 4).

Figure 4: Definition query to extract areas of tree planting from the OS Mastermap data.



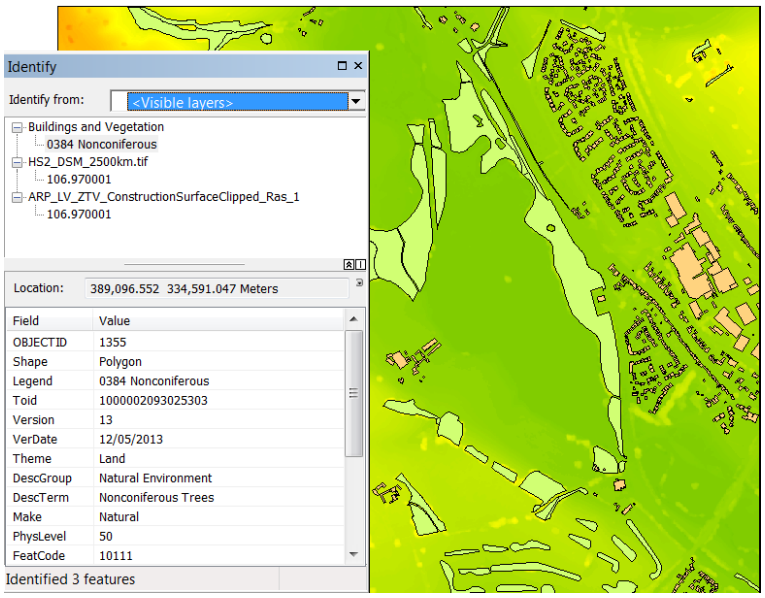
2.1.8 There is an assumption that vegetation within the land required for the Proposed Scheme will be removed during construction. This assumption together with data regarding building demolition is used to remove these features from the final mask (Figure 5) so as not to include visual barriers in the model that might be removed during the construction of the Proposed Scheme.

Figure 5: The resulting polygon feature classes are used to then extract the height data from the 2m resolution DSM using the 'Extract by Mask' tool in ArcMap.



2.1.9 This resulting data is then combined with the 5m resolution DTM using the 'Mosaic to New Raster' tool in ArcMap (Figure 6). Importantly, during this process the resolution of the final raster is set to 2m so no definition at the edges of buildings is lost. Resampling of the 5m DTM uses the nearest neighbour sampling algorithm. This is unavoidable due the fact that a raster dataset can have only one resolution. It is found that during the resampling process that the underlying original cell values of the DTM and DSM remain largely unchanged, as demonstrated in the following figures.

Figure 6: Data combined with the 5m resolution DTM using the 'Mosaic to New Raster' tool in ArcMap

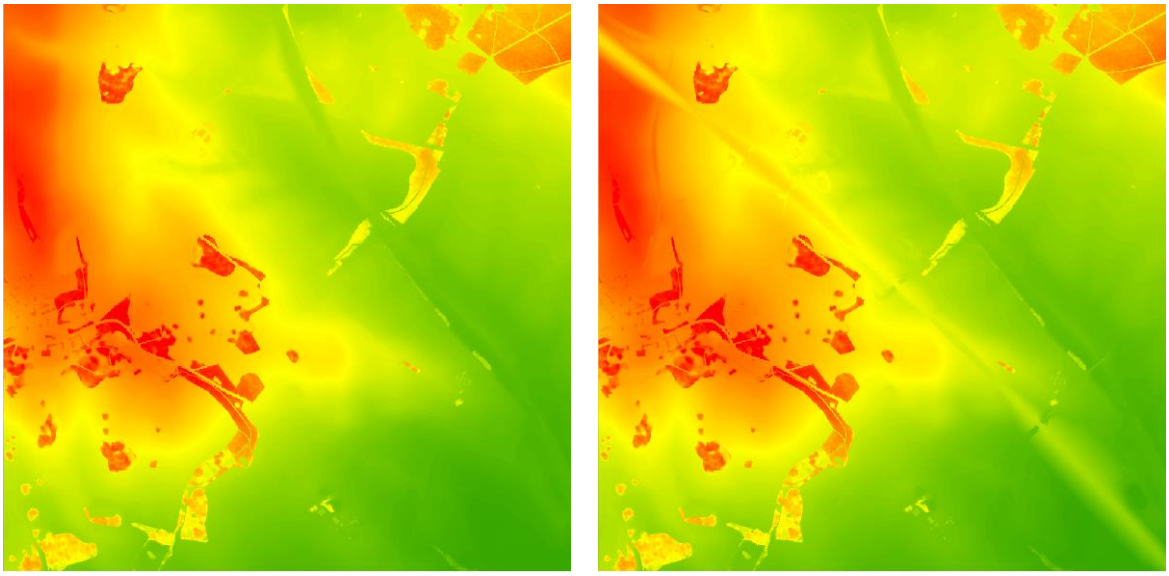


2.2 Operation year 1 model

2.2.1 The Proposed Scheme has a large amount of earthworks in the form of cuttings and embankments, which will have an effect on the visibility of the trains. To add this variable to the model, the 3D scheme data produced in the CAD files is extracted as LandXML surfaces and converted to raster format at 2m resolution.

2.2.2 The scheme raster is then added to the construction surface detailed above using the 'Mosaic to New Raster' tool in ArcMap, resulting in a raster combining existing condition and the Proposed Scheme at year 1 of operation (Figure 7).

Figure 7: Scheme raster using 'Mosaic to New Raster' tool in ArcMap for Construction and Operation year 1

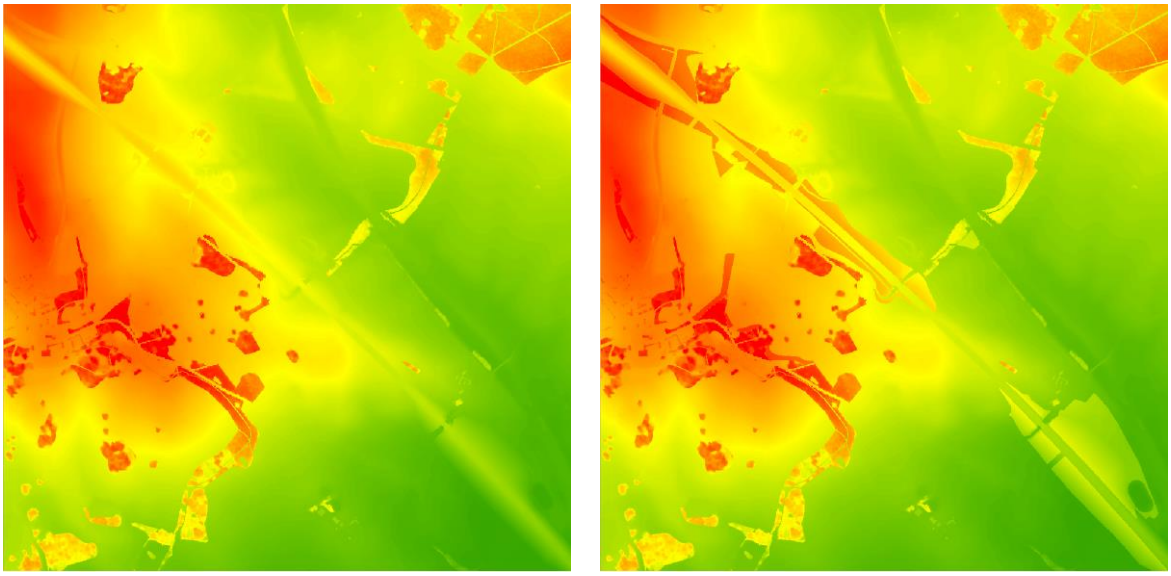


2.3 Operation year 15 model

2.3.1 After 15 years it is assumed that the vegetation planted for mitigation and screening purposes is expected to have grown 7 metres. Using this assumption, the planting data produced in the CAD files is used to create a raster to add to the year 1 model (Figure 8).

2.3.2 The planting polygons used to extract by mask the data in the operation year 1 surface. This data is then manipulated via the ArcMap Raster Calculator whereby 7.5 is added to each cell value. This results in each cell where planting occurs has a value 7.5 metres above the year 1 surface.

Figure 8: Scheme raster using 'Mosaic to New Raster' tool in ArcMap for Construction and Operation year 15



3 Modelling the construction phase ZTV

3.1.1 The extent of the visibility of the Proposed Scheme during construction was modelled on the basis of conservative assumptions about the height of typical construction plant operating along the length of the route, and at stations, depots, ventilation shafts, head houses, road diversions and any other known proposed works. These heights were added as a series of points into ArcGIS to enable the ZTV to be produced using the 'Viewshed' tool[2]. For the purposes of modelling the construction phase ZTV that focuses on the likely distribution of significant effects, heights of very tall construction plant such as cranes have been excluded.

3.1.2 Cranes have been excluded from the construction phase ZTV on the basis that these indicate widespread visibility but rarely give rise to significant effects if they are the only elements visible. With the exclusion of cranes, the construction phase ZTV gives a better indication of the possible spread of significant effects and therefore better informs the assessment process.

3.1.3 Elements modelled to enable production of the construction phase ZTV are detailed below:

- assumption of 5m above existing ground levels for the route above ground, whether it is at grade, on embankments or in cutting. This was selected on the basis of the possible height of typical construction plant expected to be used along the route;

[2] Viewshed is an ArcGIS tool which analyses where any given point is visible from by determining the raster surface locations visible to a set of observer features.

- assumption of 5m above existing ground levels for the length of proposed green tunnels, selected on the basis of the possible height of typical construction plant expected to be used at these structures, excluding cranes;
- assumption of 8m above existing ground levels around the boundary of any known construction compounds, on the basis of the possible height of typical construction plant, storage, stacked welfare facilities etc. that may be present within these areas;
- assumption of 5m above existing ground levels at the location of all tunnel portals, selected on the basis of the possible height of typical construction plant expected to be used at these structures, excluding cranes;
- assumption of 8m above existing ground levels at the location of all ventilation shafts, selected on the basis of the possible height of typical construction plant expected to be used at these structures, excluding cranes;
- assumption of 5m above existing ground levels at the location of any road diversion works, new road bridge works or utility diversion works, on the basis of the possible height of typical construction plant required;
- assumption of 2m above the height of proposed viaducts and overbridges to take account of construction plant and scaffolding required to build the structures, excluding cranes;
- assumption of 2m above the height of any demolitions required, to take account of construction plant and any scaffolding that may be required, excluding cranes; and
- assumption of 2.4m above existing ground levels (i.e. the standard hoarding height) of the temporary extent of land required to construct the Proposed Scheme.

4 Modelling the operational phase ZTV

4.1.1 The extent of the visibility of the Proposed Scheme during operation was modelled on the basis of the height of operational structures along the line of route, including stations, permanent depots, ventilation shafts, headhouses, road diversions and any other proposed works. The heights modelled take into account where the Proposed Scheme is in cutting, at grade, on embankment or on viaduct. These heights were added as a series of points into ArcGIS to enable the ZTV to be produced using the 'Viewshed' tool.

4.1.2 The base model produced for the construction phase ZTV was amended by:

- removing any buildings to be demolished during construction of the Proposed Scheme, to ensure they did not falsely block potential views when the operational ZTV was run; and
- adding new mitigation earthworks designed to screen the Proposed Scheme into the base model.

4.1.3 Elements modelled to enable production of the year 1 operational phase ZTV are detailed below:

- 4m above proposed track bed levels for trains;
- the designed height of all tunnel portal buildings, head houses and ventilation shafts;
- the designed height of all buildings associated with the permanent operation of the Proposed Scheme;
- the height of road diversions or new road bridges, excluding lighting etc.; and
- the height of any new fencing and noise barriers.

4.1.4 Overhead line equipment has been excluded from the operational phase ZTV on the basis that these indicate widespread visibility but rarely give rise to significant effects if they are the only elements visible. With the exclusion of overhead line equipment, the operational phase ZTV gives a better indication of the possible spread of significant effects and therefore better informs the assessment process.

4.1.5 The year 15 operational phase ZTV was produced using the same parameters as above, but proposed tree planting was incorporated into the base model at an assumed height of 7.5m, serving to reduce visibility of the Proposed Scheme in some locations. Due to the inaccuracy of defining assumptions so far into the future, no ZTV has been prepared for the year 60 operational phase assessment.

HS2 Phase 2a West Midlands - Crewe: Technical note - Landscape and visual - Approach to landscape sensitivity

Contents

List of figures

List of tables

1 Introduction

1.1.1 This note has been prepared to provide guidance on the revised methodology for determining the sensitivity of landscape character areas to be applied in the landscape assessment of the likely significant effects of HS2 Phase 2a West Midlands - Crewe (the Proposed Scheme). This note also provides advice on why a new methodology is required and how it differs from the methodology adopted in the HS2 Phase One Environment Statement (ES).

2 Original methodology

2.1.1 In the HS2 Phase One ES landscape character assessment methodology, the sensitivity to change of each landscape character area was assessed using the three criteria of condition, tranquillity, and value. These were determined using professional judgement, site visit data and existing documentation including local authority character assessments, historic landscape character assessments and Conservation Area character appraisals where available. This was developed with reference to the Guidelines for Landscape and Visual Impact Assessment (GLVIA) second edition[1] and some preliminary thoughts from the Landscape Institute on the content of the third edition which were unpublished at the time of producing the Scope and Methodology Report (SMR) for Phase One.

2.1.2 The presence of any combination of attributes was considered when assessing the sensitivity of a character area and these are summarised in Table 1 below.

Table 1: Criteria for assessing landsape sensitivity (HS2 Phase One methodology)

Sensitivity	Where the character area:
High	Is valued at the international, national, regional or borough/district scale
	Is predominantly characterised by landscape components that are rare and distinctive and/or listed
	Is designated as a conservation area, registered park and garden or public open space
	Has an elevated tranquillity
	Has limited tolerance to change
	Has components that are not easily replaced or substituted (e.g. mature trees)
	Has limited scope for effective mitigation in character with the existing landscape
	Is well maintained and in a good condition
Medium	Is locally valued
	Has moderate levels of tranquillity
	Is fairly tolerant of change
	Has components that are easily replaced or substituted
	Has scope for effective mitigation in character with the existing landscape

[1] Guidelines for Landscape and Visual Impact Assessment (GLVIA) second edition, 2002, Landscape Institute.

Sensitivity	Where the character area:
	Is of a fair condition
Low	Has limited landscape value Has few or no distinctive components, or components that detract from the overall character of the site Has limited tranquillity Is tolerant of change Has components that are easily replaced or substituted Has scope for effective mitigation in character with the existing landscape, and opportunities for an improvement in character Is in a poor condition

2.2 Why change methodology?

2.2.1 HS2 Phase 2a provides an appropriate opportunity to review and refine the Phase One methodology to gain greater alignment with the European Landscape Convention (ELC) definition of landscape as" an area, as perceived by people, whose character is the result of the action and interaction of natural and /or human factors''. The importance of this definition is that it focuses on landscape as a resource in its own right, as the ordinary and every day, as well as the special or valuable. This definition provides an integrated way of conceptualising the surrounding landscape and is increasingly considered to provide a useful spatial framework.

2.2.2 The GLVIA 3 guidance reiterates the definition of Landscape as a 'place' that results from the: ''interplay of the physical, natural and cultural components of our surroundings. Different combinations of these elements and their spatial distribution create the distinctive character of landscapes to be mapped, analysed and described. Character is not just about physical elements and features that make up landscape, but also embrace the aesthetic, perceptual and experiential aspects of the landscape that make places distinctive.'' (GLVIA 3 p. 21).

2.2.3 The HS2 Design Vision[2] sets out three core principles of people, place and time. In order to achieve the HS2 design vision, the HS2 Landscape Design Approach (LDA) guides and directs professionals to achieve an integrated and seamless design that is driven by an understanding of the surrounding landscape.

2.2.4 Therefore, the methodology for assessment of the sensitivity to change of each landscape character area has been devised to achieve better interpretation of the landscape character areas as 'places' in their widest context, that also responds to HS2's design vision and LDA. In summary, this methodology adopts a more holistic approach to the assessment of landscape sensitivity, which will influence the assessment of significance of effects of the proposed development during construction and during operation.

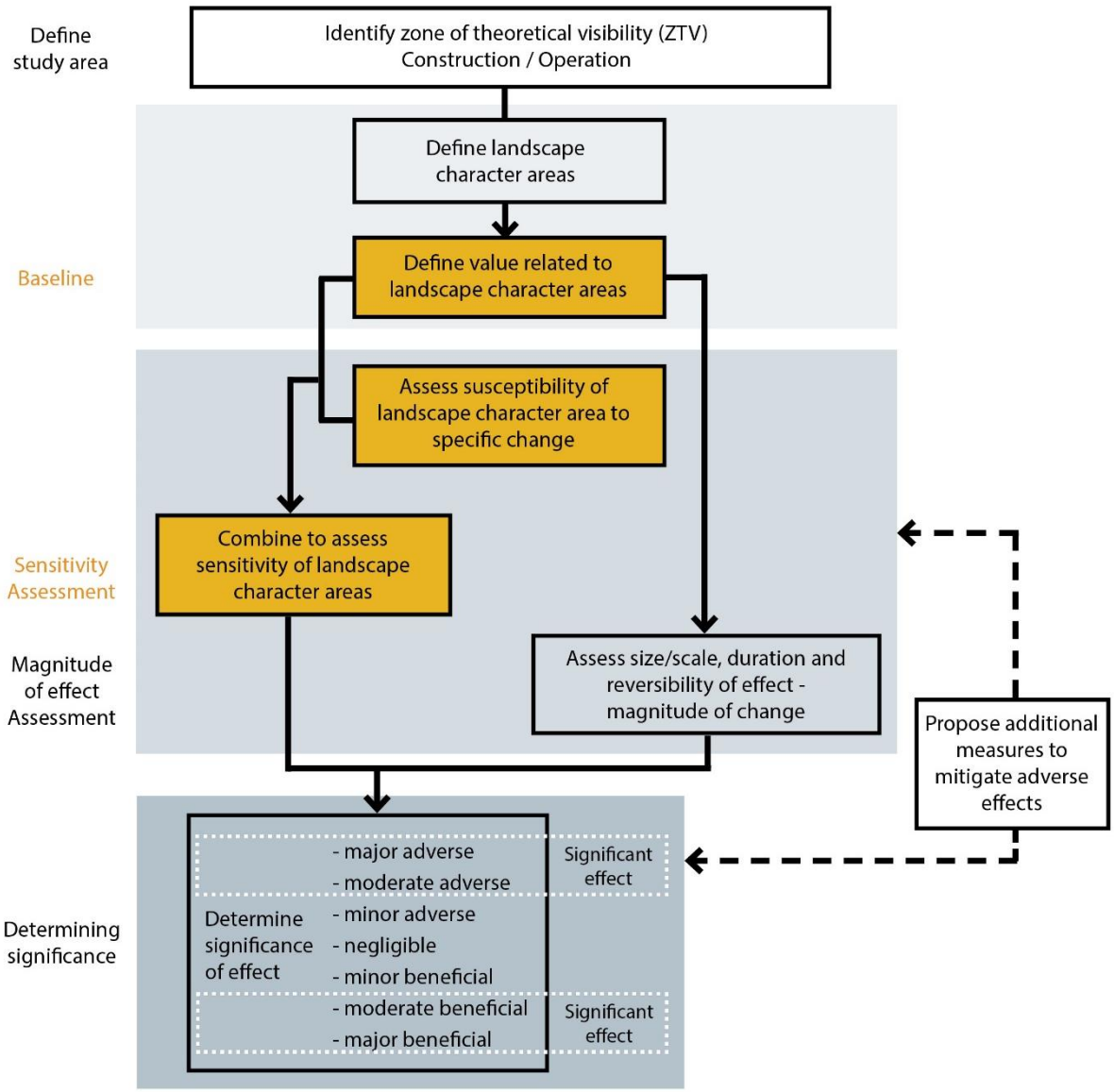
[2] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/475052/HS2_Desgn_Vision_2015.pdf

3 Revised methodology

3.1.1 In the landscape assessment methodology to be applied to HS2 Phase 2a, the sensitivity of each landscape character area is made up of judgements about the value attached to the landscape character area and the susceptibility of the landscape character area to the specific types of change that may arise from the Proposed Scheme.

3.1.2 As in the Phase One assessment the determination of the landscape value for Phase 2a will form part of the landscape character baseline. However, the judgements on susceptibility and the subsequent assessment of sensitivity to change of a range of receptors identified within each landscape character area will form part of the assessment of landscape sensitivity, rather than from part of the landscape character baseline, as in the Phase One ES.

Figure 1: The approach to landscape assessment



3.1.3 Figure 1 highlights how landscape value and landscape susceptibility form part of the assessment process for landscape assessment. The orange highlighted boxes relate to the part of the assessment process discussed in this technical note.

3.1.4 While the criteria that influence landscape sensitivity remain constant, their landscape susceptibility to effects associated with the proposed development will vary, area to area. For example, when making judgements on the perception of the landscape, the absence of visually detracting features in rural locations, e.g. built form and noise from manmade sources may be associated with high tranquillity, whereas in urban areas, enclosure and vegetation may be associated with valued areas of high tranquillity, despite the presence of built form and sources of noise.

3.1.5 Guidance on the different landscape related attributes for judging the value and susceptibility of landscape character areas in urban and rural areas is presented below in section 3.2, where relevant.

3.1.6 The presence of any combination of criteria on landscape value and susceptibility will be considered when assessing the sensitivity of a character area and these are detailed below.

3.2 Determining landscape value

3.2.1 Landscape value will be described with reference to the following criteria:

- geological, topographical and hydrological (physiographic) value;
- historic landscape value;
- natural landscape value;
- recreational value;
- perception of tranquillity;
- landscape condition; and
- scenic qualities.

3.2.2 For each criterion, the value will be determined in a scale from low to high, using professional judgement with reference to site visits and existing documentation including local authority character assessments, historic landscape character assessments, Area of Outstanding Natural Beauty (AONB) management plans and conservation area character appraisals where available.

3.2.3 An overall level of value for each landscape character area will be determined by comparing the judgements made against each of the criteria described above.

3.2.4 The attributes for consideration for each of the six criteria are described in more detail in Table 2 below:

Table 2: Criteria for judging landsape value

1.Geological, topographical and hydrological (physiographic) value

The physiographic value of each character area will be defined with reference to the extent that distinctive topography, landforms, geology and soil types or hydrological features have influenced the landscape character.

Value informed by drawing on information contained within other topic date sets, namely:

- LiDAR terrain data
- Aerial imagery
- Ordnance Survey Mapping
- Geological / soil mapping
- Hydrology maps
- Landscape character assessments
- AONB management plans
- Local Plans

Lower value		↔		**Higher value**
E.g. In rural and urban areas this may be a landscape with no distinctive physiographic features.	E.g. In rural and urban areas this may be a landscape with a very low proportion of physiographic features.	E.g. In rural and urban areas this may be a landscape with some physiographic features.	E.g. In rural and urban areas this may be a landscape with a high proportion of distinctive physiographic features.	E.g. In rural and urban areas this may be a landscape with a very high proportion of distinctive physiographic features.

2. Historic landscape value

The historic landscape value of each character area will be demonstrated by the presence of nationally and locally designated historic landscape components, e.g. Registered Parks and Gardens, internationally or nationally designated heritage assets that contribute to the character of the landscape.

Value informed by drawing on information contained within the Cultural Heritage topic data sets, namely:

- Scheduled Monuments
- Registered Parks and Gardens
- Listed Buildings
- Historic Battlefields
- Historic landscape character mapping
- Conservation Areas

Lower value		↔		**Higher value**
E.g. This may be a landscape (rural or urban) with no historic components or historic landscape types of note.	E.g. This may be a landscape (rural or urban) with very few historic components or historic landscape types.	E.g. This may be a landscape (rural or urban) with one or more distinctive historic components or historic landscape types and some that are designated or listed.	E.g. This may be a landscape (rural or urban) historic components and historic landscape types that are distinctive and/or listed.	E.g. This may be a landscape (rural or urban) predominantly characterised by historic components and historic landscape types that are rare and distinctive and/or listed. Has strong continuity of historic land uses.

3. Natural landscape value

The natural landscape value of each character area will be demonstrated by the presence of distinctive species and /or habitats that contribute to the character of the landscape. These might be veteran parkland trees, distinctive hedgerow species or ancient woodlands.

Value informed by drawing on information contained within Ecology topic date sets, namely:

- Agricultural Land Classification
- Ancient Woodland (including inventories of smaller ancient woodland sites 0.25-2ha)
- Local Nature Reserves (LNR)
- National Nature Reserves (NNR)
- Habitats of Principal Importance
- Ramsar Sites
- Special Areas of Conservation (SAC)
- Special Protection Area (SPA)
- SSSI
- Phase 1 habitat surveys

Lower value		↔		**Higher value**
E.g. This this may be a landscape (rural or urban) with no distinctive species or habitats that influence the landscape character.	E.g. This this may be a landscape (rural or urban) with few distinctive species or habitats.	E.g. This this may be a landscape (rural or urban) with some natural distinctive components value at a local scale.	E.g. This may be a landscape (rural or urban) with many natural components that are rare and distinctive, and valued at local and/regional scale.	E.g. Is predominantly characterised by natural components that are rare and distinctive and valued at a national scale.

4. Recreational value

The recreational value of each character area will be demonstrated by the extent to which the experience of the landscape makes an important contribution to recreational use and enjoyment of an area. This will be Indicated by the presence of Country Parks, visitor facilities such as car parks, and density of the local footpath network.

Value informed by drawing on information contained within other topic date sets, namely:

- National Trails and local/regional promoted routes
- Public rights of way
- Open Access land data set
- Country Parks
- Registered Common Land
- Town or Village Greens

Lower value		↔		**Higher value**
E.g. In rural areas this this may be a landscape with very few visitor facilities and a very small local footpath network. In urban areas this may be a landscape with very few parks or open spaces and leisure facilities (e.g. toilets, outdoor public sports facilities, car parks, tourist information, etc.).	E.g. In rural areas this this may be a landscape with few visitor or recreational facilities and a small local footpath network. In urban areas this may be a landscape with few parks or open spaces and recreational facilities.	E.g. In rural areas this may be a landscape with some recreational or visitor facilities and/or a small local footpath network. In urban areas this may be a landscape with some parks or open spaces or recreational facilities.	E.g. In rural areas this this may be a landscape with some recreational and visitor facilities and/or an extensive local footpath network. In urban areas this may be a landscape with some parks, open spaces and recreational facilities.	E.g. In rural areas this this may be a landscape with Country Parks, Common Land, Open access land, extensive recreational facilities and many visitor amenities such as car parks, and/or a high density of local footpaths, bridleways and/or National trails / long distance trails. In urban areas this may be a landscape dominated by many parks, open spaces and leisure facilities.

5. Perception of tranquillity

The perception of landscape character areas that are relatively remote or tranquil (due to relative freedom from human activity and disturbance or having a strong feel of traditional rurality with few modern human influences) will be defined compared to landscapes that contain signs of modern development. This is because modern development/infrastructure may / can introduce new and uncharacteristic features, which may not respond well to landscape context and which may detract from a sense of tranquillity and/or remoteness.

Value informed by drawing on information contained within other topic date sets, namely:

- LiDAR terrain data
- Aerial imagery
- Ordnance Survey Mapping
- Campaign to Protect Rural England (CPRE) Tranquility maps (2007)

Lower value		↔		**Higher value**
E.g. In rural areas this may be a landscape dominated by intense human activity and development such as large scale industrial or agricultural buildings/landscapes, noticeable presence of major infrastructure, the presence of substantial levels of artificial lighting, high levels of noise from traffic and/or high frequency of use by people.	E.g. In rural areas this may be a landscape with much human activity and dispersed modern development such as larger villages, busy roads and working agricultural buildings and activities, presence of infrastructure, levels of light artificial across the landscape and presence of noise from traffic, aircraft, people.	E.g. a rural landscape with some presence of modern development and human activity such as larger farms, and rural villages and light levels of sound from people and traffic, evidence of some infrastructure within parts of the wider setting of the area, presence of electricity pylons, some sources of low level light .	E.g. In rural areas this may be a landscape with little presence of human influence and development, no noticeable presence of major infrastructure, little sound from vehicles or people, some sources of low level light and a strong sense of nature and vegetated unspoilt countryside.	E.g. In rural areas this may be a remote or 'wild' landscape with little or no signs of current human activity and development with absences of infrastructure and sound from traffic/ people, unlit countryside and very strong sense of nature and vegetated unspoilt countryside.

In urban areas this may be the presence of high density residential land uses, industrial / commercial uses and the widespread presence of busy routes and high levels of noise.	In urban areas this may be the presence of residential land uses with some street trees and vegetation with some main roads.	In urban areas this may be the presence of residential land uses with local parks, water bodies.	In urban areas this may be the presence of vegetation and parks within low density residential development and the infrequent use by local communities.	In urban areas this may be the presence of dense vegetation, substantial parks and water bodies and the very limited presence of vehicles or the sound of vehicles. Or a strong sense of place and associations with architecture and/or adjacent spaces.

6. Landscape condition

The landscape condition of each character area will be demonstrated by the presence of characteristic natural and man-made elements, which are generally in good condition, and the absence of significant or detracting elements. Visual unity (or intactness) of the field patterns, trees and woodland.

Value informed by drawing on information contained within other topic date sets, namely:

- National and Regional Landscape Character Areas
- Aerial imagery
- Local plans and Conservation Areas

Lower value		↔		**Higher value**
E.g. In rural areas this may be a landscape in a poor condition with simple/uniform land cover pattern, with little variation in character. It may have few or no distinctive components, and contains infrastructure elements that detract from the overall character of the site. In urban areas this may be a landscape with dense infrastructure / industrial area with little variation in character or pattern and with noticeable major infrastructure elements.	E.g. In rural areas this may be a landscape with large-scale field patterns and little variety in land cover. Occasional human scale features such as trees and domestic buildings yet a simple landform pattern with very few notable features. In urban areas this may be a landscape with some variation in built character or pattern but with the presence of some infrastructure / industrial area with little variation in character.	E.g. In rural areas this may be a landscape with medium sized fields, some variations in land cover and presence of human scale features such as trees, domestic buildings or where strong medium scale field patterns are apparent and have some visual expression. May have a moderate degree of erosion of such features. In urban areas this may be a landscape with some areas of distinctive and well maintained built form with the presence of some infrastructure elements.	E.g. In rural areas this may be a landscape with irregular, largely intact small-scale fields, variety in land cover and presence of human scale features such as trees, domestic buildings, or a landscape where historic field patterns are evident. Components are generally in a good condition In urban areas this may be a landscape with extensive areas of distinctive and well maintained built form with few infrastructure elements.	E.g. In rural areas this may be an intimate scale landscape with a very strong variety in land cover; Is predominantly characterised by landscape components that are distinctive and well maintained and in a good condition. Has a strong presence of human scale features. In urban areas this may be a landscape with predominantly distinctive and well maintained built form set amongst frequent open spaces where detracting elements, such as infrastructure, are not present.

7. Scenic qualities

The scenic qualities of each character area will be defined with reference to the extent to which particular qualities of an area are expressed in the landscape and the general appeal of the landscape e.g. distinctive, dramatic or striking landform or patterns of land cover; or strong aesthetic qualities such as scale, form, colour, texture etc.

The Cannock Chase Area of Outstanding Natural Beauty (AONB), adjacent to part of the HS2 route corridor, has extensive scenic qualities that will apply to much of the surrounding landscape character. Therefore, specific reference shall be made to the AONB Management Plan and Landscape Character Assessment (LCA).

Value informed by drawing on information contained within other topic date sets, namely:

- National and regional Landscape Character Areas
- Areas of Outstanding Natural Beauty
- Local Plan, AONB management plan

Lower value		↔		**Higher value**
E.g. In rural areas this may be a landscape with greater presence of infrastructure and built elements which impact on special and scenic qualities of the landscape and with a very low presence / distribution of special landscape qualities. In urban areas this may be a landscape with the presence of extensive infrastructure or industrial development and a very low distribution of built form with aesthetic qualities.	E.g. In rural areas this may be a landscape with marked presence of elements which impact on special / scenic qualities, or one of low scenic quality or with many of the scenic / special qualities eroded. In urban areas this may be a landscape with the presence of extensive infrastructure or industrial development with a low distribution of built form with aesthetic qualities	E.g. In rural areas this may be a landscape with some evidence of the scenic and special qualities, albeit with a degree of erosion due to presence and / or infrastructure and built elements. In urban areas this may be a landscape with some evidence of distinctive built form with aesthetic qualities but with a degree of erosion due to presence of infrastructure or industrial development.	E.g. In rural areas this may be a landscape with considerable evidence of the scenic/special qualities including their flora, fauna, geological and/or historical features. In urban areas this may be a landscape with considerable evidence of distinctive built form with strong patterns and aesthetic qualities.	E.g. In rural areas this may be a landscape of very high scenic quality, with most/all of the scenic/special qualities evident, including their flora, fauna, geological and/or historic features. In urban areas this may be a landscape with very high proportion of distinctive built form with strong patterns and aesthetic qualities such as scale, form, texture etc.

3.3 Determining landscape susceptibility

3.3.1 The ability of a given landscape to accommodate the specific nature of a proposed development and/or change in land use without adverse impacts is referred to as 'susceptibility to change'.

3.3.2 Judgements on landscape susceptibility need to take into account the extent to which the attributes of the receiving landscape will be able to accommodate the proposed development without adverse change. The following five criteria have been specifically selected as applicable to the nature of the proposed scheme and will be taken into consideration in the assessment of landscape susceptibility:

- landform;
- land cover and land use;

- scale;
- prominent landmarks; and
- perceptual aspects and tranquillity.

3.3.3 For each criterion, susceptibility will be assessed on a scale from low to high using professional judgement with reference to site visits and existing documentation, to including local authority character assessments, historic landscape character assessments and conservation area character appraisals where available.

3.3.4 An overall level of susceptibility for each landscape character area will be assessed by bringing together the judgements made for each category described above.

3.3.5 Table 3 below sets out the criteria which will be used to determine the judgement on the susceptibility of the landscape character area.

Table 3: Criteria for judging susceptibility of landscape

Criterion	Definition				
Landform	**Landforms that are smooth, regular and convex, or flat and uniform, are likely to be less susceptible to the proposed route than a dramatic or rugged landform, which is prominent and distinctive in character. Extensive areas of undulating topography also have greater potential to provide enclosure, therefore limiting the perceptibility of the Proposed Scheme.**				
	SUSCEPTIBILITY				
	Lower susceptibility		↔		**Higher susceptibility**
	Very simple landform character/ topography which would have a low level of susceptibility to the Proposed Scheme.	Mostly simple landform character / topography equating to a relatively low level of susceptibility to the Proposed Scheme.	A moderate degree of landform variation with some distinctive topographic elements. In combination, resulting in a medium degree of susceptibility to the Proposed Scheme.	Prominent, relatively distinctive or complex landforms with a high level of susceptibility to change arising from the Proposed Scheme.	Highly prominent, distinctive or intricate/complex landforms, which would be extremely susceptible to change arising from the Proposed Scheme.

<table>
<tr><td>Land cover and land use</td><td colspan="5">Simple, uncluttered landscapes with sweeping lines and extensive areas of consistent ground cover are likely to be less susceptible to the Proposed Scheme than areas with more complex, or irregular landscape patterns (for example, historic field systems), where the Proposed Scheme will be more prominent. Although trees, woodlands and hedgerows add to complexity, these landscape elements, may, help to screen views of the Proposed Scheme.

In rural areas the Proposed Scheme is also likely to be less intrusive in landscapes that are characterised by large agricultural structures, large commercial forests or by the presence of existing road or rail infrastructure.

In the urban context, the most susceptible land cover elements are likely to be those of fine grain, and close knit, vernacular/intact character, whilst more consistent patterns or more modern 'edge' and industrial developments, characterised by linear infrastructure, would be less susceptible.</td></tr>
<tr><td></td><td colspan="5">SUSCEPTIBILITY</td></tr>
<tr><td></td><td colspan="2">Lower susceptibility</td><td>↔</td><td colspan="2">Higher susceptibility</td></tr>
<tr><td></td><td>A very simple uncluttered landscape with extensive areas of uniform ground cover (Potentially also woodlands), which the Proposed Scheme could positively respond/integrate with or be screened within.

Urban environments: large scale modern development/ infrastructure, or simple urban grain with extensive areas of uniform building types, and vertical infrastructure, which the Proposed Scheme could positively respond to/integrate with or be screened within.</td><td>Mostly simple, uniform/repetitive land cover pattern, with few elements of variety/which would be susceptible to the Proposed Scheme.

Urban environments: modern development or small infrastructure, likely to be characterised by some uniform building types, linear and vertical infrastructure.</td><td>Land cover pattern of intermediate complexity, possibly a partly eroded pattern (where historic field boundaries have been lost to agricultural intensification).

Urban environments: Partly intact/historic building with moderate density and moderately varied urban grain, some erosion and loss to modern development or infrastructure components.</td><td>Mostly small scale rural land uses, fairly intimate land cover pattern, and textured landscape with few obvious modern human influences. The legibility of features would be susceptible to change arising from the proposed route.

Urban environments: Mostly intact historic and/or dense, tight knit urban grain with few obvious modern development/ infrastructure influences.</td><td>Extremely small scale intimate rural land cover pattern creating a complex and/or 'textured' landscape. The legibility of such features would be highly susceptible to change resulting from the Proposed Scheme.

Urban environments: Strongly intact historic and/or dense, tight knit urban grain, with few obvious modern development/ infrastructure influences.</td></tr>
</table>

<table>
<tr><td>Scale</td><td colspan="5">A large scale landscape, where the Proposed Scheme appears more in proportion, is likely to be of lower susceptibility than a small scale landscape, where elements of the Proposed Scheme are likely to be more dominant. Scale may relate to landform, e.g. an extensive plateau, or land cover, e.g. scale of field boundary patterns. Comparison of elements of the Proposed Scheme with 'human-scale' landscape features such as individual trees and buildings may also emphasise the scale of the Proposed Scheme.

In the urban context, small scale, fine grain built form will have a far higher susceptibility to change arising from the Proposed Scheme than will large scale industrial development and those forms of development characterised by extensive and/or prominent supporting infrastructure.</td></tr>
<tr><td></td><td colspan="5">SUSCEPTIBILITY</td></tr>
<tr><td></td><td colspan="2">Lower susceptibility</td><td>↔</td><td colspan="2">Higher susceptibility</td></tr>
<tr><td></td><td>Very large scale landscape, which could easily absorb/accommodate change resulting from the Proposed Scheme without adverse effect on character.

Urban environments: Likely to be characterised by large scale, simple development, such that the Proposed Scheme could appear in character.</td><td>Large scale landscape, likely to have reasonable potential to absorb/ accommodate change resulting from the Proposed Scheme without adverse effect on character.

Urban environments: Likely to be characterised by largely eroded and/or modern built form of medium to large scale/fairly simple character.</td><td>A medium scale and partly intact landscape, such that the HS2 route would be readily apparent within the receiving landscape.

Urban environments: Medium scale, partly intact grain, likely to be a mix of vernacular and more modern/eroded elements.</td><td>Mostly intimate, small scale landscape. The Proposed Scheme would be likely to dominate many aspects.

Urban environments: Mostly small scale/tight knit and fine grained. Likely to be largely intact vernacular environments which would be susceptible to the introduction of the Proposed Scheme.</td><td>Very intimate small scale landscape, such that the Proposed Scheme would dominate such features/ interrupt their legibility.

Urban environments: Very small scale/tight knit/fine grained often highly intact vernacular environments which would be highly susceptible to the introduction of the Proposed Scheme.</td></tr>
</table>

<table>
<tr><td>Prominent landmarks</td><td colspan="5">Landscapes that do not contain prominent features or form a distinctive backdrop or which have fewer visual foci are typically less susceptible to the Proposed Scheme.

Where there are distinctive features the Proposed Scheme may interrupt the relationship between features and their landscape settings or may be prominent on skylines. Landscapes characterised by church towers and spires and other landmark features (cathedral/castle/country house/mansion or historic features) would also be susceptible to the Proposed Scheme, due to the potential for impact upon their legibility/setting).</td></tr>
<tr><td></td><td colspan="5">SUSCEPTIBILITY</td></tr>
<tr><td></td><td colspan="2">Lower susceptibility</td><td>↔</td><td colspan="2">Higher susceptibility</td></tr>
<tr><td></td><td>A landscape with very few/no prominent or distinctive elements which would be susceptible to the Proposed Scheme. Landscape may be characterised by pylons, overhead power lines, or other large/modern/ prominent forms of development.

Urban environments: Highly repetitive or very common-place built form elements.</td><td>A landscape with few prominent or distinctive elements which would be susceptible to the Proposed Scheme. There may also be some large/ modern prominent features in the landscape.

Urban environments: Largely repetitive, commonplace built form elements.</td><td>A landscape with intact/naturalistic / with prominent historic/ topographic or landscape structure elements, albeit possibly eroded by large scale infrastructure such as pylons or areas of modern development.

Urban environments: Some prominent buildings/ landmarks with potential for partial effect on their setting arising from the Proposed Scheme.</td><td>Mostly prominent and distinctive features, including landform, scarp top woodlands, reasonably prominent historic landmark features/historic settlement whose legibility would be susceptible to the Proposed Scheme. Little interference by modern development/ infrastructure.

Urban environments: Prominent distinctive/ historic buildings / landmarks whose setting would be susceptible to the Proposed Scheme.</td><td>Highly prominent and distinctive landscape features, whose legibility would be susceptible to the Proposed Scheme. E.g. ‘naturalistic’ features such as landform or sunken green lanes, highly historic landmark features or prominent traditional settlement features including church spires. Very little or no interference from modern development or infrastructure.

Urban environments: Many prominent and distinctive / historic buildings / landmarks whose setting is highly likely to be susceptible to the Proposed Scheme.</td></tr>
</table>

Perceptual aspects and tranquillity	**Landscapes that provide opportunities to experience a sense of relative wildness, remoteness and/or relative tranquillity, including a lack of overt man-made structures, and perceived naturalness may be more susceptible to the Proposed Scheme than landscapes that lack these qualities.** **In urban areas the presence of dense vegetation, substantial parks and water bodies and the very limited presence of vehicles or the sound of vehicles may be more susceptible to the Proposed Scheme.**				
	SUSCEPTIBILITY				
	Lower susceptibility		↔	Higher susceptibility	
	A landscape very heavily interrupted by discordant features which significantly reduce sense of tranquillity. The presence of the Proposed Scheme would not alter the perception of this landscape, and would not erode tranquillity.	A landscape mostly interrupted by discordant features which markedly reduce sense of tranquillity.	A landscape with some sense of tranquillity and remoteness in parts, but partly interrupted by features of a moderately discordant nature.	A landscape with a clear/strong sense of tranquillity or mostly remote character with few detracting features.	A landscape with a very clear/strong sense of tranquillity, mostly remote character with no detracting features The presence of the Proposed Scheme would erode the remote, and tranquil perception of this landscape. E.g. by introducing artificial lighting into intrinsically dark areas such as National Parks and AONB.

3.3.6 With reference to the overall value and susceptibility of the landscape, the sensitivity of the character areas will be assessed. The assessment of sensitivity requires the application of professional judgement, in line with guidance provided by the Landscape Institute. The presence of any combination of attributes within the five criteria above may be considered when assessing the sensitivity of a character area, including published character assessments which attribute sensitivity to landscape character areas.

