E57

High Speed Rail (West Midlands - Crewe)

Environmental Statement

Volume 5: Technical appendices

Electromagnetic Interference

Affected receptors within 50m of railway and associated risks and mitigation (EM-001-000)

July 2017

ES 3.5.0.12

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Department for Transport

High Speed Two (HS2) Limited has been tasked by the Department for Transport (DfT) with managing the delivery of a new national high speed rail network. It is a non-departmental public body wholly owned by the DfT.

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A report prepared for High Speed Two (HS2) Limited:

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1.1 Introduction

1.1.1 This Appendix provides a summary of the likely significant impacts and route-wide effects to electrical equipment and human health resulting from the generation of electromagnetic fields as a result of the construction and operation of the Proposed Scheme. It covers High Speed Rail (West Midlands - Crewe) which will pass through the following community areas (CA):

- CA1: Fradley to Colton;
- CA2: Colwich to Yarlet;
- CA3: Stone and Swynnerton;
- CA4: Whitmore Heath to Madeley; and
- CA5: South Cheshire.

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) can cause three 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;
- the potential to cause harmful effects in the human body through EMF; and
- the creation of induced voltages in metallic infrastructure where there is parallel running for a significant distance e.g. the Proposed Scheme running parallel and close to overhead electric power lines or metallic fences.

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 The principal source of EMF will be the traction power supply system which will power trains. Emissions from trains, signalling and communication systems and electrical and mechanical systems generally only affect the internal railway operating system and are therefore not considered further as having a wider potential effect.

1.2 Policy framework

1.2.1 There are no planning policies that specifically refer to EMI in any of the local development frameworks; however British and European standards exist which set safe limits for exposure. The Proposed Scheme will comply with these standards.

1.2.2 There are a number of British Standards and European Directives that are applicable to the emission and control of EMF that the Proposed Scheme will comply with:

- International Commission on Non-Ionising Radiation Protection (ICNIRP) guidelines, which sets acceptable levels for EMF exposure of the general public and workers to provide protection against known adverse health effects[1];
- EU Directive 2013/35/EU[2], which is based on the ICNIRP 2010 guidelines;
- European Commission (EC) Recommendation 1999/519/EC, which provides levels for public exposure to EMF;
- Electromagnetic Compatibility Regulations Statutory Instrument 3418:2006[3].These regulations require that equipment shall be so designed and manufactured as to ensure that the electromagnetic disturbance generated does not exceed the level above which electrical and electronic equipment cannot operate as intended or allows it to operate without unacceptable degradation of its intended use; and
- BS EN 61000-6-1[4] and BS EN 61000-6-2[5], which specify the acceptable level of protection for equipment in residential and industrial environments respectively.

1.2.3 The Proposed Scheme will be built to comply with the BS EN 50121 series of standards, Railway Applications, Electromagnetic Compatibility[6].

1.2.4 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[7].

1.3 Assessment scope

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

1.3.2 The primary causes of EMI and EMF will come from the traction power distribution and overhead line electrification. The level of EMF diminishes rapidly with distance from the source, so 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 was selected to identify all potential receptors within that area to demonstrate that the level of risk will be limited to a much shorter distance from the railway. Any receptor outside of the 50m corridor will not be affected.

[1] ICNIRP (2010), *Guidelines for Limiting Exposure to Time Varying Electric, Magnetic and Electromagnetic Fields (1Hz to 100kHz)*, Health Physics, 99(6): pp. 818-836
[2] *Directive 2013/35/EU, on the minimum health and safety requirements regarding the exposure of workers to the risks arising from the physical agents (electromagnetic fields) 2013.*European Parliament and European Council
[3] *The Electromagnetic Compatibility Regulations 2006 (SI 2006/3418)* (2006), London. Her Majesty's Stationary Office
[4] British Standards Institution (2007), *BS EN 61000-6-1:2007 (Electromagnetic compatibility (EMC). Part 6.1: Generic standards- immunity for residential, commercial and light industrial environments)*
[5] British Standards Institution (2005), *BS EN 61000-6-2:2005 (Electromagnetic compatibility (EMC). Part 6.2: Generic standards- immunity for industrial environments)*
[6] British Standards Institution (2015), *BS EN 50121:2015. Railway applications - Electromagnetic compatibility Parts 1 to 5*
[7] *British Standards Institution (publication date depends on the standard in the series), BS EN 50122 series (Railway applications. Fixed installations Electrical safety, earthing and the return circuit) Parts 1 to 3*