HS2 Phase 2a West Midlands - Crewe: Technical note - Landscape and visual -

Approach to night time 'darkness' surveys

Contents

1 Scope of the night time 'darkness' surveys

1.1 Introduction

1.1.1 This note has been prepared to provide guidance on undertaking the night time 'darkness' surveys to assess the potential impacts of lighting as part of the visual assessment, as defined in the Guidelines for Landscape and Visual Impact Assessment (GLVIA)[1]. The assessment of lighting on the night-time visibility will be qualitative and will not include quantitative assessments of illumination levels. Quantitative illumination levels will form part of a lighting impact assessment, completed by competent lighting professionals, as defined in the Guidance on Undertaking Environmental Lighting Impact Assessments[2].

1.1.2 Impacts at night relate to the introduction of additional lighting into a view, as experienced by a visual receptor. These impacts could arise during construction and/or during operation.

1.1.3 The impact of lighting on the character of the landscape will be assessed as part of the landscape assessment, as defined in the Landscape Sensitivity technical note contained in the Phase 2a EIA Scope and Methodology Report (SMR)[3] .

1.2 Scope of night time surveys

1.2.1 The following visual receptors will be considered in the night time 'darkness' surveys:

- occupiers of residential properties;
- students staying overnight in schools; and
- residents of staying in hotels and healthcare institutions.

1.2.2 Other receptors will not be considered on the basis that either they would generally not be present late at night (e.g. recreational) or their immediate context would be brightly lit if they were present at night (e.g. employment / formal sports). Further detail on the sensitivity of each visual receptor is defined within the SMR.

Potential visual impacts arising from additional lighting at night during construction

- typical working hours would require some lighting in the morning and evening, particularly during winter months. However, at these times the receptors which could be affected are likely to have their properties lit and have the curtains drawn/window blinds down, meaning their attention is very unlikely to be focused on the landscape. Lighting during typical working hours will not be considered as part of the night time assessment;

[1] GLVIA3 Landscape Institute 2013 Para. 6.12.
[2] PLG 04 Institute of Lighting Professionals (ILP) guidance 2013.
[3] Volume 5: Appendix CT-001-001, Scope and Methodology Report.

- at some locations, including compounds and tunnel portals, continuous working and/or overnight working will be required for periods of time. This will be considered as part of the night time assessment; and
- at some locations, extended working hours would be required intermittently (e.g. for large concrete pours which need to be completed in one exercise). This would typically extend lighting at a site into the late evening. However, on the basis that this would be an intermittent exercise and it would not run through the night to times when people are most sensitive to additional lighting, such instances will not be considered as part of the night time assessment.

Potential visual impacts arising from additional lighting at night in operation

- at some locations, continuous working will be required for periods of time. This will be considered as part of the night time assessment;
- at sidings and maintenance depots working may be limited to night time only. This will be considered as part of the night time assessment;
- at some locations, lighting of new road junctions and roundabouts will be required. This will be considered as part of the night time assessment; and
- lighting from moving trains may be intermittently visible to visual receptors for up to 12 times per hour in each direction during peaks hours (from approximately 5am through to midnight). However, on the basis that this would be intermittent lighting, often broken by intervening topography, vegetation and built form and would not be present through the night (times when people are most sensitive to additional light) this scenario will not be considered as part of the night time assessment.

2 Night time 'darkness' surveys

2.1.1 Using construction phase and operational activity information to establish which visual receptors would require an assessment of impacts at night, night time 'darkness' surveys will be carried out at these locations[4] to understand existing conditions. No night time photographs will be included in the Volume 5 technical appendices, due to the difficulty of taking night time images that give an accurate or helpful representation of the night time environment. (Long exposures may tend to accentuate sky glow impacts or apparent brightness of spill light areas, while short exposures may make areas appear to be darker than they appear to the naked eye.)

2.1.2 Night time surveys will be undertaken in good weather conditions between 10pm and 3am in summer months and between 6pm and 5am in winter. The time and weather conditions, including the phase of the moon and any starlight/moon light impacts will be recorded.

[4] Such locations include the railhead and Stone Infrastructure Maintenance Base - Rail.

2.1.3 The night time baseline situations will be set out in the viewpoint descriptions, Volume 5 (technical appendices to the Environmental Statement (ES)), including detail on the foreground, middle ground and background context of the view to lighting. The baseline lighting conditions will consider:

- visibility, brightness and prominence of the actual source of the lighting within the view (e.g. security lighting within the Pasture Fields industrial estates and adjacent rail works, or buildings visible in Stafford), and/or
- comments on light spill, glare[5], and sky glow[6].

2.1.4 Qualitative descriptions on the general after-dark nature of existing lighting in the area will be made rather than quantitative descriptions on the types and levels of lighting within it. Interactive satellite maps of England's dark skies, produced by the Campaign to Protect Rural England (CPRE)[7], will also be used to help ascertain existing levels of light.

2.1.5 Where available 'Environmental Zone' classifications will also be used to reflect the general nature of existing lighting levels of the area. These range from E1, which are dark landscapes such as large areas of National Parks, to E4 for bright inner city areas.[8]

3 Potential impacts of lighting as part of the visual assessment

3.1.1 The baseline description and the proposed change in the night time environment will be presented for each relevant viewpoint.

3.1.2 The visual impacts at night will follow descriptions of day time impacts for both the construction and operation assessments within the ES Landscape and visual section.

3.1.3 The magnitude of change and level of significant effect for visual impacts at night will be made for each relevant viewpoint for year 1 winter only, as the worst-case scenario. Any change in effect between year 1 winter and year 1 summer, year 15 and year 60 will be noted for the day-time visual assessments only, as set out within the HS2 Phase 2a SMR.

[5] 'glare' is the "uncomfortable brightness of a light source when viewed against a darker background": Guidance Notes for the Reduction of Obtrusive Light, ILP GN01:2011.
[6] "sky glow" is "the brightening of the night sky": Guidance Notes for the Reduction of Obtrusive Light, ILP GN01:2011.
[7] http://nightblight.cpre.org.uk/maps/?_ga=2.208860177.285529541.1496757195-846886392.1468921309
[8] CIE document (CIE 150:2003 Guide on the limitation of the effects of obtrusive light from outdoor lighting installations).

Hs2 Phase 2a West Midlands - Crewe: Technical note - Landscape and visual -

Approach to verifiable photomontages

Contents

List of figures

1 Introduction

1.1 Introduction

1.1.1 This document has been prepared to describe the technical process undertaken to prepare verifiable photomontages in support of the landscape and visual assessment for HS2 Phase 2a West Midlands to Crewe (the Proposed Scheme).

1.2 Verifiable photomontage definition

1.2.1 A photomontage is the superimposition of an image onto a photograph for the purposes of creating a representation of potential changes to any view.

1.2.1 "The objective of a photomontage is to simulate the likely visual changes that would result from a proposed development, and to produce printed images of a size and resolution sufficient to match the perspective in the same view in the field."[1]

1.2.2 Photomontages are distinct from other images that show the nature of the Proposed Scheme as they are technically accurate and illustrate the effects on viewers rather than to illustrating specific scheme elements.

1.2.3 A verifiable photomontage is a photomontage based on a replicable, transparent and structured process, so that the accuracy of the representation can be verified by an independent party. Collaboration between all organisations, relevant stakeholders and disciplines is essential throughout the whole project to ensure that the visualisation information is consistent and robust.

1.2.4 The verifiable photomontages that will be included in the Environmental Statement (ES) must meet appropriate standards. The methodologies for their production are based on current best practice and follow recommendations from The Landscape Institute's Guidelines for Landscape and Visual Impact Assessment Advice Note 01/11[2] and Guidelines for Landscape and Visual Impact Assessment (GLVIA).[3]

2 Selection of photomontages

2.1 Selection of viewpoints

2.1.1 Viewpoints will represent what people with a view of the Proposed Scheme (visual receptors) may be able to see during construction or operation. The process for selecting viewpoints is described in the Hs2 Phase 2a Environmental Impact Assessment (EIA) Scope and Methodology Report (SMR)[4].

2.1.2 Verifiable photomontages will be prepared from a selection of these viewpoints, and in consultation with statutory consultees, where:

[1] P.3 of The Landscape Institute's Guidelines for Landscape and Visual Impact Assessment Advice Note 01/11.
[2] The Landscape Institute (2011) Photography and photomontage in landscape and visual impact assessment, Landscape Institute Advice Note 01/11.
[3] 3rd edition; Landscape Institute, April 2013,specifically paragraphs 8.18-8.34.
[4] Scope and Methodology Report, Volume 5: Appendix CT-001-001.

- the receptor is highly sensitive to change (the sensitivity of visual receptors is described in the SMR); and
- level of effect cannot be easily assessed with reference to plans, sections and elevations, or where the precise position of elements has a particular importance in relation to the composition of a view.

2.2 Verifiable photomontage types

2.2.1 The landscape and visual assessment considers effects for a number of different scenarios through the construction and operational phases of the Proposed Scheme. Verifiable photomontages will be prepared for the following scenarios:

- **construction, winter, daytime** – Illustrative representations of how the site may look during the peak phase of construction taking into account:
  - demolition, tree removal and vegetation clearance required;
  - the extent of land required temporarily to build the Proposed Scheme;
  - the type of structure being built in the view;
  - the types of operations and construction plant likely to be present in order to construct the structure in the view, including temporary stockpiles and cranes; and
  - any measures contained within the draft Code of Construction Practice (CoCP)[5] relevant to the particular view.

2.2.2 Construction photomontages will only be prepared for winter in line with the methodology for undertaking the visual assessment described in the SMR.

- **operation, year 1 (2027), winter, daytime** – Illustrative representations of how the Proposed Scheme may look during the winter of 2027[6], taking into account:
  - the accurate 3D models prepared to show the geometry of elements of the Proposed Scheme, including the route, overhead line equipment and gantries, earthworks, retaining walls, proposed highways including earthworks, balancing ponds, viaducts and bridges, ventilation shafts and head houses;
  - the accurate 2D lines prepared to show the geometry of elements of the Proposed Scheme, including fences, noise barriers, planting and habitat creation areas; and
  - design principles / intent relating to the appearance of structures described above, including retaining walls, viaducts, bridges, ventilation shafts, head houses, fencing, noise barriers, planting and habitat creation areas.
- **operation, year 1 (2026), summer, daytime** – Illustrative representations of how the Proposed Scheme may look during the summer of 2026 taking into account the same elements as above. These have only been prepared where it

[5] Draft Code of Construction Practice, Volume 5: Appendix CT-003-000.
[6] Also year 60 for selected locations.

was not possible to obtain a winter photograph due to limitations such as site access.

- **operation, year 15 (2041), summer, daytime** – Illustrative representations of how the Proposed Scheme may look in the summer of 2041 during operation, taking into account (in addition to the above) how new planting will mature (assumed as 7.5m growth for all tree planting at year 15).

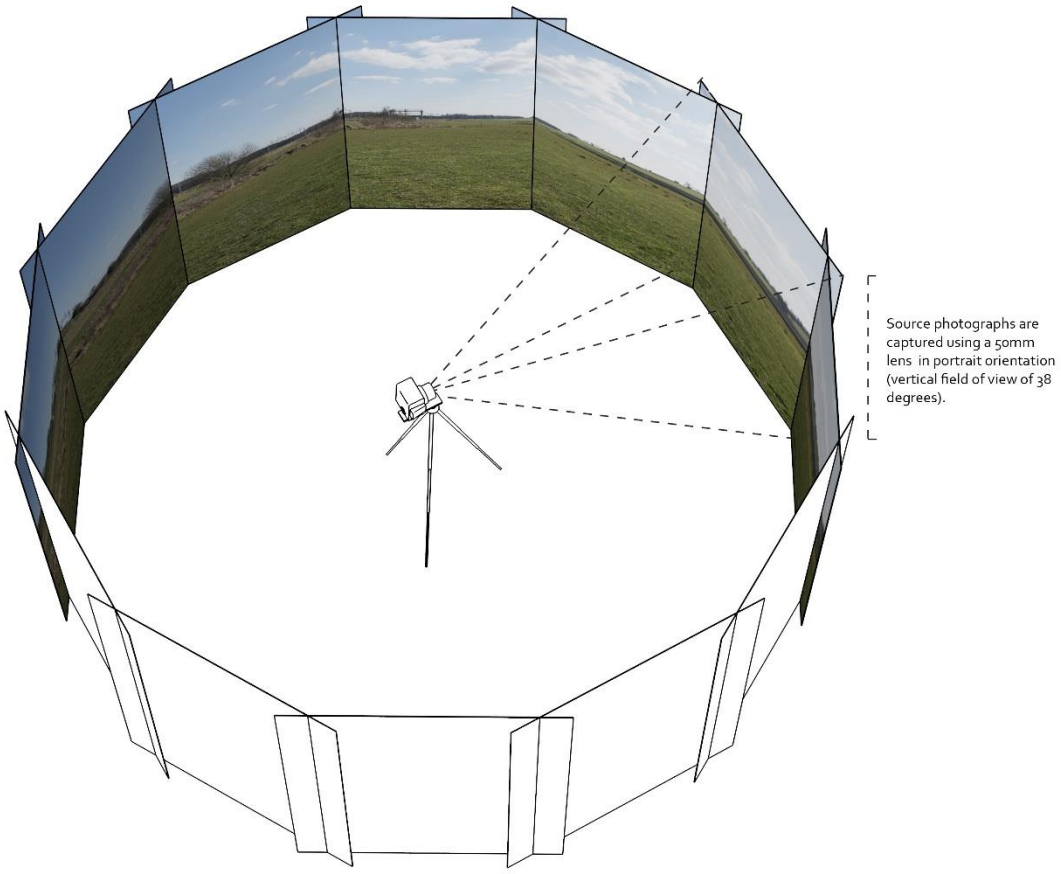
3 Verifiable photography and survey

3.1 Methodology

3.1.1 The verifiable photomontages will be based on accurately taken and surveyed verifiable photography. The first round of Winter photography was undertaken between 8th March and 1st April 2016. A second round of winter photography commenced in November 2016. Summer photography was undertaken between June and September in 2016.

3.1.2 All photographs will be taken as a series of overlapping portrait photographs rotated around a single point so that a full 360 capture of the viewpoint is obtained. A vertical field of view of 38 degrees will be taken on each of the overlapping photographs. (Figure 1).

Figure 1: 360 Capture of verifiable photography



3.1.3 The photography and surveying is undertaken simultaneously in order that ranging rods can be deployed into the views by the surveyor and to avoid problems with markers in soft ground moving or being removed.

3.2 Verifiable photography specification

3.2.1 All verifiable photography will be taken using a high quality full frame digital camera with a resolution of 7952 x 5304 pixels. Photographs will be taken in suitable weather and light conditions avoiding rain, fog, mist and snow. Photographs will be taken using a tripod at a typical viewing height of 1.6m above ground. Refer to Appendix 1 for the detailed image specification and data requirements.

3.3 Stitching site photography into panoramas

3.3.1 The site photography will be stitched together using PTGui (professional stitching software).

3.3.2 The camera tilt and roll is checked on the source photographs to ensure the horizon line is accurately positioned within the exported panorama.

3.3.3 Equirectangular projection is used with a field of view of 360 degrees by 38 degrees.

3.4 Verifiable surveying specification

3.4.1 Each camera location will be surveyed together with a series of clearly defined detail points within the photograph (e.g. ranging rods, corners of road markings, features on road signs, corners of building features etc.). Each photograph has a minimum of 10-12 clearly defined detail points taken across the width of the photograph and at near, mid and far distance (i.e. a balance of points across the photograph).

3.4.2 The surveyor's deliverables are:

- point for the camera locations and each detail point is given a unique number that relates to the viewpoint number;
- a computer aided design (CAD) file containing the detail points and camera positions as vertical lines;
- a spreadsheet of the camera locations and detail points with annotated descriptions; and
- a copy of the photograph showing the detail points.

3.4.3 All survey data will be stored in GIS feature classes and have attribute data as specified by HS2.

4 Camera matching

4.1.1 The process of camera matching creates a virtual camera in the same location and height as the physical camera used on site to take the photograph.

4.1.2 The orientation of the virtual camera will be matched to the physical camera by aligning the 3D points provided by the surveyor to the marked up panorama also provided by the surveyor (Figure 2).

Figure 2: Camera matching CAD data within photograph

5 Production of 3D model

5.1.1 The 3D model of the Proposed Scheme will be produced in a series of tiles along the route. All data will be moved to these offsets to avoid accuracy problems caused in the software programme 3D Studio Max (3DS Max) when working on images[7] at a distance from the global origin point. This process will improve how 3DS Max handles the data in the later stages of modelling and ensures accuracy. The CAD drawing units will be in metres.

5.1.2 The 3D model of the Proposed Scheme will be created using:

- the designer's 3D model of the Proposed Scheme including the centreline, rail earthworks, highway centrelines, kerblines, highway earthworks, mitigation earthworks and balancing ponds. These elements form the digital terrain model of the Proposed Scheme;
- models of all structures including viaducts, highway bridges, pedestrian bridges, tunnel portals, auto-transformer stations;
- models of all buildings including headhouses and ventilation shafts, buildings within maintenance depots and stations; and
- models of all further elements including noise fence barriers, fencing, planting, overhead line equipment, new/relocated pylons etc.

5.1.3 Models of structures and buildings will be created using the designer's 3D models or 2D elevations, sections and plans depending on availability and appropriateness of purpose.

5.1.4 All elements of the 3D model will be resolved from all angles, for example the abutment of bridges and viaducts will be modelled in full to ensure the robustness of the overall 3D model.

5.1.5 Within 3DS Max, all surfaces created as part of the 3D model will be checked to ensure no co-planar faces exist anywhere in the model, with all faces appropriately sub-divided.

[7] The use of the term 'image' within this technical note relates to an original 'photograph' that has been manipulated.

5.1.6 All elements within the 3DS Max model files will be named appropriately. There will be no generic names within the model files e.g. box, circle, cylinder etc. to ensure all objects can be selected and all users have full control of the 3DS Max scene.

5.1.7 Textures will be applied at a real world scale to ensure they appear at the correct scale for the image and 3D model.

5.2 Model assembly

5.2.1 A 3DS Max model file for each viewpoint will be assembled before rendering (Figure 3). The assembled model will contain the relevant Proposed Scheme digital terrain model tiles and any structures, buildings or further elements (as defined above) that can be seen from the viewpoint.

Figure 3: Model within image prior to blending and rendering

6 Rendering

6.1.1 Each of the views will be rendered using the V-Ray Rendering[8] software. This utilises the physical sun, sky and compass system to replicate the light conditions present in the Base photo (Figure 4).

Figure 4: Base photo

6.1.2 Individual elements will be rendered out (Figure 5) using different map channels to create masks (for example mask for the digital terrain model, earthworks, overhead line equipment, fencing, shadows etc.). These masks will ensure each visible element of the Proposed Scheme can be independently selected when individually placed into the Adobe Photoshop file for final production.

[8] V-Ray is a commercial rendering plug-in for 3D computer graphics software applications

Figure 5: Model render

7 Post production

7.1.1 The renders of the 3D model will be superimposed onto the base photos in Adobe Photoshop. The visible foreground in front of the Proposed Scheme will then be carefully copied and masked (Figure 6) to ensure the render of the 3D model sits accurately within the depth of the view.

Figure 6: Foreground and tree masking

7.1.2 The textured render of the 3D model will then be further adjusted to match the resolution, colouring and saturation of the base photo to create an accurate impression of what the textures of the buildings and structures will look like. This will be a qualitative exercise and requires interpretation by the designer on how the structures will look.

7.1.3 The masked out elements will be combined with the render (Figure 7) and then superimposed into the base photo (Figure 8).

Figure 7: Render and masking combined

Figure 8: Image, render and masking combined

7.1.4 A final qualitative check of all of the verifiable photomontages will be undertaken to ensure that they provide objectively accurate views of the Proposed Scheme.

8 Photomontage presentation

8.1.1 All final panoramic photomontages will be extracted into a series of rectilinear images (typically 4, based upon the field of view of a 50mm lens) for ease of presentation on flat media and viewing in the field (Figure 9).

Figure 9: The four rectilinear images extracted for final panoramic photomontage

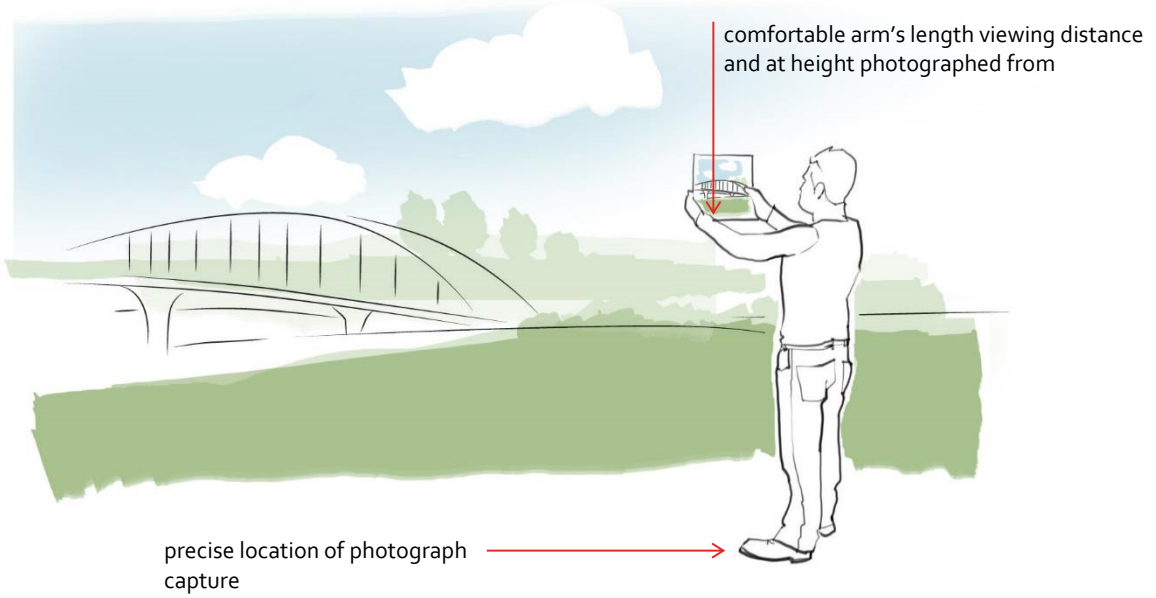
8.1.2 For viewing within the ES the series of images will be printed together on A3 landscape sheets, for practicality.

8.1.3 At this scale the images do not lend themselves to direct comparison out in the field. Therefore, for viewing in the field, it is recommended that each image from the panoramic photomontage is printed individually, at a width of 34.57cm x 23.04cm (printed at 300dpi) onto an A3 landscape sheet for a viewing distance of 500mm. This specification is in line with guidance provided in the Landscape Institute Advice note 01/11.

8.1.4 Guidance recommends that the verified photomontage extracts are viewed at a comfortable arm's length viewing distance and at the height photographed from, in order to closely match what is being seen in the field (Figure 10). It is recommended that the most suitable way to view photomontages is in the field, standing in the precise location of where the photograph was taken from. The viewpoint location plan, grid reference and photograph of the tripod location (provided with each photomontage) will assist in achieving this.

8.1.5 Although viewing photomontages in the field is desirable, it is acknowledged that this is not always possible. One of the purposes of photomontages is to make up for the fact that not all interested parties can visit the site. Every effort has been made to represent the scheme fairly and accurately so it can be understood within its landscape context.

Figure 10: Viewing a verified photomontage



Appendix 1 –Verifiable photography specification

Image specification for site capture of verifiable photography:

- RAW and JPEG images are captured at 7952 x 5304 pixels.

Image processing:

- Processing includes corrections for lens distortions[9], removal of vignetting[10] and chromatic aberrations[11] .

Data requirements:

- Exchangeable image format[12] (EXIF) data provided in the file properties:
- focal length, aperture, shutter speed and ISO;
- lens and camera body; and
- date and time.

[9] Displacement or errors in the images caused by irregularities in camera lens.
[10] Reduction of an image's brightness or saturation at the periphery when compared to the centre of the image.
[11] Colour distortion in an image caused by the inability of the camera lens to bring the various colours of light to focus at a single point
[12] Data embedded within the properties of an image.

Annex J: Major accidents and natural disasters – technical note

The following technical note is contained in this Annex:

- Major accidents and natural disasters.

HS2 Phase 2a West Midlands - Crewe: Technical note - Major accidents and natural disasters

Contents

List of figures

List of tables

1 Introduction

1.1 Purpose of this technical note

1.1.1 The purpose of this technical note is to provide further definition of the scope and methodology for identifying and assessing likely significant environmental effects arising directly from the construction, operation and maintenance of the HS2 Phase 2a West Midlands – Crewe scheme (hereafter the Proposed Scheme), associated with its vulnerability to a major accident and/or natural disaster.

1.1.2 The overarching objective of the assessment, as derived from Paragraph 15 of the revised EIA Directive (2014/52/EU) is to ensure that appropriate precautionary actions are identified and integrated into the design and execution of the Proposed Scheme, including consideration of the likelihood of increased frequency of extreme weather events as a result of climate change, to address vulnerability to a major accident and/or natural disaster which would have significant environmental effects.

1.2 Context

1.2.1 The starting point for the scope and methodology of this assessment is that the Proposed Scheme, as a modern, high-speed railway, will be designed, built and operated in line with best international current practice with embedded climate change resilience. HS2 Ltd has committed to deliver levels of passenger safety performance in line with best current international practice which is as good, or better than, HS1[1].

1.2.2 A guiding principle of safety risk management for the Proposed Scheme, is to manage all risks to be As Low As Reasonably Practicable (ALARP) as set out in HS2's Development Agreement and accepted by the Office of Road and Rail (the regulator).

1.2.3 HS2 Ltd's Railway System Safety Strategy presents the approach to ensuring operational safety through:

- delivering a reliable and resilient railway system;
- delivering an effective design process; and
- effective, progressive systems assurance, robust verification and validation of Systems Safety Requirements within the design, delivery and handover phases.

1.2.4 The safety record of HS1 is therefore taken as one of the benchmarks of safety performance for this assessment. UK railways in general are among the safest in Europe[2], even allowing for the legacy features of much of the UK rail network which was designed and constructed over 150 years ago.

1.2.5 Rail transport also remains one of the safest modes of transport on a per traveller km basis[2].

[1] HS2 and Department for Transport development agreement (December 2014) https://www.gov.uk/government/publications/hs2-development-agreement-december-2014

[2] RSSB (2015) Annual Safety Performance Report 2014/15 http://www.rssb.co.uk/Library/risk-analysis-and-safety-reporting/2015-07-aspr-key-findings-2014-15.pdf

1.2.6 Therefore, the section of Volume 3 of the Environmental Statement (ES) that presents an assessment of major accidents and natural disasters should demonstrate that an appropriate risk management structure is in place, for both health and safety and environmental risks, and that the potential for major accidents and/or natural disasters to impact on human health or the environment has been identified and will be managed to be ALARP by HS2 Ltd and its suppliers. The section should also present any identified risks which may require further precautionary mitigation actions beyond those already integrated into the design and execution of the Proposed Scheme.

1.3 Contents of this technical note

1.3.1 Drawing from available relevant guidance and other established processes for the identification and assessment of major accident and/or natural disaster risks, the remainder of this document provides:

- a glossary of the key terminology used in this technical note and in the ES (Section 2);
- an overview of the revised 2014 EIA Directive to which this assessment is responding (Section 3);
- Section 4 defines the scope of the assessment, in terms of what constitutes a major accident or what constitutes a natural disaster, and whether these could lead to likely significant environmental effects and also what constitutes an environmental receptor in the context of this assessment;
- Section 5 then describes the risk assessment methodology used to identify which risks would require further consideration;
- Section 6 summarises the note.

2 Definitions and abbreviations

2.1.1 Key terms and abbreviations used in this topic assessment are defined in Table 1.

Table 1: Definitions and abbreviations used in this technical note

Term	Definition
ALARP	As Low As Reasonably Practicable
CDM	Construction, Design and Management
COMAH	Control of Major Accident Hazards
CSM-RA	Common Safety Method (Risk Assessment)
EIA	Environmental Impact Assessment
Environmental receptor	Features of the environment that are subject to assessment under Article 3 of the amended 2014 EU EIA Directive, namely population and human health, biodiversity, land, soil, water, air and climate, material assets, cultural heritage and landscape. These are categorised consistently with the ES structure.

Term	Definition
Exposure	A component of *vulnerability*. Exposure defines the extent to which a feature of the Proposed Scheme may be subjected to a *risk event*.
Hazard	A situation or biological, chemical or physical agent that has the potential to harm or cause adverse impacts on an *environmental receptor*.
Likelihood	The chance that something might happen. By definition, *risk events* are not certain to occur. The likelihood of a risk event occurring is assessed (a) qualitatively using expert opinion and engineering judgement or (b) quantitatively, as a probability or frequency of occurrence using statistical modelling and/or relevant historical data from the same and / or similar industries.
Likely significant effect	This is the expected outcome or consequence of the impact to an *environmental receptor*, should the *major accident* or *natural disaste*r occur. The significance of the effect takes into account the magnitude of the impact and the sensitivity of the receptor.
Major accident	A major accident, in the context of the Proposed Scheme, is an event or situation which threatens immediate or delayed serious damage to human health, welfare and/or the environment and requires the use of resources beyond those of the HS2 Ltd or its contractors. Serious damage includes the loss of life or permanent injury and/or permanent or long-lasting damage to an environmental receptor which cannot be restored through minor clean-up and restoration efforts.
Natural disaster	A naturally occurring phenomenon such as an extreme weather event (storm, flood, temperature) or ground-related hazard events (subsidence, landslide, earthquake) with the potential to cause an event or situation that meets the definition of a *major accident* above. In the context of this assessment, *natural* disasters are defined, since a disaster triggered by human actions is already covered in the definition of a *major accident*.
ORR	Office of Rail and Road (the regulator for the rail industry).
Reasonable worst case environmental effect	A challenging manifestation of the consequence(s) of a risk event occurring, after highly implausible or less significant consequences are excluded.
Resilience	A component of *vulnerability*. Resilience defines the ability of the proposed scheme to absorb, adapt to and/or rapidly recover from a disruptive event.
Risk	The likelihood of an impact occurring, combined with effect or consequence(s) of the impact on a receptor if it does occur.
Risk event	An identified, unplanned event, which is considered relevant to the Proposed Scheme and has the potential to be a major accident or natural disaster subject to assessment of its potential to result in a significant adverse effect on an environmental receptor.
Serious damage	Serious damage includes the loss of life, permanent injury and temporary or permanent destruction of an *environmental receptor*.
TSI	Technical Specifications for Interoperability
Vulnerability	In the context of the 2014 EU EIA Directive, the term refers to the '*exposure* and *resilience*' of the proposed scheme to the risk of a major accident and/or natural disaster. Vulnerability is influenced by sensitivity, adaptive capacity and magnitude of impact.

3 Assessment requirement: the revised EIA Directive (2014/52/EU)

3.1.1 The need to consider the vulnerability of the Proposed Scheme to major accidents and/or natural disasters, and the consequential significant adverse effects on the environment is a new topic which was not addressed in the Environmental Statement (ES) for Phase One. The assessment of the vulnerability of the Proposed Scheme to major accidents and natural disasters is included in this ES following changes to EU and UK legislation. The revised EIA Directive 2014/52/EU (revised Directive) requires the assessment of the expected significant adverse effects of the project on the environment deriving from the vulnerability of the project to risks of major accidents and/or natural disasters. The Town and Country Planning (EIA) Regulations 2017 has transposed the revised Directive into UK law.

3.1.2 The revised EIA Directive 2014/52/EU came into force on 15th May 2014 and supersedes the 2011/92/EU EIA Directive. The revised Directive states that in order to ensure a higher level of protection of the environment, precautionary actions need to be taken for certain projects which have a high vulnerability to major accidents and/or natural disasters.

3.1.3 The context for such precautionary actions is given in the introductory Recital 15 of the revised Directive which states in its first part:

3.1.4 *"In order to ensure a high level of protection of the environment, precautionary actions need to be taken for certain projects which, because of their vulnerability to major accidents, and/or natural disasters (such as flooding, sea level rise, or earthquakes) are likely to have significant adverse effects on the environment. For such projects, it is important to consider their vulnerability (exposure and resilience) to major accidents and/or disasters, the risk of those accidents and/or disasters occurring and the implications for the likelihood of significant adverse effects on the environment."*

3.1.5 Article 3 of the revised Directive requires that the EIA shall identify, describe and assess in the appropriate manner, the direct and indirect significant effects on population and human health, biodiversity, land, soil, water, air and climate, material assets, cultural heritage and landscape deriving from (amongst other things) the vulnerability of the project to risks of major accidents and/or disasters that are relevant to the project concerned.

3.1.6 Annex IV of the revised Directive defines the information that should be presented in the ES. Paragraph 8 thereof requires the ES to contain:

"A description of the ***expected significant adverse effects*** *of the project o****n the environment*** *deriving from t****he vulnerability of the project to risks of major accidents and/or disasters*** *which are relevant to the project concerned. [….] Where appropriate, this description should include measures envisaged to prevent or mitigate the significant adverse effects of such events on the environment and details of the preparedness for the proposed response to such emergencies."*

3.1.7 Recital 15 of the new EIA Directive states in its second part: *"In order to avoid duplications, it should be possible* ***to use any relevant information available and obtained through risk assessments carried out*** *pursuant to Union legislation, such as*

Directive 2012/18/EU of the European Parliament and the Council, and Council Directive 2009/71/Euratom, or through relevant assessments carried out pursuant to national legislation provided that the requirements of this Directive are met." The specific Directives referred to in recital 15 are not applicable to the Proposed Scheme as they relate to operating sites containing large quantities of hazardous substances (for example oil refineries, oil storage depots and nuclear facilities). However, the principle of using relevant information obtained through risk assessments undertaken as part of the Proposed Scheme development is adopted here.

3.2 Other obligations

3.2.1 The development and execution of the Proposed Scheme is subject to a number of other requirements in addition to the revised EIA Directive. These include obligations relevant to the identification and management of health, safety and environmental risks. As provided for in Article 15 of the revised EIA Directive (see paragraph 3.1.7), relevant information from existing risk assessments and risk management processes is used to inform the major accidents and natural disasters topic. Key requirements include:

- Health and Safety at Work etc. Act 1974 (HSWA);
- The Management of Health and Safety at Work Regulations (1999);
- Construction (Design and Management) (CDM) 2015 Regulations;
- The Workplace (Health, Safety and Welfare) Regulations 1992;
- EU Regulation 402/2013 on the Common Safety Method on Risk Evaluation and Assessment (CSM-RA) (as amended by Regulation EU 2015/1136);
- The Railways and Other Guided Transport Systems (Safety) Regulations 2006 (as amended) (ROGS); and
- The Railways (Interoperability) Regulations 2011 (as amended) (RIR).

3.2.2 An overview of these regulations is provided in Appendix B together with an explanation of their relevance to this assessment. Broadly, they define the requirement, duties, and in some cases, establish the mechanisms by which risks associated with major accidents and natural disasters are identified, assessed and reduced during the design, construction, operation and maintenance of the Proposed Scheme.

3.2.3 In addition to these regulations, the Proposed Scheme is also being designed and its implementation guided by numerous other industry standards and codes, many of which are mandatory. These require infrastructure and systems to be designed in accordance with the latest safety standards and codes so that risks to people and the environment are either eliminated or reduced to levels that are legally considered acceptable. HS2 Ltd also has its own set of technical standards for design, construction and operation of the HS2 network.

4 Assessment scope

4.1.1 In order to define the scope of this assessment, the following key terms, from the revised EIA Directive require definition:

- major accidents and/or natural disasters;
- significant adverse effect; and
- human health and/or the environment.

4.1.2 Definitions found within various external sources are provided in Table 2 in order to provide context. The remainder of this section then sets out how definitions for the bullet points above have been reached, together with additional guidance criteria.

4.2 Major accidents and/or natural disasters

Table 2: Definitions of major accidents and natural disasters

Source	Definition	Comment
Oxford English Dictionary	Accident: 'something that happens by chance or without expectation' Disaster: 'a sudden accident or a natural catastrophe that causes great damage or loss of life'	
Civil Contingencies Act 2004 and Her Majesty's Government's accompanying non-statutory guidance[3]	In order to satisfy the definition of "emergency" under the Act, the event or situation must threaten *serious damage* to human welfare in, or the environment of, a place in the United Kingdom. Additionally, to constitute an emergency, an incident or situation must also pose a considerable test of an organisation's ability to perform its functions. The common themes of an emergency are: the scale of the impact of the event or situation; the demands it is likely to make of local responders; and the exceptional deployment of resources.	This Act provides an overarching framework for preparing for and responding to civil emergencies within the United Kingdom
Railway Safety Directive (Directive 2004/49/EC)	'Serious accident' means any train collision or derailment of trains, resulting in death of at least one person or serious injury to five or more persons, or extensive damage to rolling stock, the infrastructure, or the environment, and any other similar accident with an obvious impact on railway safety regulation or the management of safety. 'Extensive damage' means damage that can immediately be assessed by the investigating body to cost at least €2 million in total.	The definition applies to a wider scope of impacts than required under the EIA Directive (refer to section 4.4).
The Seveso III Directive (Directive 2012/18/EU)	'An occurrence such as a major emission, fire, or explosion resulting from uncontrolled developments in the course of the operation of any establishment covered by this Directive, and leading to serious danger to human health or the environment, immediate or delayed, inside or outside the	Relates to the control of major accident hazards involving dangerous substances.

[3] HM Government (2013) Emergency Response and Recovery – *Non-statutory guidance accompanying the Civil Contingencies Act 2004,* Cabinet Office, 28 October 2013.

Source	Definition	Comment
	establishment, and involving one or more dangerous substances'.	
The Control of Major Accident Hazards (COMAH) regulations, 2015 and the HSE guidance on implementing them[4]	Events with the potential to result in: • the death or adverse effects on local populations of species or organisms, with lower thresholds for high-value or protected species; • contamination of drinking water supplies, ground or groundwater; • damage to designated areas, habitats or populations of species within the areas; • damage to listed buildings; • damage to widespread habitats; and • damage to the marine or aquatic environment.	The requirements of the Seveso III Directive are transposed into UK legislation via the COMAH regulations.
Major Accident Off-Site Emergency Plan (Management of Waste from Extractive Industries) (England and Wales) Regulations 2009[5]	'Major accident' is defined as an occurrence on site [...] leading to a loss of life or serious danger to human health and/or the environment, whether immediately or over time, on-site or off-site. 'Serious danger to human health' relates to people present permanently or for prolonged periods of time in the potentially affected area but excludes workers operating at the facility. Injuries leading to disability or prolonged states of ill health shall count as serious dangers to human health. 'Serious danger to the environment' relates to: • a contaminant source strength that does not decrease significantly within a short time; • permanent or long-lasting environmental damage; and • the affected environment not being restored through minor clean-up and restoration efforts.	These regulations implement the provisions of the Mining Waste Directive (Directive 2006/21/EC).
The Proposed Scheme	A major accident, in the context of the Proposed Scheme, is an event or situation which threatens immediate or delayed serious damage to human health, welfare and/or the environment and requires	

[4] Health and Safety Executive (2015) The Control of Major Accident Hazards Regulations 2015: Guidance on Regulations, L111, Third Edition, June 2015.
[5] Department of Environment, Food and Rural Affairs (2011) Guidance: Major Accident Off-Site Emergency Plan (Management of Waste from Extractive Industries) (England and Wales) Regulations 2009 Mining Waste Directive: Article 6 Category "A" Waste Facilities. Department of Environment, Food and Rural Affairs, August 2011.

Source	Definition	Comment
	the use of resources beyond those of the HS2 Ltd or its contractors. Serious damage includes the loss of life or permanent injury and/or permanent or long-lasting damage to an environmental receptor which cannot be restored through minor clean-up and restoration efforts. A natural disaster, in the context of the Proposed Scheme, would include an extreme weather event (e.g. storm, flood, temperature) or ground-related hazard events (subsidence, landslide, earthquake) with the potential to cause an event or situation as described above.	

4.3 Significant adverse effect

4.3.1 Factors to consider in determining whether potential adverse effects are 'significant' include:

- the geographic extent of the effects. Effects beyond the project boundaries are more likely to be considered significant;
- the duration of the effects. Effects which are permanent (i.e. irreversible) or long lasting are considered significant;
- the severity of the effects in terms of number, degree of harm to those affected and the response effort required. Effects which trigger the mobilisation of substantial civil emergency response effort are likely to be considered significant;
- the sensitivity of the identified receptors; and
- the effort required to restore the affected environment. Effects requiring substantial clean-up or restoration efforts are likely to be considered significant.

4.3.2 Annex VI of the Seveso III Directive defines criteria for notifying the European Commission of the occurrence of a 'major accident' (Table 3). While these criteria provide a useful guide to what might constitute a 'significant adverse effect' they diverge in some cases from what would be considered significant in the context of the Proposed Scheme and also require quantitative evaluation which may not always be possible in the context of this assessment.

Table 3: Selected criteria for notification of a major accident to the European Commission under Article 18(1) of Directive 2012/18/EU and Regulation 26 of the COMAH Regulations 2015

A major accident meets the criteria for notifying the European Commission, if it has at least one of the consequences described in paragraphs 1 to 4 below:

1. Injury to persons and damage to property –
   - A. a death
   - B. six persons injured within the establishment and hospitalized for at least 24 hours
   - C. one person outside the establishment hospitalised for at least 24 hours
   - D. a dwelling outside the establishment damaged and unusable as a result of the accident;
   - E. the evacuation or confinement of persons for more than 2 hours where the value (persons × hours) is at least 500; or
   - F. the interruption of drinking water, electricity, gas or telephone services for more than 2 hours where the value (persons × hours) is at least 1,000
2. Immediate damage to the environment –
   - A. permanent or long-term damage to terrestrial habitats –
     - i. 0.5 hectares or more of a habitat of environmental or conservation importance protected by legislation; or
     - ii. 10 or more hectares of more widespread habitat, including agricultural land;
   - B. significant or long-term damage to freshwater and marine habitats –
     - i. 10 km or more of river or canal;
     - ii. 1 hectare or more of a lake or pond;
     - iii. 2 hectares or more of delta; or
     - iv. 2 hectares or more of a coastline or open sea; or
   - C. significant damage to an aquifer or underground water: 1 hectare or more;
3. Damage to property –
   - A. damage to property in the establishment, to the value of at least EUR 2,000,000; or
   - B. damage to property outside the establishment, to the value of at least EUR 500,000;
4. Cross-border damage: any major accident directly involving a dangerous substance giving rise to consequences outside the territory of the Member State concerned.

4.3.3 Drawing from this context, for the Proposed Scheme, a significant adverse effect is considered to mean *the loss of life or permanent injury*, and/or *permanent or long-lasting damage to an environmental receptor* (see Section 4.4). The significance of this effect takes into account the extent, severity and duration of harm and the sensitivity of the receptor.

4.4 Environmental receptors

4.4.1 In the context of the EIA Directive, receptors are broadly defined as human health and the environment. The Directive further clarifies that impacts on population and human health, biodiversity, land, soil, water, air and climate, material assets, cultural heritage and landscape should be considered. An environmental receptor is therefore considered to be any of these. For consistency with the structure of the ES, potential receptors are considered in terms of the following ES topics:

- agriculture, forestry and soils;
- air quality;
- climate change;

- community;
- cultural heritage;
- ecology and biodiversity;
- health;
- land quality;
- landscape and visual;
- socio-economics;
- sound, noise and vibration;
- traffic and transport;
- waste and material resources; and
- water resources and flood risk.

4.4.2 The above list, which includes all ES topics, includes both receptors and assessment topics, such as noise, flood and climate. Therefore, the following simpler sub-list, comprising only relevant receptors for this topic, is used:

- people (including health, wellbeing, property and community);
- socio-economics (including agriculture and land use, traffic and transport and essential infrastructure);
- environment (including ecology, land quality, air quality, water resources and landscape); and
- cultural heritage (including archaeology and built heritage).

4.4.3 Assessments within the ES such as the resilience of the Proposed Scheme to climate change, and the flood risk assessment are relevant to this topic. However, they are not receptors as defined above, but are potential hazards that may lead to risk events, and have been considered accordingly.

4.4.4 Certain receptors are excluded from the assessment, for the reasons described in Table 4 below:

Table 4: Receptors excluded from the assessment

Excluded Receptors	Reason for Exclusion
Employees of HS2 Ltd and/or its suppliers, whether during construction, operation or maintenance of the Proposed Scheme	HS2 Ltd's commitment and obligations to manage risks to employees are described in other documents.
Train staff and passengers	Comprehensive demonstration to the regulator (the ORR) that the risk of accidents on the Proposed Scheme are being managed as low as reasonably practicable is a fundamental requirement of the licence to operate a railway (see also Appendix B). This assessment goes through an independent review process, is approved by the regulator, and is not repeated here;[6]
Members of the public who are wilfully trespassing	The safety and security of the Proposed Scheme from trespassers is mandated within a number of documents including the development agreement, the Supply Chain health and safety standard, and the Code of Construction Practice. There are measures described to educate the local communities including school children on the risks associated with the Proposed Scheme. On the basis that these measures are required to be in place to demonstrate compliance with these standards, it is assumed that any members of public who are wilfully accessing unauthorised areas are not a valid receptor in the context of this assessment
HS2 Ltd as an organisation, i.e. programme or cost of the Proposed Scheme, or HS2 Ltd's reputation.	These will be managed in accordance with the development agreement between HS2 Ltd and the Department for Transport, but there is no valid receptor as defined in Section 4.4.

4.5 Scope of risk events

4.5.1 By definition, all accidents and disasters are uncertain events, meaning that it is not certain whether they will occur or not during the timescales of the Proposed Scheme. This uncertainty is represented in deliberations of such matters by the use of a likelihood or frequency of occurrence. The major accidents and natural disasters considered in this assessment are rare events. Understanding their likelihood of occurrence is necessary to ascertain whether the proposed mitigation measures are adequate. Put simply, a highly unlikely event (say one which *may* occur in a project's lifetime) does not warrant the same level of mitigation as a highly likely event (expected to occur many times) where both have the same level of expected impact.

4.5.2 All *low consequence events*, whatever their likelihood, do not meet the definition of major accidents and/or natural disasters. For example, minor spills which may occur during construction, but would be limited in area and volume and temporary in nature do not meet the definition of a major accident. Such minor events would be dealt with under the contractors' Environmental Management System (EMS), as described in the draft Code of Construction Practice[7] (CoCP) for the Proposed Scheme (Section 3.2.3).

4.5.3 *High likelihood, high consequence events* are unacceptable for the Proposed Scheme, and are avoided or managed out. Only *low likelihood, high consequence events* (see Figure 1) are therefore in the scope of this topic.

[6] The potential for an accident causing harm to an environmental receptor as defined in paragraph 4.4.2, as well as train staff and passengers, is considered in these other regulatory processes (refer to Appendix B).
[7] Volume 5, Appendix CT-003-000, Draft Code of Construction Practice.

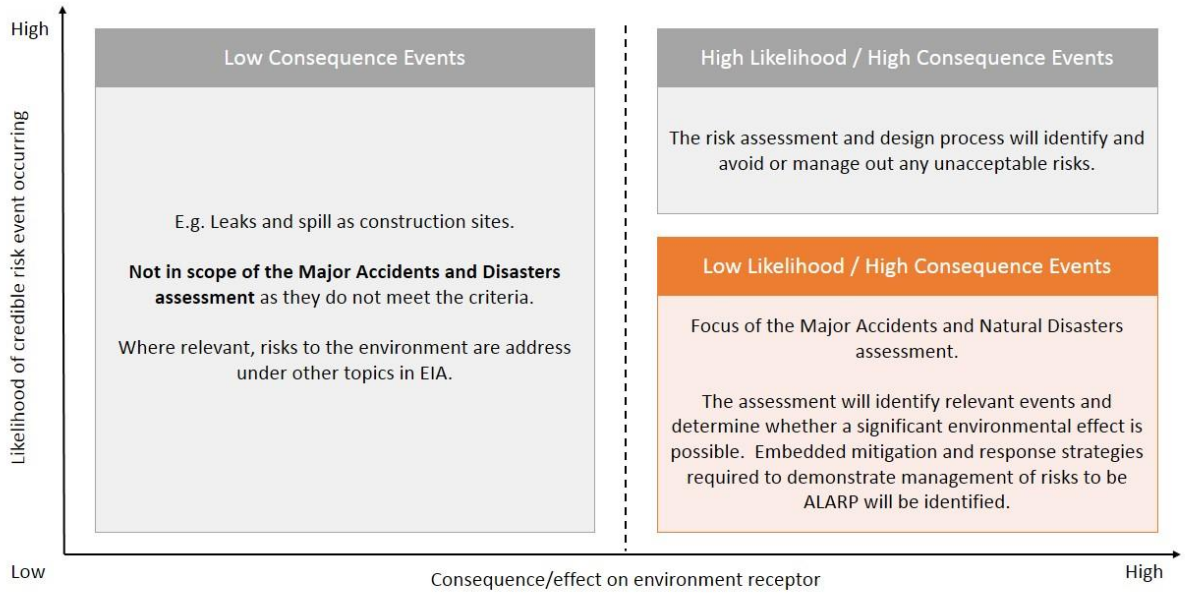
4.5.4 *Low likelihood* is defined for the purposes of this assessment, as:

> *'May occur during the lifetime of the Proposed Scheme, so no more than once in 10 years for the construction phase, and no more than once in 120 years for the operational phase.'*

4.5.5 This is an upper boundary for low likelihood. Very low likelihood events are also included in the assessment, which may only occur at most once in every 1,000 years. Mitigation measures will reflect what is reasonable for such rare events, considering their potential consequence, within the guiding principle of risks being ALARP.

4.5.6 *High consequence* is considered a significant adverse effect as defined in paragraph 4.3.3.

Figure 1: Summary of risk events considered in the scope of the assessment



Spatial scope

4.5.7 The assessment will be undertaken at a route-wide level but will, where relevant reflect any locations considered more vulnerable to a major accident and natural disasters and/or sensitive to significant adverse effects.

5 Risk assessment - methodology

5.1.1 The potential for identified relevant major accident and/or natural disaster events to result in a significant adverse environmental effect will be evaluated using a risk based approach. The approach will consider the environmental consequences of a risk scenario, the likelihood of these consequences occurring taking into account planned mitigation, and the acceptability of the subsequent risk to the environment. Selected relevant guidance is summarised in Appendix C and the full Environmental Risk Record will be included in Volume 5 of the ES. The following sections describe each of the steps to be followed; identifying risks, screening these risks, defining the impact, assessing the likelihood and then assessing the risk.

5.1.2 It is important to state that no additional risk assessments will be undertaken specifically for the major accidents and natural disasters section of the Volume 3 of the ES. Accidents on the railway, including those initiated by natural events, are controlled through the rail regulatory framework. The requirement to satisfy that framework has led to the identification of many safety-relevant hazards which include those that might have an environmental effect. Therefore, the section will not present a new risk assessment of hazards that were previously unidentified, but rather a collation and review to determine whether significant effects on the environment have been assessed, and whether such risks have been managed and mitigated to be as low as reasonably practicable.

5.2 Identify risks

5.2.1 Risk identification will use existing sources of information wherever possible such as risk assessments undertaken for the Proposed Scheme as part of other processes (many of which are required by law) and by referring to the risk events identified within the UK's current National Risk Register[8]. In order to identify whether a risk event has the potential to be a major accident and/or natural disaster which also has the potential to have a significant adverse effect on an environmental receptor, three components need to be present: a source, a pathway (between source and receptor) and a receptor. As such, and as recommended by Defra (2011), the assessment will use the following conceptual model:

- the **source** is the original cause of the hazard, which has the potential to cause harm, for example a moving train with the potential to derail. There are a number of generic risk events related to high speed rail which are not relevant to the Proposed Scheme as the source is not present (e.g. new stations, level crossing, conductor rail).;
- the **pathway** is the route by which the source can reach the receptor, for example via the derailment of a train; and
- the **receptor**, which is the specific component of the environment that could be adversely affected, if the source reaches it (e.g an ancient woodland).

5.2.2 Risk events which do not have all three components will be screened out from the assessment.

5.3 Screen risks for those within scope

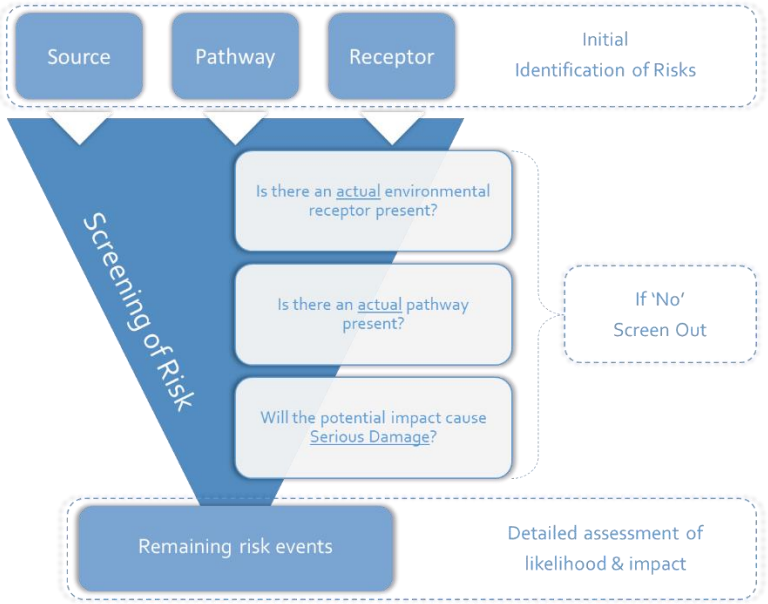
5.3.1 The following screening process will therefore be used to identify those risk events which may require further consideration within this assessment (Figure 2):

- is there a potential source, pathway and receptor as defined in paragraph 5.2 above? If not, no further assessment required;
- is there a relevant environmental receptor (Section 4.4) present in the locations where the risk event could occur, and a pathway whereby the source of harm can reach the receptor? If not, no further assessment required; and

[8] HM Government (2015) National Risk Register of Civil Emergencies, 2015 Edition, Cabinet Office, March 2015.

- does the potential impact on the environmental receptor meet the definition of 'a significant adverse effect' given in paragraphs 4.3.3? If not, no further assessment required.

Figure 2: Screening process flow diagram



5.3.2 For those risk events which are not screened out during the three steps above, the assessment methodology described below will be followed. This assessment will form the basis for recommending additional mitigation measures, as appropriate.

Embedded mitigation

5.3.3 Several mechanisms are in place to reduce the vulnerability of the Proposed Scheme to major accidents and/or natural disasters, or mitigate the effects on the environment should they occur. All measures to manage and reduce risk of significant adverse effects occurring as a result of the vulnerability of the Proposed Scheme to major accidents and/or natural disasters are considered to be 'embedded' mitigation measures for the purposes of the assessment. This framework and the measures therein of relevance to this assessment will be described in the ES.

5.4 Define impact

5.4.1 A reasonable worst case environmental impact(s) will be identified for each risk event which remains in scope following assessment through consultation with relevant discipline leads[9] for each topic within the ES and review of the Environmental Risk Record which can be found in Volume 5 of the ES. Where relevant, specific receptors along the route will be considered. The Environmental Risk Record will be updated reflecting this review, and recording the consultation outcome.

5.5 Assess likelihood

[9] Discipline leads are technical professionals with a minimum 15 years' experience in their specialist field and professional institution membership.

5.5.1 The likelihood of the reasonable worst case environmental effect(s) occurring will be evaluated taking into account:

- the likelihood of the risk event occurring considering the measures already embedded into the design and execution of the Proposed Scheme; and
- the likelihood that an environmental receptor is affected by the risk event.

5.5.2 This evaluation will refer to existing risk assessments as well as consultation with relevant discipline leads for each topic as defined in Section 5.4, with reference to the definition of *low likelihood* in paragraph 4.5.4.

5.6 Assess risk

5.6.1 The assessment of the risk will be carried out in accordance with Sections 5.1 to 5.5 and the results will be presented in the Environmental Risk Record included in Volume 5 of the ES. Where likely significant adverse effects are identified, mitigation measures must be in in place, commensurate with the likelihood of the event occurring.

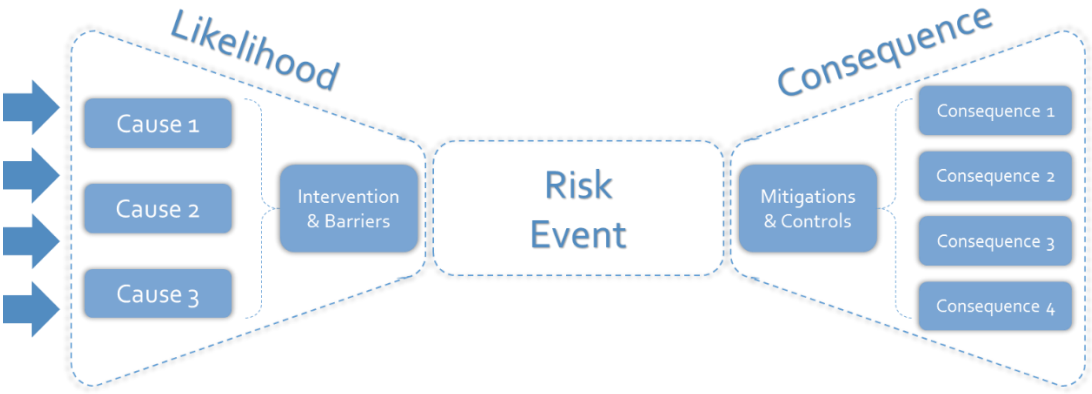
5.7 Appraise risk management options

5.7.1 Risk management options, including embedded mitigation, will fall into one of the following categories consistent with the mitigation hierarchy used for the EIA:

- **eliminate** (or 'avoid') the risk, by adopting alternative processes in order to eliminate the source of the hazard, or remove the receptor;
- **reduce** the risk by adapting proposed processes such that either the likelihood or the impact of the risk event can be reduced;
- **isolate** the risk, by using physical measures to ensure that should the risk event occur, it can be effectively isolated such that there is no pathway;
- **control** the risk, by ensuring that appropriate control measures are in place (e.g. emergency response) so that should a risk event occur, it can be controlled and managed appropriately. The EIA mitigation hierarchy of repair and compensate any significant damage to environmental receptors may then apply following a control measure; and
- **exploit** the risk, if it presents potential benefits or new opportunities.

5.7.2 Figure 3 shows the principles of managing risk as a 'bow tie' diagram, where measures to prevent a risk event occurring are barriers or intervention measures (for example appropriate site selection), or mitigations and controls in place should an event occur (for example, firewater containment measures).

Figure 3: The principles of managing risks both pre- and post-event



6 Summary

6.1.1 This technical note provides definition of the methodology for identifying and assessing the likely significant environmental (including human health and population) effects arising directly from the Proposed Scheme associated with its vulnerability to a major accident or natural disaster. Justification is also provided on how the scope of the assessment has been derived.

6.1.2 The proposed scope and methodology draws on available relevant guidance and other established processes for the identification and assessment of the vulnerability of the Proposed Scheme to major accident and/or natural disaster risks. The proposed methodology uses a risk-based approach and the scope focuses on risk events that have a low likelihood of occurrence, but that could result in significant adverse effects on in-scope receptors if they were to occur.

6.1.3 Receptors identified as being relevant to the assessment include members of the public and local communities; infrastructure and the built environment; the natural environment and the historic environment but excludes; employees of HS2 Ltd and/or its suppliers, train and staff passengers, members of the public who are wilfully trespassing and HS2 Ltd as an organisation.

7 References

Department of Environment, Food and Rural Affairs (2011) Guidelines for Environmental Risk Assessment and Management: Green Leaves III, Cranfield University and Department for Environment, Food and Rural Affairs, November 2011.

Department of Environment, Food and Rural Affairs (2011) Guidance: Major Accident Off-Site Emergency Plan (Management of Waste from Extractive Industries) (England and Wales) Regulations 2009 Mining Waste Directive: Article 6 Category "A" Waste Facilities. Department of Environment, Food and Rural Affairs, August 2011.

Health and Safety Executive (2013) Managing for health and safety (HSG65); Third Edition, 2013.

Health and Safety Executive (2015) The Control of Major Accident Hazards Regulations 2015: Guidance on Regulations, L111, Third Edition, June 2015.

HM Government (2013) Emergency Response and Recovery – *Non-statutory guidance accompanying the Civil Contingencies Act 2004*, Cabinet Office, 28 October 2013.

HM Government (2015) National Risk Register of Civil Emergencies, 2015 Edition, Cabinet Office, March 2015.

Office of Rail Regulation (2015) Common Safety Method for risk evaluation and assessment: Guidance on the application of Commission Regulation (EU) 402/2013, March 2015.

Rail Safety and Standards Board (2015) Annual Safety Performance Report 2014/15.

Secretary of State for Transport and HS2 Ltd (2014) Development Agreement relating to the High Speed Two Project; 8 December 2014.

Appendix A – Development Agreement between the Secretary of State for Transport and HS2 Ltd 2014, Annex 4: HS2 Ltd's Functional Response, Section 2 - Safety

The following text is extracted from HS2 Ltd's development agreement with the Department for Transport 2014, setting out its commitments with respect to safety.

HS2 Ltd will design, build and operate the Railway to meet or better the performance standard of HS1, to reduce safety risks as low as reasonably practicable and in line with best current international practice.

HS2 Ltd will produce health and safety strategies to support compliance with its duties under the Health and Safety at Work Act 1974 and other safety legislation, in respect of health and safety in the management of design and construction. These strategies will describe:

- Roles and responsibilities of the parties involved;
- Responsibilities of individuals within HS2 Ltd;
- Principles to be applied to the assurance of safety throughout the Project lifecycle including design, construction and operation;
- How the strategies interface with the 'System Safety Strategy' (as discussed below) and operation documentation and other parties to the 'Health and Safety Management System'; and
- The process and organisation for the obtaining of safety approvals by HS2 Ltd.

Through its 'Health and Safety Management System', 'System Safety Strategy' and other supporting documents, HS2 Ltd will:

- Prepare a safety programme with defined principles, objectives and targets;
- Engage with notified bodies, designated bodies and assessment bodies;
- Deliver a Railway that is safe to operate and maintain;
- Deliver a Railway designed to be constructed safely and without risk to health as far as is reasonably practicable;
- Develop a systematic framework of degraded operating modes and fall-back procedures which will be developed to provide safe operation under degraded conditions;
- Take all necessary steps in operation and maintenance of the Railway to protect public and rail user safety;
- Provide safe access and egress between the areas of public access and all transport services at every stage of construction (including in relation to emergency evacuation and access by the emergency services);

- Develop an approach to health and safety in construction that builds on the success of other major infrastructure projects that assists in developing the UK construction industry;
- Set up a HSQE Department led by an executive level director and nominate a Board member to have special responsibility on matters relating to health and safety; and
- Establish a governance structure for providing direction and scrutinizing performance on matters relating to health and safety at the Board and Executive level.

HS2 Ltd will apply a health and safety programme to establish clear health and safety targets for the Project and all persons involved in it.

HS2 Ltd recognises the importance of safety in design as a means of mitigating hazards at source. To capture this opportunity HS2 Ltd will apply a structured approach to the definition of scope and systems, the robust identification of hazards and clear risk acceptance principles and criteria. In identifying options to eliminate and mitigate risk HS2 Ltd will work collaboratively with industry partners and experts. The selection and application of mitigations will be evaluated on a 'so far as reasonably practical' basis and further informed by HS2 Ltd's "Design Vision" objectives (as set out in as described in Section 12).

HS2 Ltd will prepare "Engineering Safety Management Plans" that set out how compliance with the European Common Safety Method Regulation for Risk Evaluation and Assessment will be achieved.

HS2 Ltd will learn from the safety performance of other high speed rail systems and use this to inform and improve the design of HS2. HS2 Ltd will develop a model of the risk profile of the future operational railway to allow comparison with relevant systems and help inform the Project about the level of residual risk.

HS2 Ltd will seek authorisation to place into service the structural subsystems for the Infrastructure and produce the appropriate technical file for submission to the ORR.

Appendix B – Legal obligations covering design, construction, operation and maintenance of the Proposed Scheme

Table B1: Legislation applicable to the Proposed Scheme of relevance to the assessment of Major accidents and natural disasters

Legislation	Overview description	Relevance to the EIA
Construction (Design and Management) Regulations 2015 (CDM)	These regulations place legal duties on almost all parties involved in construction work. The regulations place specific duties on clients, designers and contractors, so that health and safety is taken into account throughout the life of a construction project from its inception to its subsequent final demolition and removal. Under CDM regulations, designers have to avoid foreseeable risks so far as is reasonably practicable by: eliminating hazards from the construction, cleaning, maintenance, and proposed use and demolition of a structure, reducing risks from any remaining hazard, and giving collective safety measures priority over individual measures.	Hazards with the potential to cause a major accident during railway construction, operation and maintenance are identified, assessed and mitigated. The regulations ensure that mechanisms are in place to continually identify, evaluate and manage safety risks throughout the design and construction phases of the Proposed Scheme. Many of the risks identified and managed out at the design phase also serve to eliminate or reduce the risk of a major accident (and therefore environmental consequence) occurring during the operational phase.
Health and Safety at Work etc. Act 1974 (HSWA)	The Act provides the framework for the regulation of industrial health and safety in the UK. It places general duties on employers, people in control of premises, manufacturers and employees. The overriding principle is that foreseeable risks to persons shall be reduced so far as is reasonably practicable and that adequate evidence shall be produced to demonstrate that this has been done. Health and safety regulations made under this Act contain more detailed provisions. For example, the Management of Health and Safety at Work Regulations 1999 (MHSWR) make more explicit what employers are required to do to manage health and safety under the HSWA.	The Act provides a regulatory mechanism for occupational safety hazards and risks to be continually identified, evaluated and managed throughout the design, construction and operational lifetime of the Proposed Scheme. This serves to eliminate or reduce the risk of a major accident (and therefore environmental consequence) occurring.
Regulation (EU) No 402/2013 on the Common Safety Method on Risk Evaluation and Assessment (CSM-RA) (as amended by Regulation EU 2015/1136)	The CSM-RA was introduced to ensure that levels of safety are maintained or improved when and where necessary and reasonably practicable, in accordance with the Railway Safety Directive (2004/49/EC). The CSM-RA describes a common mandatory European risk management process for the rail industry to assess compliance with safety levels and safety requirements. It applies when any technical, operational or organisation change is proposed to the railway system which has the potential to impact on safety. There is also a CSM-RA independent assessment body (AsBo) which reviews, assesses and reports on the safety assessment. The assessment and the AsBo	Under the CSM-RA, HS2 Ltd is conducting a systematic risk assessment of all aspects of the operational railway. This includes infrastructure, railway systems, rolling stock, operations (including all procedures) and the organisational structure of the operators. This assessment will ensure that all hazards have been identified and the risk reduced ALARP. Furthermore, the CSM-RA establishes a mandatory mechanism for safety hazards and risks to be continually identified, evaluated and managed throughout the design, construction and operational lifetime of the Proposed Scheme. This serves to eliminate or reduce the risk of a

Legislation	Overview description	Relevance to the EIA
	report both go to the regulator (ORR) to get permission for authorisation to place into service and put into use. See http://orr.gov.uk/__data/assets/pdf_file/0006/3867/common_safety_method_guidance.pdf	major accident (and therefore environmental consequence) occurring.
The Railways and Other Guided Transport Systems (Safety) Regulations 2006 (ROGS) (as amended)	The ROGS place a duty on Railway Undertakings (RUs) and Infrastructure Managers (IMs) to: • develop safety management systems (SMS) that must meet certain requirements; • have a safety certificate (for RUs) or a safety authorisation (for IMs); • show that they have procedures in place to introduce new or altered vehicles or infrastructure safely; • carry out risk assessments and put in place the safety measures they have identified as necessary to make sure that the transport system is run safely; and • work together to make sure the transport system is run safely (ROGS regulation 22).	The Regulations ensure that mechanisms are in place and implemented for the operation of the Proposed Scheme that will eliminate or reduce the risk of a major accident (and therefore environmental consequence) occurring.
The Railways (Interoperability) Regulations 2011 (as amended) (RIR)	These regulations implement the EU Railway Interoperability Directive 2008/57/EC[10], which had the purpose of establishing common operational standards and practices across European railways, including adoption of the CSM-RA.	HS2 Ltd is designing a railway according to the European Technical Specifications for Interoperability (TSIs). TSIs define the technical standards required to satisfy the essential requirements set out in the Directive to achieve interoperability. These requirements include safety, reliability and availability, health, environmental protection and technical compatibility along with others specific to certain subsystems. The development process for TSIs are managed and published by the European Union Agency for Railways (formerly the European Railway Agency).

[10] *Directive of the European Parliament and of the Council on the Interoperability of the Rail System in the Community*, 17 June 2008, 2008/57/EC.

Appendix C – selected relevant guidance for the risk assessment methodology

Table C1: Guidance relevant to the assessment

Guidance	Description
Defra (2011) 'Green Leaves III' Guidelines for Environmental Risk Assessment and Management[11]	These guidelines provide generic guidance for the assessment and management of environmental risks. A cyclical framework for risk management is provided which identifies four main components of risk assessment: 1. formulating the problem; 2. carrying out an assessment of the risk; 3. identifying and appraising the management options available; and 4. addressing the risk with a risk management strategy. A source-pathway-receptor model is suggested as a tool to assist in risk screening and an example is provided of applying the following filters to prioritise significant hazards for further investigation: • the plausibility of linkages between the source of a hazard and a receptor; • the relative potency of a hazard, availability of a pathway, or vulnerability of a receptor; • the likelihood of an event, on the basis of historic occurrence or of changed circumstances; or • a view on the performance of current risk management measures that, if they were to fail, may increase the potential for future harm.
Chemical and Downstream Oil Industries Forum, (2013), Guideline – Environmental Risk Tolerability for COMAH Establishments	These guidelines provide a common screening methodology for carrying out an environmental risk assessment under the COMAH Regulations. Amongst other things, the guidance: • defines the types of harm that should be considered in an environmental risk assessment, and how the harm should be characterised for the assessment; • defines the risk criteria to be used in assessing tolerability of the environmental risk from an establishment, and where appropriate, individual scenarios; and • explains how risks may be evaluated. The guidelines present a series of thresholds that can be used to 'screen' the potential for a Major Accident to the Environment (MATTE) to relevant environmental receptors. The thresholds have been developed based on the criteria for reporting a major accident to the European Commission defined in the Seveso III Directive and COMAH Regulations (see Table 3 in the main document), and to guidance on MATTE issued by the then Department of the Environment, Transport and the Regions in 1999[12]. The thresholds are presented in two dimensions, namely (i) extent and severity and (ii) duration of harm; and thresholds for both dimensions must be exceeded for the scenario to be considered a potential MATTE.
The International Standards Organization's ISO 31000: 2009 Risk Management – principles and guidelines	This guideline identifies a number of principles that need to be satisfied to make risk management effective. If the standards are adopted and applied the management of any risk should help minimise losses, improve resilience, improve controls and improve the identification of opportunities and threats.

[11] Defra (2011) Guidelines for Environmental Risk Assessment and Management: Green Leaves III, Cranfield University and Department for Environment, Food and Rural Affairs, November 2011.
[12] DETR (1999) Guidance on the Interpretation of Major Accident to the Environment for the Purposes of the COMAH Regulations, Department of the Environment, Transport and the Regions, 1999.

Guidance	Description
	The ISO standard states that when defining risk criteria, the following factors should be considered: • the nature and types of causes and consequences that can occur and how they will be measured; • how likelihood will be defined; • the timeframe(s) of the likelihood and/or consequence(s); • how the level of risk is to be determined; • the views of stakeholders; • the level at which risk becomes acceptable or tolerable; and • Whether combinations of multiple risks should be taken into account and, if so, how and which combinations should be considered.

Annex K: Socio-economics – technical notes

The following technical note is contained in this Annex:

- Socio-economics assessment.

HS2 Phase 2a West Midlands - Crewe: Technical note - Socio-economics assessment

Contents

List of tables

1 Introduction

1.1 Introduction

1.1.1 This technical note provides further guidance on the assessment methodology for assessing potential socio-economic impacts and effects considered likely to arise from the construction and operation of High Speed Two (HS2) Phase 2a (West Midlands - Crewe) or the Proposed Scheme.

1.1.2 The technical note builds upon and should be read alongside the HS2 Phase 2a Environmental Impact Assessment (EIA) Scope and Methodology Report (SMR)[1].

1.2 Socio-economics

1.2.1 The socio-economic assessment will identify impacts on businesses and organisations and effects on employment levels. It will consider the potential for the Proposed Scheme to generate impacts and effects on:

- existing businesses and organisations;
- local economies including employment; and
- planned growth and development.

1.2.2 The socio-economic assessment will provide inputs to the community assessment and draw upon other topic assessments where relevant such as agriculture, forestry and soils.

1.3 Other environmental impacts

1.3.1 There are a number of other environmental topics such as air quality; climate; landscape and visual impact; sound, noise and vibration; and traffic and transport that inform the socio-economic assessments. An understanding of these topics and their methodologies will be required to give context for potential in-combination effects arising from impacts related to these topics.

1.4 Structure of the technical note

1.4.1 This technical note is structured as follows:

- Section 2 provides core definitions for the receptors and resources which are relevant in assessing potential socio-economic effects;
- Section 3 sets out further details of the socio-economic assessment criteria and guidance on how this will be applied; and
- Section 4 provides a list of assumptions which have been applied to the socio-economic assessments.

[1] Environmental Impact Assessment Scope and Methodology Report, Volume 5: Appendix CT-001-001

2 Receptors and resource definitions

2.1 Socio-economic resources and receptors

2.1.1 Socio-economic resources and receptors are set out below. These resources and receptors are applicable to construction, operation and wider development effects and are applicable to all phases.

2.2 Resources: property units

2.2.1 Property units are considered to be those units supporting the employment of persons, which may be physically affected by the Proposed Scheme.

2.2.2 Property units consist of identifiable land and property including:

- commercial offices;
- warehousing;
- retail;
- open land storage;
- partial covered land storage;
- surface plant and machinery;
- land used for the production of agricultural produce (crops and/or livestock);
- institutional uses (e.g. public administration, armed forces, police, regulatory bodies);
- community infrastructure, open space and play space and recreational infrastructure where they have employment and/or economic characteristics; and
- communal residential establishments (residential and nursing homes, dormitories).

2.3 Resources: businesses

2.3.1 Businesses are considered to be all legal entities with definable establishments and employing persons within the impact area based on a minimum distance of 250m from the edge of the Proposed Scheme (see SMR) or within the envelope of assessment used by other disciplines informing indirect effects - air quality; landscape and visual; sound, noise and vibration; and traffic and transport. Legal entities are considered to be:

- sole traders;
- partnerships;
- limited companies;
- public limited companies;

- social enterprises (including companies limited by guarantee, co-operatives, charitable trusts and community interest organisations);
- membership and representative bodies (political parties, professional associations, trade unions and unincorporated societies); and
- public services.

2.3.2 Businesses are considered to carry out a recognisable activity including any of the following from their establishment:

- agriculture, forestry and fishing;
- manufacturing;
- wholesale and retail trade;
- repair of motor vehicles and motorcycles;
- accommodation and food service activities;
- electricity, gas, steam and air conditioning supply;
- water supply, sewerage, waste management and remediation activities;
- construction;
- transportation and storage;
- information and communication;
- public administration and defence;
- compulsory social security;
- other service activities (excluding those covered under the community assessment);
- financial and insurance activities;
- real estate activities;
- professional, scientific and technical activities;
- administrative and support service activities; and
- arts, entertainment and recreation.

2.3.3 The effect on agricultural businesses will be covered under the agriculture, forestry and soils assessment and the results summarised in the socio-economic assessment together with other economic impacts.

2.4 Receptors

2.4.1 Receptors consist of people in employment associated with a resource including:

- employees in employment;

- sole traders; and
- partners.

2.5 Exclusions

2.5.1 Businesses concerned with health and social care and education and other service delivery activity play a dual role in the assessment in so far as they provide services to people as individuals as well as performing a role as an employing business. Impacts on the delivery of services to people and in-combination impacts on employees and organisations are considered under the community assessment, whilst impacts on employment will fall under the remit of the socio-economic assessment.

2.5.2 Property units that support embedded infrastructure such as pipe line networks, digital communications or utility network infrastructure are not considered to support employment in a direct sense; rather this is a matter for consideration in relation to service diversions/relocations.

2.5.3 For the purposes of assessing the impacts on home based businesses, all such businesses are considered to be ancillary to the main use as a residence (unless separately rated) unless evidence of actual employment in-situ is identified (i.e. actual employment recorded in a reviewed data source and physical evidence of property adaptation/signage). The loss of residences will be captured under the community assessment. Businesses operated as an ancillary activity will be considered to follow the relocation of any affected household.

2.5.4 The employment associated with the extraction of identified mineral reserves e.g. sand and gravel has not been accounted for due to the unpredictability of extraction activity and likely duration.

2.5.5 Businesses without employment include companies registered to an address or companies remotely operating physical assets e.g. sub-let premises. The latter include owners of tenanted properties e.g. buy to let landlords or institutional owners. In these instances, the impacts affecting occupiers as individuals will be assessed under community impacts.

2.5.6 Businesses operating in the informal economy may be encountered. Businesses who have no formal title to land/property used in pursuit of a business activity are presumed to lie outside the scope of this assessment e.g. car repairs operated from a residential garage.

3 Socio-economic assessment criteria

3.1 Introduction

3.1.1 The Environmental Statement (ES) uses both the terms 'impact' and 'effect' in all environmental topics. An impact will be generally considered to be a physical change caused by the Proposed Scheme (and in this context changes in air quality, noise levels or the quality of a view for example will be 'impacts'). The consequences of impacts on the receptors will be generally termed effects.

3.1.2 For the socio-economic assessments, resources are those assets and facilities which are impacted. Receptors are the operators, users or beneficiaries of those resources.

Resources and receptors will vary for each type of impact and effect. So for example, increased construction traffic may have a range of impacts, such as congestion on the roads. The effects of this congestion could be disturbance and disruption for local businesses.

3.2 Impacts and effects

3.2.1 Impacts relevant to the socio-economic assessments fall broadly within the following categories:

- demolition and direct land possession;
- intrusion/disturbance to businesses and community facilities caused by other environmental impacts; and
- the economic consequences for local economies, for example via multiplier mechanisms.

3.2.2 Impacts will generate the following broadly defined effects on receptors and resources:

- loss or gain: a loss or gain to a resource or receptor. For example, an increase in employment opportunities as a result of construction;
- displacement: displacement means the relocation of receptors from one location to another location within the study area, for example businesses moving from their premises. The assessment recognises that in some cases businesses may cease to trade if they are forced to relocate, and some businesses may relocate outside of the study area (referred to as leakage);
- change in the combined environmental effects on business: the benefits of enjoyment and wellbeing that receptors gain from a resource in line with its intended function. The combination of factors such as: noise and vibration; heavy goods vehicle (HGV) construction traffic; air quality; and visual impacts can affect the level of enjoyment/wellbeing experienced by receptors. The socio-economic assessment will consider when changes of this nature could potentially result in a loss of trade for affected businesses; and
- isolation: in the context of this assessment, isolation will be measured by potential isolation and islanding of businesses. This includes physical islanding (i.e. non-economic) and the effects of this on businesses. The socio-economic assessment considers when isolation of a business or group of businesses might potentially result in a loss of trade for those affected businesses.

3.3 Assessment criteria

3.3.1 Significance will be determined by assessing both the magnitude of the impact and the sensitivity of resources and receptors for each effect. Taken together, magnitude and sensitivity will determine whether effects are considered to be 'significant' or 'not significant'. All effects are to be assessed, including adverse and beneficial.

3.3.2 There are several factors which determine the magnitude of impact and sensitivity of resources and receptors. These factors and thresholds of significance vary for each theme of the socio-economic assessments.

3.3.3 The assessment criteria described in Table 1 highlight the types of impacts and effects on resources and relevant receptors. This includes guidance on the factors to consider and thresholds to ensure a consistent approach to assessing significance.

3.3.4 This table has been established using professional judgement and existing precedents and will be used as the starting point for assessment. In some instances, it may be considered appropriate to adjust sensitivity and magnitude in the light of specific circumstances.

3.3.5 Table 1 provides a basis for determining both construction phase effects and operational phase effects. Whether a particular resource and receptor needs separate assessment for the construction and operational phases will depend upon the specifics of the Proposed Scheme. Some receptors need different assessments for both construction and operational phases, while other receptors will only require an assessment for one of the phases. There will also be instances in which it will be appropriate to take into account the construction phase effects when carrying out the assessment of the operational phase, for example if a facility will be closed down during the construction phase and would only be partly reopened during the operational phase.

Table 1: Guidance on assessing sensitivity and magnitude

Theme	Effects	Effects		Magnitude of effect	Sensitivity of receptor/ resource
		On resources	On receptors		
Existing businesses and organisations – due to land required for the Proposed Scheme and amenity impacts	Businesses (including community) lost due to land required for the Proposed Scheme	Loss or impairment of business activities	Change in employment and skills mix	Individual receptors: • HIGH: estimated loss/relocation of more than 50 jobs; • MEDIUM: estimated loss/relocation of between 10 and 50 jobs; • LOW: estimated loss/relocation of between 2 and 9 jobs; and • NEGLIGIBLE: loss/relocation of 1 or less jobs. Possible variations: • where the number of employees is a high/low proportion of the size of a local community/business cluster it may be appropriate to increase/reduce the magnitude assessment. Route-wide: • HIGH: estimated loss/relocation of more than 5,000 jobs; • MEDIUM: estimated loss/relocation of between 1,000 and 5,000 jobs; • LOW: estimated loss/relocation of between 100 and 999 jobs; and • NEGLIGIBLE: estimated	Sensitivity will vary significantly and depend upon a range of factors: • availability of alternative, suitable premises; • site specific issues; • size of local labour market; • skill levels and qualifications of local people; and • levels of unemployment. Assessors should use the question prompts in List B (refer to Section 3.4) when weighing up sensitivity.

Theme	Effects	Effects		Magnitude of effect	Sensitivity of receptor/ resource
		On resources	On receptors		
				loss/relocation of less than 100 jobs.	
	Businesses (including community): amenity value of infrastructure is changed resulting in an impact on the operations of businesses and organisations	Character or quality of businesses and organisations' environment changes	Change in employment and skills mix	The primary test of magnitude will be the nature of the effects on the function of the resource. Also of relevance is the duration of the impact. Magnitude of impact is anticipated to vary significantly depending upon the characteristics of each situation. Generally, though, the magnitude of socio-economic impacts will depend upon the magnitude of other environmental impacts. The following guide is consequently suggested at the receptor level: Effect on function of resource and implications for receptors: • HIGH: three or more residual significant other effects; and • MEDIUM: two significant residual other environmental effects. The amenity assessment will only consider the in-combination significant residual effects from other topics so the LOW and NEGLIGIBLE categories are not considered to be applicable with regards to magnitude of impact.	Sensitivity will vary significantly depending upon a wide range of characteristics of each business/ organisation. Generally, more sensitive receptors are likely to fall in sectors including: • hospitality; • recreation and culture; • retail; and • education and training. Assessors should use the question prompts in List B (refer to Section 3.4) when weighing up sensitivity.

Theme	Effects	Effects		Magnitude of effect	Sensitivity of receptor/ resource
		On resources	On receptors		
				Potentially other effects include relevant elements of: air quality; landscape and visual; sound, noise and vibration; and traffic and transport (in terms of impacts of HGV (construction traffic) movements. Duration: The duration of the impact should be taken into account. Generally speaking where duration is less than 6 months it may be appropriate to reduce the magnitude of the impact below the initial effect thresholds. Given the uncertainties of estimating such employment losses/relocations at an individual receptor level, the individual assessments will be used as an input to estimate an aggregated route-wide level impact: • HIGH: estimated loss/relocation of more than 500 jobs; • MEDIUM: estimated loss/relocation of between 100 and 500 jobs; • LOW: estimated loss/relocation of between 10 and 99 jobs; and • NEGLIGIBLE: estimated loss/relocation of less than 10 jobs.	

Theme	Effects	Effects		Magnitude of effect	Sensitivity of receptor/ resource
		On resources	On receptors		
	Isolation of infrastructure from receptors resulting in an impact on businesses and organisations	Physical e.g. islanding or isolation of resource results in change to businesses and organisations	Change in employment and skills mix	Magnitude of impact will vary depending upon a number of factors including: • closures of roads/ Public Rights of Way (PRoW) and duration of closures; • extent of diversions; and • potential delay/disruption. Assessors should use the question prompts in List A (refer to Section 3.4) when weighing up magnitude. Given the uncertainties of estimating such employment losses/relocations at an individual receptor level, the individual assessments will be used as an input to estimate an aggregated route-wide level impact: Route-wide: • HIGH: estimated loss/relocation of more than 500 jobs; • MEDIUM: estimated loss/relocation of between 100 and 500 jobs; • LOW: estimated loss/relocation of between 10 and 99 jobs; and • NEGLIGIBLE: estimated loss/relocation of less than 10	Sensitivity will vary significantly depending upon a wide range of characteristics of each business/organisation. Generally, more sensitive receptors are likely to fall in sectors including: • hospitality; • recreation and culture; • retail; and • education and training. Assessors should use the question prompts in Assessors should use the question prompts in List B (refer to Section 3.4) when weighing up sensitivity.

Theme	Effects	Effects		Magnitude of effect	Sensitivity of receptor/ resource
		On resources	On receptors		
				jobs.	
Employment associated with construction	Direct employment opportunities associated with the construction phase	Demand for construction phase services	Demand for construction phase associated jobs and change in opportunities for local employment	Route-wide: • HIGH: estimated creation of more than 10,000 person years[2] of construction employment; • MEDIUM: estimated creation of between 5,000 and 10,000 person years of construction employment; • LOW: estimated creation of between 100 and 4,999 person years of construction employment; and • NEGLIGIBLE: estimated creation of less than 100 person years of construction employment.	Sensitivity in this context is taken to cover the benefit that individuals will derive from employment and this is assumed to be significant. Consequently, sensitivity is usually assessed to be: • HIGH.
	Indirect impacts on the economy of the construction phase	Indirect impacts on other construction sector projects, multiplier impacts on the wider economy	Demand for construction sector jobs and change in opportunities for local employment	Route-wide: • HIGH: estimated creation of more than 10,000 person years of construction employment; • MEDIUM: estimated creation of between 5,000 and 10,000 person years of construction employment; • LOW: estimated creation of between 100 and 4,999 person years of construction employment; and	Sensitivity in this context is taken to cover the benefit that individuals will derive from employment and this is assumed to be significant. Consequently, sensitivity is usually assessed to be: • HIGH.