1.3.3 Preliminary traction power modelling has been undertaken which has identified proposed electromagnetic emissions data throughout the route. This preliminary EMF data has formed the baseline for HS2 Ltd to identify those receptors that may be at risk. HS2 Ltd will comply with BS EN 50121[8], which limits the maximum EMF at the railway boundary.

1.3.4 HS2 data for levels of traction current is based on estimated maximum power usage at typical locations along the route and has generated estimated EMF contour plots that show worst case levels of EMF.

1.3.5 Modelling traction power at this early stage is a complex process, which will undergo much iteration throughout the design of the Proposed Scheme, right up to the detailed design stage. Actual levels of EMF emitted cannot be confirmed until the Proposed Scheme is operational; however levels of emitted EMF should not exceed those used for this assessment.

1.3.6 Possible third party receptors to EMI and EMF were identified by mapping and analysing the route. From this information, third party receptors that fell within the 50m corridor either site of the centreline of the nearest track and also the proposed power equipment, e.g. overhead lines and traction substations, were identified.

1.3.7 Typical receptors identified by the study includes; residential zones, commercial zones, the current National Grid infrastructure and existing railways.

1.3.8 Using the methodology detailed above the baseline data was tabulated. Once each potential receptor had been identified, an assessment was undertaken for compliance with the ICNIRP Guidelines and applicable harmonised EMC standards and to identify the level of risk and, if required, potential mitigation for each site.

1.3.9 Infrastructure running parallel to the proposed scheme for any significant distance that may be susceptible to the effects of induced voltages was also identified. This included power lines and other aerial cable routes, metal fences, pipe lines and motorway telecommunication cables.

1.4 Baseline

1.4.1 The Proposed Scheme will:

- require demolition of a small number of commercial and residential properties that lie within the land required for construction. Of the properties that will remain, very few will be within 20m from the centre of the nearest track;
- cross or run adjacent to existing Network Rail railway routes;
- run adjacent to and under existing National Grid overhead power lines; and
- cross or run adjacent to existing motorways. Motorways often have telecommunication and data cables running underneath, which may be at risk of induced voltages.

[8] British Standards Institution (2017), *BS EN 50121-1:2017. Railway applications - Electromagnetic compatibility Part 1: General*

1.5 Comparisons with other railways

1.5.1 High Speed One was the first high speed railway to be built in the UK and is a 108km railway between St. Pancras International station in London and the Channel Tunnel in Kent. Trains operate at speeds of up to 300kph for much of its route. High Speed One has been operating for the last ten years.

1.5.2 Although the electrification systems of both High Speed One and the Proposed Scheme operate at 25kV, there are differences in system configuration. Currently around 3,500 miles of the UK railway system is electrified with 25kV overhead line electrification. EMF emissions from existing railways are not significant to cause risk to human health.

1.6 Emission levels

1.6.1 The preliminary results of the traction power modelling have identified estimated levels of EMF and EMI along the route and have been used in determining the level of risk for each receptor. The level of risk 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.

1.6.2 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.

1.6.3 The modelling results indicate less than 10μT (microtesla) level of EMF at distances of between 7-10m from the centre line of the nearest track. This level is significantly lower than the 200μT ICNIRP recommendation for general public exposure.

1.6.4 Outside the boundary of land required for the operation of the Proposed Scheme, the levels of radiated electric fields generated from the traction power will not exceed the 5kV/m (kilovolts per metre) threshold within the ICNIRP guidelines and will have no adverse effect on human health.