[2] Construction labour is reported in construction person years, where one construction person year represents the work done by one person in a year composed of a standard number of working days.

Theme	Effects	Effects		Magnitude of effect	Sensitivity of receptor/ resource
		On resources	On receptors		
				• NEGLIGIBLE: estimated creation of less than 100 person years of construction employment.	
Employment associated with operations	Direct employment opportunities associated with the operations phase	Demand for operational phase services	Change in employment and skills and change in opportunities for local employment	Route-wide: • HIGH: estimated net creation of more than 5,000 jobs over baseline; • MEDIUM: estimated net creation of between 1,000 and 5,000 jobs over baseline; • LOW: estimated net creation of between 100 and 999 jobs over baseline; and • NEGLIGIBLE: estimated net creation of less than 100 jobs over baseline.	Sensitivity in this context is taken to cover the benefit that individuals will derive from employment and this is assumed to be significant. Consequently, sensitivity is usually assessed to be: • HIGH.
	Indirect impacts on the economy of the operations phase	Indirect impacts on sectors of the economy, multiplier impacts on the wider economy	Change in employment and skills and change in opportunities for local employment	Route-wide: • HIGH: estimated net creation of more than 5,000 jobs over baseline; • MEDIUM: estimated net creation of between 1,000 and 5,000 jobs over baseline; • LOW: estimated net creation of between 100 and 999 jobs over baseline; and • NEGLIGIBLE: estimated net creation of less than 100 jobs over baseline.	Sensitivity in this context is taken to cover the benefit that individuals will derive from employment and this is assumed to be significant. Consequently, sensitivity is usually assessed to be: • HIGH.

3.4 Assessment criteria checklist

Magnitude of impact

3.4.1 In considering the magnitude of an impact on a resource and its receptors, assessors consider each impact against the checklist of magnitude questions presented in List A (below). The questions are designed to assist in deciding on magnitude and judging whether there could be any specific circumstances in which the magnitude ranking should differ from the thresholds (see Table 1). Not every question may have relevance to the circumstances under consideration.

3.4.2 Some situations/outcomes may not be known for certain. Assessors base their work on an assessed mostly likely situation/outcome.

List A: Questions relevant to the assessment of magnitude of impact

Impact on function of resource and implications for receptors:

- How will the impact affect the functioning of the resource? To what degree can it absorb the change?
- What is the severity/intensity of the impact on people's lives and activities?
  - Do other ES topics conclude a significant effect?

Duration – temporal scope of impact on receptor:

- What is the temporal scope of the impact?
  - Does the impact occur at specific times of the day?
  - For how long does the impact occur?
  - How regularly does the impact occur?
  - Is the impact temporary or permanent?

Sensitivity of receptors

3.4.3 In considering the sensitivity of receptors to an impact, assessors consider each impact against the checklist of sensitivity questions given in List B (below). Not every question will be relevant to the circumstances of each receptor. The questions are designed to assist in deciding on sensitivity and judging whether there could be any specific circumstances in which the sensitivity ranking should differ from the thresholds (see Table 1).

3.4.4 Some situations/outcomes may not be known for certain. Assessors should base their work on assessed mostly likely situations/outcomes.

3.4.5 For the assessment of combined environmental impacts, sensitivity should be considered as a separate step in the socio-economic assessment process. Where there is an overlap with other disciplines and this is considered by assessors to be important, they should ensure that the overall significance rating is consistent with the other relevant assessments.

List B: Questions relevant to the assessment of sensitivity

Scarcity/alternatives for receptors

3.4.6 What is the scarcity of the affected resource and what is the availability of alternatives? Factors to consider include:

- what is the catchment area of the affected resource?
- are there comparable alternative resources available within the relevant catchment area?
- how easy is it to replace the resource? e.g. does it have special site requirements that are difficult to replicate or are its locational requirements generic and relatively easily met elsewhere?
- what is the spare capacity of the alternative resources and is this potentially available to the users of the affected resource?
- what is the likelihood that alternative resources/sites/options will become available?

Capacity to respond to loss/gain for receptors

- what is the receptor's capacity to experience a loss or gain of the affected resource?
- nature of suppliers – are suppliers to the resource unduly concentrated such that their capacity to experience a loss or gain in the affected resource will be magnified in the local economy?
- nature of users – are they concentrated in the local area? Are they a specialised interest group? Are they local/ regional/ national/ international? Does this nature then influence their capacity to experience a loss or gain in the affected resource?

4 Socio-economic assumptions

4.1 Introduction

4.1.1 The key assumptions underlying the socio-economic assessments are set out below.

Socio-economic assumptions

Direct effects

4.1.2 The impacts of the Proposed Scheme on socio-economic resources (property units supporting employment) and the consequential effects on receptors (users of the resource or its service/goods) is considered in terms of full time equivalent (FTE) jobs gained, lost or relocated.

4.1.3 Loss of trade within a business can be considered as a loss of turnover and represented as a change in employment at the affected business (assuming a positive relationship between growth/contraction in a business' turnover and growth/contraction in employment at that business).

4.1.4 Since the level and intensity of proposed construction activity will vary during the construction period, the level of significant effects on socio-economic resources could vary. The assessment reported is focused on the construction activities and durations, which could lead to the greatest potential impact.

4.1.5 Where practicable, land required temporarily during the construction period will be returned to its previous use after construction unless that use cannot continue or resume within a reduced area. Where the use cannot resume, the effect is treated as permanent.

4.1.6 The assessment considers the construction phase (2020 - 2026) and the first year of operation (2027), which is considered to provide a worse-case forecast of effects.

4.1.7 The different assessments within the socio-economic section (socio-economic resources affected by the land required for the Proposed Scheme, isolation and changes in combined environmental effects) are not directly comparable when considering the significance of effect.

4.1.8 For resources affected by the land required for the Proposed Scheme, the implication is that the employment within these resources will either relocate or be lost and the significance of this has been assessed. For resources affected by isolation and/or changes in combined environmental effects, the situation is less clear in terms of employment implications.

4.1.9 With this in mind, impacts are assessed and reported at an individual resource level although any employment implications are assessed at route-wide level.

4.1.10 The assessment considers the potential reduction in economic output arising as a consequence of direct impacts – the relocation or closure of businesses located on land required for the Proposed Scheme. For the purposes of this assessment, the indicative rate of successful business relocations is judged to be 88% and no employment at these businesses will be lost. The rate of closure of directly affected businesses is therefore 12% and all employment within these businesses is assumed to be lost.

Indirect effects

4.1.11 The socio-economic business combined environmental effects assessment draws on the residual significant effect findings from other topics. These findings are combined to determine whether there is a significant combined environmental effect. Findings from other topic assessments are not directly comparable in terms of their scale of effects.

4.1.12 The business assessment of combined environmental effects considers whether a business may lose trade as a result of its users/customers' ability to use the resource being affected by the Proposed Scheme and the potential employment consequences.

4.1.13 Employment implications on individual socio-economic resources, which result from single topic significant residual effects, are outside the scope of this assessment. At route-wide level, any employment implications of this nature are considered to be limited and not significant.

4.1.14 The socio-economic assessment does not assess localised impacts on tourism/visitors to venues along the route of the Proposed Scheme. There is no robust evidence (or method of assessment) to determine whether or not there is a significant displacement of employment at these venues as a result of the Proposed Scheme.

4.1.15 With regards to the combined environment and isolation assessments, the sensitivity of receptors will vary from business to business but will be dependent on whether the Proposed Scheme will be likely to have an adverse effect on trade. Businesses located in the hospitality, recreation and culture, and retail sectors are most likely to have receptors with high levels of sensitivity given the risk of trade diversion as a result of the Proposed Scheme. In determining sensitivity, consideration is given to catchment of the affected socio-economic resource, alternative unaffected competitor business, attraction of the facility to customers and type and make-up of facility.

4.1.16 For the combined environment and isolation assessments, it is assumed a business establishment experiencing an adverse effect on trade can adopt a number of strategies before reducing employment (e.g. cancel/postpone investment in premises/stock/machinery, reduce staff working hours, family members working longer hours, cancel/postpone plans to expand the business, temporary laying-off staff, renegotiate loans or mortgage, increase marketing or advertising activity etc.). Any reduction in employment has been calculated by estimating the total employment of the business(es) affected; then, based on the business activity/sector type, by applying a percentage to represent the likely proportion of employment which could be significantly affected by changes in combined environmental or isolation effects.

4.1.17 Increases in HGV construction traffic flows as a result of construction of the Proposed Scheme will affect the capacity of local businesses and organisations to attract trade. This information is taken from the traffic and transport assessment. This aspect of the assessment is concerns the presence of HGV on routes and their proximity to socio-economic resources.

4.1.18 Information on duration of significant residual effects is provided by other topics where available. Where the relevant information is available, socio-economic assessors will use duration to determine when significant residual effects from other topics occur simultaneously.

4.1.19 In cases where certain socio-economic resources have not been explicitly identified in other topics, such as landscape and visual impact; and sound, noise and vibration, socio-economic assessors will apply professional judgement based on consultation with relevant topics concerning significant effects. For the purposes of establishing combined environmental effects on business, any significant effects findings established through professional judgement are used in the same way as findings derived by technical assessment and provided directly by the other topics.

4.1.20 Magnitude of impact within the combined environmental effects assessment is anticipated to vary significantly depending upon the characteristics of each situation. Generally, the magnitude of impact will depend upon the magnitude of other environmental effects. However, in certain circumstances it is appropriate to acknowledge that some significant residual effects from other topics (for example

visual) may not be appropriate to apply to particular socio-economic resources in terms of contributing to a possible impact.

4.1.21 Socio-economic resources identified as part of cumulative schemes may interact with the Proposed Scheme during their construction and as a result of their occupation by new receptors during the time when the Proposed Scheme is being constructed and beyond. During their construction, cumulative projects have the potential to create their own environmental impacts. Additional air quality and dust; landscape and visual; sound, noise and vibration; and HGV traffic movement impacts risk compounding those effects generated by the Proposed Scheme. However, given construction of these projects will occur many years into the future, lack of information prevents any meaningful assessment of effect being undertaken.

4.1.22 Employment within socio-economic resources is estimated through a combination of sources, for example, business consultation, Experian employment dataset, employment floor space (obtained from either the Valuation Office Agency or an estimate made via site visits and GIS mapping) and the Homes and Communities Agency (HCA) Employment Density Guide[3]. The estimate is calculated using standard employment density ratios and estimates of floor areas and may vary from actual employment at the sites.

4.1.23 Construction labour is reported in construction person years, where one construction person year represents the work done by one worker in a year composed of a standard number of working days.

4.1.24 It is assumed that the demand for and supply of construction labour will remain largely the same as at the present time, up to the commencement of the Proposed Scheme. Employment effects associated with the construction phase of the Proposed Scheme are presented in gross and net terms, whereas operational employment of the Proposed Scheme is reported as gross. Employment on the classic network is assumed to remain the same as the present time as released capacity is utilised by new services.

Future baseline

4.1.25 The future baseline is taken to be the existing employment position of those socio-economic resources identified as being directly affected or indirectly affected by the Proposed Scheme. It can be expected, due to changes in socio-economic conditions, that there would be changes in the number and type of business activities of those resources affected from that which is currently observed. For instance, businesses may open or close, and sites or premises that are currently occupied may become unoccupied. However, in the absence of information about the specific economic circumstances of the businesses, their financial plans, owner intentions, or whether the capacity of the commercial site or building is likely to change in the long term, it is not possible to forecast how employment could change with any certainty before commencement of the Proposed Scheme.

4.1.26 The future baseline will also consider the implications of planned development on both new and existing non-agricultural employment receptors, with a view to

[3] Homes and Communities Agency (2015), *Employment Density Guide.*

establishing whether there are any significant effects arising from interaction with the Proposed Scheme had these planned developments proceeded in the absence of the Proposed Scheme. Consented development will assume to have been completed by the date of construction commencement (2020) using known characteristics of such development to determine a likely employment effect. Given the impossibility of determining the future employment associated with businesses occupying development in the future, these developments and their related employment will be assumed to remain unchanged for the purposes of assessing any significant effects arising from operations in 2027.

Route-wide

4.1.27 Additionality of the Proposed Scheme is defined as the impact that arises as a result of an intervention (in this case the Proposed Scheme) that would have not have occurred in the absence of that intervention.

4.1.28 The route-wide additionality assumptions for the intervention case are set out in Table 2 and inform the assessment of route-wide effects contained in ES Volume 3. Additionality is assessed through the use of rates set out in the English Partnerships Additionality guidance[4] , which make allowances for the effect of leakage, displacement and multipliers:

Table 2: Proposed Scheme: route-wide additionality assumptions

	Effect rate	**Effect level**
Leakage	0%	None
Displacement	25%	Low
Substitution	0%	None
Multiplier	1.5	Medium

4.1.29 Leakage[5] impacts are considered at the UK level. Leakage for all types of impact is therefore assumed to be zero.

4.1.30 Displacement[6] refers to the potential change in economic output from businesses as a consequence of the Proposed Scheme. Displacement is estimated in relation to:

- Construction employment created by the Proposed Scheme: a low displacement is applied to reflect the uniqueness of the project and high demand for specialist, skilled workers, resulting in a lower likelihood of displacing other construction projects or construction jobs over the relevant time period.
- The contraction in economic output as a consequence of employment losses at businesses directly affected (business relocations or closure) or indirectly affected (changes in combined environmental and isolation effects) during the

[4] English Partnerships (2008), *Additionality guidance*.
[5] Leakage: the number or proportion of outputs that benefit those outside of the intervention's target area or group should be deducted from the gross direct effects.
[6] Displacement: the number or proportion of intervention outputs accounted for by reduced outputs elsewhere in the target area should also be deducted.

construction phase is reflected by the resultant displacement effects on other parts of the economy: a low level of displacement is applied to employment identified as being potentially lost in these businesses to reflect the likelihood that these businesses operate in an established and competitive economy.

- The operational phase: during the operational phase, it is assumed that operational jobs will not supplant other economic activities from taking place, and therefore a low degree of displacement is assumed.
- Substitution[7]: for all types of impact, zero substitution effects are assumed as employment created by the Proposed Scheme (during construction and operation) is not thought to be directly supported by initiatives which generate public sector assistance.
- Composite multiplier[8]: the medium level composite multiplier is identified as being typical of the majority of public sector interventions.

4.1.31 Employment loss within agricultural organisations has been estimated by the agriculture, forestry and soils topic and will be reported in aggregate at a route-wide level in ES Volume 3.

[7] Substitution effects: this effect arises where a firm substitutes one activity for a similar one (such as recruiting a jobless person while another employee loses a job) to take advantage of public sector assistance. Again, these effects need to be deducted.
[8] Multiplier effects: further economic activity (jobs, expenditure or income) associated with additional local income, local supplier purchases and longer-term development effects then need to be added.

Annex L: Traffic and transport – technical note

The following technical note is contained in this Annex:

- Guidance on significance criteria for traffic and transport.

HS2 Phase 2a West Midlands - Crewe: Technical note – Traffic and transport - Guidance on significance criteria for traffic and transport

Contents

List of tables

1 Introduction

1.1 Introduction

1.1.1 This technical note provides further guidance to that contained in the Phase 2a Environmental Impact Assessment (EIA) Scope and Methodology Report[1] (SMR) on how traffic and transport effects will be determined for the Environmental Statement (ES) for the Proposed Scheme. This guidance is based on criteria already specified in the Phase 2a EIA SMR.

1.1.2 The methodology builds on that described in the SMR and further describes the process by which the significance of traffic and transport impacts and effects will be determined and applied in the ES.

1.1.3 The assessment process includes:

- establishing a future baseline that includes traffic and transport; and
- undertaking an impact assessment to understand the ability of the receptors (modes and/or networks) to adapt to future transport demands during the construction and operation of the Proposed Scheme (where appropriate).

1.2 Use of this guidance

1.2.1 Use of this guidance will require analysis of transport data, technical assessments and professional judgments to be made and assessors should use this report to provide guidance rather than as a series of strict rules. Judgements which result in an effect being assessed as more than one category higher or lower than indicated should be exceptional and any variation will need clear justification.

1.2.2 Where specific types of information referred to in this guidance are not available, the assessments can be based on alternative datasets so long as these are judged to be robust and appropriate for the needs of the ES. If there is any doubt on how to apply these guidelines then advice should be sought from HS2 Ltd.

1.3 Prediction and evaluation of impacts and effects

1.3.1 The ES will describe the likely significant effects including the direct effects and any indirect, secondary, cumulative, short, medium and long-term, permanent and temporary, positive and negative effects of the Proposed Scheme.

1.3.2 A distinction has been made in the assessment between impacts and effects, where:

- impacts are defined as the predicted change to the baseline environment attributable to the Proposed Scheme (e.g. changes in traffic levels or delays); and

[1] Volume 5: Appendix CT-001-001, Scope and Methodology Report.

- effects are the consequence of impacts on environmental resources or receptors of particular value or sensitivity and, most commonly for transport, the number of people affected or the importance of a link disrupted.

1.3.3 The primary objective of the assessment is to identify likely "significant" effects. This will be achieved by firstly assessing the magnitude of an impact and then by reviewing the extent (e.g. temporal and spatial) to which it affects receptors. The process for determining whether the result is deemed to be significant is described below.

1.4 Impact assessment

1.4.1 Table 1 shows the impacts that will be assessed, for both the construction and operational stages of the Proposed Scheme.

Table 1: Impacts to be assessed

Traffic and transport impacts
Public transport delay
Disruption at stations/interchanges
Delays to vehicle occupants and severance for non-motorised users due to traffic flow changes
Parking and loading
Vulnerable road user delay, amenity and ambience
Accidents and safety
Severance
Waterways

1.4.2 The SMR identifies that significant effects may occur on receptors in two ways, when:

- a particular threshold is passed; or
- there is a particular combination of impacts that taken together create a likely significant effect.

1.4.3 The scheme-related impacts on the receptors can be measured on a spatial and temporal basis, and will be numerically quantified or employ a qualitative judgement. Transport assessment data and relevant modelling should be used as the prime sources of information from which to identify the traffic and transport impacts.

1.5 Thresholds

1.5.1 In assessing traffic and transport impacts, thresholds are needed to define the point at which such impacts become significant effects. These effects can then be classified as of minor, moderate or major significance. The level of 'graduation' employed to define significance is therefore a key consideration of how to measure each effect.

1.6 Impacts and effects

1.6.1 The significance of a traffic and transport effect can be considered as the combination of the magnitude of the impact and the number of people affected, the duration of the impact (temporal) or the extent of its locational effects. The number of travellers affected will be important, as may be the sensitivity and/or value of the receptor. These criteria and thresholds and their measurement will be defined based on professional judgement and existing industry accepted practice.

1.6.2 Further guidance on this aspect is given in the tables that follow for each criteria. In some cases, a proxy measure is included that reflects the number of travellers affected.

1.6.3 In considering the scale of effect resulting from any particular impact identified, this can be measured according to the typical generic definitions in Table 2 below.

Table 2: Impact magnitude criteria for traffic and transport

Receptor Sensitivity	Definitions
Not significant	Unlikely to measurably affect the well-being of travellers so that the existing base case remains constant
Minor	Likely to or may affect a low number of travellers (with the number depending on the local context)
Moderate	Likely to affect a moderate number of travellers (with the number depending on the local context)
Major	Very likely to affect a major number of travellers (with the number depending on the local context)

1.6.4 Where quantitative analysis is not possible, it will be necessary to use qualitative categories for assessing the number of travellers affected (e.g. low, medium, or high). Further guidance on this aspect is also given in the tables that follow for each criteria.

1.6.5 Where relevant, receptors may in addition be considered valuable and/or sensitive if:

- they could be easily affected by, or are dependent on, specific current traffic and transport characteristics or flows; and/or
- they could be adversely affected if they are subject to long-term changes in the traffic and transport flows that differ from historic norms.

1.7 Mitigation plan

1.7.1 For effects that are classified as major significant or moderate significant, a mitigation plan proportionate to the effects should be developed where there are reasonably practicable options that address the traffic and transport scenarios and potential impacts that have been identified. It is assumed that minor effects will be mitigated during the detailed design process for the Proposed Scheme.

1.7.2 For any effects which cannot be mitigated within the scheme design (i.e. a residual impact) or through identified additional mitigation, the consequences of proceeding with the Proposed Scheme for the receptors (i.e. travellers) should be described.

2 Further definition of significance criteria

2.1 Approach to definition

2.1.1 The SMR criteria to judge significance are to be applied as:

- a binary threshold approach to significance, i.e. an effect is either significant or not significant; and
- a graduated approach which defines the 'degree' of significance.

2.1.2 The key issues addressed in this note in relation to the definition of the SMR significance criteria are:

a. the assessment of each impact to determine the degree of significance; and

b. where numerical measures can be applied.

2.1.3 When using the tables throughout this document, if a value lies exactly on the boundary between two categories, the upper (i.e. most severe) category should be used to provide a 'worst case' assessment.

2.1.4 The assessment is a two stage process as follows:

Stage one – SMR criteria

2.1.5 Utilise the SMR criteria to determine whether the effect is significant and therefore should be reported within the ES.

Stage two – refinement of assessment

2.1.6 Where the effects are deemed to be significant in the Stage 1 assessment, the Stage 2 assessment will enable them to be further categorised as being of minor, moderate or major significance.

2.1.7 The Stage 2 criteria thus build on the Stage 1 assessment, and all criteria (i.e. tabulated, bulleted or in text) need to be considered and assessed.

2.1.8 Many of the criteria set out in the SMR have a temporal scope to the assessment of an impact, which is a 'fixed' criteria that should be applied in combination with all other 'variable' criteria such as changes in journey times, numbers, percentages etc.

2.1.9 While temporal scope is generally defined as a continuous period, where there are frequent shorter duration impacts (for example a large number of weekend closures of a busy passenger rail service) judgment will be needed to determine whether these impacts when taken in combination amount to significant effects even if individually they would not.

3 Significance criteria for construction assessment

3.1 Introduction

3.1.1 The criteria outlined below will be used to assess the significance of traffic and transport impacts and effects during construction of the Proposed Scheme.

3.1.2 Any permanent effects of construction will be considered in the operations phase assessments for traffic and transport. Thus, the impact of any ongoing permanent changes introduced during construction will be considered together with increases in travel demand and the wider effects of the operations phase.

3.2 Public transport delay

Stage 1 - SMR criteria

3.2.1 A significant impact on journeys by bus and heavy and light rail modes caused by the Proposed Scheme will be identified from the traffic and transport assessment and the transport modelling results and is defined as any of the following where this lasts for more than four consecutive weeks in any 12 month period:

- changes of more than 10% in a majority of journey times by rail based modes;
- changes in journey distance by bus of more than 400m in urban areas and 1km in rural areas;
- a relevant delay, disruption or overcrowding impact affecting the public transport network over a wide area; and
- a relevant change to service frequency, capacity, loss of through connections or reduction in hours of operation.

3.2.2 The journey times to be considered are the typical journey times that would be expected over the additional distance introduced as a result of the intervention, rather than specifically those of individual passenger journeys.

Stage 2 – refinement of criteria

3.2.3 The criteria shown in Tables 3 and 4 should be applied in Stage 2, with different criteria being applied in the rural and urban areas. The bus and train profiles relating to low, medium and high frequencies are intended to reflect the numbers of people using the routes.

Table 3: Criteria for Stage 2 assessment - public transport delay, rural

ASSESSMENT OF PUBLIC TRANSPORT DELAY DURING CONSTRUCTION - RURAL							
Magnitude of impacts							
Criteria		**Not significant**	**Minor**		**Moderate**		**Major**
Percentage change in route end-to-end journey time		<10%	10-20%		20-40%		40% or more
Distance change		<1km	1-2km		2-4km		4km or more
Significance of effect							
No. of travellers affected/duration of impact		<4 weeks	4 weeks-4 months	4 months or more	4 weeks-4 months	4 months or more	>4 weeks
<3 buses or trains/hr	**Low**	Not significant	Minor	Minor	Minor	Moderate	Moderate
Between 3-6 buses or trains/hr	**Medium**	Not significant	Minor	Moderate	Moderate	Major	Major
>6 buses or trains/hr	**High**	Not significant	Moderate	Moderate	Major	Major	Major

Table 4: Criteria for Stage 2 assessment - public transport delay, urban

ASSESSMENT OF PUBLIC TRANSPORT DELAY EFFECTS DURING CONSTRUCTION - URBAN							
Magnitude of impacts							
Criteria		**Not significant**	**Minor**		**Moderate**		**Major**
Percentage change in route end-to-end journey time		<10%	10-20%		20-40%		40% or more
Distance change		<400m	400-800m		800-1,200m		1,200m or more
Significance of effect							
No. of travellers affected/duration of impact		<4 weeks	4 weeks-4 months	4 months or more	4 weeks-4 months	4 months or more	>4 weeks
<8 buses or trains/hr OR less than 5,000 passengers/day	**Low**	Not significant	Minor	Minor	Minor	Moderate	Moderate
Between 8-20 buses or trains/hr OR between 5,000 and 10,000 passengers/day	**Medium**	Not significant	Minor	Moderate	Moderate	Major	Major

>20 buses or trains/hr OR more than 10,000 passengers/day	**High**	Not significant	Moderate	Moderate	Major	Major	Major

Guidance on terminology

3.2.4 The following guidance on terminology is highlighted:

- relevant delay, disruption or overcrowding impact are those caused by the Proposed Scheme during the construction phase; and
- the loss of a through connection or direct linkage resulting in the inability to make a direct connection, so requiring some form of interchange to be made.

3.3 Disruption at stations/interchanges

Stage 1 - SMR Criteria

3.3.1 A significant impact on stations/interchanges is defined as a change in the vicinity that lasts for more than four consecutive weeks in any 12 month period including:

- loss of physical linkage for the next stage of the journey;
- loss of or relocation of more than 100m of bus facilities and operations (e.g. of bus stops, passenger waiting facilities, bus stands or operator facilities);
- loss of or relocation of more than 100m of taxi facilities and operations (e.g. taxi stands, passenger waiting facilities or operator facilities); and
- loss of or relocation of more than 100m of 'park-and-ride' facilities or operations (e.g. dropping off areas).

Stage 2 – refinement of criteria

3.3.2 The criteria shown in Table 5 below should be applied in Stage 2.

Table 5: Criteria for Stage 2 assessment - disruption at stations/interchanges

ASSESSMENT OF DISRUPTION AT STATIONS/ INTERCHANGES DURING CONSTRUCTION							
Magnitude of impacts							
Criteria		**Not significant**	**Minor**		**Moderate**		**Major**
Change in distance to replacement facility		<100m	100-200m		200-400m		400m or more
Significance of effect							
No. of travellers affected/duration of impact		<4 weeks	4 weeks-4 months	4 months or more	4 weeks-4 months	4 months or more	>4 weeks
See Table 6 below	**Low**	Not significant	Minor	Minor	Minor	Moderate	Moderate
See Table 6 below	**Medium**	Not significant	Minor	Moderate	Moderate	Major	Major
See Table 6 below	**High**	Not significant	Moderate	Moderate	Major	Major	Major

3.3.3 In considering relocation, the convenience of any alterative location should be taken account of and the distance should relate to the change in convenience. Where there are few, if any, passengers affected and the public transport operator would not be adversely affected, judgment should be used to determine whether there is any significant effect and this should be explained in the transport assessment (TA).

3.3.4 An example pen portrait for disruption at stations/interchanges is set out in Table 6, this distinguishes the number of people using the station per day in rural and urban situations. The bus and train profiles relating to low, medium and high usage are again intended to reflect the numbers of people using the routes.

Table 6: Pen portrait for disruption at stations/interchanges

	Rural	**Urban**
Low	<3 buses or trains/hr	<8 buses or trains/hr OR less than 5,000 passengers/day
Medium	Between 3-6 buses or trains/hr	Between 8-20 buses or trains/hr OR between 5,000 and 10,000 passengers/day
High	>6 buses or trains/hr	>20 buses or trains/hr OR more than 10,000 passengers/day

3.3.5 The loss of a through connection or physical linkage results in the inability to make a direct connection, requiring some form of interchange movement to be made. If this occurs, then a judgement should be made as to how the movement would be made

and this should then be assessed using the public transport delay criteria in Tables 5 and 6.

3.4 Traffic flows and delays to vehicle occupants

Stage 1 - SMR criteria

3.4.1 A significant change in driver/vehicle passenger delay (including delays to bus and coach passengers) is defined as any one of the following:

- a diversion for more than four consecutive weeks in any 12 month period that leads to an increase in journey length of more than 1km on a route carrying more than 100 vehicles per day, or 5km on a route carrying more than 40 vehicles per day, or 10km on any other route;
- where a significant change in delay relating to junction congestion resulting from the construction of the Proposed Scheme is forecast in the traffic and transport assessment and the outputs from the traffic modelling. The junctions for consideration will be discussed with the local highways authority, based on the increase in the level of congestion at the relevant location. This will be measured either as the forecast ratio of flow to capacity or degree of saturation; and
- where there is a change in traffic flow along a road link and the capacity of that link is constrained to a greater extent than the junctions along it, then a similar approach to that set out below will be used to assess potential delays to road users.

3.4.2 A change in traffic levels can result in changes to traffic related severance for non-motorised road users, particularly pedestrians using or seeking to cross a road. A significant change is defined as a 30% increase in traffic flows (heavy goods vehicles (HGVs) or all vehicles)[2], where the increase is greater than 40 vehicles per day in urban areas or 10 vehicles per day in rural areas.

3.4.3 Where HGV traffic, including HS2 related traffic, is less than 10% of total traffic, the significance level of any adverse effect would be reduced such that, for example, what would otherwise be assessed as a moderate significant effect would be considered to be a minor significant effect.

3.4.4 Where the road affected by increased traffic levels is not, in any case, suitable for pedestrians crossing (such as a high speed dual carriageway) or safe and adequate crossing points exist, increased traffic levels would not generally be considered significant in relation to traffic related severance for non-motorised users. Similarly, where there are existing pedestrian crossings the significance level of any adverse effect may be reduced.

[2] Based on The Institute of Environmental Assessment, Guidelines for the Environmental Assessment of Road Traffic, 1993.

Stage 2 – refinement of criteria

3.4.5 The above criteria will be used to reflect the impacts of: changes to traffic flows in terms of: changes to congestion; changes to journey lengths due to diversions; and changes to the difficulty (traffic related severance) for pedestrians crossing the road, where there may be a lack of safe adequate pedestrian crossing facilities.

3.4.6 Effects that are of duration less than 4 consecutive weeks in any 12 month period will be assessed as being not significant.

3.4.7 Changes in overall flows will be related to the Annual Average Weekday Traffic (AAWT) flows. Where AAWT flows are not available, the criteria should be applied for those periods assessed e.g. such as 12 hour, AM or PM peak hour, with the vehicle number thresholds adjusted accordingly. Congestion indicators will be measured based on the forecast ratio of flow to capacity (RFC), degree of saturation (DoS) or the practical reserve capacity (PRC), generally for the AM and PM peak hours. Where congestion is likely to be higher outside the AM and PM peaks due to HS2 impacts or background conditions such that the effect on congestion will be greater in such periods, relevant periods should be assessed.

3.4.8 The transport assessment will provide the following information where the capacities of a junction are assessed, as follows:

- the congestion indicator for an approach where it increases to over 85% during the construction of the Proposed Scheme and the increase is 2% or more due to the Proposed Scheme; or
- where the congestion indicator for an approach is over 85% in the baseline and during the construction of the Proposed Scheme increases by 2% or more due to the Proposed Scheme.

3.4.9 This criterion can be simplified to a single test where the congestion indicator for an approach is over 87% with HS2 construction traffic and during the construction of the Proposed Scheme it is increased by 2% or more.

3.4.10 This process will identify those junctions affected by construction of the scheme. The criteria shown in Tables 7 to 10 should be applied in Stage 2 as appropriate. These tables relate to the changes associated with the introduction of the Proposed Scheme, over and above those without the scheme.

3.4.11 The assessment of the change in junction capacity will draw upon a range of techniques as appropriate to the location. Where a well validated network traffic model is available and network wide impacts can be expected, this would generally be used to identify the impacts.

3.4.12 In instances where a robust traffic model is not available (e.g. in some rural areas), there may be a difficulty in establishing the congestion indicators for the junctions potentially impacted by the additional traffic. In these situations, 'rule of thumb' assessments based on professional judgement (such as those set out in Table 9) of junction throughputs and link capacity can be used to identify potential areas of concern and where this is the case local models should be considered as necessary.

Junction capacities of minor roads with other roads will not be modelled, although they may be qualitatively assessed.

3.4.13 Increases in traffic may also have other impacts which will be identified and may need to be assessed by other disciplines.

Table 7: Criteria for Stage 2 assessment – traffic severance for non-motorised users due to changes in traffic flows

ASSESSMENT OF TRAFFIC SEVERANCE FOR NON-MOTORISED USERS DUE TO CHANGES IN TRAFFIC FLOWS DURING CONSTRUCTION							
Magnitude of impacts							
Criteria		**Not significant**	**Minor**	**Moderate**			**Major**
Increase in traffic flows (HGVs or all vehicles), where the increase is greater than 40 vehicles per day in urban areas or 10 vehicles per day in rural areas		<30%	30-60%	60-120%			120% or more
Significance of effect							
No. of travellers affected/duration of impact		<4 weeks	4 weeks-4 months	4 months or more	4 weeks-4 months	4 months or more	>4 weeks
Road can be safely and easily crossed (<250 veh/hr inc. Proposed Scheme traffic) or there are safe crossing facilities available	**Low**	Not significant	Minor	Minor	Minor	Moderate	Moderate
Road moderately difficult to cross safely (250-750 veh/hr inc. Proposed Scheme traffic) and there is a lack of safe crossing facilities available	**Medium**	Not significant	Minor	Moderate	Moderate	Major	Major
Road difficult to cross safely, controlled crossing facility required (>750 veh/hr inc. Proposed Scheme traffic) and there is a lack of safe crossing facilities available	**High**	Not significant	Moderate	Moderate	Major	Major	Major

Table 8: Criteria for Stage 2 assessment – traffic flows and delays to vehicle occupants (traffic diversions)

ASSESSMENT OF TRAFFIC FLOWS AND DELAYS TO VEHICLE OCCUPANTS (Traffic Diversions) DURING CONSTRUCTION							
Magnitude of impacts							
Criteria		**Not significant**	**Minor**	**Moderate**	**Major**		
Diversion distance change	**Roads carrying >100 veh/day**	<1km	1-2km	2-4km	>4km		
	Roads carrying >40 veh/day	<5km	5-7.5km	7.5-15km	>15km		
	Any other route	<10km	10-15km	15-20km	>20km		
Significance of effect							
No. of travellers diverted/duration of impact		<4 weeks	4 weeks-4 months	4 months or more	4 weeks-4 months	4 months or more	>4 weeks
Between 100-1,000 veh/day	**Low**	Not significant	Minor	Minor	Minor	Moderate	Moderate
Between 1,000-10,000 veh/day	**Medium**	Not significant	Minor	Moderate	Moderate	Major	Major
>10,000 veh/day	**High**	Not significant	Moderate	Moderate	Major	Major	Major

Table 9: Criteria for Stage 2 assessment – traffic flows and delays to vehicle occupants (traffic congestion) where detailed traffic models not available, generally only in rural areas

ASSESSMENT OF TRAFFIC FLOWS AND DELAYS TO VEHICLE OCCUPANTS (Traffic Congestion) DURING CONSTRUCTION –where detailed traffic models not available								
Magnitude of impacts								
Criteria		**Not significant**	**Minor**		**Moderate**		**Major**	
Change in peak hour two-way traffic flow		<5%	<100 veh/hr		100-250 veh/hr		>250 veh/hr	
Peak hour two-way traffic flow including Proposed Scheme traffic		<500 veh/hr	>500 veh/hr		>500 veh/hr		>500 veh/hr	
Reserve capacity (including Proposed Scheme traffic) at non-minor road junctions or links		>15%	8-15%		2-8%		<2%	
Significance of effect								
No. of travellers affected/duration of impact		<4 weeks	4 weeks – 4 months	more than 4 months	4 weeks – 4 months	more than 4 months	4 weeks – 4 months	more than 4 months
<2% change in reserve capacity	**Very Low**	Not significant	Not significant	Not significant	Not significant	Not significant	Not significant	Not significant
2 -5 % change in reserve capacity	**Low**	Not significant	Minor	Minor	Minor	Minor	Minor	Moderate
Between 5-10% change in reserve capacity	**Medium**	Not significant	Minor	Minor	Minor	Moderate	Moderate	Major
>10% change in reserve capacity	**High**	Not significant	Minor	Minor	Moderate	Major	Moderate	Major

Table 10: Criteria for Stage 2 assessment – traffic flows and delays to vehicle occupants (traffic congestion), where detailed traffic models available, generally urban areas

ASSESSMENT OF TRAFFIC FLOWS AND DELAYS TO VEHICLE OCCUPANTS (Traffic Congestion) DURING CONSTRUCTION - where detailed traffic models available								
Magnitude of impacts								
Criteria		**Not significant**	**Minor**		**Moderate**		**Major**	
Future with-scheme Congestion Indicator (junction or link)		<87%	87 - 92%		92 - 98%		98% or more	
Significance of effect								
No. of travellers affected/duration of impact		<4 weeks	4 weeks – 4 months	more than 4 months	4 weeks – 4 months	more than 4 months	4 weeks – 4 months	more than 4 months
<2% change in congestion indicator	**Very Low**	Not significant	Not significant	Not significant	Not significant	Not significant	Not significant	Not significant
2-5% change in congestion indicator	**Low**	Not significant	Minor	Minor	Minor	Minor	Minor	Moderate
Between 5-10% change in congestion indicator	**Medium**	Not significant	Minor	Minor	Minor	Moderate	Moderate	Major
>10% change in congestion indicator	**High**	Not significant	Minor	Minor	Moderate	Major	Moderate	Major

3.5 Parking and loading

Stage 1 - SMR criteria

3.5.1 The SMR defines the significance criteria as set out below:

3.5.2 A significant impact arising from the Proposed Scheme on parking and loading, where facilities are identified to be heavily used, is defined as a change for more than four consecutive weeks in any 12 month period of:

- a predicted increase of 10 or more, or 10%, whichever is the greater, in on-street parking demand in the vicinity of a station/interchange;
- a loss of any designated on-street or off-street spaces, including spaces for disabled persons, buses, taxis, doctors, ambulances, police vehicles and, car club bays;
- a loss of ten or more, or 10%, whichever is the greater, of restricted on-street parking (such as residents' parking bays) or private off-street car parking spaces;
- a loss of ten or more, or 10%, whichever is the greater, off-street station car parking spaces;
- a loss of ten or more, or 10%, whichever is the greater, pedal or motorcycle parking spaces; and
- a loss of 10% or more designated loading bay spaces or facilities.

3.5.3 Any loss of parking should, where relevant, be judged against both the absolute and the percentage change and whichever calculation results in the greater number of spaces takes precedence. As an example, with a 50 space car park the absolute trigger would be a loss of 10 spaces while the 10% reduction would be five. The significance criteria would be met only with a 10 space reduction. Conversely, with a 1,000 space car park, a 10% reduction would be 100 spaces and it is this level of reduction that would be required to create a significant effect.

3.5.4 Where the parking facilities are not designated or are not well used or the use can be expected to be removed as a result of the Proposed Scheme then any loss should not be considered significant.

Stage 2 – refinement of criteria

3.5.5 The criteria shown in Table 11 should be applied in Stage 2.

Table 11: Criteria for Stage 2 assessment – parking and loading

ASSESSMENT OF PARKING AND LOADING DURING CONSTRUCTION							
Magnitude of impacts							
Criteria		**Not significant**	**Minor**		**Moderate**		**Major**
Change in parking demand (number or %)		<10	10-20		20-40		>40
Change in number of designated parking spaces		0	1		2-4		4 or more
Change in availability of cycle or motorcycle spaces (number or %)		<10	10-20		20-40		>40
Significance of effect							
Proximity of alternative parking spaces/duration of impact		<4 weeks	4 weeks-4 months	4 months or more	4 weeks-4 months	4 months or more	>4 weeks
<100m	**Low**	Not significant	Minor	Minor	Minor	Moderate	Moderate
Between 100-250m	**Medium**	Not significant	Minor	Moderate	Moderate	Major	Major
>250m	**High**	Not significant	Moderate	Moderate	Major	Major	Major

Guidance on terminology

3.5.6 The following guidance on terminology is highlighted:

- heavily used – does a loss of spaces cause a deficit that cannot be accommodated; and
- loss of designated spaces – where possible these should be replaced and if necessary reallocated from other nearby provision.

3.6 Vulnerable road user delay, amenity and ambience

3.6.1 The terminology of vulnerable road user within this section relates to all pedestrian, cyclists and equestrians and should not be considered to relate solely to those with mobility impairment.

Stage 1 - SMR criteria

3.6.2 Where there are additional delays or changes to ambience of routes used by vulnerable road users, impacts of delays to pedestrians, cyclists, equestrians and others will be assessed based on changes in the 'person-minutes' of the journey times of pedestrians and other non-motorised. It should be noted that impacts due to additional traffic making it more difficult to cross the road will be considered against the traffic flows criteria and will not be part of the assessment for vulnerable road user delay. Similarly, the impact of diversion of footpaths or cycle routes, should be reported against the separate severance topic.

3.6.3 The following information will be addressed:

- numbers of pedestrians, cyclists, equestrians and others;
- changes in journey time in minutes arising from the delays; and
- changes in ambience (journey quality) of the route used.

3.6.4 Additional delays and changes in ambience will be defined in proportion to the scale of the impacts being assessed, for example as not significant (less than one minute), minor (between one and two minutes), moderate (between two and three minutes) and major (greater than three minutes); and the numbers of travellers affected per day as: minor (less than 200 in total), moderate (between 200 and 1000) and major (greater than 1000).

3.6.5 The significance of the impacts of changes in journey time is based on the matrix shown in Table 12.

Table 12: Significance levels for travellers affected by delay during construction

	Journey time changes		
Number of travellers affected	**Minor**	**Moderate**	**Major**
Minor	Neutral	Neutral	Minor
Moderate	Neutral	Minor	Moderate
Major	Minor	Moderate	Major

Source: HS2 Phase One SMR Addendum (https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/260153/Vol5_Scope_and_methodology_report_addendum_CT-001-000.2.pdf)

3.6.6 In addition, the convenience and attractiveness of the routes for vulnerable users will be considered. This should be assessed in relation to the scale of any change although this will require a more qualitative assessment. WebTAG Unit 3.3.13[3] The Journey Ambience Sub-objective, describes the assessment of ambience, which includes traveller's amenity. Traveller's journey ambience can be affected by:

- traveller care;
- travellers' views; and
- traveller stress.