1.6.5 The plots indicate a 4A/m (ampere per metre) 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 and suggests that there could be some electrical interference with susceptible electrical equipment inside this distance.

1.6.6 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. Therefore, there is potential for any conductor within 20m to exceed the 60V touch threshold 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.

1.6.7 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.

1.6.8 Motorways may have telecommunication lines that could be susceptible to induced voltages, when the motorway runs parallel to the Proposed Scheme for a significant distance (typically more than 2km and up to 200m separation). For induced voltages to occur, the motorway would have to have continuous metal cable, which is

considered unlikely due to the significant operational problems that are encountered with exceptionally long cable lengths.

1.6.9 Where the Proposed Scheme runs in tunnel, there is unlikely to be any risk from EMF or EMI due to the tunnel depth below ground level.

1.7 Construction

Assessment of effects

1.7.1 Construction machinery and plant, and associated communications (e.g. construction radios) will comply with the applicable standards for EMF and EMC. Therefore when installed, operated and maintained correctly, the risk of this apparatus producing EMF that exceeds published limits for workers and the public or causing EMI is considered to be low.

1.7.2 Power supplies used for construction are generally not sufficient to cause a major EMI risk. Specialist tunnel boring machines will be used for the construction of tunnel sections; these will typically require a high voltage electrical supply normally at 11kV. This will come from the local Distribution Network Operator to a purpose built sub-station within the work area. Such supplies will have little effect on health as the levels of EMF are very low.

1.7.3 All construction activities will be confined to local areas. Mitigation will be controlled by the adherence to British and European standards, which will be mandatory for all installation contractors.

1.7.4 It is therefore considered that there are no significant effects on a route wide basis associated with construction.

1.8 Operation

1.8.1 The primary source of EMF will be the traction power supplies generated at 25kV AC; the voltage and current generated in other railway used electrical supplies are not high enough to cause significant EMF outside of the railway boundary. The effects of EMF rapidly diminish with distance from the source, both horizontally and vertically.

1.8.2 The levels of EMF emitted by the traction power will vary considerably along the route and the maximum values will last only for a few seconds at a time. The levels at any particular location depend on a number of variables, for example:

- individual train performance at any particular instant i.e. whether it is accelerating, at constant velocity, braking or at rest;
- the number of individual trains in any one electrical section; and
- proximity to a traction feeder substation.

1.8.3 Preliminary traction power modelling has been undertaken by HS2 Ltd and the worst case values of predicted EMF have been used to estimate the levels of EMF at any particular location along the Proposed Scheme.

1.8.4 Electromagnetic emissions are controlled by compliance with the essential requirements of the Electromagnetic Compatibility Directive 2014 and

implementing UK Regulations and by application of relevant EMF standards.

Effects of EMF on human health

1.8.5 At even the closest of receptors, the estimated levels of EMF will be below 5% of the maximum values recommended by ICNIRP in relation to human health.

1.8.6 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).

1.8.7 ICNIRP identifies the reference level for short term exposure. 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'. This is supported by recent epidemiological studies of childhood cancer and EMF undertaken by The UK Childhood Cancer Study[9].

1.8.8 A few exceptional cases occur, where receptors are sufficiently close to the Proposed Scheme such that the output from the traction power modelling is inconclusive with regard to EMF risk. These receptors are included in Section 2 and they will be further assessed at detailed design stage. One example of this affects residential and commercial buildings around the Crewe Station, however there is unlikely to be any significant effect as the Proposed Scheme is in a tunnel.

1.8.9 It is therefore considered that there are no significant EMF effects on a route wide basis associated with operation. At even the closest of receptors, the estimated levels of EMF will be below 5% of the maximum values recommended by ICNIRP in relation to human health.

Effects on electrical equipment due to EMI

1.8.10 It is possible that EMI risks may only affect some residential receptors within 20m from the centre of the nearest track or industrial receptors with very sensitive electrical or electronic equipment. This distance will depend on the localised situation, for example it will depend on whether the Proposed Scheme is on a viaduct, in a cutting or tunnel. Where identified, these receptors will be further evaluated during the detailed design stage and/or at testing and commissioning and further mitigation taken, which may be in the form of replacement of equipment with less sensitive equipment. Outside of this distance, the estimated levels of EMF at the closest receptors that remain are below the threshold for electrical interference recommended by BS EN 61000-6-1, and pose no risk.