3.6.7 Traveller care for pedestrians, cyclists, equestrians and others will be considered in relation to changes to the provision and design of facilities (e.g. footpaths, cycle lanes and crossings, information) as well as their cleanliness and environment.

[3] WebTAG Unit 3.3.13 The Journey Ambience Sub-objective now subsumed in Department for Transport, TAG Unit A4.1 Social Impact Appraisal, January 2014.

3.6.8 The extent to which travellers can see the landscape or townscape view will vary with the relative height of the Proposed Scheme and the surrounding ground, vegetation, buildings and structures. Views can be categorised as providing:

- no view - where the route is in a deep cutting, a tunnel or surrounded by environmental barriers;
- restricted view - where there are frequent cuttings, tunnels or barriers;
- intermittent view - where there are shallow cuttings or barriers; and
- open view - where the view extends over many miles.

3.6.9 Traveller stress is the adverse mental and physiological effects experienced by travellers. Three main factors influence traveller stress:

- frustration;
- fear of potential accidents; and
- route uncertainty.

3.6.10 Taken together, these can lead to feelings of discomfort, annoyance, frustration or fear culminating in physical and emotional tension that detracts from the quality and safety of a journey.

3.6.11 Assessments will be made of the traveller care, travellers' views and traveller stress ambience factors in relation to the topics in Table 13. These assessments will consider changes due to the impact of the Proposed Scheme on each of these sub-factors as relevant using a simple three point scale (i.e. better, neutral or worse than existing ambience).

Table 13: Environment - Journey ambience

Factor	Sub-factor	Better	Neutral	Worse
Traveller care	Facilities			
	Cleanliness			
	Information			
	Environment			
Travellers' views	-			
Traveller stress	Frustration			
	Fear of potential accidents			
	Route uncertainty			

3.6.12 An overall impact score for the quality of a journey will be determined using the following guidelines:

- the overall assessment is likely to be neutral if the assessment is neutral for all or most of the sub-factors, or improvements on some sub-factors are generally balanced by deterioration on others;
- if the change in impact across the sub-factors is, on balance, for the better, the assessment is likely to be beneficial, and, conversely, it is likely to be adverse if there is an overall change for the worse;
- the overall assessment is likely to be minor (beneficial or adverse) where the numbers of travellers affected is low (less than 200 a day);
- the overall assessment is likely to be major (beneficial or adverse) where the numbers of travellers affected is high (more than 1,000 per day); and
- the overall assessment is likely to be moderate (beneficial or adverse) in all other cases.

3.6.13 The methodology set out above will be applied to the Proposed Scheme on a locational basis where ambience issues for pedestrian, cyclists, equestrians and others are considered likely to be of concern.

Stage 2 – refinement of criteria

3.6.14 Where there are impacts in delays to pedestrians, cyclists, equestrians and other vulnerable road users they will be assessed based on changes in the 'person-minutes' of the journey times of pedestrians and other non-motorised travellers.

3.6.15 As noted, to avoid double counting, increased journey times arising from, for example, diversion of footpaths or cycle routes, should be reported only once and this will be undertaken against the severance topic discussed in Section 3.8. Similarly, delays due to increased traffic should be reported against the traffic flows topic discussed in Section 3.4. Against this topic, changes in journey time due to delays arising from, for example, increased pedestrian crowding and congestion or new signal controls should be reported.

3.6.16 Effects that are of duration less than 4 consecutive weeks in any 12 month period will be assessed as being not significant.

3.6.17 The criteria shown in Table 14 should be applied in Stage 2.

Table 14: Criteria for Stage 2 assessment – vulnerable road user delay, amenity and ambience

ASSESSMENT OF VULNERABLE ROAD USER DELAY, AMENITY AND AMBIENCE EFFECT DURING CONSTRUCTION							
Magnitude of impacts							
Criteria		**Not significant**	**Minor**		**Moderate**		**Major**
Additional journey time delay due to pedestrian crowing/congestion or additional barriers such as signals		< 1 min	1-2 mins		2-3 mins		3 or more mins
Significance of effect							
No. travellers affected/ Duration of impact		<4 weeks	4 weeks-4 months	4 months or more	4 weeks-4 months	4 months or more	>4 weeks
<200 /day	**Low**	Not significant	Not significant	Not significant	Not significant	Not significant	Minor
Between 200-1,000 /day	**Medium**	Not significant	Not significant	Not significant	Minor	Minor	Moderate
>1,000 /day	**High**	Not significant	Minor	Minor	Moderate	Moderate	Major

3.7 Accidents and safety

Stage 1 - SMR criteria

3.7.1 Significant impacts on accidents and safety risks will be defined for links and junctions as follows:

- links and junctions for which data is available that have experienced on average more than nine personal injury accidents (PIA) in total, in a three-year period, and which would be subject to an increase of 30% or more in total traffic flow during construction for a period of more than four consecutive weeks in any 12 month period.

3.7.2 Where accident data has been collected for a period greater than three years, the number of accidents should be pro-rata to represent three years of data. Thus, for example, if five years of data were available, the number of accidents being considered would be multiplied by 3/5 (i.e. 0.6) and then the resultant number would be compared to the threshold of 9 accidents in total in the desired three year period. The grouping of accidents to establish whether the criteria of nine or more recorded PIA in total over a three year period is exceeded should be based upon the following definition of clusters of accidents:

- nine or more recorded PIA in total over a three year period within about 20m of any road junction; or
- nine or more recorded PIA in total over a three year period within about 150m along any road link.

Stage 2 – refinement of criteria

3.7.3 The criteria shown in Table 15 should be applied in Stage 2. This requires that there is a history of some accidents and that there is increased traffic as a result of HS2 construction.

Table 15: Criteria for Stage 2 assessment – accidents and safety

ASSESSMENT OF ACCIDENTS AND SAFETY DURING CONSTRUCTION					
Magnitude of impacts					
Criteria		**Not significant**	**Minor**	**Moderate**	**Major**
Change in Annual Average Daily Traffic (AADT) flow		<30%	30-60%	60-120%	120% or more
Number of PIAs within 20m of any impacted junctions		<9	9 or more	9 or more	9 or more
Number of PIAs within any 150m section of impacted road links		<9	9 or more	9 or more	9 or more
Significance of effect					
Number of travellers affected					
10% or more below average benchmark national accident rate for category of road	**Low**	Not significant	Minor	Minor	Moderate*
Within +/- 10% of the average benchmark national accident rate for category of road	**Medium**	Not significant	Minor	Moderate*	Major*
10% or more above average benchmark national accident rate for category of road	**High**	Not significant	Moderate*	Major*	Major*

Note: * will be subject to further analysis within the transport assessment process.

3.7.4 Professional judgement should be used in considering whether or not the future flows are likely to increase the risks of accidents. This should include consideration of the local conditions on the highways and junctions and the factors causing the accidents. Sections of roads or junctions that have an identifiable cluster or gathering of accidents should be identified and addressed as necessary where there is additional HS2 related traffic. Consideration should be given to the expected typical national average accident rate on this category of road, and whether or not this is being exceeded.

3.8 Severance

Stage 1 - SMR criteria

3.8.1 Severance due to, for example, extended travel distances or broken links can affect travellers using non-motorised modes, especially pedestrians. Where reasonable, practically and economically, public footpaths and routes will be reinstated or convenient alternatives provided. Cyclists and equestrians are less susceptible to severance because they can travel more quickly than people on foot, although there

may still be significant impacts on these groups. Severance[4] effects will be classified according to the following four broad levels: no impact, minor, moderate and major.

3.8.2 To ensure a consistent approach, the classification and assessment will be based only on the characteristics that would exist assuming the movement was made by a pedestrian unless a change in route is only relevant for cyclists and/or equestrians in which case the distances set out as having the potential to result in significant effects should be adjusted accordingly. The categories of effect are discussed below.

3.8.3 Minor: In general, the current journey pattern is likely to be maintained, but there may be some hindrance to movement for example:

- pedestrians at-grade crossing of a new road carrying less than 8,000 vehicles per day (annual average daily traffic - AADT); or
- a new bridge which will need to be climbed or a sub-way traversed; and/or
- journey lengths being increased by up to 100-250m (less than 100m increase in journey length is considered to be of no impact).

3.8.4 Moderate: Some residents, particularly children and elderly people, are likely to be dissuaded from making trips. Other trips will be made longer or less attractive, for example:

- two or more of the hindrances set out under `minor' applying to an individual journey; or
- pedestrians at-grade crossing of a new road accommodating between 8,000-16,000 vehicles per day (AADT) in the opening year; and/or
- journey lengths being increased by 250 – 500m.

3.8.5 Major: People are likely to be deterred from making trips to an extent sufficient to induce a change in their habits. This could lead to a change in the location of centres of activity or in some cases to a permanent loss to a particular community. Alternatively, considerable hindrance will be caused to people making their existing journeys. Such impacts can result from:

- pedestrians at-grade crossing of a new road carrying over 16,000 vehicles per day (AADT) in the opening year;
- journey lengths being increased by over 500m; and/or
- three or more of the hindrances set out under 'minor' or two or more set out under 'moderate'.

3.8.6 An overall assessment for the option will then be based on the following guidelines (in each case, the assessment is beneficial if severance is reduced and adverse if severance is increased):

[4] Based on Department for Transport (DfT) WebTAG Unit 3.6.2 now subsumed in Department for Transport, TAG Unit A4.1 Social Impact Appraisal, January 2014 and Design Manual for Roads and Bridges (DMRB) Volume 11, Section 3, Part 8, June 1993.

- the overall assessment is likely to be of negligible impact if increases in severance are broadly balanced by relief of severance;
- the overall assessment is likely to be minor where change in severance is slight or the total numbers of people affected across all levels of severance is minor (less than 200 per day);
- the overall assessment is likely to be major where the change in severance is major, and affects a moderate or high number of people or the total numbers of people affected across all levels of severance is major (greater than 1,000 per day); and
- the overall assessment is likely to be moderate where greater than 200 and less than 1,000 people per day are affected.

3.8.7 Table 16 sets out the criteria presented in the HS2 Phase One SMR Addendum[5]. This is equivalent to WebTAG's guidance on how severance without and with schemes are combined to estimate the significance of the effects in terms of severance.

Table 16: Assessment of change in severance scoring

	Change in severance scoring with the Proposed Scheme			
Numbers of travellers affected	**Not significant**	**Minor**	**Moderate**	**Major**
Minor	Not significant	Minor	Minor	Minor*/Moderate**
Moderate	Not significant	Minor	Moderate	Major
Major	Not significant	Minor	Major	Major

Notes * duration between 4 weeks and 4 months; and
** duration 4 months or more

3.8.8 Effects that are of duration of less than 4 consecutive weeks in any 12 month period will be assessed as being not significant.

Stage 2 – refinement of criteria

3.8.9 The definition of significance in Table 17 includes the criteria in paragraphs 3.8.3 to 3.8.6 to assess the change in severance impact and the numbers of travellers affected as from Table 16.

3.8.10 The assessment criteria shown in Table 17 should be applied in Stage 2.

[5] (https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/260153/Vol5_Scope_and_methodology_report_addendum_CT-001-000.2.pdf)

Table 17: Criteria for Stage 2 assessment – severance

ASSESSMENT OF SEVERANCE DURING CONSTRUCTION									
Magnitude of impacts									
Criteria		**Not significant**	**Minor**		**Moderate**		**Major**		
Incremental hindrances: additional roads with at-grade pedestrian crossings or additional bridges/subways.		none	one		2 or more minor		3 or more minor or 2 or more moderate		
Veh/day for additional at grade crossings to be traversed		N/A	<8,000		8,000-16,000		16,000 or more		
Change in journey length		<100m	100-250m		250-500m		500-1,500m		1,500m or more
Significance of effect									
No. travellers affected/ Duration of impact		<4 weeks	4 weeks-4 months	4 months or more	4 weeks-4 months	4 months or more	4 weeks-4 months	4 months or more	4 weeks or more
<200 people/day	**Low**	Not significant	Minor	Minor	Minor	Minor	Minor	Moderate	Moderate
Between 200-1,000 people/day	**Medium**	Not significant	Minor	Minor	Moderate	Moderate	Major	Major	Major
>1,000 people/day	**High**	Not significant	Minor	Minor	Major	Major	Major	Major	Major

3.9 Waterways

Stage 1 - SMR criteria

3.9.1 The document Third Party Works Procedures, Section 2, Code of Practice, British Waterways, 2012[6] (Sections 4.1 – 4.3) identifies the requirements that have to be followed in relation to works affecting the navigation or amenity of canals. In summary, these are that generally no stoppages of the canal or navigation or towpath will be allowable, except for technical reasons. Stoppages must be discussed and agreed in advance with Canal & River Trust (formerly known as British Waterways) and all the duration of stoppages must be minimised. For the purpose of the ES, a significant stoppage is defined as occurring when an unbroken stoppage exceeding six weeks in duration is required, as this is when specific arrangements regarding the transfer of boats around the works by road may be required.

Stage 2 – refinement of criteria

3.9.2 For the purpose of the ES, a stoppage of less than six weeks will be considered not significant. Significant effects arising from stoppages are defined as:

- minor: when an unbroken stoppage exceeding six weeks but less than 12 weeks in duration is required;
- moderate: when an unbroken stoppage exceeding 12 weeks but less than 24 weeks is required; and
- major: when an unbroken stoppage exceeding 24 weeks is required.

3.9.3 The Canal & River Trust also require that towing paths must remain open wherever possible. If a diversion is unavoidable, these should be localised. They may be used by the Canal & River Trust maintenance plant and be of a standard to allow continued use by existing visitors – walkers, anglers, people with disabilities, cyclists etc. Only as an unusual event would towing paths be permitted to be used for access to the temporary and permanent works for the Proposed Scheme because of conflict with visitors and the unsuitability of the towing path for vehicular use.

3.9.4 Any impacts on pedestrians, cyclists, mobility impaired persons and equestrians using the towing paths should be assessed in relation to the vulnerable road user and ambience heading and associated criteria.

4 Significance criteria for operational assessment

4.1 Introduction

4.1.1 The criteria outlined in this chapter will be used to assess the significance of traffic and transport impacts and effects during the operational phase of the Proposed Scheme.

[6] British Waterways (2012), Third Party Works Procedures.

4.2 Public transport delay

Stage 1 - SMR criteria

4.2.1 Significant permanent impacts on journeys by bus and heavy and light rail affected by the Proposed Scheme will be identified from the traffic and transport assessment and the transport modelling results; and are defined as any of the following:

- a 10% change in a majority of journey times by any public transport mode; and
- a change in journey distances by bus of more than 400m in urban areas and 1km in rural areas.

4.2.2 In the consideration of these criteria for the construction phase, as described in paragraph 3.2.1, account will be had of changes in journey times and distances; delays, disruption, overcrowding; and changes to service frequencies, capacity, loss of through connections and reductions in hours of services. Whilst many of these impacts will be taken account of within the design of the facilities, they will also be assessed for the operational phase of the Proposed Scheme. If there are any significant effects these will be reported.

4.2.3 The journey times to be considered are the typical journey times that would be expected over the additional distance introduced as a result of the intervention, rather than specifically those of individual passenger's journeys.

Stage 2 – refinement of criteria

4.2.4 The criteria shown in Tables 18 and 19 should be applied in Stage 2, respectively in rural and urban situations.

Table 18: Criteria for Stage 2 assessment – public transport delay, rural

ASSESSMENT OF PUBLIC TRANSPORT DELAY DURING OPERATION - RURAL						
Magnitude of impacts						
Criteria			**Not significant**	**Minor**	**Moderate**	**Major**
Percentage change in route end-to-end journey time			<10%	10-20%	20-40%	40% or more
Distance change			<1km	1-2km	2-4km	4km or more
Significance of effect						
No. of travellers affected	**<3 buses or trains/hr**	**Low**	Not significant	Minor	Moderate	Moderate
	Between 3-6 buses or trains/hr	**Medium**	Not significant	Moderate	Major	Major
	>6 buses or trains/hr	**High**	Not significant	Moderate	Major	Major

Table 19: Criteria for Stage 2 assessment – public transport delay, urban

ASSESSMENT OF PUBLIC TRANSPORT DELAY EFFECTS DURING OPERATION - URBAN						
Magnitude of impacts						
Criteria			**Not significant**	**Minor**	**Moderate**	**Major**
Percentage change in route end-to-end journey time			**<10%**	**10-20%**	**20-40%**	**40% or more**
Distance change			**<400m**	**400-800m**	**800-1,200m**	**1,200m or more**
Significance of effect						
No. of travellers affected	**<8 buses or trains/hr** **OR** **<5,000 passengers/day**	**Low**	Not significant	Minor	Moderate	Moderate
	Between 8-20 buses or trains/hr **OR** **Between 5,000 and 10,000 passengers/day**	**Medium**	Not significant	Moderate	Major	Major
	>20 buses or trains/hr **OR** **Over 10,000 passengers/day**	**High**	Not significant	Moderate	Major	Major

4.3 Station/interchange impacts

Stage 1 - SMR criteria

4.3.1 The SMR defines the significance criteria as impacts that may be caused by additional passengers of the Proposed Scheme arriving and departing at the stations/interchanges. This will be assessed using modelling information, taking account of:

- forecast numbers of additional passengers using the Proposed Scheme;
- local transport conditions at each location;
- resulting increases in crowding and congestion levels arising from increased usage or changed journey patterns arising from the arrival and departure, by all available modes, of passengers using the Proposed Scheme; and
- any loss of physical linkage for the next stage of the journey.

Stage 2 – refinement of criteria

4.3.2 The results from the traffic and transport assessment and modelling will be used to identify if there are any significant journey time, interchange and accessibility changes for travellers. This will include consideration of:

- resulting increases in crowding and congestion levels arising from increased usage or changed journey patterns arising from the arrival and departure, by all available modes, of passengers using the Proposed Scheme. Where relevant these will be quantitatively assessed using the transport models developed within the transport assessment. Criteria that will be assessed include:
  - results of pedestrian capacity modelling, where there is a change (increase) of at least one Fruin Level of Service (LoS)[7]; and
  - likelihood of congestion causing delays at the kerbside or at station facilities e.g. bus station or taxi ranks.
- any loss of physical linkage for the next stage of the journey.

4.3.3 It is however expected that the new transport infrastructure will be designed to cater for the forecast levels of future demands and mitigate any impacts that the Proposed Scheme might otherwise have been expected to cause.

4.3.4 The criteria shown in Table 20 should be applied in Stage 2.

[7] Pedestrian planning and design, 1971, John J Fruin.

Table 20: Criteria for Stage 2 assessment – station/interchange impacts

ASSESSMENT OF DISRUPTION AT STATIONS/ INTERCHANGES DURING OPERATION						
Criteria			**Magnitude of impacts**			
			Not significant	**Minor**	**Moderate**	**Major**
Pedestrian modelling (Fruin LoS)			C or less	D increased by 2 or more levels or E increased by 1 level	E increased by 2 or more levels or F increased by 1 level	F increased by 2 or more levels
		Significance of effect				
No. of travellers affected	**See Table 6 above**	**Low**	Not significant	Minor	Moderate	Moderate
	See Table 6 above	**Medium**	Not significant	Moderate	Major	Major
	See Table 6 above	**High**	Not significant	Moderate	Major	Major

Guidance on terminology

4.3.5 The following guidance on terminology is highlighted:

- resulting increases in congestion levels will be as assessed and informed by the transport assessment and modelling; and
- the loss of a physical linkage is the inability to make a direct connection.

4.4 Traffic flows and delays to vehicle occupants

Stage 1 - SMR criteria

4.4.1 The SMR criteria include that a significant impact in traffic levels (i.e. HGVs and all vehicles) and driver and vehicle passenger delay will be defined as any of the following:

- a permanent diversion that results in an increase in journey length of more 1km;
- where a significant change in delay relating to junction congestion resulting from the operation of the Proposed Scheme is forecast in the traffic and transport assessment and the outputs from the traffic modelling. The junctions for consideration will be discussed with the local Highways Authority, based on the increase in the level of congestion at the location. This will be measured with congestion indicators based on the forecast ratio of flow to capacity (RFC), degree of saturation (DoS) or the practical reserve capacity (PRC); and
- where there is a change in traffic flow along a road link that cause the design capacity to become exceeded and the capacity of that link is constrained to a

greater extent than the junctions along it, then a similar approach to that set out below will be used to assess potential delays to road users.

4.4.2 A change in traffic levels can result in changes to traffic related severance for non-motorised road users, particularly pedestrians using or seeking to cross a road. A significant change is defined as:

- a 10% increase in peak hour two-way traffic flows where the increase is greater than 40 vehicles per day in urban areas or 10 vehicles per day in rural areas; and
- a 30% increase in the average off-peak hour two-way traffic flows where the increase is greater than 40 vehicles per day in urban areas or 10 vehicles per day in rural areas.

4.4.3 Where HGV traffic, including HS2 related traffic, is less than 10% of total traffic, the significance level of any adverse effect would be reduced such that, for example, what would otherwise be assessed as a moderate significant effect would be considered to be a minor significant effect.

4.4.4 Where the road affected by increased traffic levels is not, in any case, suitable for pedestrians crossing (such as a high speed dual carriageway) or safe and adequate crossing points exist, increased traffic levels would not generally be considered significant in relation to traffic related severance for non-motorised users. Similarly, where there are existing pedestrian crossings the significance level of any adverse effect may be reduced.

Stage 2 – Refinement of criteria

4.4.5 The criteria shown in Tables 21 to 24 should be applied in Stage 2 in relation to the impacts and effects during the operational stage of the Proposed Scheme.

4.4.6 These criteria have been developed, to include in the assessment of the operational scenario the same application of "HGV or all vehicle" thresholds as adopted in the assessment of the construction scenario.

4.4.7 The daily HGV or all vehicle thresholds in Table 21 are the same as those adopted in paragraph 3.4.1-3.4.2, although these will, where relevant, be adjusted accordingly to peak hour flows, if necessary, to correspond with the peak hour data that will be used in this assessment.

Table 21: Criteria for Stage 2 assessment – traffic severance for non-motorised users due to changes in traffic flows

ASSESSMENT OF TRAFFIC SEVERANCE FOR NON-MOTORISED USERS DUE TO CHANGES IN TRAFFIC FLOWS DURING OPERATION						
Magnitude of impacts						
Criteria			**Not significant**	**Minor**	**Moderate**	**Major**
Increase in peak hour traffic flows (HGVs or all vehicles) where the increase is greater than 40 vehicles per day in urban areas or 10 vehicles per day in rural areas			<10%	10-20%	20-40%	40% or more
Increase in off-peak hour traffic flows (HGVs or all vehicles) where the increase is greater than 40 vehicles per day in urban areas or 10 vehicles per day in rural areas			<30%	30-60%	60-120%	120% or more
Significance of effect						
No. of travellers affected	**Road can be safely and easily crossed (<250 veh/hr inc. Proposed Scheme traffic), or there are, safe crossing facilities available**	**Low**	Not significant	Minor	Moderate	Moderate
	Road moderately difficult to cross safely (250-750 veh/hr inc. Proposed Scheme traffic) and there is a lack of safe crossing facilities available	**Medium**	Not significant	Moderate	Major	Major
	Road difficult to cross safely, controlled crossing facility required (>750 veh/hr inc. Proposed Scheme traffic) and there is a lack of safe crossing facilities available	**High**	Not significant	Moderate	Major	Major

Table 22: Criteria for Stage 2 assessment –traffic flows and delays to vehicle occupants (traffic diversion)

ASSESSMENT OF TRAFFIC FLOWS AND DELAYS TO VEHICLE OCCUPANTS (Traffic Diversions) DURING OPERATIONS						
Magnitude of impacts						
Criteria			**Not significant**	**Minor**	**Moderate**	**Major**
Diverted distance			<1km	1-5km	5-10km	10km or more
Significance of effect						
No. of travellers affected	**Between 100-1,000 veh/day**	**Low**	Not significant	Minor	Moderate	Moderate
	Between 1,000-10,000 veh/day	**Medium**	Not significant	Moderate	Major	Major
	>10,000 veh/day	**High**	Not significant	Moderate	Major	Major

Table 23: Criteria for Stage 2 assessment – traffic flows and delays to vehicle occupants (traffic congestion), where detailed traffic models not available, generally only in rural areas

ASSESSMENT OF TRAFFIC FLOWS AND DELAYS TO VEHICLE OCCUPANTS (traffic congestion) DURING OPERATION - where detailed traffic models not available						
Magnitude of impacts						
Criteria			**Not significant**	**Minor**	**Moderate**	**Major**
Change in peak hour traffic flow			<2%	N/A	N/A	N/A
Reserve junction capacity (including Proposed Scheme traffic)			>15%	8-15%	2-8%	<2%
Significance of effect						
No. of travellers affected	**<2% change in reserve capacity**	**Very Low**	Not significant	Not significant	Not significant	Not significant
	2-5% change in reserve capacity	**Low**	Not significant	Minor	Minor	Moderate
	Between 5-10% change in reserve capacity	**Medium**	Not significant	Minor	Moderate	Major
	>10% change in reserve capacity	**High**	Not significant	Minor	Major	Major

Table 24: Criteria for Stage 2 Assessment – traffic flows and delays to vehicle occupants (traffic congestion), where detailed traffic models available, generally urban areas

ASSESSMENT OF TRAFFIC FLOWS AND DELAYS TO VEHICLE OCCUPANTS (Traffic Congestion) DURING OPERATION - URBAN						
			Magnitude of impacts			
Criteria			Not significant	Minor	Moderate	Major
Future with-scheme Congestion Indicator (junction or link)			<85%	85 - 92%	92 - 98%	98% or more
			Significance of effect			
No. of travellers affected	<2% change in reserve capacity	Very Low	Not significant	Not significant	Not significant	Not significant
	2-5% change in Congestion Indicator	Low	Not significant	Minor	Minor	Moderate
	Between 5-10% change in Congestion Indicator	Medium	Not significant	Minor	Moderate	Major
	>10% change in Congestion Indicator	High	Not significant	Minor	Major	Major

Guidance on terminology

4.4.8 The following guidance on terminology is highlighted:

- a significant change in delay will be as assessed and informed by the transport assessment.

4.5 Parking and loading

4.5.1 The assessment criteria for the operational phase of the Proposed Scheme will be the same as those described for the longer term impacts that may occur during the construction phase. These are shown in Table 25 below.

Table 25: Criteria for Stage 2 assessment – Parking and loading

ASSESSMENT OF PARKING AND LOADING DURING OPERATION						
			Magnitude of impacts			
Criteria			**Not significant**	**Minor**	**Moderate**	**Major**
Change in parking demand (number or %)			<10	10-20	20-40	>40
Change in number of designated parking spaces			0	1	2-4	4 or more
Change in availability of cycle or motorcycle spaces (number or %)			<10	10-20	20-40	>40
			Significance of effect			
Proximity of alternative parking spaces	**<100m**	**Low**	Not significant	Minor	Moderate	Moderate
	Between 100-250m	**Medium**	Not significant	Moderate	Major	Major
	>250m	**High**	Not significant	Moderate	Major	Major

4.6 Vulnerable road user delay, amenity and ambience

4.6.1 The assessment criteria for the operational phase of the Proposed Scheme are the same as those described for the longer term impacts that may occur during the construction phase. These are shown in Table 26.

Table 26: Criteria for Stage 2 assessment – vulnerable road user delay, amenity and ambience

ASSESSMENT OF VULNERABLE ROAD USER DELAY, AMENITY AND AMBIENCE EFFECT DURING OPERATION						
Magnitude of impacts						
Criteria			**Not significant**	**Minor**	**Moderate**	**Major**
Additional journey time delay due to pedestrian crowing/congestion or additional barriers such as signals			< 1 min	1-2 mins	2-3 mins	3 or more mins
Significance of effect						
No. of travellers affected	**<200 /day**	**Low**	Not significant	Not Significant	Not Significant	Minor
	Between 200-1,000 /day	**Medium**	Not significant	Not significant	Minor	Moderate
	>1,000 /day	**High**	Not significant	Minor	Moderate	Major

4.7 Accidents and safety

4.7.1 The assessment criteria for the operational phase of the Proposed Scheme will be the same as those described in Section 3.7 for the construction phase (see Table 15).

4.8 Severance

4.8.1 The assessment criteria for the operational phase of the Proposed Scheme are the same as those described for the longer term impacts that may occur during the construction phase. These are shown in Table 27.

Table 27: Criteria for Stage 2 Assessment – Severance

ASSESSMENT OF SEVERANCE DURING OPERATION							
Magnitude of impacts							
Criteria			**Not significant**	**Minor**	**Moderate**	**Major**	
Incremental hindrances: additional roads with at-grade pedestrian crossings or additional bridges/subways.			N/A	As below	2 or more minor	3 or more minor or 2 or more moderate	
Veh/day for additional at grade crossings to be traversed			N/A	<8,000	8,000-16,000	16,000 or more	
Change in journey length			<100m	100-250m	250-500m	500-1,500m	1,500m or more
Significance of effect							
No. of travellers affected	**<200 people/day**	**Low**	Not significant	Minor	Minor	Moderate	Moderate
	200-1,000 people/day	**Medium**	Not significant	Minor	Moderate	Major	Major
	>1,000 people/day	**High**	Not significant	Minor	Major	Major	Major

4.9 Waterways

The assessment criteria for the operational phase of the Proposed Scheme will be the same as those described above for the construction phase (see Section 3.9).

Annex M: Waste and material resources – technical notes

The following technical notes are contained in this Annex:

- Waste forecasting and assessment methodology; and
- Rationale for landfill significance criteria.

HS2 Phase 2a West Midlands - Crewe: Technical note: Waste forecasting and assessment methodology

Contents

1 Introduction

1.1 General

1.1.1 This technical note sets out the detailed methodology for the forecasting of waste arisings and the route-wide assessment of the likely significant environmental effects associated with the off-site disposal to landfill of solid waste that will be generated by construction and operation of the Proposed Scheme.

1.1.2 The scope of this technical note covers:

- waste that will be generated by excavation, demolition and construction activities undertaken during the proposed construction period;
- waste that will be generated by occupants of worker accommodation sites during the proposed construction period; and
- waste generated by the operation of the Proposed Scheme.

2 Waste forecast

2.1 General

2.1.1 This section sets out how the quantities of waste likely to be generated during the construction and operational phases of the Proposed Scheme will be forecast.

2.1.2 All waste arisings will be reported in tonnes rounded to the nearest whole number.

Excavated material

2.1.3 Excavated material will be generated to accommodate cuttings, foundation construction sites, drainage excavations and through tunnelling operations etc.

2.1.4 The volume of excavated material to be generated will be determined and converted to mass using a density conversion factor of 2.042 tonnes/m^3 [1].

2.1.5 The quantity of hazardous waste (i.e. unacceptable material Class U2 [2] that will be generated as a result of the excavation of contaminated soils, and which cannot be remediated and reused on- or off-site), will be determined. It will be assumed that all hazardous waste generated by the excavation of contaminated soils will require off-site disposal to a hazardous waste landfill.

2.1.6 Quantities of both excavated material to be reused and surplus excavated material for disposal will be presented in Environmental Statement (ES) Volume 5, Appendices. The likely significant environmental effects associated with the off-site disposal to landfill of surplus excavated material will be assessed.

[1] In line with evidence-based research undertaken to inform the value of the density conversion factor

[2] Department for Transport; *Highways Agency, Manual of Contract Documents for Highway Works, Volume 1 – Specification for Highway Works, Series 600 Earthworks*, http://www.standardsforhighways.co.uk/ha/standards/mchw/vol1/pdfs/600.pdf

Demolition waste

2.1.7 Demolition waste will be generated by the removal of existing buildings, structures and infrastructure elements such as bridges, roads, railways and utilities.

2.1.8 The quantity of waste (in tonnes) that will be generated by specified demolition activities within each community area will be forecast using the 'Net Waste Tool – Demolition Bill of Quantities Estimator'[3] that uses the basic dimensions and typology of buildings to forecast waste arisings.

Construction waste

2.1.9 Waste will be generated by the construction of track, buildings and other structures, including stations, maintenance sheds and stabling yards.

2.1.10 The quantity of waste (in tonnes) that will be generated by specified construction activities within each community area will be forecast using a waste generation rate of 26.4 tonnes/£100,000 of construction value. This waste generation rate has been derived from industry-wide benchmark performance data procured from the Building Research Establishment.[4]

Workers' accommodation site waste

2.1.11 The quantity of waste (in tonnes) that will be generated at worker accommodation sites within each community area will be forecast using a waste generation rate of 0.027 tonnes/person/month. This waste generation rate is derived from the average annual household waste generation in the UK of 407kg/person in 2015[5] and has been adjusted assuming an average 5.5-day working week.[6]

Railway systems waste

2.1.12 Waste arising from the construction of railway system elements shall be forecast using the cost-related construction waste generation rate of 26.4 tonnes per £100,000 of construction spend.

2.1.13 For simple structures, where the dimensions of the structure are known (i.e. length, width and height), rail systems design teams shall determine the quantity of waste likely to be generated by multiplying the total volume of the structure by a suitable material density conversion factor. Material density conversion factors agreed for the Proposed Scheme shall be used.

[3] WRAP Net Waste Tool, http://nwtool.wrap.org.uk/ToolHome.aspx
[4] Building Research Establishment Ltd (2013), *Construction Waste Benchmarks for Railway Projects*
[5] Department for Environment Food and Rural Affairs (2017) Digest of Waste and Resource Statistics – 2017 Edition (revised), https://www.gov.uk/government/statistics/digest-of-waste-and-resource-statistics-2017-edition
[6] Department for Environment, Food and Rural Affairs; Waste and Recycling Statistics https://www.gov.uk/government/organisations/department-for-environment-food-rural-affairs/series/waste-and-recycling-statistics

2.1.14 The quantity of waste likely to be generated by removal of individual railway system elements can also be forecast, where the number of units and weight per unit is known. Weights for individual units agreed for the Proposed Scheme shall continue to be used. These are:

- rail – one tonne per 18.2m (or 60ft) of rail;
- sleepers (hard wood) – 200kg (0.2 tonnes) per sleeper; and
- sleepers (concrete) – 300kg (0.3 tonnes) per sleeper.

2.2 Operational waste

2.2.1 All operational waste forecasts for the Proposed Scheme will be on an annual basis and an assumption of maximum capacity in the first year of operation (2027).

2.2.2 The scope of operational waste forecasting covers:

- railway station and train waste;
- rolling stock maintenance waste;
- ballast track maintenance waste;
- slab track maintenance waste; and
- ancillary infrastructure waste (relating to waste arising from depots, signalling locations and operations and maintenance sites). Waste from 'maintenance sites' in this context excludes the aforementioned rolling stock maintenance waste and track maintenance waste.

2.2.3 Individual waste forecasts for each of the above listed categories will be combined to provide an overall forecast of operational waste arisings.

Railway station and train waste

2.2.4 Railway station and train waste refers to waste that will arise at each station and includes:

- waste from individual functions within stations such as retail units, food and beverage outlets etc.; and
- waste removed from trains, which will be the case at terminating stations only.

2.2.5 There are no railway stations along the route of the Proposed Scheme. No railway station waste will therefore arise. It is recognised that waste will arise at terminal stations on or remote from the Proposed Scheme from passengers travelling on the Proposed Scheme that were not considered as part of the Phase One assessment. However, the quantities of this waste will be relatively small and no significant effect is likely to arise. This waste will therefore be scoped out of the Phase 2a assessment.

Rolling stock maintenance waste

2.2.6 Rolling stock maintenance waste is that which will be generated by the relevant train operating company (or its fleet maintenance contractor) and thus reported separately to ancillary infrastructure waste and track maintenance waste that will be generated by Network Rail.

2.2.7 In the absence of new data from existing train operating companies, the waste generation rate that will be used to forecast rolling stock maintenance waste is the same as that used for Phase One. The waste generation rate has been adopted from British Standard (BS) 5906:2005 Waste Management in Buildings – Code of Practice. This relates to a waste generation rate of 5 litres/m^2/week for an industrial unit, which has been converted to an annual tonnage rate using a waste density conversion factor of 1.16 tonnes/m^3.[7]

2.2.8 The annual quantity of rolling stock maintenance waste (in tonnes) that will be generated will be forecast and reported according to the community area in which it will arise. The Proposed Scheme includes one Infrastructure Maintenance Base - Rail (IMB-R) located in the Staffordshire area. This will be done using a waste generation rate of 0.3 tonnes/m^2/year applied to the gross floor area of the IMB-R.

2.2.9 Where a rolling stock maintenance depot forms part of a larger depot (e.g. that also incorporates ancillary infrastructure and track maintenance facilities), the proportion of floor space provided solely for rolling stock maintenance will be used in the waste generation forecast.

2.2.10 A landfill diversion rate of 80% will apply to rolling stock maintenance waste. This figure has been assumed on the basis of professional judgement taking into account the following information:

- Network Rail's target to divert 60% of operational waste from landfill by 2014 (as applied to ancillary infrastructure waste for this assessment);
- Network Rail's average landfill diversion rate (85% for track maintenance wastes); and
- generic landfill diversion data published by Alstom[8] and Bombardier[9] (both of which have significant business activities in rolling stock maintenance) ranging from 78% to 90%.

Track maintenance waste

2.2.11 Track maintenance waste is that which will be generated and reported separately to ancillary infrastructure waste and rolling stock maintenance waste.

2.2.12 Track maintenance waste will be reported as ballast track maintenance waste; slab track maintenance waste or both, depending on the proposed track installation.

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[7] Based on an average of waste density conversion factors for heavy scrap metal (1.78 tonnes/m3), light scrap metal (0.74 tonnes/m3) and oils, tars and asphalts (0.95t/m3); taken from Tchobanoglous, G., Theisen, H., Vigil, S.A. (1993), *Integrated Solid Waste Management.* Engineering Principles and Management Issues. McGraw-Hill

[8] Alstom has a target to achieve 80% landfill diversion of total waste generated by 2015, against which it had achieved 78% by 2011, http://www.alstom.com/about-us/sustainability/our-way-of-operation/environmental-footprint/recovering-waste/

[9] Data reported by Bombardier's Transportation Group indicates a landfill diversion performance of 84% in 2010, and 90% in both 2011 and 2012

Ballast track maintenance waste

2.2.13 The waste generation rate that will be used to forecast ballast track maintenance waste has been formulated on the basis of data provided by Network Rail.

2.2.14 The annual quantity of ballast track maintenance waste (in tonnes) that will be generated will be forecast according to the total length of track within each community area using a waste generation rate of 8.23 tonnes/km/year. This is the same waste generation rate as used for Phase One.

2.2.15 For any track sections with two or more lines, the distance vector will be scaled up according to the number of lines (e.g. doubled for a twin track, trebled for three lines etc.). This is because the waste generation rate to be used is based on the length of a composite track comprising of two rails, sleepers, clips and ballast etc.

2.2.16 Based on Network Rail's average landfill diversion rate of 85% across a range of material types for ballast track maintenance waste:

- 7.00 tonnes/km/year of waste will be diverted from landfill; and
- 1.23 tonnes/km/year of waste will be landfilled.

Slab track maintenance waste

2.2.17 The waste generation rate that will be used to forecast slab track maintenance waste has been formulated on the basis that the rails and clips will require replacement at regular intervals but the slab itself is effectively maintenance free, having a design life of 60 years.

2.2.18 The annual quantity of slab track maintenance waste (in tonnes) that will be generated will be forecast according to the total length of rail within each community area using a waste generation rate of 0.05495 tonnes/m/year. This waste generation rate is the same as that used for forecasting rail systems waste, specifically the rail component of redundant rail infrastructure.

2.2.19 The distance vector will be scaled up to reflect that single track sections comprise two rails, clips etc.; double track sections comprise of four rails, clips etc.; and so on.

2.2.20 As slab track maintenance waste consists solely of steel rails and clips which can be fully recycled, a landfill diversion rate of 100% shall apply to slab track maintenance waste:

- 0.05495 tonnes/m/year of waste will be diverted from landfill; and
- 0 tonnes/m/year of waste will be landfilled.

Ancillary infrastructure waste

2.2.21 Ancillary infrastructure waste refers to waste that will arise from depots, signalling locations, operations and maintenance sites excluding track maintenance waste and rolling stock maintenance waste (according to the scope of the waste generation rate used).

2.2.22 The waste generation rate that will be used to forecast ancillary infrastructure waste has been formulated on the basis of data provided by Network Rail.

2.2.23 The annual quantity of ancillary infrastructure waste (in tonnes) that will be generated will be forecast according to the total length of track within each community area using a waste generation rate of 0.692 tonnes/km/year. This is the same as the waste generation rate used for Phase One.

2.2.24 For any sections with two or more lines, the distance vector will be scaled up according to the number of lines (e.g. doubled for a twin track, trebled for three lines etc). This is because the waste generation rate to be used is based on the length of a composite track comprising of two rails, sleepers, clips and ballast etc.

2.2.25 Based on the Network Rail target to divert 60% of operational waste from landfill by 2014:

- 0.415 tonnes/km/year of waste will be diverted from landfill; and
- 0.277 tonnes/km/year of waste will be landfilled.

3 Assessment methodology

3.1 Background

3.1.1 There is no recognised methodology or waste significance criteria available to assess the likely significant environmental effects associated with the off-site disposal to landfill of solid waste that will be generated by the construction and operation of the Proposed Scheme.

3.1.2 The assessment methodology that will be used is based on professional judgement and experience with the application of Environmental Impact Assessment (EIA) to Phase One of the Proposed Scheme, rail-related and other large-scale transport infrastructure projects.

3.1.3 The assessment will consider the types and quantities of waste that will be generated during construction and operation and the severity of the likely significant environmental effects that may arise from the quantity of waste requiring off-site disposal to landfill (this being the least preferred waste management option).

3.1.4 This approach takes into account the overall quantity of waste likely to be generated, the types and quantities of waste likely to require off-site disposal to landfill and the projected availability of landfill disposal capacity in the defined study area.

3.2 Legislation and guidance

3.2.1 Assessment and mitigation of the likely significant environmental effects of waste generation will be considered with respect to relevant legislation, policy and guidance governing the management of waste in England. A summary of applicable legislation, policy and guidance is provided below.

Legislation

3.2.2 The key items of relevant legislation are as follows:

- the Waste (England and Wales) Regulations 2011 SI No. 988 (as amended)[10], which transpose the provisions of the 'EU Waste Framework Directive' (2008/98/EC)[11] into English and Welsh legislation;
- the Controlled Waste (England and Wales) Regulations 2012 SI No. 811 (as amended[12], which sets out the definition of controlled waste to which waste management regulatory controls apply;
- the Environmental Permitting (England and Wales) Regulations 2010 SI No. 675 (as amended)[13], which provide a consolidated system for permitting of waste operations (amongst other activities not relevant in this context);
- the Hazardous Waste (England and Wales) Regulations 2005 SI No. 894 (as amended)[14], which set out the regime for the control and tracking of the movement of hazardous waste;
- the List of Wastes (England) Regulations 2005 SI No. 895 (as amended)[15], which provides for the classification of wastes and determination of hazardous wastes; and
- the Site Waste Management Plans Regulations 2008 SI No. 314[16] have been repealed as part of the Defra Red Tape Challenge. The purpose of the site waste management plan was to identify opportunities to design out waste; as well as identifying the types and quantities of waste likely to be produced during construction; the opportunities for sustainable management of the waste to be identified; and to monitor and report on the actual management of these wastes throughout the construction period. HS2 Ltd will apply these principles to the construction of the Proposed Scheme ensuring an integrated approach to the design of the Proposed Scheme, aiming to maximise the beneficial reuse of excavated material where possible, and minimise the generation of waste, which will be facilitated through the implementation of the Code of Construction Practice (CoCP) for the Proposed Scheme.

Policy

3.2.3 The Government Review of Waste Policy in England 2011[17] sets out the Government's long-term strategy for the prevention and management of waste in England. It follows the waste hierarchy approach set out in the EU Waste Framework Directive.

3.2.4 National Planning Policy for Waste[18] along with the National Waste Management Plan for England[19] sets out Government policy on waste planning, which is of relevance to

[10] *Waste (England and Wales) Regulations 2011* SI No. 988 (as amended). Her Majesty's Stationery Office, London
[11] Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on Waste and Repealing Certain Directives
[12] *The Controlled Waste (England and Wales) Regulations 2012* SI No. 811 (as amended). Her Majesty's Stationery Office, London
[13] *The Environmental Permitting (England and Wales) Regulations 2010* SI No. 675 (as amended). Her Majesty's Stationery Office, London
[14] *The Hazardous Waste (England and Wales) Regulations 2005* SI No. 894 (as amended). Her Majesty's Stationery Office, London
[15] *The List of Wastes (England) Regulations 2005* SI No. 895 (as amended). Her Majesty's Stationery Office, London
[16] *The Site Waste Management Plans Regulations 2008 SI No. 314*. Her Majesty's Stationery Office, London
[17] Department for Environment, Food & Rural Affairs (2011), *The Government Review of Waste Policy in England*. Her Majesty's Stationery Office, London
[18] Department for Communities and Local Government (2014), *National Planning Policy for Waste*. Her Majesty's Stationery Office, London https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/364759/141015_National_Planning_Policy_for_Waste.pdf
[19] Department for Environment, Food and Rural Affairs (2013), *National Waste Management Plan for England*. Her Majesty's Stationery Office, London

the management strategy for solid waste generated during the construction and operation of the Proposed Scheme.

3.2.5 Regional and local planning policy, such as Staffordshire and Stoke-on-Trent Joint Waste Core Strategy 2010 - 2026[20], sets out strategic planning policies for the management of waste generated in Staffordshire and elsewhere along the route of the Proposed Scheme. Specifically, these policies seek to minimise the amount of waste generated, increase the reuse and recycling of waste and reduce waste to landfill.

Guidance

3.2.6 Relevant guidance includes The Definition of Waste: Development Industry Code of Practice[21] and the Waste and Resources Action Programme (WRAP) guidance and tools developed to achieve better resource efficiency in construction projects. This includes designing out waste tools such as the Designing out Waste Tool for Civil Engineering and the Net Waste Tool[22].

3.3 Significance criteria

3.3.1 There are no recognised significance criteria against which the likely significant environmental effects associated with the off-site disposal to landfill of solid waste from construction and operation can be assessed.

3.3.2 Significance criteria for the assessment have been derived based on professional judgement and as previously applied to large-scale infrastructure projects. Significance criteria take into account the change in waste arisings overall as a result of the Proposed Scheme, and the severity of the likely significant environmental effects that may arise from the quantity of waste requiring off-site disposal to landfill.

3.3.3 A technical note[23] setting out the landfill significance criteria to be used has been developed and should be read in conjunction with this technical note.

Construction effects

3.3.4 The basis of the assessment of the likely significant environmental effects associated with the off-site disposal to landfill of solid waste from construction will be the forecast of the quantity of construction, demolition and excavation waste to be generated during the proposed construction period. The forecast will also include waste generation associated with the worker accommodation sites, where applicable.

3.3.5 The methodology for forecasting construction, demolition and excavation waste, as well as waste generation associated with worker accommodation sites, is outlined in Section 2 of this technical note.

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/265810/pb14100-waste-management-plan-20131213.pdf

[20] Staffordshire County Council (Adopted 2013), *Staffordshire and Stoke-on-Trent Joint Waste Core Strategy 2010-2026* https://www.staffordshire.gov.uk/environment/planning/policy/thedevelopmentplan/wastelocalplan/Staffordshire-and-Stoke-on-Trent-Joint-Waste-Local-Plan-2010-to-2026-adopted-March-2013.pdf

[21] Contaminated Land: Applications in Real Environments, *Definition of Waste: Development Industry Code of Practice* http://www.claire.co.uk/index.php?option=com_content&view=article&id=210&Itemid=82

[22] Waste and Resources Action Programme; Construction; http://www.wrap.org.uk/category/sector/construction

[23] Technical Note: Rationale for landfill significance criteria (contained the Scope and Methodology Report Addendum, Volume 5: Appendix CT-001-002.

3.3.6 In quantifying waste arisings to landfill, evidence-based assumptions will be applied for construction, demolition and worker accommodation site waste as follows:

- construction waste – landfill diversion rate of 90%;
- demolition waste – landfill diversion rate of 90%; and
- worker accommodation site – landfill diversion rate of 50%.

3.3.7 The quantity of excavated material requiring disposal (surplus excavated material) will be derived from the cut and fill balance for the Proposed Scheme.

3.3.8 It will be assumed that 100% of any hazardous waste arisings will require off-site disposal to a hazardous waste landfill (i.e. zero landfill diversion rate).

3.3.9 Following this, the total quantity of waste requiring off-site disposal to landfill during the proposed construction period (2020 - 2027) will be assessed in relation to the significance criteria to be used.

Operational effects

3.3.10 The assessment of operational effects will rely on the total annual quantity of waste forecast to be generated during the first full year of operation of the Proposed Scheme (i.e. 2027). The operational waste forecast will be undertaken as described in Section 2 of this technical note.

3.3.11 In quantifying waste arisings to landfill, assumptions will be applied as set out within Section 2.2 of this technical note. These assumptions will be:

- ancillary infrastructure waste – landfill diversion rate of 60%;
- ballast track maintenance waste – landfill diversion rate of 85%;
- slab track maintenance waste – landfill diversion rate of 100%; and
- rolling stock maintenance waste – landfill diversion rate of 80%.

3.3.12 Following this, the total quantity of waste requiring off-site disposal to landfill during the year of operation (2027) will be assessed in relation to the significance criteria for non-hazardous waste.

Cumulative effects

3.3.13 The assessment of cumulative effects with respect to waste and material resources will focus on inter-project effects i.e. effects that will arise as a result of interactions between the Proposed Scheme and other projects.

3.3.14 Such interactions in this context will be the combined quantity of waste requiring off-site disposal to landfill as a result of the construction and/or operation of the Proposed Scheme and other committed developments (i.e. other reasonably foreseeable developments that are likely to be under construction or will be completed at the same time as the Proposed Scheme).

3.3.15 The total quantity of waste likely to be generated by other committed developments (including that which will require subsequent off-site disposal to landfill) will be

assessed qualitatively according to professional judgement based on the known type and extent of development. This is because:

- forecast waste arisings and landfill disposal assumptions may not have been published for other committed developments; and
- published forecast waste arisings and landfill disposal assumptions may not have been developed on the same basis as for the Proposed Scheme and hence may not be directly comparable.

Off-route effects

3.3.16 Where relevant, this technical note will also apply to the assessment of off-route effects that will be described in ES Volume 4, Off-route effects.

Climate change impacts

3.3.17 Whilst there are some potential climate change impacts on waste and material resources, these are not considered to have any significant direct impact and hence will not be considered further within the assessment.

Mitigation, enhancement and off-setting

3.3.18 Mitigation of construction and operation effects will be considered in line with key principles of waste and material resources management including the waste hierarchy, proximity principle and product (or development) lifecycle. Mitigation will also have regard to relevant legislation, policy and guidance.

3.3.19 Residual environmental effects will be identified, subsequent to the application of any mitigation measures.

HS2 Phase 2a West Midlands to Crewe: Technical Note -Rationale for Landfill Significance Criteria

Contents

List of figures

List of tables

1 Introduction

1.1 General

1.1.1 This technical note sets out the rationale for the development of the significance criteria for inert, non-hazardous and hazardous landfill to be used in the assessment of the likely significant environmental effects associated with the disposal of solid waste arising from the Proposed Scheme.

1.1.2 There is no Environmental Impact Assessment (EIA) guidance in the UK which provides an authoritative methodology and waste significance criteria for the assessment of the likely significant environmental effects of solid waste generation. EIA guidance for other countries exists (for example Hong Kong) but this sets out significance criteria based on qualitative factors.

1.1.3 The Planning Practice Guidance on environmental impact assessments[1] states that an EIA is likely to be required for a landfill site for the disposal of household, industrial and/or commercial waste where new capacity is created to hold more than 50,000 tonnes per annum, or to hold waste of 10 hectares (ha) or more. More importantly, it also states that sites seeking only to accept inert wastes (demolition waste etc.) are unlikely to require an EIA (see Appendix A).

1.1.4 The Design Manual for Roads and Bridges[2] does not set any criteria for assessing waste arising as a result of the construction of roads or bridges.

2 Rationale for inert landfill significance criteria

2.1 General

2.1.1 This section of the technical note sets out the rationale for the development of the significance criteria for inert landfill to be used in the assessment of the significance of environmental effects associated with the disposal of inert waste arising from the Proposed Scheme.

2.2 Inert waste legislative guidance

2.2.1 Guidance by the Environment Agency provides a definition for inert waste as per the EU Landfill Directive 99/31/EC, article 2(e):[3]

'Inert waste' means waste that does not undergo any significant physical, chemical or biological transformations. Inert waste will not dissolve, burn or otherwise physically or chemically react, biodegrade or adversely affect other matter with which it comes into contact in a way likely to give rise to environmental pollution or harm human health. The total leachability and pollutant content of the waste and the ecotoxicity of the leachate

[1] Department for Communities and Local Government (2015), Planning Practice Guidance: Environmental Impact Assessment.
[2] Department of Transport (2001), The Design Manual for Roads and Bridges, Volume 11, Section 3, Part 6.
[3] Environment Agency (June 2009), Environmental Permitting Regulations: Inert Waste Guidance - Standards and Measures for the Deposit of Inert Waste on Land.

must be insignificant, and in particular not endanger the quality of surface water and/or groundwater.'

2.2.2 The EU Landfill Directive sets rigorous standards to reduce the impact from waste disposed of to landfill including inert waste acceptance criteria.

2.2.3 The Environment Agency Technical Guidance WM3 'Waste Classification: Guidance on the Classification and Assessment of Waste'[4], although intended for hazardous waste assessment, provides a useful waste assessment methodology and guidance on waste classification using the European Waste Catalogue, transposed into English legislation by the List of Wastes (England) Regulations 2005 (SI 2005 No. 895) (as amended)[5].

2.2.4 Inert waste is likely to comprise those wastes stated in the List of Wastes (England) Regulations 2005 (SI 2005 No. 895) (as amended) Chapter 17 'Construction and Demolition Wastes (including excavated soils from contaminated sites)'. However, if no suitable waste codes are available in Chapter 17 then other chapters will need to be explored, for example, Chapter 1 'Wastes Resulting from Exploration, Mining, Quarrying, and Physical and Chemical Treatment of Minerals' or Chapter 19 'Waste from Waste Treatment Facilities'.

2.2.5 The EU Landfill Directive 99/31/EC defines landfill as waste disposal sites for the deposit of waste onto or into land and divides landfill into three classes: (i) landfills for hazardous waste; (ii) landfills for non-hazardous waste; and (iii) landfill for inert waste.

2.3 Other major infrastructure projects

2.3.1 EIAs for other major infrastructure projects such as Crossrail have relied on a qualitative assessment. The Crossrail target for diverting clean excavation materials from landfill is 95% with a stretch target of 100%. The target for diverting construction and demolition waste from landfill is 90% with a stretch target of 95%. The forecast material generation for Crossrail is set out in Table 1 below. The figures include a bulking factor (i.e. increase in volume following excavation).

Table 1: Crossrail waste material estimates

Material classification	**Volume (m^3)**
Clean excavated material (non-contaminated)*	6.0 million
Contaminated material	1.2 million
Contaminated material	0.5 million
Demolition material	0.3 million

* Crossrail has stated the following: 'All of Crossrail's 5.6 million m^3 of clean excavated material will be beneficially reused'.

[4] Environment Agency (2015), Waste Classification: Guidance on the Classification and Assessment of Waste (1st Edition) – Technical Guidance. WM3.
[5] The List of Wastes (England) Regulations 2005 (SI 2005 No. 895). London, Her Majesty's Stationery Office.

2.3.2 The Olympic Delivery Authority (ODA) set targets of reclaiming 90% of demolition waste by weight for reuse and recycling, and to divert 90% of construction waste from landfill for construction of the facilities for the London 2012 Olympic Games. The ODA recycled 97.7% of demolition waste and achieved their target for diversion of construction waste from landfill. Additionally, 80% of contaminated soil was cleaned and reused through the use of soil washing and bioremediation technologies. This equated to 1.3 million tonnes of soil.

2.3.3 The Tideway (formerly Thames Tideway Tunnel) project has a target to divert at least 80% of construction and demolition waste from landfill as well as to beneficially use a minimum of 85% of the clean excavated material. The Environmental Statement (Volume 2: Environmental assessment methodology)[6] does not provide a specific assessment methodology for waste. It is stated that 'The excavation, storage and movement of excavated material and waste generated on site have been considered within each of the individual topics: transport, noise and vibration, air quality, land quality, historic environment, townscape and socio-economics within each site volume, rather than as an individual topic'. The Excavated Materials and Waste Strategy[7] also does not include an assessment methodology or criteria for waste. However, it includes an appraisal of the disposal of waste on the 'Impact on regional waste infrastructure' but does not provide any statement on its significance.

2.4 Inert waste management infrastructure

2.4.1 The number of material recovery facilities for inert and non-inert (mixed) construction and demolition materials has increased over the past 10 years contributing to improved resource efficiency in the construction industry. It is possible for a single construction and demolition waste recovery facility to be capable of processing significantly in excess of one million tonnes of inert waste per annum. For example, the Powerday facility in North West London is permitted to process 1.6 million tonnes per annum on a 3.9ha site[8]. The McGee Bedrock Thames Wharf site in East London is permitted to process 750,000 tonnes per annum on a 1.4ha site[9].

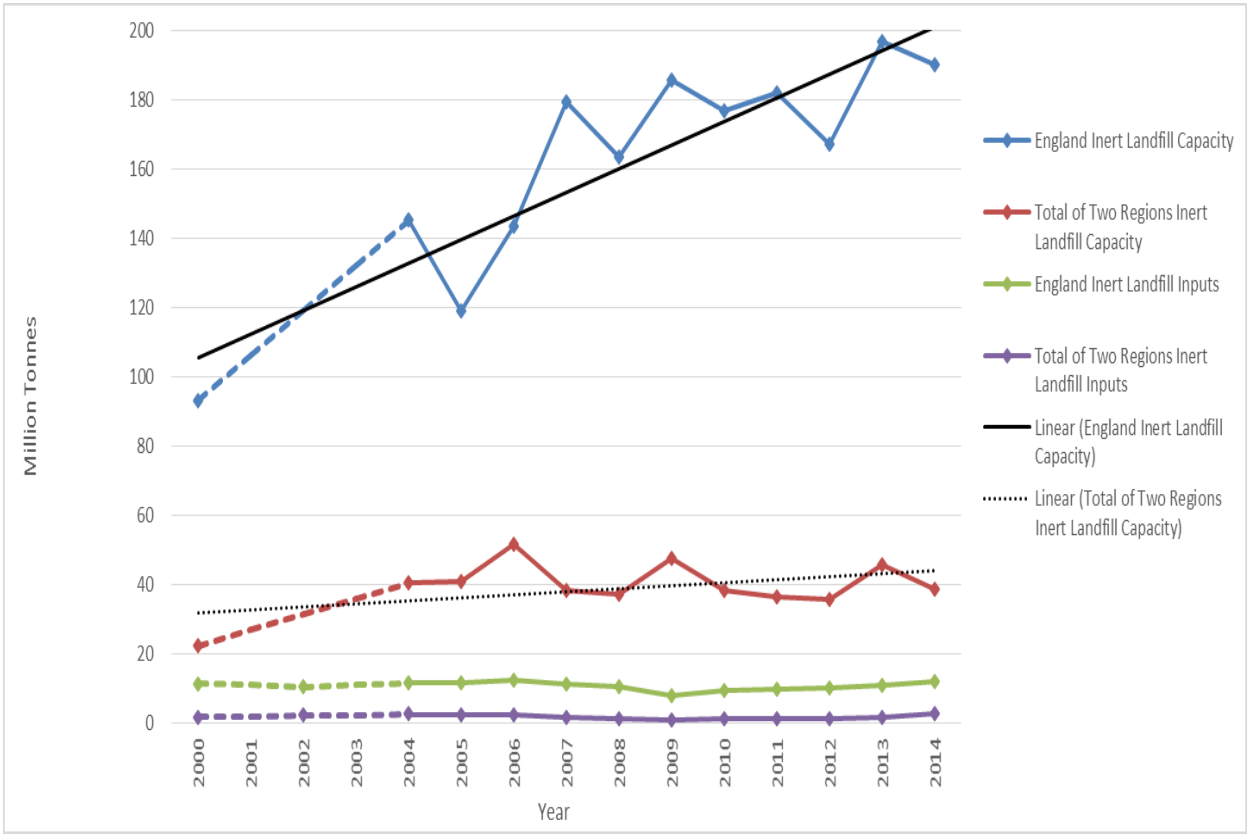
2.4.2 Typically, a large proportion of inert waste, which is destined for landfill disposal, is used for landfill engineering and capping purposes.

2.4.3 Latest available data published by the Environment Agency[10] shows that inert landfill capacity in England has more than doubled over a period of 14 years from approximately 93 million tonnes in 2000 to almost 190 million tonnes in 2014, as shown in Figure 1. The data shows that inert landfill capacity in the two former planning regions (i.e. West Midlands and North West) along the route corridor of the Proposed Scheme (hereafter referred to as the 'two regions') has overall increased from approximately 22 million tonnes in 2000 to almost 39 million tonnes in 2014 (see Figure 1).

[6] Thames Water (2013), Environmental Statement Volume 2: Environmental Assessment Methodology.
[7] Thames Water (2011), Environmental Statement Volume 3: Project-Wide Effects Assessment Appendices.
[8] Powerday; Construction & Demolition; http://www.powerday.co.uk/recycling/candd-operations/60/.
[9] Greater London Authority; Planning Reports PDU/1125/01 & 1555/01, 7 November 2006 – Thames Wharf Olympic Business Relocations, Dock Road, Silvertown.
[10] Environment Agency; Waste Management 2014 in England: Data Tables; https://www.gov.uk/government/statistics/waste-management-for-england-2014.

2.4.4 The data shows that inert landfill inputs in England between 2000 and 2014 have been relatively stable on average with just under 11 million tonnes per annum. The average total for the two regions was just under two million tonnes over the same period (see Figure 1).

Figure 1: Inert landfill capacity and inputs in England/two regions (2000 to 2014)*



* Dashed coloured lines represent extrapolated data

2.5 Inert landfill significance criteria

2.5.1 The significance criteria in Table 2 have been developed for inert landfill (excluding hazardous substances) as part of the HS2 Phase 2a EIA Scope and Methodology Report (SMR)[11]. They are relevant for inert waste, which may arise from site clearance works, demolition of existing buildings and structures, and the earthworks associated with the construction of the Proposed Scheme.

[11] Volume 5: Appendix CT-001-001, Environmental Impact Statement Scope and Methodology Report

Table 2: Inert landfill significance criteria (excluding hazardous substances)

Degree of significance	Inert landfill criteria
Major adverse	Net increase in waste arisings relative to the future baseline leading to a severe, national and regional scale reduction in inert landfill void space capacity. Need for additional large-scale waste treatment and/or disposal capacity of greater than 10,000,000 tonnes per annum. Effect may be judged to be of importance in the national planning context and, therefore, of potential concern to a project depending upon the importance attached to the issue in the decision making.
Moderate adverse	Net increase in waste arisings relative to the future baseline leading to a regional scale reduction in inert landfill void space capacity. Need for additional medium to large scale waste treatment and/or disposal capacity of between 2,000,000 to 10,000,000 tonnes per annum. Effect may be judged to be important in the regional planning context, for example, where effects are permanent or long-term and the effect on local waste treatment and disposal infrastructure is such that additional capacity may be required.
Minor adverse	Net increase in waste arisings relative to the future baseline leading to local scale reduction in inert landfill void space capacity. Need for additional small scale waste treatment and/or disposal capacity of up to 2,000,000 tonnes per annum. Effect is of low importance in the decision-making process but may be of relevance to the detailed design and mitigation of a project.
Negligible	No significant increase in waste arisings relative to the future baseline or reduction in inert landfill void space capacity. No appreciable adverse or beneficial effects.
Beneficial	Net reduction in waste arisings and diversion of waste from inert landfill relative to the future baseline resulting in an environmental improvement. Positive effect on waste arisings overall and available capacity of waste treatment and disposal infrastructure.

2.5.2 The upper 'threshold value' for minor adverse effects has been set as 2,000,000 tonnes per annum of inert landfill disposal capacity. This threshold has been based on providing additional small scale inert landfill disposal capacity equivalent to a 10ha inert landfill site assuming an inert waste thickness of approximately 15m (i.e. 1,500,000m^3 of inert landfill capacity or approximately 2,000,000 tonnes using a volume to mass density conversion factor of 1.5 tonnes/m^3)[12]. Based on the threshold described in the Planning Practice Guidance and the inert nature of the waste (i.e. reduced potential of generating greenhouse gas emissions and leachate), it is considered unlikely that landfill and/or land raise would result in pollution of the environment and/or harm to human health. This would need to be confirmed when applying for an environmental permit for an individual site.

2.5.3 The disposal of 2,000,000 tonnes per annum of inert waste would represent about 5% of the inert landfill capacity in the combined two regions and 1% of the national inert landfill capacity, based on the most recently available figures for 2014 from the Environment Agency[13].

[12] Department of the Environment (1995), Waste Management Paper 26B, Landfill Design, Construction and Operational Practice.
[13] Environment Agency; Waste Management for England 2014: Data Tables; https://www.gov.uk/government/statistics/waste-management-for-england-2014.

2.5.4 The threshold values for moderate and major adverse environmental effects have been based on professional judgement. These are extrapolations of the threshold value for minor adverse environmental effects based on an incremental increase of the total inert waste quantity to be disposed of by applying a factor of five to define the moderate adverse environmental effects upper threshold value (i.e. 2,000,000 to 10,000,000 tonnes per annum), and the major adverse environmental effects threshold value (i.e. greater than 10,000,000 tonnes per annum).

2.5.5 The disposal of 10,000,000 tonnes per annum of inert waste represents approximately 26% of the total inert landfill capacity in the combined two regions, and approximately 5% of inert landfill capacity in England based on the 2014 inert landfill capacity data from the Environment Agency.

2.5.6 The Proposed Scheme would be constructed over a period of approximately seven years (i.e. 2020 to 2026) starting initially with enabling works followed by the earthworks such as tunnelling etc. Any inert surplus excavated material generated by the Proposed Scheme would not occur all in a single year but extend over several years reducing the pressure on inert landfill capacity.

2.5.7 A wide range of factors influence the available landfill capacity such as the regulatory regime, fiscal measures, waste generation rates and measures to divert waste from landfill (e.g. reuse, recycling/composting and energy recovery). This makes the forecasting of future landfill capacity difficult and inexact. It is recognised that landfill capacity is a limited resource, however, data from the Environment Agency indicates an increase in inert landfill capacity in the combined two regions and in England as a whole between 2000 and 2014 (see Figure 1).

3 Rationale for non-hazardous landfill significance criteria

3.1 General

3.1.1 This section of the technical note sets out the rationale for the development of the significance criteria for non-hazardous landfill to be used in the assessment of the significance of environmental effects associated with the disposal of non-hazardous waste arising from the Proposed Scheme.

3.2 Non-hazardous waste legislative guidance

3.2.1 Non-hazardous waste means waste which is not hazardous (see Section 4 for hazardous waste). It will comprise waste generated during the construction (e.g. worker accommodation site waste) and operation (e.g. railway station and train waste) of the Proposed Scheme.

3.2.2 Non-hazardous waste is also covered by the revised EU Waste Framework Directive 2008/98/EC (rWFD)[14], and UK waste policy, legislation and guidance.

[14] *Council Directive 2008/98/EC on waste 2008.* Strasbourg, European Parliament and European Council.

3.2.3 Non-hazardous waste landfill sites typically accept municipal solid waste along with non-hazardous waste (including inert waste) from any other sources. There are no numerical waste acceptance criteria for non-hazardous waste but the List of Waste Regulations provides absolute non-hazardous waste entries for wastes which are deemed to be non-hazardous. However, the main requirement is to ensure that the waste landfilled is not hazardous.

3.3 Other major infrastructure projects

3.3.1 As stated in Section 2, EIAs for other major infrastructure projects such as Crossrail have relied on a qualitative assessment, and have not developed assessment criteria for the disposal of non-hazardous waste.

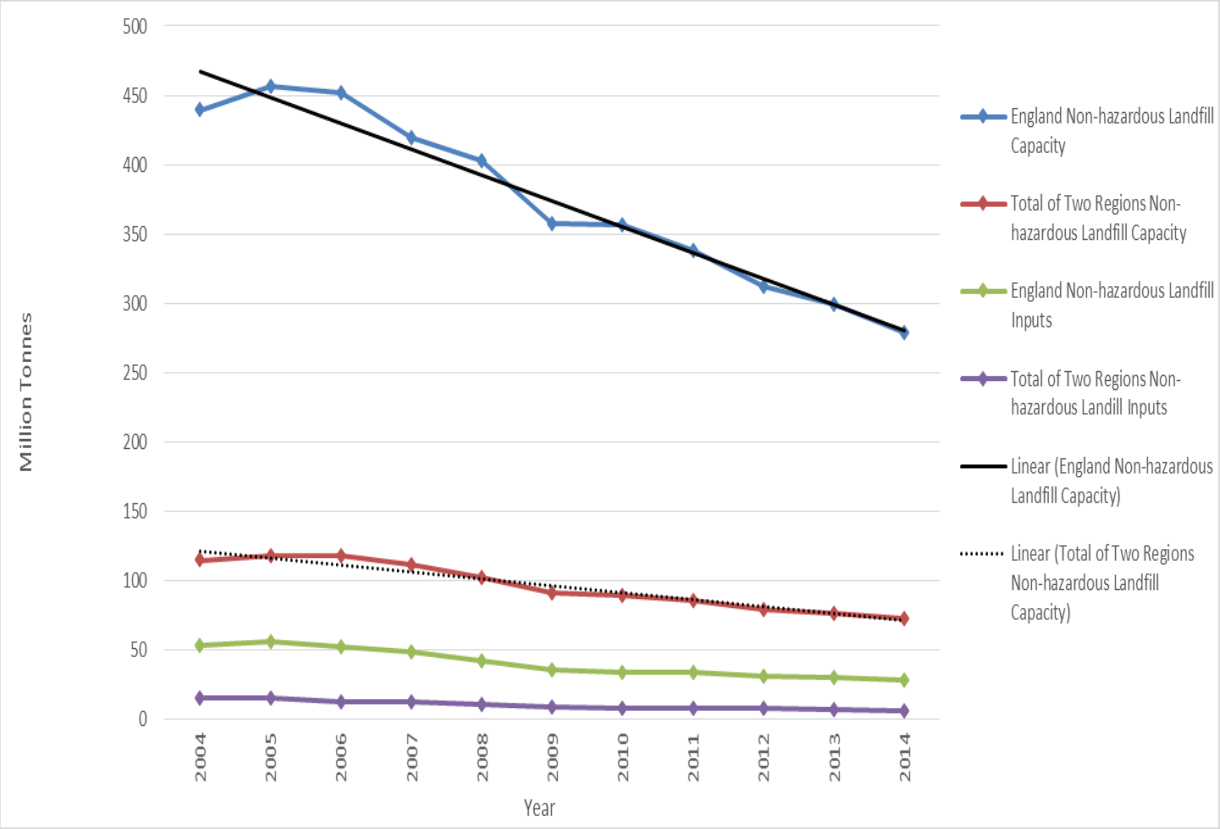
3.4 Non-hazardous waste management infrastructure

3.4.1 Data published by the Environment Agency between 2005 and 2014, set out in Figure 2, shows a downward trend of non-hazardous waste landfill capacity in England (indicated by the linear trend line) with about 439 million tonnes in 2004 declining to approximately 279 million tonnes in 2014 (approximately 37% reduction). Over the same period, the non-hazardous waste input rates have decreased even more steeply from 53 million tonnes to 28 million tonnes (approximately 46% reduction).

3.4.2 This downward trend is mainly driven by EU and UK sustainable waste management policy promoting the reduction and reuse of waste, increasing recycling and energy recovery and thereby reducing the quantity of biodegradable municipal waste being disposed of to landfill.

3.4.3 There has been a significant increase in the provision of alternative waste treatment infrastructure (e.g. materials recovery facilities, composting and anaerobic digestion plants and waste to energy facilities) to enable the diversion of waste away from landfill.

Figure 2: Non-hazardous landfill capacity and inputs in England/two regions (2004 to 2014)



3.5 Non-hazardous landfill significance criteria

3.5.1 The significance criteria in Table 3 have been developed for non-hazardous waste landfill as part of the SMR for the Proposed Scheme. They are relevant for non-hazardous waste, which will arise from the construction and operation of the Proposed Scheme.

Table 3: Non-hazardous landfill significance criteria

Degree of significance	Non-hazardous landfill criteria
Major adverse	Net increase in waste arisings relative to the future baseline without the Proposed Scheme leading to a severe national and regional-scale reduction in landfill void space capacity for non-hazardous waste. Need for additional large-scale waste treatment and/or disposal capacity of greater than 250,000 tonnes per annum. Effect may be judged to be of importance in the regional planning context and, therefore, of potential concern to a project depending upon the importance attached to the issue in decision-making.
Moderate adverse	Net increase in waste arisings relative to the future baseline without the Proposed Scheme leading to regional-scale reduction in landfill void space capacity for non-hazardous waste. Need for additional medium-scale waste treatment and/or disposal capacity of between 50,000 to 250,000 tonnes per annum. Effect may be judged to be important in the local planning context, e.g. where effects are permanent or long-term and the effect on local waste treatment and disposal infrastructure is such that additional capacity may be required.

Degree of significance	Non-hazardous landfill criteria
Minor adverse	Net increase in waste arisings relative to the future baseline without the Proposed Scheme leading to local-scale reduction in landfill void space capacity for non-hazardous waste. Need for additional small scale waste treatment and/or disposal capacity of up to 50,000 tonnes per annum. Effect is of low importance in the decision-making process but may be of relevance to the detailed design and mitigation of a project.
Negligible	No significant increase in waste arisings relative to the future baseline without the Proposed Scheme or reduction in landfill void space capacity for non-hazardous waste. No appreciable adverse or beneficial effects.
Beneficial	Net reduction in waste arisings and diversion of waste from landfill relative to the future baseline without the Proposed Scheme resulting in an environmental improvement. Positive effect on waste arisings overall and available capacity of waste treatment and disposal infrastructure.

3.5.2 For minor adverse environmental effects, the upper threshold value has been set as 50,000 tonnes per annum. This threshold value has been selected with reference to the Planning Practice Guidance on environmental impact assessments, which states in the Annex containing information on the indicative screening thresholds and criteria for identification of Schedule 2 development requiring EIA and indicative values for determining significant effects, that an EIA for installations for the disposal of waste is more likely to be required where new capacity is created to hold more than 50,000 tonnes per year.

3.5.3 The threshold values for moderate and major adverse environmental effects have been based on professional judgement. These are extrapolations of the threshold value for minor adverse environmental effects based on an incremental increase of the total non-hazardous waste quantity to be disposed of by applying a factor of up to five to define the moderate adverse environmental effects upper threshold value (i.e. 50,000 to 250,000 tonnes per annum), and by applying a factor of five to define the major adverse environmental effects threshold value (i.e. greater than 250,000 tonnes per annum).

3.5.4 The disposal of 250,000 tonnes of non-hazardous waste represents approximately 0.34% of the total non-hazardous landfill capacity in the combined two regions, and approximately 0.09% of non-hazardous landfill capacity in England based on the 2014 inert landfill capacity data from the Environment Agency[15]. Non-hazardous waste generated by the Proposed Scheme will arise during the seven year construction period (2020 to 2026), and also during the operational period starting in 2027.

3.5.5 The Proposed Scheme would be constructed over a period of seven years (i.e. 2020 to 2026) starting initially with enabling works followed by the earthworks such as tunnelling etc. Any non-hazardous waste generated during the construction period of the Proposed Scheme would not occur all in a single year, which will reduce the pressure on non-hazardous landfill capacity.

[15] Environment Agency; Waste Management for England 2014: Data Tables; https://www.gov.uk/government/statistics/waste-management-for-england-2014..

4 Rationale for hazardous landfill significance criteria

4.1 General

4.1.1 This section of the technical note sets out the rationale for the development of the significance criteria for the disposal of hazardous waste to be used in the assessment of the significance of environmental effects associated with the disposal of hazardous waste arising from the Proposed Scheme.

4.1.2 In determining the quantity of hazardous waste, the designers of the Proposed Scheme have considered the treatment of the hazardous waste on and off-site to reduce its hazardousness and moving waste management up the waste hierarchy.

4.1.3 Hazardous waste covered by this technical note comprises contaminated soils (i.e. unacceptable material Class U2)[16], which cannot be remediated on or off-site, and therefore are unacceptable for reuse within the engineering or environmental mitigation earthworks of the Proposed Scheme. It also covers hazardous waste generated from demolition works associated with the construction of the Proposed Scheme. However, it does not include, for example, radioactive contaminated land containing dangerous substances etc.

4.2 Hazardous waste legislative guidance

4.2.1 The rWFD provides a European-wide definition of hazardous waste. Hazardous waste is defined as a waste possessing one or more of the 15 hazardous properties set out in Annex III of the rWFD.

4.2.2 The rWFD also provides a list of wastes, known as the European Waste Catalogue (EWC), to classify wastes and identify those which are considered to be hazardous because of the hazardous properties set out in Annex III of the rWFD.

4.2.3 The EWC is a catalogue of all wastes, grouped according to generic industry, process or waste type. It differentiates between non-hazardous and hazardous by identifying hazardous waste entries with an asterisk (*).

4.2.4 The Hazardous Waste (England and Wales) Regulations 2005 (as amended) [17] set out the regime for the control and tracking of the movement of hazardous waste for the purpose of implementing the EU Hazardous Waste Directive 91/689/EEC[18].

4.2.5 The Environment Agency Technical Guidance WM3 'Waste Classification: Guidance on the Classification and Assessment of Waste'[19], provides a definition for hazardous waste as per the rWFD. The technical guidance also provides a useful waste assessment methodology and guidance on waste classification using the EWC,

[16] Department for Transport (2009), Highways Agency, Manual of Contract Documents for Highway Works, Volume 1 – Specification for Highway Works, Series 600 Earthworks; http://www.standardsforhighways.co.uk/ha/standards/mchw/vol1/pdfs/600.pdf.
[17] The Hazardous Waste (England and Wales) Regulations 2005 (SI 2005 No. 894). London, Her Majesty's Stationery Office.
[18] *Council Directive 91/689/EEC on hazardous waste 1991*. Strasbourg, European Parliament and European Council.
[19] Environment Agency (2015), Waste Classification: Guidance on the Classification and Assessment of Waste (1st Edition) – Technical Guidance WM3.

transposed into English legislation by the List of Wastes (England) Regulations 2005 (SI 2005 No. 895) (as amended)[20].

4.3 National Policy Statement for hazardous waste

4.3.1 The Department for Environment, Food and Rural Affairs (Defra) National Policy Statement (NPS) for Hazardous Waste[21] provides planning guidance in relation to nationally significant hazardous waste infrastructure. The capacity threshold[22] stated in the NPS for hazardous waste landfill is 100,000 tonnes per annum, which in turn reflects the threshold set out in s.30 of the Planning Act 2008[23]. This threshold is based on total weight of waste and not just on the weight of any hazardous components.

4.4 Other major infrastructure projects

4.4.1 The London 2012 Olympic Park is constructed on land previously used by a variety of industries, which left a legacy of soil and groundwater contamination. The ODA used in-situ and ex-situ soil cleaning techniques to enable the reuse of 80% of contaminated soil thereby reducing the quantity of hazardous waste that required landfill disposal.

4.5 Hazardous waste management infrastructure

4.5.1 In 2014, a total of 4,203,220 tonnes of hazardous waste was sent for treatment/ disposal in England of which 853,955 tonnes was landfilled (i.e. 20%). Of this total, 514,549 tonnes (i.e. 60%) comprised construction and demolition waste (including asbestos and excavated soils from contaminated sites). Environment Agency hazardous waste data for England for the period 2006 to 2014 is shown in Table 4.

4.5.2 The List of Wastes (England) Regulations 2005 includes Chapter 17 'Construction and Demolition Waste (including excavated soils from contaminated sites)'. The nature of the Proposed Scheme suggests that the majority of hazardous waste for disposal will be construction and demolition waste.

Table 4: Construction and demolition waste (including excavated soils from contaminated sites) to hazardous landfill for England[24]

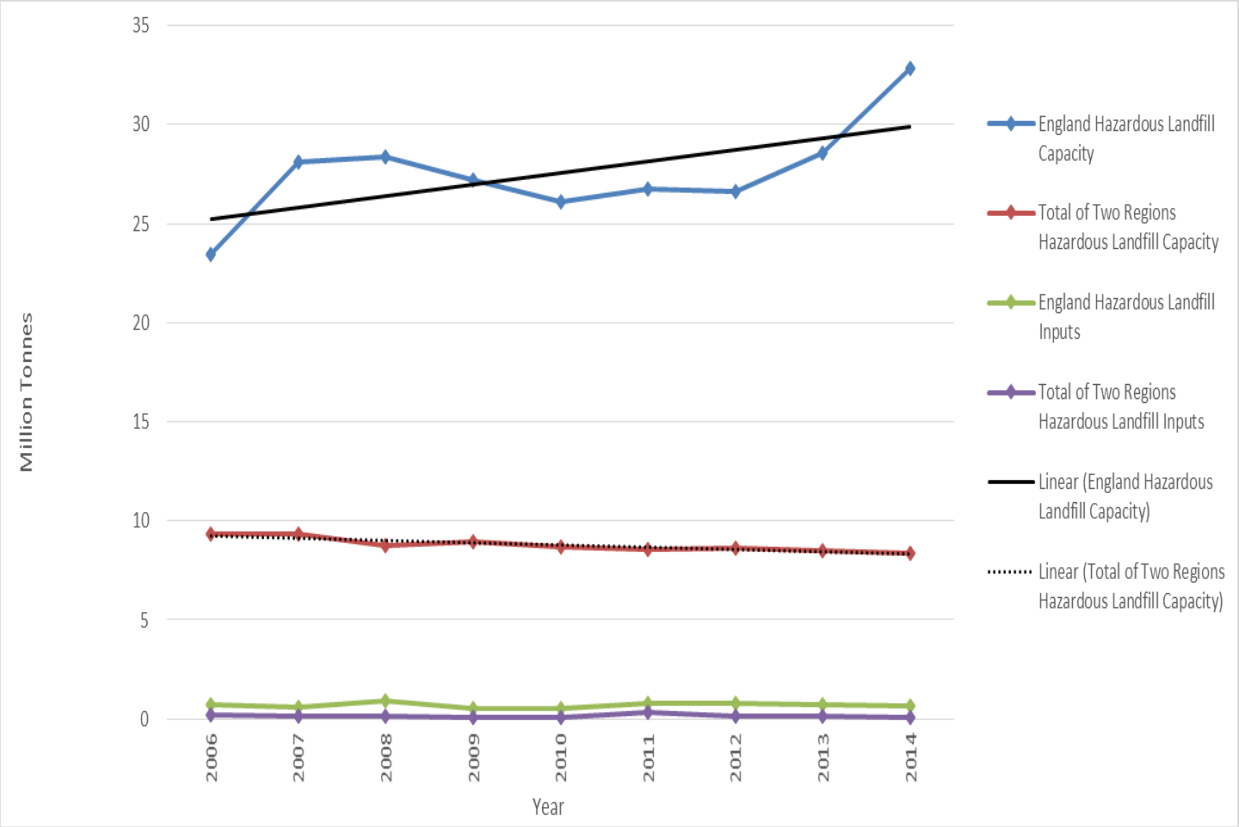
Year	2006	2007	2008	2009	2010	2011	2012	2013	2014
Tonnes	643,989	642,303	771,599	372,801	328,395	733,716	519,004	350,212	514,549
As % of total hazardous waste inputs	89%	114%[25]	84%	68%	62%	91%	67%	51%	78%

[20] The List of Wastes (England) Regulations 2005 (SI 2005 No. 895). London, Her Majesty's Stationery Office.
[21] Department for Environment, Food and Rural Affairs (2013), National Policy Statement for Hazardous Waste: A Framework Document for Planning Decisions on Nationally Significant Hazardous Waste Infrastructure.
[22] This is the capacity threshold at which the construction of new hazardous waste landfill disposal capacity becomes nationally significant.
[23] Planning Act 2008. London, Her Majesty's Stationery Office.
[24] Environment Agency; Waste Management for England 2014: Data Tables; https://www.gov.uk/government/statistics/waste-management-for-england-2014.
[25] Assumes difference sent to non-hazardous SNRHW landfill – see Section 2.4.

4.5.3 There are a number of off-site soil treatment centres in England for the treatment and reuse of contaminated soils. There are also on-site treatment technologies available depending on the nature of the soil contamination.