1.8.11 The estimated levels of EMF at the closest receptors are below the threshold for electrical interference recommended by BS EN 61000-6-2, the threshold for industrial properties and pose no risk.

[9] The Childhood Cancer Research Group, www.ukccs.org

1.8.12 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. The regulatory body responsible is the Medicines and Healthcare Products Regulatory Authority, which does not consider EMF generated from power lines a significant risk to the operation of pacemakers[10]. Users of such equipment should seek advice from their general practitioner if in doubt.

Other effects

1.8.13 Where the Proposed Scheme runs close to the existing Network Rail railway route, any effects of EMC, EMI or EMF will be mitigated by complying with the BS EN 50121 and BS EN 50122 suite of standards. It may be necessary for HS2 Ltd to agree and implement specific design solutions with Network Rail.

1.8.14 Induced voltages from the HS2 overhead traction power may affect metallic infrastructure that runs parallel to the Proposed Scheme. For this to have any significant effect, the infrastructure will have to run close to the Proposed Scheme and for a considerable distance, typically greater than 2km. Any effects will therefore be localised, but they can be mitigated by adopting design solutions that meet British and European standards and electrical engineering best practice.

1.8.15 Other effects, such as induced voltages, earthing and bonding issues associated with the interface with other railways, will be mitigated through design and construction in compliance with British, European Standards and best practice. It may be necessary for HS2 Ltd to agree and implement specific design solutions with affected third parties such as Network Rail, National Grid and the Highways Agency.

Wildlife

1.8.16 The limited number of published studies 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.

1.9 Climate change

1.9.1 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.

1.10 Receptors

1.10.1 A list of receptors that may be at risk from EMF and EMI is detailed in Section 2.

1.10.2 Receptors that have been identified as being at risk from EMF (health immunity) are those residential and commercial buildings that will remain within 10m of the centre of the nearest track.

[10] Medicines and Healthcare Products Regulatory Authority, www.mhra.gov.uk

1.10.3 The EMF contour plots[11] are difficult to interpret below 10m from the centre of the nearest track and for this reason receptors below this value have been detailed within Section 2. It is unlikely that the levels of EMF will exceed the 200μT as the Proposed Scheme will comply with BS EN 50121-1, which limits the level of EMF at the railway boundary to below those recommended by ICNIRP.

1.10.4 Receptors at risk from EMC (equipment immunity) are those residential and commercial buildings that will remain within 20m of the centre of the nearest track.

1.10.5 Within 20m, the levels of EMF emitted may cause some interference to sensitive electrical equipment. A further review will be undertaken at detailed design and/or testing and commissioning. Where electrical equipment is found to be adversely affected, mitigation proposals will be to reposition the equipment, or if not possible, replace with less sensitive equipment.

1.10.6 Receptors at risk from induced voltages are infrastructure running close to and parallel for over 2km in length and include: other railway infrastructure, metallic fences, pipelines, overhead power cables and telecommunications cables on motorways.

1.10.7 Where induced voltages have been highlighted as a risk, the risk will be eliminated by designing, building, operating and maintaining the Proposed Scheme to current standards. The same will be done for any other railway.