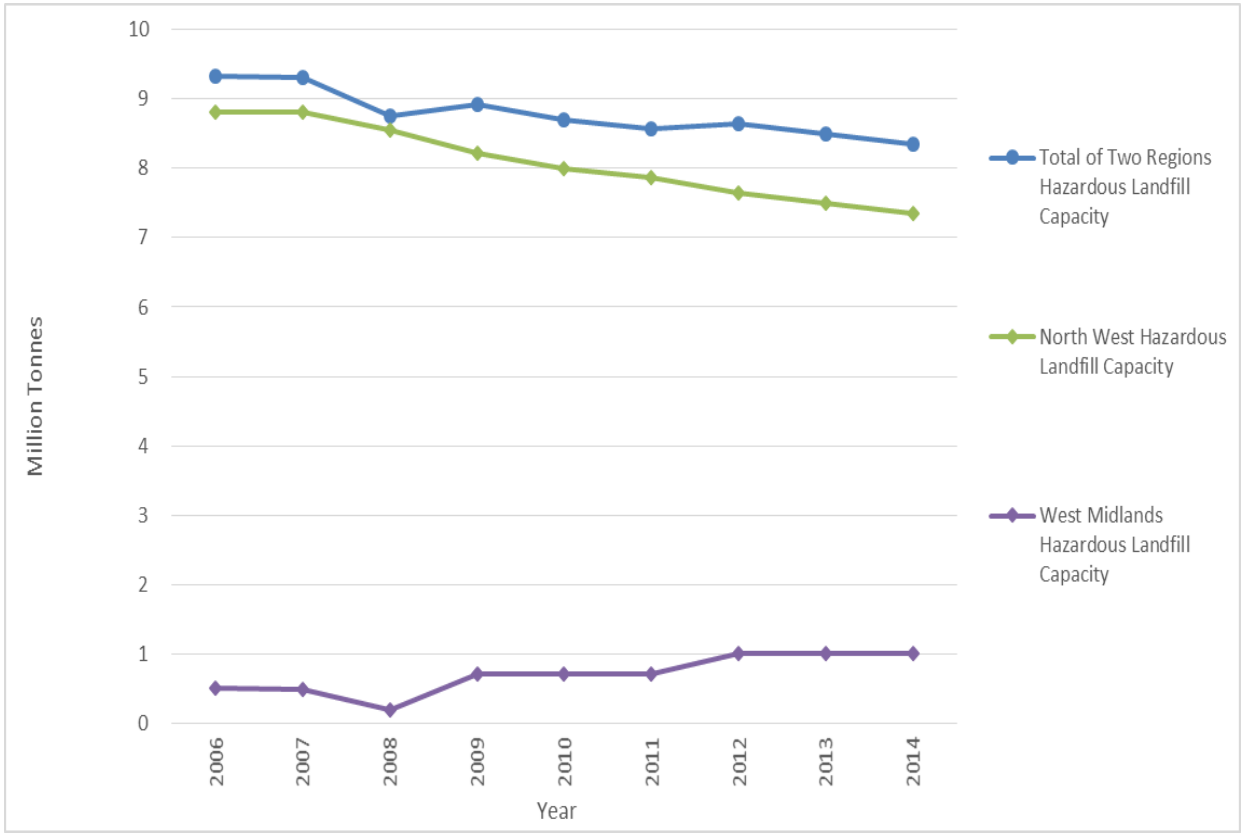
4.5.4 Data published by the Environment Agency for the period 2006 to 2014, set out in Figure 3 shows a slightly upward trend of hazardous waste landfill capacity in England (indicated by the linear trend line) with about 23 million tonnes in 2006 increasing to almost 33 million tonnes in 2014.

Figure 3: Hazardous landfill capacity and inputs in England/two regions (2006 to 2014)



4.5.5 The hazardous waste landfill capacity data for the combined two regions indicates an overall slight downward trend (indicated by the linear trend line) from just over nine million tonnes in 2006 to just over eight million tonnes in 2014 (see Figure 4). There has been an increase in capacity in the West Midlands but a decrease in capacity in the North West.

Figure 4: Hazardous landfill capacity trend of the two regions



4.6 Hazardous landfill significance criteria

4.6.1 The significance criteria in Table 5 have been developed for hazardous waste landfill as part of the SMR for the Proposed Scheme. They are relevant for hazardous waste, which will arise from the construction of the Proposed Scheme associated with the excavation of contaminated land.

Table 5: Hazardous landfill significance criteria

Degree of significance	Hazardous landfill criteria
Major adverse	Net increase in waste arisings relative to the future baseline leading to a severe national and regional-scale reduction in hazardous waste landfill void space capacity. Need for additional large-scale hazardous waste disposal capacity of greater than 100,000 tonnes per annum[26]. Effect may be judged to be of importance in the regional planning context and, therefore, of potential concern to a project depending upon the importance attached to the issue in the decision-making process.
Moderate adverse	Net increase in waste arisings relative to the future baseline leading to regional-scale reduction in hazardous waste landfill void space capacity or need for additional medium-scale waste hazardous waste disposal capacity of between 20,000 to 100,000 tonnes per annum. Effect may be judged to be important in the local planning context, e.g. where effects are permanent or long-term and the effect on local waste treatment and disposal infrastructure is such that additional capacity may be required.

[26] Figure is threshold value given in s.30 Planning Act 2008 and referenced in National Policy Statement for Hazardous Waste.

Degree of significance	Hazardous landfill criteria
Minor adverse	Net increase in waste arisings relative to the future baseline leading to local-scale reduction in hazardous waste landfill void space capacity or need for additional small scale hazardous waste disposal capacity of up 20,000 tonnes per annum. Effect is of low importance in the decision-making process but may be of relevance to the detailed design and mitigation of a project.
Negligible	No significant increase in waste arisings relative to the future baseline or reduction in landfill void space capacity. No appreciable adverse or beneficial effects.
Beneficial	Net reduction in hazardous waste arisings and diversion of waste from landfill relative to the future baseline resulting in an environmental improvement. Positive effect on waste arisings overall and available capacity of hazardous waste treatment and disposal infrastructure.

4.6.2 The threshold value of 100,000 tonnes per annum has been chosen for major adverse environmental effects based on the nationally significant hazardous waste infrastructure threshold given in the NPS for hazardous waste.

4.6.3 The disposal of 100,000 tonnes of hazardous waste would represent about 0.3% of the hazardous landfill capacity in England and about 1.2% of the combined two regions, based on data published by the Environment Agency between 2006 and 2014.

4.6.4 The threshold values for minor and moderate adverse environmental effects have been based on professional judgement. These are extrapolations of the threshold value for major adverse environmental effects based on an incremental decrease of the total hazardous waste quantity to be disposed of using a reduction factor of up to five to define the upper threshold value for moderate environmental adverse effects of 100,000 tonnes per annum and a reduction of five to define the upper threshold value for minor environmental adverse effects of 20,000 tonnes per annum.

4.6.5 Landfill for non-hazardous waste may be used to dispose of stable non-reactive hazardous waste (SNRHW) providing such disposal does not occur in the same landfill cell as non-hazardous waste. SNRHW must exhibit leaching behaviour equivalent to non-hazardous waste. In practice, this restricts the disposal of hazardous wastes to non-hazardous landfill to material such as asbestos waste (e.g. asbestos cement board). Environment Agency landfill data does not quantify the amounts of hazardous waste sent to non-hazardous SNRHW landfill but does state it is usually a small part of the overall capacity of the site.

4.6.6 The Proposed Scheme would be constructed over a period of seven years (i.e. 2020 to 2026) starting initially with enabling works followed by the earthworks such as tunnelling etc. Any hazardous waste generated by the Proposed Scheme would not occur all in a single year but extend over at least a two year period, which will reduce the pressure on hazardous landfill capacity.

Appendix A: EIA Guidance

The Department for Communities and Local Government, Planning Practice Guidance: Environmental Impact Assessment provides the indicative screening criteria and thresholds set out in Table 6, for installations for the disposal of non-hazardous waste and inert waste.

Table 6: Thresholds and Criteria for the identification of Schedule 2 development requiring Environmental Impact Assessment and indicative values for determining significant effects

Development type	Schedule 2 criteria and thresholds	Indicative criteria and threshold	Key issues to consider
(b) Installations for the disposal of waste (unless included in Schedule 1);	(i) The disposal is by incineration; or (ii) the area of the development exceeds 0.5 hectare; or (iii) the installation is to be sited within 100 metres of any controlled waters.	Installations (including landfill sites) for the deposit, recovery and/or disposal of household, industrial and/or commercial wastes where new capacity is created to hold more than 50,000 tonnes per year, or to hold waste on a site of 10 hectares or more. Sites taking smaller quantities of these wastes, sites seeking only to accept inert wastes (demolition rubble etc.) or Civic Amenity sites, are unlikely to require Environmental Impact Assessment.	Scale of the development and the nature of the potential impact in terms of discharges, emissions or odour.

Annex N: Water and flood risk – technical notes

The following technical notes are contained in this Annex:

- Surface water quality assessment;
- Groundwater assessment;
- Spillage risk assessment; and
- Water Framework Directive (WFD) compliance assessment process.

HS2 Phase 2a West Midlands - Crewe: Technical note -

Water resources and flood risk technical note – Surface water quality assessment

Contents

1 Introduction

1.1.1 This technical note has been prepared as guidance in the assessment of the effects of the Proposed Scheme on the quality of surface waters. It should be read in conjunction with the HS2 Phase 2a Environmental Impact Assessment (EIA) Scope and Methodology Report (SMR)[1]. Mitigation of these effects and reporting of residual effects should be carried out as stated in the SMR.

1.1.2 This note is intended as a guide to ensure a consistent approach across the Proposed Scheme, not as an exhaustive and prescriptive methodology.

1.1.3 This note should not be used to assess the following:

- effects from construction of the project;
- effects on groundwater (see Water resources and flood risk technical note – groundwater assessment method); and
- effects from accidental spillages (see Water resources and flood risk technical note – Spillage risk assessment).

2 Baseline assessment

2.1 Baseline definition

2.1.1 Where there is a defined impact pathway for the operation of the Proposed Scheme to have an effect on the quality of surface water receptors, the baseline condition of those water body receptors shall be defined.

2.1.2 The baseline assessment for each surface water body shall be recorded using the Water Framework Directive[2] (WFD) status classification system.

2.1.3 Within the context of the water resources and flood risk topic, the following elements of a water body's WFD status will be considered within the surface water quality baseline:

- physico-chemical and specific pollutants components of the water body's 'ecological status';
- where appropriate, the priority substances components of the water body's 'surface water chemical status'.

2.1.4 The baseline assessment will also consider other potential quality elements not specifically used in determining WFD status where a scheme impact may affect this element e.g. suspended solids, or nitrate concentrations for fluvial systems in Nitrate Vulnerable Zones.

[1] Scope and Methodology Report, Volume 5: Appendix CT-001-001.
[2] European Commission (EC), 2000, *Water Framework Directive (2000/60/EC)*, EC.

2.1.5 A report assessing the extent to which the Proposed Scheme complies with the WFD will be included in the Environmental Statement (ES).

2.2 Data from the Environment Agency and others

2.2.1 The assessment of the baseline conditions will generally utilise water quality data received from the Environment Agency, water companies or local authorities. This data is expected to be sufficient for the vast majority of locations where a baseline assessment is required. All such received data should meet the criteria set out in paragraph 2.2.3.

2.2.2 The baseline assessment shall be recorded using the existing WFD status class of the receiving or receptive water body.

2.2.3 Where a baseline assessment is required, but no data is available at the point of potential impact, the next downstream location where data is available will be used. The data is considered appropriate for use in an assessment if:

- the location is within 5km, taking into account the locations of sensitive receptors downstream from the point of impact (such as a Site of Special Scientific Interest (SSSI), Special Protection Area (SPA), Special Area of Conservation (SAC), Water Protection Zone (WPZ) or Ramsar Wetland);
- there is no significant change in land use, which could result in the introduction of different diffuse pollutants, between the impact point and sample point; and
- there is no discharge entering the downstream length of the water body that results in, or has the potential to effect a significant change in any element of the physico-chemical or specific pollutant standards of a water body's WFD ecological status or the water body's WFD chemical status.

2.2.4 If no data is available from a downstream location, the Environment Agency will be approached, as they may hold unpublished data that would be appropriate.

2.2.5 A potential impact source resulting in water quality effects could be:

- pollution from a new station;
- pollution from a new depot;
- pollution from other Proposed Scheme infrastructure;
- pollution from a public road; or
- physical changes to water body morphology (e.g. channel diversion or river crossings).

2.2.6 If a potential impact pathway is identified from any of these impact sources to a receptor where no baseline data (that meets the criteria in this section) is available then targeted water sampling will be considered taking into account the locations of sensitive receptors (such as a water abstraction, SSSI, SPA, SAC, WPZ or Ramsar Wetland).

2.3 Water sampling protocol

2.3.1 Prior to undertaking water sampling, the consultant/contractor should consult with the Environment Agency regarding the frequency and method of sampling.

3 Scope of impact assessment

3.1.1 The method in this section should be used to assess the effects on surface water quality for all locations on the project, with the exception of:

- roads where the annual average daily traffic of Heavy Goods Vehicles is forecast to exceed 500, where the Highways Agency Water Risk Assessment Tool (HAWRAT) method in Design Manual for Roads and Bridges (DMRB) Volume 11, Section 3, Part 10 (HD45/09)[3] should be used; and
- locations where all the drainage will be discharged to a foul sewer.

3.1.2 When assessing the effects on the quality of surface watercourses, the following will be used where appropriate: characteristics of the receiving watercourse (particularly its water quality, hardness, flow rate and velocity) and an estimate, based on a combination of expert judgement and analysis, of the quality of the water that could be released during routine operations. Estimates will be conservative and assume little or no dispersion.

3.1.3 Where flow information for a watercourse is not available from a suitable monitoring location, natural flow estimates will be derived for that location using, where appropriate, either the method in Institute of Hydrology Report 1083 or from Low Flows 2 software, available from Wallingford HydroSolutions Ltd, or an appropriate alternative.

3.1.4 The method shall consider the effects of the operation of the Proposed Scheme, including minor maintenance such as treatment with herbicides or pesticides, and treatment with de-icing materials.

4 Mitigation measures

4.1.1 Mitigation measures should be identified to avoid, reduce or offset significant surface water pollution risks.

4.1.2 These may include, but are not limited to, drainage features such as swales, ponds, wetlands, ditches, detention basins, silt traps, filter drains, soakaways and oil separators.

4.1.3 For roads, reference should be made to the DMRB: Volume 4, Section 2, Part 1 (4.2.1)4 (HA103/06); 4.2.3 (HD33/06)5 and 4.2.8 (HA118/06). All three documents give examples of measures that can be used to control the effects of routine runoff from highways on receiving waters.

[3] DMRB (November 2009), Volume 11 Section 3 Part 10: HD45/09: Road Drainage and the Water Environment.

4.1.4 Surface water monitoring may be required to monitor the effectiveness and on-going management of mitigation measures to protect the water environment. Monitoring should be undertaken as part of a wider environmental monitoring strategy and should cover the period before, during and after construction. The purpose of the monitoring would also be to define the environment and design baseline condition and ensure compliance with relevant environmental legislation.

5 Reporting residual effects

5.1.1 The ES will present the residual effects following the implementation of mitigation measures[4,5,6].

[4] DMRB, Volume 4 Section 2 Part 1: HA103/06 Vegetative Treatment Systems for Highway Runoff.
[5] DMRB, Volume 4 Section 2 Part 3: HD33/06 Surface and Sub-surface Drainage Systems for Highways
[6] DMRB, Volume 4 Section 2 Part 8: HA118/06 Design of soakaways.

HS2 Phase 2a West Midlands - Crewe: Technical note -

Water resources and flood risk – Groundwater assessment method

Contents

1 Introduction

1.1.1 This technical note has been prepared to provide guidance in the assessment of the effects of the Proposed Scheme on groundwater quantity and quality. It should be read in conjunction with the HS2 Phase 2a Environmental Impact Assessment (EIA) Scope and Methodology Report (SMR)[1]. Mitigation of these effects and reporting of residual effects should be carried out as stated in the SMR.

1.1.2 This technical note is intended as a guide to ensure a consistent approach across the Proposed Scheme, not as an exhaustive and prescriptive methodology.

1.1.3 This note should not be used to assess the following:

- effects on surface water (see Water resources and flood risk technical note – Surface water quality assessment);
- effects from accidental spillages (see Water resources and flood risk technical note – spillage risk assessment).

1.1.4 This technical note is set out in four sections covering baseline, impact assessment, mitigation (including monitoring) and residual effects.

1.1.5 There is overlap between groundwater and other topics including surface water, flood risk, ecology, land quality and geotechnics. These are referred to as necessary in the following sections to provide guidance on areas of responsibility.

2 Baseline

2.1 Baseline data

2.1.1 Where recent (since 2015) groundwater quality datasets are available, these can be used to define up to date baseline groundwater quality. In the absence of such data, the Water Framework Directive (WFD) Status of groundwater bodies will be used, if available. Historical data prior to 2015 should be considered where these may help to interpret the current groundwater status, particularly where trends can be identified leading up to the present day or where bulk water-rock interactions may be in evidence and are likely to be ongoing.

2.1.2 Water quality standards (WQS) can be used to indicate baseline groundwater quality. Two forms of WQS are available: drinking water standards (DWS) and environmental quality standards (EQS). DWS are defined to protect human health (i.e. are suitable for potable supply); whereas, EQS are defined to protect sensitive aquatic ecology from any surface water body receiving groundwater via baseflow. The appropriate WQS should be chosen based upon site conditions; where both are applicable, the more stringent WQS should be applied. Reference should be made to the conditions of each WQS, for instance, whether the standard applies to an annual average concentration or the maximum admissible concentration, and a consistent and

[1] Scope and Methodology Report, Volume 5: Appendix CT-001-001.

appropriate approach should be taken, based upon WQS conditions and data availability.

2.1.3 Groundwater level data should extend back as far as possible so that seasonal and long term fluctuations can be identified. Peak wet years and extended drought periods should be used to determine maximum and minimum ranges in groundwater levels where possible.

2.1.4 Project specific groundwater data should be collected if the opportunity arises in sensitive areas.

2.2 Baseline conditions

2.2.1 The base case to be adopted will depend on data availability but ideally should extend to 2015 for variables such as water quality and groundwater levels.

2.2.2 The cut-off date for data such as Environment Agency groundwater levels and licensed abstractions should be clearly stated.

2.2.3 Information on aquifer hydraulic parameters (e.g. hydraulic conductivity data) are unlikely to be time sensitive and so all published data may be relevant.

2.2.4 The main geological mapping scale to be used is 1:50,000, with detail at 1:10,000 in selected areas if needed.

2.2.5 Baseline contamination data will be collected by the land quality teams. The geology baseline description will be based on that prepared by the land quality teams to ensure consistency. Baseline ecology and identification of groundwater dependent ecosystems will be collected by the ecology teams.

3 Impact assessment

3.1 Groundwater quantity and flow

3.1.1 Dewatering and mounding effects will be assessed qualitatively unless the design assumption of 1m below track bed can be used to quantify effects in combination with accepted hydrogeological solutions, for example Theis well theory or Darcy's Law.

3.1.2 Greater emphasis and attempts to quantify impacts should be focussed on areas of high risk.

3.1.3 Dewatering calculations will give an indication of magnitude of impact based on selected hydraulic conditions. The aim is to estimate the potential effect and thus identify mitigation rather than make accurate predictions. Once site specific data are available the estimates may change.

3.1.4 Dewatering impacts (flow rates and drawdown) as a result of temporary shafts, cuttings or portal dewatering will be quantified for the purpose of the Environmental Statement (ES) using site data where available or using data from existing groundwater models where available. In the absence of such data, hydraulic values

from the British Geological Survey (BGS) Aquifer Properties Manual[2] should be used. To be conservative a higher hydraulic conductivity and lower storage coefficient are recommended. Professional judgement may also be used.

3.1.5 Drawdowns will be based on measured groundwater levels, where available, or on water strikes from borehole / drillers logs where applicable.

3.1.6 For shaft dewatering, if the highest groundwater level in the aquifer is below the base of the excavation at the time of casting, then it will be assumed that dewatering is not required.

3.1.7 Initial estimates of the flow rates required for dewatering shafts can be made using the Thiem and Sichardt equations. These equations apply to an idealised aquifer which is horizontal, confined above and below and between impermeable formations, infinite in horizontal extent, of constant thickness and homogeneous and isotropic with respect to its hydrogeological parameters.

$$Q = \frac{2\pi kD(H-h)}{\ln(R_o / R_e)}$$ Thiem equation for confined conditions

$$R_o = C(H-h)\sqrt{k}$$ Sichardt formula

Where;

Q = flow rate (m^3/d)

Qpp = flow rate adjusted for partial penetrating wells

k = hydraulic conductivity (m/d)

D = thickness of the confined aquifer (m)

d = depth well penetrates into aquifer (m)

H = initial piezometric level in the aquifer (m)

h = target drawdown level in the equivalent well (m)

Ro = radius of influence (m)

Re = effective radius of dewatering (m) (taken as 5m more than the shaft radius)

C = empirical calculation factor

3.1.8 Where the dewatering wells are partially penetrating the flow rate will be adjusted to Qpp as follows:

$$Qpp = Q \times \frac{d}{D}$$

[2] BGS, 1997, The Aquifer Properties of Major Aquifers in England and Wales.

3.1.9 The equations represent steady state conditions and are therefore appropriate if dewatering is likely to occur over a number of months to a point where groundwater level changes stabilise. For shorter scale works, such as manholes, transient, non-steady state methods will be applied, where appropriate, to determine the dewatering requirements.

3.1.10 Impacts of temporary dewatering in shallow aquifers where a steady state is not reached will be based on the Cooper Jacob equation for non-steady state conditions where appropriate. The drawdown, s, at a distance, r, from the dewatering borehole assuming semi-confined aquifer conditions, is given by:

$$s = \frac{2.303Q\log 10(2.25kDt/(r^2S))}{4\pi kD}$$

Where

Q = flow rate from well (m3/day)

r = radius of interest (m)

s = drawdown (m)

S = specific yield of aquifer

3.1.11 The impact of dewatering shafts on Sites of Special Scientific Interest (SSSI) and other sensitive receptors will be estimated, where appropriate, using the following mathematical equations:

For plane flow (to a cutting): $$L_0 = \sqrt{\frac{12Tt}{S}}$$

Or radial flow: $$R_0 = \sqrt{\frac{2.25Tt}{S}}$$

Where

Lo or Ro are the distance of influence (m)

T is the transmissivity in (m^2/d)

t is time (days)

S is the confined or unconfined storage depending on aquifer conditions

3.1.12 Further details and approach to be used for dewatering assessments for other design elements such as cuttings, are provided in the CIRIA Publication on Groundwater control: design and practice (Second Edition)[3].

3.1.13 Dewatering impacts on surface water bodies and wetland hydrology (where these are known or anticipated to be in hydraulic continuity (linked) with groundwater) will be

[3] Preene, M., Roberts, T.O.L. and Powrie, W., (2016), Groundwater control: design and practice. CIRIA Publication C750.

covered by the groundwater section, based on the baseline conditions provided by these topics.

3.1.14 The effects of dewatering or mounding may extend beyond the construction period and beyond the standard 1km groundwater assessment distance, and will be considered as exceptions, as set out in the SMR.

3.1.15 To quantify seepages into the tunnels, guidance such as the specification for tunnelling[4] can be used as appropriate.

3.2 Groundwater quality

3.2.1 Effects on groundwater quality will be assessed qualitatively.

3.2.2 The groundwater section will assess pollution risks as a result of groundwater being both a pathway and/or receptor. The land quality topic will assess these effects as well as pathways other than groundwater and receptors other than groundwater.

3.3 Assessment methodology

3.3.1 The operational impacts will be assessed as per the SMR. The maximum and minimum groundwater level or other condition may be more relevant in some circumstances.

3.3.2 The effects are to be assessed for receptors in the catchment or area under consideration; sources may fall within another catchment or area.

4 Mitigation

4.1.1 The general approach to mitigation (including environmental monitoring) is set out in Volume 1 of the ES. Other avoidance and mitigation measures such as minimising dewatering, groundwater cut-off or re-routing of groundwater flows, water recirculation, reinjection and pollution control are discussed in the water resources and flood risk assessments. Note that water discharges during construction and operation will require consents from the Environment Agency.

5 Reporting residual effects

5.1.1 The ES will present the residual effects following the implementation of mitigation measures. Measures to mitigate residual effects may include compensation for derogation of licensed abstractions or other effects where monitoring confirms that the effect is significant.

[4] British Tunnelling Society and The Institution of Civil Engineers (2010), Specification for Tunnelling.

HS2 Phase 2a West Midlands - Crewe: Technical note – Water resources and flood risk - Spillage risk assessment

Contents

1 Introduction

1.1 Introduction

1.1.1 This technical note has been prepared to give further guidance in the assessment of the risk of spillages and the possible environmental effects on the quality of the water environment. It should be read in conjunction with the HS2 Phase 2a Environmental Impact Assessment (EIA) Scope and Methodology Report (SMR)[1]. Mitigation of these effects and reporting of residual effects should be carried out as stated in the SMR.

1.1.2 This note is intended as a guide to ensure a consistent approach across the Proposed Scheme, not an exhaustive or prescriptive methodology.

1.2 Scope of technical note

1.2.1 The note covers the assessment of the risks to water quality from accidents, spillages and incidents during the operation of the railway.

1.2.2 The note covers all parts of this project constructed within the land required for the Proposed Scheme. It covers three main categories of asset as a source of spillage risk:

- the railway and associated infrastructure such as tunnels, embankments and viaducts;
- new or modified roads; and
- the Stone Infrastructure Maintenance Base – Rail (IMB-R).

1.2.3 This note should not be used to assess the following:

- surface water pollution risks during the construction phase of the project;
- surface water pollution risks that occur during routine maintenance work; and
- surface water pollution risks in locations where drainage is discharged to a foul sewer.

2 Baseline assessment

2.1.1 The baseline assessment should consider the risk of spillages and their consequences for the water environment.

2.1.2 At many locations, for example existing agricultural land, the existing spillage risks are negligible. In other locations, for example existing roads, the baseline risks may exceed the future risks, due to improvement in the layout or pollution control measures in the roads.

[1] Scope and Methodology Report, Volume 5: Appendix CT-001-001.

2.1.3 The baseline condition of surface water receptors to be adopted is defined in the HS2 Phase 2a West Midlands to Crewe 'Water resources and flood risk technical note – Surface water quality assessment'.

2.1.4 The baseline condition of groundwater receptors to be adopted is defined in the HS2 Phase 2a West Midlands to Crewe 'Water resources and flood risk technical note – Groundwater assessment method'.

3 Spillage risk methodology

3.1 Railway and associated infrastructure

3.1.1 The risk of pollution of the water environment from spillages from the Proposed Scheme is considered very low, as the significant majority of trains will be electric passenger trains, and the Proposed Scheme will not be used to transport freight [2]. Spillages on the route are only likely following derailments, collisions, or major on board incidents, all of which are considered highly improbable.

3.1.2 If a spillage of a pollutant does occur, it will not necessarily lead to a pollution incident, as the pollutant may not reach a receiving water body, either because of prompt action by emergency personnel or as a result of pollution control measures, such as shut-off valves, balancing ponds, and silt traps, or because the pollutant is absorbed by soil or vegetation.

3.1.3 The risk at a discharge outfall will be a function of the generic risk, the length of the catchment draining to that outfall and the sensitivity of the receptor.

3.1.4 The risk of pollution from a spillage is a function of the source rather than the receptor and therefore these spillage risks will be assessed on a route wide basis.

3.2 Roads

3.2.1 The spillage risks for all roads should be assessed using the methodology set out in the Design Manual for Roads and Bridges (DMRB) Volume 11, Section 3, Part 10[3] (HD45/09) Annex I Method D.

3.2.2 Roads where the annual average daily traffic of Heavy Goods Vehicles is less than 500 are unlikely to pose a significant spillage risk. Assessment of such roads is not required unless there are local conditions that warrant it. Examples of such conditions could include the use of a road to convey highly polluting materials, or the close proximity to the road of a sensitive water body (such as a Site of Special Scientific Interest (SSSI), Special Protection Area (SPA), Special Area of Conservation (SAC), Water Protection Zone (WPZ) or Ramsar Wetland).

[2] Any future changes to the use of the Proposed Scheme (such as for freight transportation) will be required to comply with the Environmental Minimum Requirements, and specifically the level of impact identified in the original Environmental Impact Assessment. Should freight transportation be considered in the future, and the updated assessment identify a significant additional adverse effect then pollution prevention measures will have to be agreed with the Environment Agency and applied as appropriate.

[3] DMRB (2006), Volume 11 Section 3 Part 10: HD45: Road Drainage and the Water Environment. Her Majesty's Stationery Office, London.

3.3 Infrastructure Maintenance Base - Rail

3.3.1 Roof drainage discharging directly to a drain or water body is considered not to pose a spillage risk. Areas draining to a foul sewer do not need to be assessed for risk of spillages. Remaining areas, such as those used for the storage of potential contaminants, should be assessed using an appropriate combination of expert judgment and analysis.

4 Mitigation measures

4.1.1 Mitigation measures will be identified to avoid, reduce or offset significant spillages risks. These will be described in the Environmental Statement (ES). These may include physical measures, such as spillage basins or control valves, or may include operating procedures, such as spillage kits, contingency plans and drainage layouts showing which section of the Proposed Scheme drains to which outfall.

4.1.2 For roads, reference should be made to Design Manual for Roads and Bridges (DMRB) 4.2.1[4] (HA 103) and DMRB 4.2.3[5] (HD33). Both documents give examples of suitable measures to reduce spillage risk from roads.

4.1.3 For depots, reference, where necessary, should be made to the environmental good practice advice in the Pollution Prevention Guidelines (PPG) available from NetRegs[6], together with the replacement guidance series, Guidance for Pollution Prevention (GPP) as and when this becomes available.

4.1.4 Of particular relevance are the following PPGs:

- PPG 18: Managing fire water and major spillages;
- PPG 21: Pollution incident response planning; and
- PPG 22: Incident response - dealing with spills.

4.1.5 Environmental monitoring may be required to monitor the effectiveness and on-going management of mitigation measures to protect the water environment. Monitoring should be undertaken as part of a wider environmental monitoring strategy and should cover the period before, during and after construction. The purpose of the monitoring would also be to define the environment and design baseline condition and ensure compliance with relevant environmental legislation.

5 Reporting residual effects

5.1.1 The ES will present the residual effects following the implementation of mitigation measures.

[4] Highways Agency (2009) *DMRB Volume 4, Section 2, Part 1 (HA103), Her Majesty's Stationery Office, London.*
[5] Highways Agency (2009) *DMRB Volume 4, Section 2, Part 3 (HD33), Her Majesty's Stationery Office, London.*
[6] http://www.netregs.org.uk/environmental-topics/pollution-prevention-guidelines-ppgs-and-replacement-series/guidance-for-pollution-prevention-gpps-full-list/

HS2 Phase 2a West Midlands - Crewe: Technical note – Water resources and flood risk – Water Framework Directive (WFD) compliance assessment process

Contents

List of figures

List of tables

1 Introduction

1.1.1 This technical note has been prepared as guidance for the assessment of compliance with European Union Water Framework Directive (WFD) legislation[1]. It should be read in conjunction with the Hs2 Phase 2a Environmental Impact Assessment (EIA) Scope and Methodology Report (SMR)[2]. It is intended as a guide to ensure a consistent approach is adopted across the Proposed Scheme. It is not an exhaustive and prescriptive methodology.

1.1.2 The WFD shall be considered from pre-hybrid Bill stage through to final detailed design and construction.

1.1.3 A WFD Compliance Assessment (henceforth named as a WFD Assessment) is required for the Proposed Scheme as agreed with the Environment Agency. This is to be prepared on a route-wide basis for each phase in general accordance with this guidance.

1.1.4 There is no established methodology or published Environment Agency guidance for assessing compliance with WFD legislation. This WFD Assessment will be based largely on internal Environment Agency guidance[3], the prior experience of HS2 Ltd. on Phase One (London-West Midlands) and professional judgement.

1.1.5 During Phase One, workshops were held with the Environment Agency to agree the scope and approach to the WFD Assessment. HS2 Ltd will continue to work with the Environment Agency through all phases from outline to detailed design.

1.1.6 The WFD classification data that will be assessed is taken from the Environment Agency Cycle 2 River Basin Management Plan annexes, which are based on 2015 data (https://www.gov.uk/government/collections/river-basin-management-plans-2015).

1.1.7 Where baseline data is limited or unavailable, professional judgement will be used in the assessment and a precautionary approach will be adopted.

1.1.8 The WFD Assessments prepared for each phase of the Proposed Scheme are "living" documents, which will be updated periodically to reflect the latest iteration of the design and assessment process.

2 Overview of the WFD

2.1 Aims

2.1.1 The WFD aims to protect and enhance the quality of the water environment across all European Union (EU) member states. It takes a holistic approach to the sustainable management of water by considering the interactions between surface water, groundwater and water-dependent ecosystems.

[1] Water Framework Directive - Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy, Strasbourg, European Parliament and European Council.
[2] Scope and Methodology Report, Volume 5: Appendix CT-001-001.
[3] Environment Agency (2010) *Assessing new modifications for compliance with WFD: detailed supplementary guidance.*

2.1.2 Under the WFD, 'water bodies' are the basic management units and are defined as all or part of a river system or aquifer. These water bodies form part of a larger 'River Basin District' (RBD), for which 'River Basin Management Plans' (RBMP) are developed by EU member states and environmental objectives are set. These RBMP are produced every six years, in accordance with the river basin management planning cycle.

2.1.3 The WFD requires all EU member states to classify the current condition or 'status or potential' of surface water and groundwater bodies and to set a series of objectives for maintaining or improving conditions so that water bodies maintain or reach 'good status or potential'.

2.2 WFD requirements for new developments

2.2.1 To ensure compliance with the WFD, decision makers must consider whether proposals for new developments have the potential to:

- cause a deterioration of a water body from its current status or potential;
- prevent future attainment of good status or potential where not already achieved;
- impact on protected or priority species and habitats; and/or
- provide opportunities to improve the water environment.

2.2.2 A ruling by the European Union Court of Justice on 1st July 2015[4] has significant implications for projects that may impact water bodies, namely:

- Consent for development must not be granted by an authorising authority – unless a derogation is granted - where the project may cause a deterioration in the status of a body of surface water or where it jeopardises the attainment of good ecological surface water status or of good ecological potential and good surface water chemical status by the date laid down in the directive;
- That "deterioration of the status" of the relevant body of surface water includes a fall by one class of any element of the "quality elements" within the meaning of Annex V of the WFD even if the fall does not result in a fall of the classification of the body of surface water as a whole; and
- If the quality element is already in the lowest class, any deterioration of that element represents deterioration of status within the meaning of Article 4(1)(a)(i).

2.2.3 In the event that a proposed development does not fully mitigate the risks of deterioration occurring, or it prevents future attainment of good status or potential,

[4] Case 461/13 Bund für – Umwelt Und Naturschutz Deutschland v Bundesrepublik Deutschland ("the Bund case") concerning the interpretation of Article 4(1)(a)(i) to (iii) of the Water Framework Directive 2000/60/EC ("WFD").

then evidence would need to be provided to satisfy all the requirements of Article 4.7 of the WFD legislation in order to be compliant, namely that:

- all practicable steps have been taken to mitigate the adverse impact on the status of the water body;
- the reasons for the modifications or alterations are specifically set out and explained in the RBMP;
- the reasons for the modifications or alterations are of overriding public interest and/or the benefits to the environment and to society of achieving the WFD objectives are outweighed by the benefits of the new modifications or alterations to (among other things) sustainable development; and
- the beneficial objectives served by the modifications or alterations of the water body cannot for reasons of technical feasibility or disproportionate cost be achieved by other means, which are a significantly better environmental option.

2.2.4 Thus with regard to the Proposed Scheme, if the hybrid Bill design and Environmental Statement (ES) cannot demonstrate that there will be no deterioration, then a derogation will need to be prepared under Article 4.7 to ensure that the Proposed Scheme is compliant under the WFD legislation and the Bill can pass through parliament. Further information that would be prepared through the design process may alleviate the need for a derogation on particular water bodies but will have to be prepared to ensure compliance can be attained.

3 Determination of WFD status

3.1 Introduction

3.1.1 Surface water bodies and Groundwater bodies are defined within WFD legislation. There are three types of surface water body, as follows:

- natural water bodies;
- heavily modified water bodies (HMWBs);
- artificial water bodies (AWBs).

3.1.2 The overall status of natural surface water bodies is determined on the basis of their ecological status and chemical status. The overall status of heavily modified and artificial water bodies is classified based on their ecological potential and chemical status. The overall status of groundwater bodies is determined on the basis of their quantitative status and chemical status.

3.1.3 Groundwater bodies are defined within WFD legislation as Groundwater Management Units (GWMU) and Water Resource Management Units (WRMU) and their status is determined on the basis of quantitative and chemical sub-elements.

3.1.4 The means by which these determinations are made for both surface water and ground water bodies is described below.

3.2 Determination of the status of natural surface water bodies

Ecological status

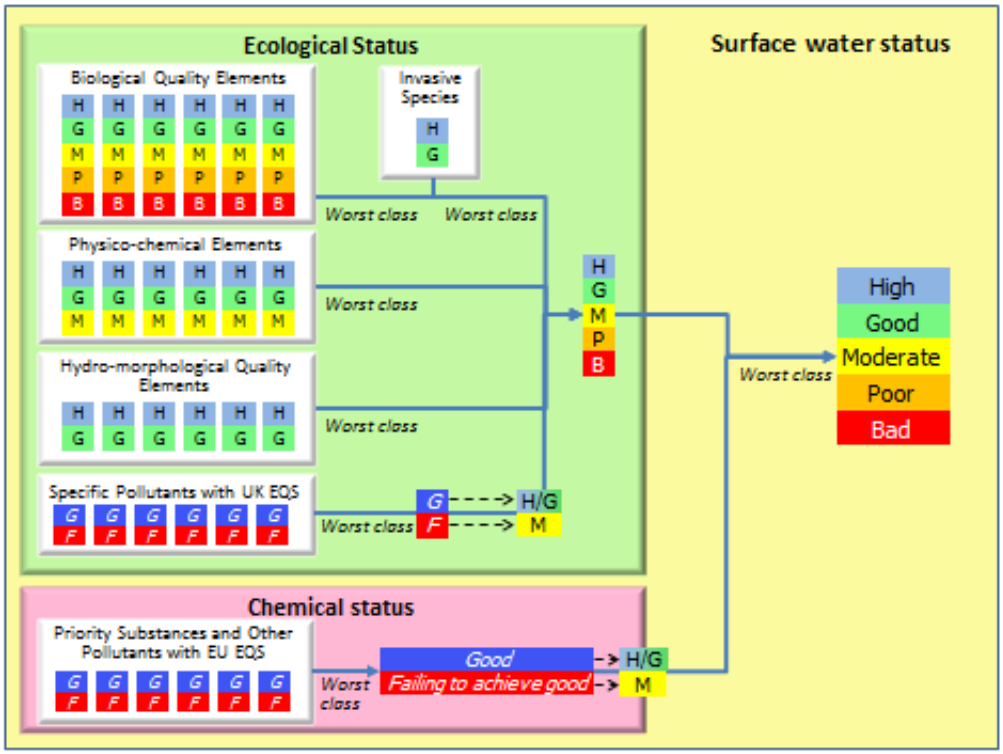
3.2.1 Ecological Status is defined by the overall quality of the structure and functioning of aquatic ecosystems associated with surface waters, i.e. the condition of the watercourse. This is assigned on a scale of high, good, moderate, poor or bad, and on the basis of four classification elements or 'tests', as follows:

- Biological - This test is designed to assess the status indicated by a biological quality element such as fish, invertebrates, macrophytes or phytobenthos (diatoms). The biological quality elements can influence an overall water body status from bad through to high. It is also important to note that the presence of invasive species prevents a water body from achieving high status when all other elements attain high;
- Physico-chemical - This test is designed to assess the status indicated by physico-chemical quality elements such as dissolved oxygen, phosphorus and ammonia, against environmental standards. The physico-chemical quality elements can only influence an overall water body status from moderate through to high;
- Specific pollutants - This test is designed to assess compliance with environmental standards for concentrations of specific pollutants, such as zinc, cypermethrin or arsenic. As with the physico-chemical test, the specific pollutant assessment can only influence an overall water body status from moderate through to high; and
- Hydromorphology - For natural surface water bodies this test[5] is undertaken by the Environment Agency during classification when the biological and physico-chemical tests indicate that a water body may be of high status. It specifically assesses hydromorphological quality elements such as water flow, sediment composition and movement, continuity, and structure of the habitat against reference or 'largely undisturbed' conditions. If the hydromorphological quality elements do not support high ecological status, then the status of the water body is limited to good overall status. Hydromorphological assessments are used to determine 'high' overall ecological status only, and are not be used to drive a water body status class below good. The 'does not support good' classification should be reported for the purposes of identifying water bodies which fail the flow test

3.2.2 The worst case classification is assigned as the overall surface water body status, in a 'one-out all-out' system. This system is summarised in Figure 1.

[5] Environment Agency (2015), Rules for assessing Surface Water Body Status and Potential, Decision document for 2015 new building block (cycle 2) Water Framework Directive classifications (version 2.0).

Figure 1: WFD classification elements for surface water body status. Source: Environment Agency Rules for Assessing Surface Water Body Status and Potential (2015)



Chemical status

3.2.3 Chemical status is defined by compliance with environmental standards for chemicals that are priority substances and/or priority hazardous substances, in accordance with the Environmental Quality Standards Directive (2008/105/EC)6. This is assigned on a scale of good or fail.

3.2.4 Surface water bodies are only monitored for priority substances where there are known discharges of these pollutants; otherwise surface water bodies are reported as being of good chemical status.

3.3 Determination of ecological potential for heavily modified (and artificial) water bodies

3.3.1 Ecological potential is assigned to artificial water bodies (AWB) (such as reservoirs and canals), or natural water bodies which, as a result of physical alterations by human activity, are substantially changed in character. The latter are termed heavily modified water bodies (HMWB). The term 'ecological potential' is used to classify AWBs and HMWBs as it may be impossible for these water bodies to achieve good ecological status (GES) because of their creation or modification for a specific use, such as navigation, water supply or flood protection. The ecological potential of an AWB or HMWB represents the degree to which the quality of the water body approaches the optimum condition it could achieve given its artificial or heavily modified state.

[6] Directive 2008/105/EC pf the European Parliament and of the Council of 16 December on environmental quality standards in the field of water policy, Strasbourg, European Parliament and European Council.

3.3.2 AWB and HMWBs are subject to an additional set of rules that need to be implemented prior to running the one-out-all-out process. These rules determine which biological quality elements should be used in the water body ecological potential classification. Under normal circumstances, AWB and HMWBs are classified according to an assessment of mitigation measures, which defines good ecological potential (GEP) in water bodies where all applicable mitigation is in place, and moderate ecological potential in water bodies where some or all relevant mitigation is missing. However, to prevent AWB and HMWBs being incorrectly classified as good potential in situations where all mitigation is in place, but other pressures are causing an impact (e.g. nutrient enrichment or pollution from toxic substances), the methodology adopted in the UK additionally considers biological indicators providing they are not sensitive to the heavily modified nature of the water body.

3.3.3 AWB and HMWB hydromorphological elements are assessed using a three stage process, firstly looking at flow, then mitigation measures and biological quality elements.

3.3.4 Flow conditions are assessed initially on a fail or pass basis to determine which of the biological and physico-chemical quality elements should be used in the classification of ecological potential.

3.3.5 Where the flow conditions are unaffected by the physical modification (flow conditions pass), the water body potential is determined by the worst of either the mitigation measures assessment, or any element that is not sensitive to the modified nature of the water body.

3.3.6 Where the flow conditions are significantly impacted by the physical modification (flow conditions fail), the water body potential is determined by the worst of any of the mitigation measures assessments or the assessment of biological quality elements, physico-chemical quality elements or specific pollutants.

3.3.7 Where a water body is designated as artificial or heavily modified for water resources usage, either solely or jointly with other uses, the flow condition is assumed to be good (pass).

3.4 Determination of the status of groundwater bodies

3.4.1 Under the WFD, groundwater body status is classified on the basis of quantitative status and chemical status. The groundwater bodies are separated into Groundwater Management Units (GWMU) and Water Resource Management Units (WRMU). GWMU are sub-divisions of the groundwater to aid the resource assessment process. WRMU are sub-divisions according to the water resource availability and the management of water.

Quantitative status

3.4.2 Quantitative status is defined by the quantity of groundwater available as base flow to watercourses and water-dependent ecosystems and as 'resource' available for use as drinking water and other consumptive purposes. It is assigned on a scale of good or poor, and on the basis of four classification elements or 'tests' as follows:

- Saline or other intrusions - This test is designed to identify groundwater

bodies where the intrusion of poor quality water, such as saline water or water of different chemical composition, as a result of groundwater abstraction is leading to sustained upward trends in pollutant concentrations or significant impact on one or more groundwater abstractions;

- Surface water - This test is designed to identify groundwater bodies where groundwater abstraction is leading to a significant diminution of the Ecological Status of associated surface water bodies;
- Groundwater Dependent Terrestrial Ecosystems (GWDTE) - This test is designed to identify groundwater bodies where groundwater abstraction is leading to significant damage[7] to associated GWDTE; and
- Water balance - This test is designed to identify groundwater bodies where groundwater abstraction exceeds the 'available groundwater resource', defined as the rate of overall recharge to the groundwater body itself less the rate of flow required to meet the ecological needs of associated surface water bodies and GWDTE.

Chemical status

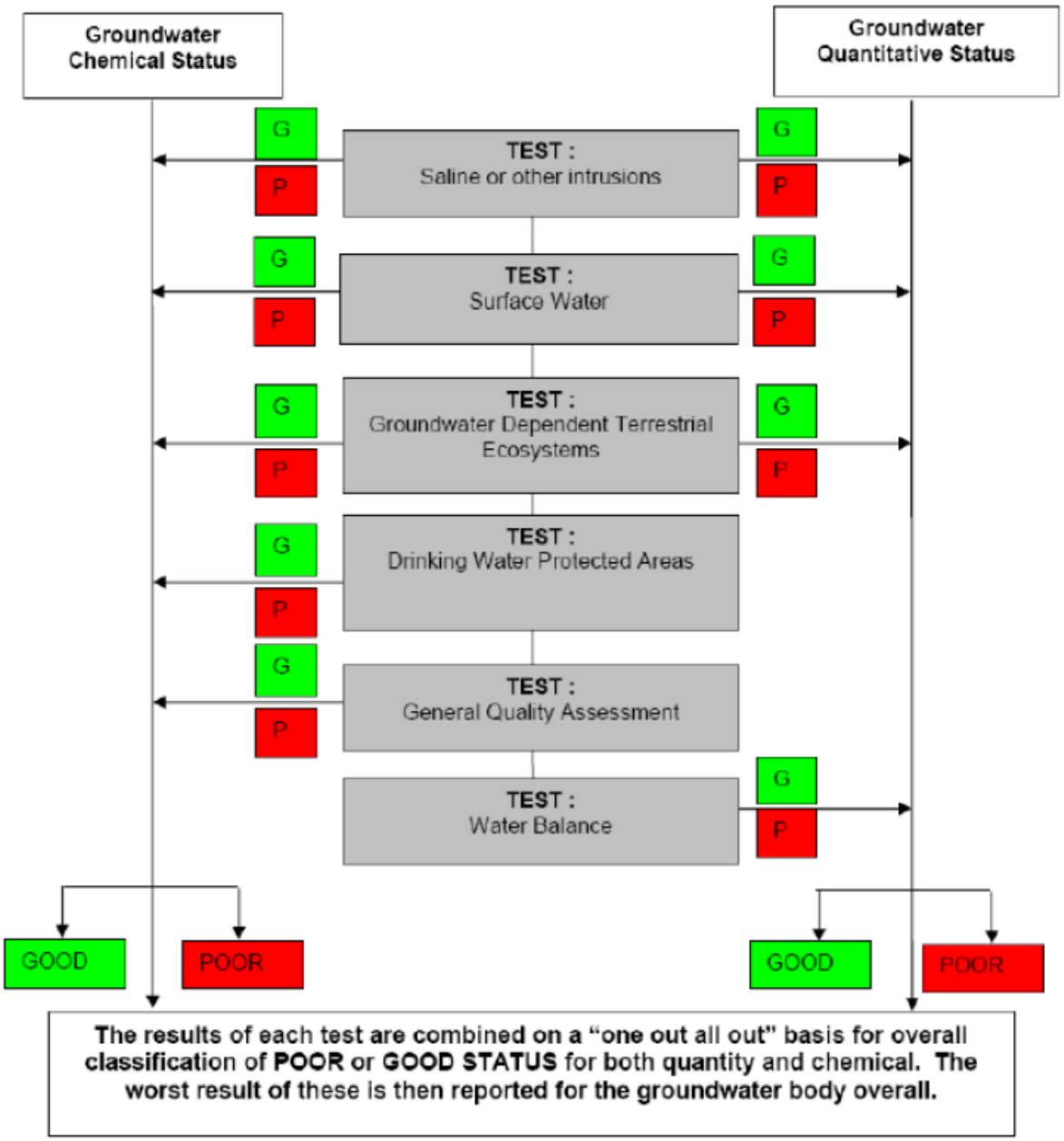
3.4.3 Chemical status is defined by the concentrations of a range of key pollutants, by the quality of groundwater feeding into watercourses and water-dependent ecosystems and by the quality of groundwater available for drinking water purposes. This is assigned on a scale of good or poor, and on the basis of five classifications elements or 'tests', as follows:

- Saline or other intrusions - This test is designed to identify groundwater bodies where the intrusion of poor quality water, such as saline water or water of different chemical composition, as a result of groundwater abstraction is leading to sustained upward trends in pollutant concentrations or significant impact on one or more groundwater abstractions;
- Surface water - This test is designed to identify groundwater bodies where groundwater is leading to a significant diminution of the chemical status of associated surface water bodies;
- GWDTE - This test is designed to identify groundwater bodies where groundwater is leading to significant damage[8] to associated GWDTE;
- Drinking Water Protected Areas (DrWPA) - This test is designed to identify groundwater bodies failing to meet the DrWPA objectives defined in Article 7 of the WFD or at risk of failing in the future. The aim is no deterioration in quality of waters for human consumption, and
- General quality assessment - This test is designed to identify groundwater bodies where widespread deterioration in quality has, or will, compromise the strategic use of groundwater. The aim is no significant impairment of

[7] As described in Environment Agency Method Statement for Groundwater Quantitative Status Assessment (Classification).
[8] As described in Environment Agency Method Statement for Groundwater Chemical Status Assessment (Classification).

human use of groundwater and no significant environmental risk from pollutants across a groundwater body. Status is assessed primarily using data collected from the Environment Agency monitoring network; therefore the scale of assessment means that groundwater status is mainly influenced by larger scale effects such as significant abstraction or widespread diffuse pollution. The worst case classification is, as with surface water bodies, assigned as the overall groundwater body status, in a 'one-out all-out' system. This system is summarised below in Figure 2.

Figure 2: WFD classification elements for groundwater body status. Source: Environment Agency Groundwater Quantitative Status Assessment (Classification) Method Statement



4 Scope of assessment

4.1 Spatial and temporal scope

4.1.1 The spatial scope of the assessment includes all WFD designated and non WFD designated water bodies within 1km of the centre-line of the proposed route. This may be extended or reduced depending on the sensitivity of the water body and the nature of the likely impacts upon it.

4.1.2 As well as WFD water bodies, the assessment of impacts on fish will also include non WFD water bodies which are upstream tributaries of water bodies directly affected by the Proposed Scheme. This is in recognition of the migratory habits of fish and the potential presence of spawning habitats in the tributaries.

4.1.3 Temporary impacts (defined as less than three years) are not considered to result in deterioration in WFD status. Impacts are not considered to constitute deterioration of status of the water body if the water body:

- is only impacted for a short time period (less than three years);
- recovers within a short time period (less than three years); and/or
- recovers without the need for any restoration measures.

4.2 Technical scope

Surface water

4.2.1 No biological, physico-chemical, specific pollutants, or hydromorphological quality elements have been scoped out of the assessment.

Groundwater

4.2.2 No quantitative status or chemical status sub-elements have been scoped out of the assessment.

4.3 Assumptions

4.3.1 Watercourses that are crossed by the Proposed Scheme which are not officially designated as WFD water bodies by the Environment Agency will be included in the assessment. It will be assumed that these water bodies have the same status objectives as the designated water body into which they flow. However, the measures proposed to mitigate any adverse impacts on these water bodies will aim to be appropriate to their local context.

4.3.2 Articles 4 and 17 of the WFD include requirements to implement measures necessary to prevent or limit the input of pollutants into groundwater and to prevent the deterioration of the status of all bodies of groundwater. The Groundwater Directive (2006/118/EC)[9] complements the Water Framework Directive (WFD) and includes a requirement for measures to prevent or limit inputs of pollutants into groundwater so that WFD environmental objectives can be achieved.

[9] http://www.eea.europa.eu/policy-documents/groundwater-directive-gwd-2006-118-ec

4.3.3 Much of the embedded mitigation incorporated into the design is aligned to the 'prevent and limit' objective. Compliance with this will not be explicitly assessed as part of the water body status assessment; however, it will be taken into account during the assessment of the General Quality Assessment WFD element, which considers the potential impacts of the Proposed Scheme on groundwater quality as a whole.

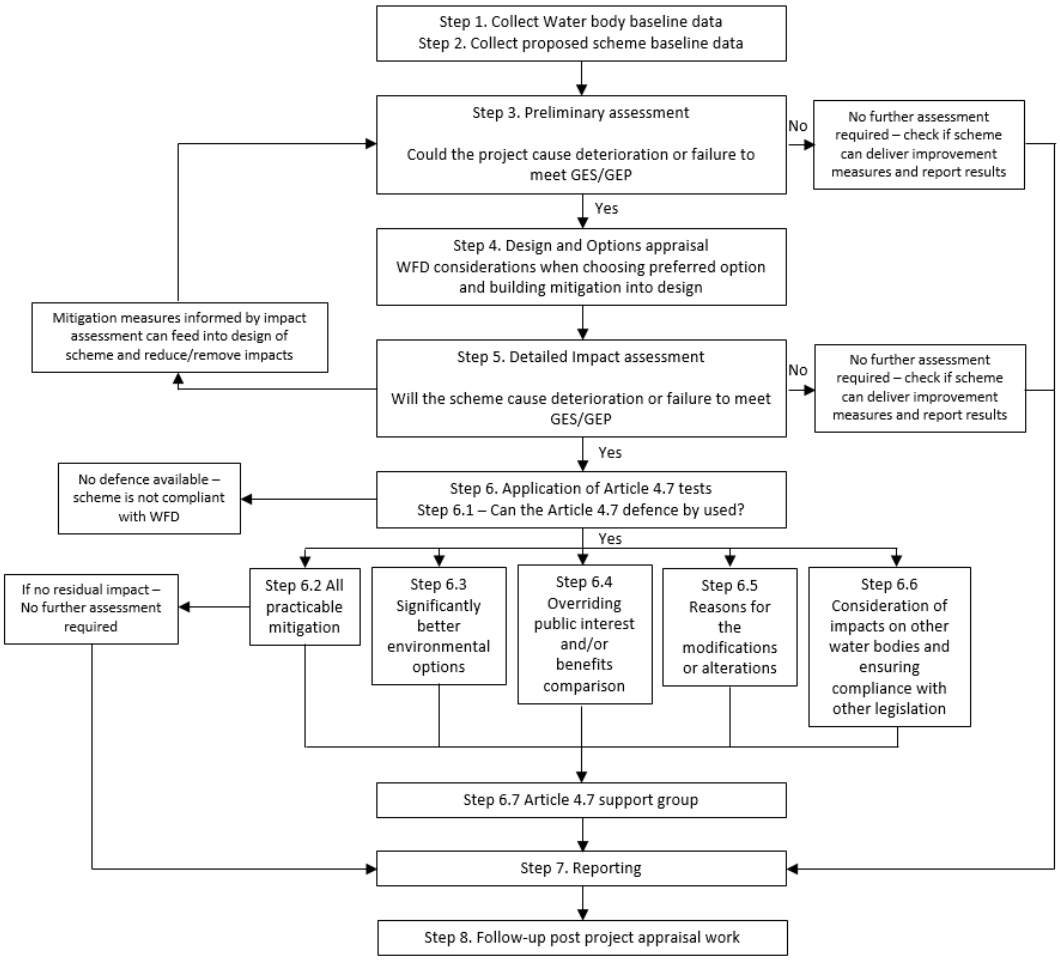
5 Process overview

5.1.1 The WFD assessment will be undertaken as a stepped process, which can be summarised in the following steps:

- **Step1:** Collect water body baseline data;
- **Step 2:** Collect Proposed Scheme baseline data;
- **Step 3:** Preliminary assessment;
- **Step 4:** Design options appraisal and selection of preferred option;
- **Step 5:** Detailed impact assessment;
- **Step 6:** Application of Article 4.7 where applicable;
- **Step 7:** Reporting;
- **Step 8:** Follow-up post-project appraisal work.

This process is illustrated in Figure 2.

Figure 2: Steps in the WFD assessment process



6 Reporting

6.1.1 The WFD Assessment will be a stand-alone route-wide report for each phase of the Proposed Scheme. The structure of the report will reflect the process outlined in Section 5, with detailed content as per Appendix A.

6.1.2 The WFD Assessment will inform the content of the ES, as follows:

- Where a non-compliance is identified as part of the WFD Assessment, it will be reported as a significant effect within the ES; and
- The WFD Assessment will inform the mitigation proposed in the ES.

Appendix A

1 Introduction

1.1.1 This appendix summarises the key steps involved in undertaking the WFD Assessment (as described in Section 5). This includes an overview of the scope, methodology and data requirements of each step.

2 Water body baseline establishment

2.1 Baseline definition

2.1.1 Baseline information will be gained from available sources, such as the Environment Agency and Natural England. The WFD Assessment shall start with a desk-top exercise to collate the available background information in relation to surface water and groundwater bodies adjacent to the Proposed Scheme and the risk of deterioration in WFD status will be assessed on this basis.

2.1.2 Environment Agency data (2015 Cycle 2 Water Body Status Classification data) will be reviewed to define the baseline conditions as part of the desktop assessment.

2.1.3 Where a desktop assessment has identified water bodies at risk of potential deterioration, WFD baseline surveys will be undertaken, to provide further information to inform the assessment; however, these are subject to constraints, such as seasonality and access. Taking this into consideration the general survey requirements are provided in the subsequent sections.

Ecology baseline

General

2.1.4 Any collected ecology baseline survey data required to inform the WFD Assessment, aim to assess a stretch of river a minimum of 100m upstream and downstream of the route crossing point. Ecological baseline surveys will be undertaken alongside the hydromorphology surveys, to inform the need for further fish, macroinvertebrate, macrophyte and phytobenthos (diatoms) surveys.

2.1.5 Field surveys will only be carried out where required and/or where land access allows.

2.1.6 Where no baseline survey data is available, for example where third party access was not granted, the water body assessment will be estimated based on the status class information. Estimated assessments are precautionary (i.e. where there is doubt regarding the sensitivity of the species assemblage, a higher level of sensitivity will be assumed).

2.1.7 Ecological baseline survey data for WFD water bodies will be collected using a methodology compliant with Environment Agency WFD standard practices and as part of the ES includes (where appropriate and access allows):

- Macroinvertebrates[10];
- Fish[11];
- River Habitat Surveys (RHS)[12]; and
- River Corridor Surveys (RCS).

Macroinvertebrates

2.1.8 The macroinvertebrate baseline data includes biological indices, including Whalley Hawkes Paisley Trigg (WHPT), Average Score Per Taxon (ASPT), Lotic-invertebrate Index for Flow Evaluation (LIFE) and River Invertebrate Classification Tool (RICT) scores.

Fish

2.1.9 The baseline fish data will include reference to species protected under the Salmon and Freshwater Fisheries Act 1975[13] and EU Freshwater Fish Directive (FFD)[14]. The operative provision of the Freshwater Fish Directive has been taken over into the WFD, allowing the FFD to be repealed.

RHS and RCS

2.1.10 The data from these surveys is not directly relevant to the WFD Assessment, although they may provide some indication of macrophyte cover and contextual information on habitat quality and the potential influence of other pressures within the catchment (such as damage to channel habitats from grazing, existing structures, shading etc.). They also contain information on the principal plant species present and their extent.

Physico-chemical baseline

2.1.11 Physico-chemical sub-element status from the RBMPs will be assessed. Where required, data on surface water discharge consents and dilution or mass balance calculations for specific water bodies will be taken from the water resource appendices (contained in Volume 5 of the ES).

Hydromorphology baseline

2.1.12 Hydromorphology is the study of the physical form and function of water bodies, and the basis for assessing physical habitats and whether alterations to water bodies would be detrimental to existing or potential water body functioning. It therefore also constitutes a substantial part of determining appropriate mitigation to offset the impacts of alterations.

2.1.13 Hydromorphological surveys are required in water bodies for which there is a potential risk of deterioration; this is to provide a baseline dataset for the WFD elements:

[10] Environment Agency (2009), Freshwater macro-invertebrate sampling in rivers, Operational instruction 018_08.
[11] BS EN 14011: 2003 Water Quality Sampling of Fish with Electricity.
[12] Environment Agency (2003), River Habitat Survey in Britain and Ireland, Field Survey Guidance Manual.
[13] http://www.legislation.gov.uk/ukpga/1975/51/contents/enacted
[14] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:264:0020:0031:EN:PDF

Supporting Conditions (quantity and dynamics of flow and morphology). These surveys will only be carried out where required and land access allows.

2.1.14 Where no baseline survey data is available, for example where third party access was not granted, the water body assessment will be estimated based on the status class information and any map based information available which may provide some indication of the nature of the water body and any processes acting within it.

2.1.15 The surveys will focus in detail on the area immediately adjacent to the impact location (typically 100m up and downstream of the impact location). Where access is permitted, the surveys should include a walkover survey of up to 2 km upstream and downstream (in total). The surveys shall assess the local hydromorphological features, processes and existing anthropogenic influences.

2.1.16 Hydromorphological surveys do not routinely form part of the suite of baseline surveys undertaken for ES. Some hydromorphological information is collected as part of the RHS and RCS methodology. However, the Environment Agency's internal guidance for WFD assessment recommends that specialised hydromorphological surveys are also undertaken.

Groundwater baseline

2.1.17 Baseline information on the groundwater bodies and on groundwater dependent features will be obtained from British Geological Survey (BGS) and Environment Agency mapping.

2.1.18 There is typically limited site-specific groundwater level or quality data. Groundwater data is generally obtained from boreholes. Although there are some boreholes along the route, none have been drilled for the Proposed Scheme. Where no baseline data is available the groundwater body assessment is precautionary.

2.1.19 GWDTE and potential GWDTE have been identified from published databases of designated statutory and non-statutory sites as well as water-dependent ecological features identified in the ES.

2.1.20 Groundwater surveys shall focus on areas of potential groundwater emergence, including springs and wetland areas.

2.1.21 Groundwater surveys will include an assessment of groundwater-surface water interactions. These surveys will only be carried out where required and/or land access allows. Surveys shall include field estimates of spring flows and basic groundwater quality (temperature, pH, EC) in the vicinity of the Proposed Scheme (typically within 1 km) and where access is possible. The need for further surveys will be identified, including determination of suitable locations for long-term monitoring installations such as staff gauges, transducers or weirs.

3 Scheme baseline establishment

3.1 Objectives

3.1.1 The objectives are to establish the key components of the Proposed Scheme design and their likely impacts to inform the preliminary assessments undertaken in Step 3.

3.2 Scheme components

3.2.1 The CT-06 map series (which are presented in the ES) is the primary source of Proposed Scheme design information.

3.2.2 The assessment will include all construction proposals associated with the Proposed Scheme, which have the potential to permanently affect surface water and groundwater bodies, and therefore have the potential to impact on WFD status. Proposals will either be assessed as individual structures or as a combination of proposed features (e.g. river diverted and straightened into a culvert).

3.3 Initial identification of potential impacts

3.3.1 The range of direct impacts likely to be associated with the typical Proposed Scheme components are summarised in Table 1 for surface water and Table 2 for groundwater. The impact of other structures (such as earth bunds, material storage areas, temporary haulage routes, etc.) on water bodies within or adjacent to the route are also considered.

Table 1: Identified impacts of scheme elements on surface water bodies

	Design component												
Impact considered	**Bored tunnel**	**Green tunnel**	**Viaduct**	**Clear span bridge**	**Bridge with footings in water body**	**Culvert**	**Siphon**	**River realignment / diversion**	**Cutting**	**Retaining walls**	**Embankments**	**Stations**	**Borrow pits**
Footprint	✓	✓	✓	X	✓	✓	✓	✓	X	✓	✓	✓	✓
Changes in flow velocity and volume due to dewatering	✓	✓	X	X	X	X	X	X	✓	✓	X	X	✓
Noise and vibration during construction	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Shading	X	X	✓	✓	✓	✓	X	X	X	X	✓	X	X
Drainage	X	✓	✓	✓	✓	✓	✓	X	X	X	✓	✓	✓
Changes to water body hydromorphology leading to changes in river processes and habitats upstream and downstream	X	X	✓	X	✓	✓	✓	✓	X	X	X	X	✓
Change in water quality due to discharge of groundwater to a surface water body	✓	✓	X	X	X	X	X	X	✓	✓	X	X	✓
Creation of new habitats	X	X	X	X	X	X	X	✓	X	X	X	X	X
Settlement of ground leading to enhancement of fractures and increased vertical permeability where applicable	✓	X	X	X	X	X	X	X	X	X	X	X	X

Table 2: Identified impacts of scheme elements on groundwater bodies

	Design component							
Impact considered	**At grade**	**Embankment**	**Cutting**	**Retaining walls**	**Stations**	**Bored tunnel**	**Green tunnel**	**Viaduct foundations**
Lowering of groundwater levels and reduction in groundwater contributions to surface water bodies, GWDTE or groundwater abstractions by temporary dewatering/permanent groundwater control	X	X	✓	✓	✓	✓	✓	X
Disturbing or mobilising existing poor quality groundwater by temporary dewatering or depressurisation and permanent groundwater control	X	X	✓	✓	✓	✓	✓	X
"Damming" of groundwater flow and reduction in groundwater contributions	X	X	✓	✓	✓	✓	✓	✓
Creating or altering of pathways along which existing poor quality groundwater can migrate	X	X	✓	✓	✓	✓	✓	✓

4 Preliminary assessment

4.1 Objectives

4.1.1 The objective of the preliminary assessment is to establish the likely effects and whether any components of the Proposed Scheme could cause deterioration in, or failure of a water body to achieve, GES or GEP. Only those scheme components that could result in deterioration or failures of this kind should be taken forward for more detailed assessment.

4.2 Consideration of likely effects

4.2.1 The preliminary assessment should take into account both the positive effects of 'embedded mitigation' (i.e. measures such as habitat compensation/offsetting that have been incorporated into the design of the Proposed Scheme), as well as the potentially negative impacts of scheme components.

4.2.2 Positive benefits for biological and hydromorphological quality elements are likely to arise primarily from river diversions and or realignments, which will be designed to include a range of channel and bankside habitats, including pools, riffles, runs and marginal berms (where appropriate and reasonably practicable). Habitat enhancements will be incorporated, where reasonably practicable, into the design at most culvert locations in order to provide refuges areas for fish, both up and downstream of the culverts.

Biological effects

4.2.3 Effects on biological quality elements will be considered in terms of likely change in composition and abundance of phytobenthos, macrophytes and macroinvertebrate communities and for fish on composition, abundance and age structure.

Physico-chemical effects

4.2.4 Effects on physico-chemical quality elements will be considered in relation to likely changes in the chemical composition of phosphate, ammonia and specific pollutants and for physical changes which cause variations in dissolved oxygen and temperature within a water body.

Hydromorphological effects

4.2.5 Effects on hydromorphological quality elements will be considered in relation to quantity and dynamics of flow, river continuity (including existing restrictions such as sluices and weirs), river depth and width variation, structure and substrate and structure of the riparian zone.

Groundwater effects

4.2.6 Effects on quantitative sub-elements will be considered in terms of the likely changes in groundwater levels, groundwater flows and the hydraulic regime, spring flows and rates of baseflow to surface waters.

4.2.7 Effects on chemical sub-elements will be considered in terms of the likely changes in water quality.

4.3 Cumulative effects

4.3.1 Cumulative effects are likely to include:

- The interpretation of a range of different impacts acting upon a single quality element within a water body;
- multiple scheme elements on a single water body resulting in additive impacts on one or more quality element; and
- effects likely to be transmitted downstream to a different WFD designated water body which may also be directly affected by the Proposed Scheme.

4.4 Traffic light system

4.4.1 The assessment process agreed with the Environment Agency is to use a traffic light rating system. A system was developed for the Phase One ES and then revised following the European Union Court of Justice ruling as discussed in Section 2.2 of this technical note. The revised system was used to identify:

- **Dark Blue**: beneficial effect of a scale sufficient to increase status class for the quality element at water body scale (certain);
- **Light Blue**: beneficial effect resulting in a localised improvement, but insufficient to increase status class for the quality element at water body scale (certain);
- **Green:** no measureable change to (or effect on) status class for the quality element at water body scale (certain);
- **Yellow:** minor localised and/or temporary effect when balanced against likely embedded mitigation – insufficient to affect status class for the quality element at water body scale (certain);
- **Amber**: an adverse effect is possible when balanced against likely embedded mitigation – the extent of effect is uncertain, and there remains a potential to affect status class for the quality element at water body scale. Effects need to be considered with additional mitigation; and
- **Red**: adverse effect of sufficient scale to impact on status class for the quality element at a water body scale (certain).

5 Design and options appraisal

5.1 Objectives

5.1.1 The objectives of this step are to identify the options available that are most compatible with achieving WFD objectives and to develop the design of any additional mitigation required to reduce the risk of the Proposed Scheme causing deterioration in any one of the elements used to determine an affected water body's status.

5.2 Rationale

5.2.1 The Proposed Scheme will seek to avoid direct or indirect harm to landscape, water and ecological resources, to mitigate adverse impacts where necessary, and to enhance such resources where reasonably practicable.

5.2.2 Where potentially significant adverse environmental effects have been identified during the assessment process, developing appropriate mitigation will be an iterative part of the Proposed Scheme development following the hierarchy below:

a) avoidance – incorporate measures to avoid the effect, for example, alternative design options or modifying the Proposed Scheme programme to avoid environmentally sensitive periods;

b) reduction – incorporate measures to lessen the effect, for example, fencing off sensitive areas during construction and implementing a Code of Construction Practice (CoCP) to reduce the potential impacts from construction activities;

c) remediation – as a form of mitigation, for example the re-provision of habitat to replace that lost to Proposed Scheme construction, or remediation such as the clean-up of contaminated soils; and

d) compensation – to be considered in the context where mitigation at the affected location is not possible to avoid or reduce a significant effect, in which case offsetting measures should be considered at other locations.

5.2.3 The term "enhancement" refers to providing measures over and above those needed to mitigate the adverse effect, and/or maximising the opportunity for beneficial effects from the Proposed Scheme.

5.2.4 Effects that remain after mitigation are referred to as "residual effects". Therefore, the key outcome of the assessment is the significance of the residual effects after mitigation or enhancement.

5.2.5 The WFD Assessment will be undertaken assuming all the embedded mitigation presented in the ES is in place and that all design elements will be developed in accordance with current best practice.

5.2.6 Where a Proposed Scheme element cannot be redesigned to avoid an adverse impact that would still result in a deterioration to a surface water and/or groundwater body element under the WFD, additional mitigation will be identified where possible to avoid or minimise the impacts and ensure compliance with the WFD. Priority should be given to undertaking this within the Proposed Scheme's footprint on the same water body.

5.3 Mitigation

Design

5.3.1 Potential impacts to water bodies can often be addressed through the design process by embedding mitigation to help ensure compliance with the WFD.

5.3.2 The Proposed Scheme will, where it is reasonably practicable to do so, aim to eliminate or minimise adverse ecological impacts through avoiding ecological impacts at source.

5.3.3 In addition to mitigation, compensation measures will be considered within the Proposed Scheme design process. Where reasonably practicable, habitat creation or enhancement measures will be incorporated into the design.

Construction

5.3.4 Management of risks to water bodies during construction should comply with the draft CoCP[15] as well as including, but is not being limited to, the following mitigation adopted where reasonably practicable:

- limit the working width in sections of the route passing through sites and habitats of known conservation value;
- avoiding fragmentation and isolation of habitats, species or features. However, where there is no option but to cause fragmentation/severance, attempt to maximise the size of the habitat/population/feature which is considered to be of the greatest value;
- locating temporary works compounds, storage areas and temporary haulage routes within areas known to be of limited nature conservation value;
- ensuring that engineering design retains an adequate 'buffer' around sites, habitats or features of ecological value, sufficient in order to ensure their continued ecological functionality. The scale of the required buffer will be site specific and should take into account the nature of the features for which it is of value. Suitable fencing to maintain such buffer zones should be specified where this is considered to be required;
- minimising the impacts of severance as a consequence of the Proposed Scheme through the inclusion of features, such as oversized culverts etc., to facilitate movement of species across the track alignment at appropriate locations identified from baseline data. Where necessary these features should be used in conjunction with appropriate wildlife proof fencing (e.g. permanent amphibian fencing) and any landscape planting required to increase their effectiveness;
- minimising the requirements for temporary watercourse diversions during construction and implementing appropriate measures to minimise impacts on habitats/sites of nature conservation value;
- utilising best practice methodologies for earthworks, including the removal, handling and storage of soils, with, in particular, adoption of appropriate measures to prevent surface water run-off carrying sediments and pollutants;
- where sites/habitats/species of significant ecological value will be impacted

[15] Draft Code of Construction Practice, Volume 5: Appendix CT-003-000.

by temporary works, appropriate measures will be specified to protect, re-instate or recreate these habitats;

- control of surface water discharge from the site, both in terms of attenuation, flood management and pollution control. This will include the use of silt traps or other sediment control measures where appropriate;
- minimising dewatering requirements, including for example, the use of temporary cut-off walls;
- control of materials, including temporary material stockpiles, bunding of stored chemicals, fuels, oils etc.; and
- contingency planning for spillages and floods.

Operation

5.3.5 A range of mitigation will be proposed to prevent deterioration of water resources and ecological function during operations.

5.3.6 Operational risks will be mitigated primarily through the design process.

5.3.7 Additional mitigation for the operational phase may include, but is not limited to, the following measures:

- a draft operation and maintenance plan aimed at ensuring that potential impacts occurring as a consequence of the Proposed Scheme are minimised as far as is reasonably practicable. This will include contingency plans to manage the consequences of unplanned incidents and protocols for use of pesticides and herbicides; and
- monitoring and management of water, habitats and species to demonstrate that ecological functionality has been maintained.

Investigation and monitoring

5.3.8 Site-specific intrusive ground investigation and monitoring for the Proposed Scheme will be undertaken as detailed design progresses.

5.3.9 Monitoring will be undertaken in consultation with the Environment Agency prior to, during and post-construction, to establish baseline conditions for surface water and groundwater to confirm the effectiveness of any temporary and permanent mitigation.

5.4 Enhancements

5.4.1 A primary driver of the WFD is to promote improvements in overall or element status and/or take advantage of opportunities to enhance the environmental and ecological quality of water bodies.

5.4.2 Specific water body pressures are listed within the relevant RBMPs at the outset and where reasonable and practical enhancement opportunities are identified.

5.4.3 Small scale enhancements such as, for example, planting, fencing, setting back existing embankments, shall be considered for implementation on a site-by-site basis where reasonably practicable. These may not directly mitigate impacts, but may further contribute towards the wider objectives of the WFD.

6 Detailed impact assessment

6.1 Objectives

6.1.1 The objective of this step is to assess in detail whether all components of the Proposed Scheme, following incorporation of the measures identified in Step 4, will result in:

- no deterioration of existing status; and
- not preventing achievement of good status in the future.

6.2 No deterioration assessment

6.2.1 The approach to the assessment against the 'no deterioration' objective broadly follows the standard ecological impact assessment method of considering the sensitivity (i.e. to the impact) of the receptor, with the magnitude of the impact. The outcome is a decision on whether there will be an effect on status for the quality element in question.

6.2.2 The Environment Agency provides guidance on the definition of no deterioration (Environment Agency, 2013[16]). Necessary measures must be taken to prevent deterioration from one water body status class to a lower one. Furthermore, according to the recent European Union Court of Justice ruling (see Section 2.2), within-class deterioration will also be considered as an overall deterioration of the water body status.

6.2.3 The matrix presented in Table 3 will be used to assign surface water bodies into colour-coded categories according to potential effect on status class. It ranges from a major beneficial effect i.e. a positive change in overall WFD status (dark blue) through no effect to certain deterioration in overall status class (red). The colour codes, summarised in Table 3, are applied in the assessment worksheets for each surface water body.

6.2.4 The matrix presented in Table 4 will be used to assign ground water bodies into colour-coded categories according to potential effect on status class. It ranges from a negligible effect (green) to certain deterioration in overall status class (red). The colour codes, summarised in Table 4, are applied in the assessment worksheets for each groundwater.

[16] As described in the EA Technical Briefing, https://www.wfduk.org/sites/default/files/Media/Setting%20objectives%20in%20the%20water%20environment/Prevent%20deterioration%20of%20status_Draft_010506.pdf

Table 3: Decision matrix for assessing effect on surface water status class

Type of effect	Impact of scheme element on WFD element i.e. in individual cells	Impact on WFD element i.e. at end of row	Impact on WFD water body i.e. the combined effect on the water body as a result of all the effect on WFD elements	Examples	Outcome
Major Beneficial	Impacts when taken on their own have the potential to lead to significant improvement.	Impacts in combination with others have the potential to lead to the improvement in the class of a WFD element.	Impacts in combination with others have the potential to lead to the improvement in the WFD status of the water body.	Creation of significant areas of riparian habitats (for example, within a river diversion) which enhance the value of the water body.	Increase in status class for that water body.
Minor/localised beneficial	Impacts when taken on their own have the potential to lead to a minor localised or temporary improvement.	Impacts in combination with others have the potential to lead to a minor localised or temporary improvement of the WFD element.	Impacts in combination with others have the potential to lead to a minor localised or temporary improvement that does not affect the overall WFD status of the water body.	Minor habitat creation measures such as creation of marginal berms up/downstream of a structure.	Localised improvement, no change in status of WFD water body.
Green (no effect)	No measureable change to any quality elements.	No measureable change to any quality elements.	No measureable change to any quality elements.	Macrophytes Clear span bridge which causes no significant light shading. Invertebrates Changes to flow with no likely effect in macroinvertebrate community/contamination in areas with highly tolerant invertebrate community (e.g. ASPT <4). Fish Minor, temporary encroachment	No change
Yellow – Localised/ temporary adverse effect	Impacts when taken on their own have the potential to lead to a minor localised or temporary effect.	Impacts in combination with others have the potential to lead to a minor localised or temporary effect on the WFD elements. Consideration will be given to habitat creation measures.	Impacts in combination with others have the potential to lead to a minor localised or temporary effect on the WFD elements. Consideration will be given to habitat creation measures.	Macrophytes/phytobenthos Loss of macrophytes/phytobenthos due to shading from a bridge or other structure. Temporary loss of invertebrates/macrophytes etc. during channel re-alignment. Invertebrates	No change in status of WFD water body when balanced against mitigation embedded in the scheme.

Type of effect	Impact of scheme element on WFD element i.e. in individual cells	Impact on WFD element i.e. at end of row	Impact on WFD water body i.e. the combined effect on the water body as a result of all the effect on WFD elements	Examples	Outcome
				Estimated loss in diversity of invertebrates for e.g. <100m of water body (due to habitat loss, changes to flow etc.). Fish Localised loss of fish habitat/numbers of fish.	
Amber – adverse widespread or prolonged effect	Impacts when taken on their own have the potential to lead to a widespread or prolonged effect. Consideration will be given to habitat creation measures.	Impacts in combination with others have the potential to have an adverse effect on the WFD element. Additional mitigation will be applied.	Impacts in combination with others have the potential to have an adverse effect on the WFD water body. The current WFD risk category will be taken into account when assessing these combined impacts. Consideration will be given to habitat creation measures.	Macrophytes/phytobenthos Loss of macrophytes/phytobenthos for a significant length of water due to shading from a long (e.g. >200m) culvert or other similar structure. Invertebrates Likely significant drop in invertebrate diversity over e.g. >300m of water body (due to habitat loss /siltation or combination of various impacts etc.). Fish Obstruction to upstream migration of fish to spawning grounds in a salmonid river therefore affecting fish in the whole of the WFD water body.	Adverse effect but risk of status change needs to be considered with any additional mitigation, and taking into account the level of confidence.
Red – adverse effect on an individual quality element and/or overall status of water body	Impacts when taken on their own have the potential to lead to a widespread or prolonged effect even with mitigation in place.	Impacts in combination with others have the potential to have an adverse effect on the WFD element and change its class. Consideration will be given to habitat creation measures.	Impacts in combination with others have the potential to have an adverse effect on the WFD water body and change its status. The current WFD risk category will be taken into account when assessing these combined impacts. Consideration will be given to habitat creation measures.	Any change in status of an element regardless of whether it leads to an overall deterioration of WFD status of a water body – this colour is only assigned when the positive benefits from mitigation for that water body are outweighed by negative impacts.	Decrease in status of WFD element and/or water body when balanced against additional mitigation. Outcome is considered to be certain.

Table 4: Decision matrix for assessing effect on groundwater body status class

Type of effect	Magnitude of impact of scheme element on WFD element i.e. in individual cells	Impact on WFD element at scale of scheme (at end of row)	Impact on WFD element at groundwater body scale (at end of row)	Example	Outcome
Green (no impact)	No measurable change to groundwater levels or quality.	No measurable change to groundwater levels or quality.	No measurable change to groundwater levels or quality.	Cutting above the water table.	No change.
Yellow – localised/ temporary adverse effect	Impacts when taken on their own have the potential to lead to a minor localised or temporary effect	Combined impacts have the potential to lead to a minor localised or temporary effect on the WFD element.	Combined impacts have the potential to lead to a minor localised or temporary effect on the WFD element. No change to groundwater body status.	Cutting above the water table but drainage returned to ground within the same groundwater body and surface water catchment.	No change in status of WFD water body when balanced against mitigation embedded in the scheme.
Amber – adverse widespread or prolonged effect	Impacts when taken on their own have the potential to lead to a widespread or prolonged effect.	Combined impacts have the potential to have an adverse effect on the WFD element.	Combined impacts have the potential to have an adverse effect on the WFD element, but not change its status at groundwater body scale.	Dewatering of cutting reduced baseflow to tributary but no adverse effect at scale of whole surface water body.	Adverse effect but risk of status change needs to be considered with any additional mitigation, and taking into account the level of confidence.
Red – adverse effect on an individual quality element and/or overall status of water body	Impacts when taken on their own have the potential to lead to a significant effect.	Combined impacts in combinations with others will have a significant adverse effect on the WFD element.	Combined impacts in combination with others will have an adverse effect on the WFD element AND change its status at groundwater body scale.	Dewatering of cutting reduces baseflow to surface water body with adverse effects at scale of whole surface water body.	Decrease in status of WFD water body when balanced against additional mitigation. Outcome is considered to be certain.

6.3 Prevention of future ecological status or ecological potential objective assessment

6.3.1 RBMPs outline the pressures and the actions required for each RBD. The current RBMPs were issued in 2016.

6.3.2 Article 4 of the WFD sets out the default environmental objectives, two of which are targeted at raising the future status of surface waters. These are;

- aim to achieve good ecological and good surface water chemical status in water bodies by 2015, 2021 or 2027; and
- for water bodies that are designated as artificial or heavily modified, aim to achieve good ecological potential by 2015, 2021 or 2027.

6.3.3 Where a water body is deemed unlikely to achieve either of these objectives, an alternative objective will be provided, along with justification as to why an alternative objective has been set.

6.3.4 The Proposed Scheme will be assessed against the measures defined for each water body. The assessment considers whether the development of the Proposed Scheme would prevent the defined measures from being implemented effectively.

6.3.5 Where the RBMP measures refer to proposed future changes in regulation, research and development projects and awareness-raising campaigns, it will be assumed that such measures are insensitive to impact by the Proposed Scheme.

7 Application of Article 4.7 test

7.1.1 Article 4.7 of the WFD directs that Member States will not be in breach of the Directive when failure to meet its environmental objectives is the result of either new modifications to the physical characteristics of a water body or as a result of new human sustainable development, on the proviso that the modifications or new development proposed are compliant with four key conditions as outlined below. In so doing, Article 4.7 provides a means whereby a derogation for a proposed modification or sustainable development may be granted where it meets these four conditions.

7.1.2 The content of an Article 4.7 test report should document clearly how:

- all practicable steps have been taken to mitigate the adverse impact on the status of the water body;
- the reasons for the modifications or alterations are of overriding public interest and/or the benefits to the environment and to society of achieving the objectives are outweighed by the benefits of the new modifications or alterations to human health, to the maintenance of human safety or to sustainable development; and
- the beneficial objectives served by the modifications or alterations of the water body cannot for reasons of technical feasibility or disproportionate cost be achieved by other means, which are a significantly better environmental option.

7.1.3 In addition, the reasons for the modifications or alterations will need to be clearly identified to the Environment Agency so that they can be specifically set out and explained in the RBMP required under Article 13. These objectives are reviewed every six years. This condition will be addressed at a route-wide level.

7.1.4 Whilst every effort will be made to ensure an Article 4.7 test is not required, where unavoidable such a test may need to be prepared for particular water bodies. In all circumstances appropriate evidence will need to be collated and presented to aid in the design decision making process and ensure that any justification is appropriate.

8 Reporting

8.1 Surface water body assessments

8.1.1 The assessment for each water body will be presented in a table format. WFD quality elements will be listed against the Proposed Scheme elements. Individual impacts arising from each scheme element will be grouped under each Proposed Scheme element.

8.1.2 An assessment of the effects of the scheme element will be presented for each of the quality elements. An assessment will be made of the cumulative effects of the Proposed Scheme on the status/potential of that quality element. Decisions regarding the cumulative effects on status are based on the approach presented in Table 3.

8.1.3 The prevention of future good status assessment will be presented for those surface water bodies currently at poor status. An assessment will be made taking into account the reasons for failure, programme of measures and RBMP mitigation measures.

8.1.4 Where a designated heavily modified or artificial water body has associated RBMP mitigation measures, an assessment will also be carried out for each mitigation measure proposed, whether it is 'in place' or 'not in place', for the water body as a whole. The impacts on RBMP mitigation measures will then be summarised in the prevention of future ecological status assessment.

8.1.5 The prevention of future ecological status assessment will be assessed taking into account the Environment Agency reasons for failure and programme of measures in the RBMP.

8.2 Groundwater body assessments

8.2.1 The assessment for each water body will be presented in a table format. WFD quantitative and chemical sub-elements will be listed against the Proposed Scheme elements. Individual impacts arising from each Proposed Scheme element will be grouped into a set of columns under the scheme element.

8.2.2 An assessment of the effects of the scheme element will be presented for each of the sub-elements. An assessment will be made of the cumulative effects of the Proposed Scheme on the status/potential of that sub-element. Decisions regarding the cumulative effects on status are based on the approach presented in Table 4.

8.2.3 The prevention of future good status assessment will be presented for those groundwater bodies currently at poor status. An assessment will be made taking into

account the reasons for failure, programme of measures and RBMP mitigation measures.

8.3 Reporting residual effects

8.3.1 The ES will detail the residual effects including mitigation.

9 Further assessment

9.1.1 The WFD Assessment will provide an initial assessment of the compliance of the Proposed Scheme with the objectives of the WFD. The assessment will be updated in response to any design changes and in accordance with the requirements of the Environment Agency during the detailed design stage, prior to the consenting process and commencement of any monitoring works.

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