1.10.8 No other EMI risks have been identified.

[11] *Environmental Impact Assessment Scope and Methodology Report Addendum*, Volume 5: Appendix CT-001-002

2 Potentially affected receptors

2.1 Fradley to Colton (CA1)

Electromagnetic field exposure assessment (health immunity)

2.1.1 No health immunity risks have been identified within this community area.

Electromagnetic compatibility assessment (equipment immunity)

Table 1: Potentially affected receptors within CA1 for electromagnetic compatibility assessment (equipment immunity)

Identifier	Approximate railway chainage km + m	Distance from route centreline (m)	Sensitive installation	Receptor	Reference	Immunity limit (A/m)	Estimated emission level (A/m)	Is there any credible EMC risk? (Y/N)	Mitigation measures	Comments
CA1-006	191+300	9	Cape Warwick Ltd, Shaw House, Shaw Lane.	Commercial	EMI Technical Note[11] (EMF plots), BS EN 61000-6-1[4]	3	Greater than 3	Y	Reposition sensitive equipment or replace with less sensitive equipment	Proposed Scheme on viaduct (rail height approximately 15m). Undertake another review at detailed design and/or testing and commissioning and replace equipment then, if necessary.
CA1-018	191+300	9	Office/ work studio, Shaw House, Shaw Lane	Commercial	EMI Technical Note[11] (EMF plots), BS EN 61000-6-1[4]	3	Greater than 3	Y	Reposition sensitive equipment or replace with less sensitive equipment	Proposed Scheme on viaduct (rail height approximately 15m). Undertake another review at detailed design and/or testing and commissioning and replace equipment then, if necessary.

Electromagnetic interference assessment (induced voltages on cables)

2.1.2 No induced voltage risks have been identified within this community area.

2.2 Colwich to Yarlet (CA2)

Electromagnetic field exposure assessment (health immunity)

2.2.1 No health immunity risks have been identified within this community area.

Electromagnetic compatibility assessment (equipment immunity)

Table 2: Potentially affected receptors within CA2 for electromagnetic compatibility assessment (equipment immunity)

Identifier	Approximate railway chainage km + m	Distance from route centreline (m)	Sensitive installation	Receptor	Reference	Immunity limit (A/m)	Estimated emission level (A/m)	Is there any credible EMC risk? (Y/N)	Mitigation measures	Comments
CA2-067	208+650	0	Development site for 1 no. wind turbine	Light industrial	EMI Technical Note[11] (EMF plots), BS EN 61000-6-1[4]	3	Greater than 3	Y	Reposition sensitive equipment or replace with less sensitive equipment.	This is a committed development site for a wind turbine, with a transformer station at the base of the turbine, with Planning Application reference: 14/20752/FUL. Proposed Scheme in cutting (rail depth approximately 17m). Undertake another review at detailed design and/or testing and commissioning and replace equipment then, if necessary.

Identifier	Approximate railway chainage km + m	Distance from route centreline (m)	Sensitive installation	Receptor	Reference	Immunity limit (A/m)	Estimated emission level (A/m)	Is there any credible EMC risk? (Y/N)	Mitigation measures	Comments
CA2-068	215 +800	0	Grove Farm, Stone Road.	Residential	EMI Technical Note[11] (EMF plots), BS EN 61000-6-1[4]	3	Greater than 3	Y	Reposition sensitive equipment or replace with less sensitive equipment.	This is a committed development site for use of land as domestic garden with Planning Application reference: 13/18321/COU. Proposed Scheme in cutting (rail depth approximately 21m). Undertake another review at detailed design and/or testing and commissioning and replace equipment then, if necessary.
CA2-069	212+000 to 213 600	Varies along the route	Development site for housing development	Residential	EMI Technical Note[11] (EMF plots), BS EN 61000-6-1[4]	3	Greater than 3	Y	Reposition sensitive equipment or replace with less sensitive equipment.	This is a committed development site delivering approximately 3,100 new homes, with Planning Application reference: Policy Stafford 2 - North of Stafford - Housing. Part of Proposed Scheme in cutting (rail depth approximately 16m). Part of Proposed Scheme on embankment (rail height approximately 10m). Undertake another review at detailed design and/or testing and commissioning and replace equipment then, if necessary.

Electromagnetic interference assessment (induced voltages on cables)

Table 3: Potentially affected receptors within CA2 for electromagnetic interference assessment (induced voltages on cables)

Identifier	Approximate railway chainage km + m	Distance from route centreline (m)	Sensitive installation	Receptor	Reference	Touch voltage limit (V)	Estimated level (V)	Is there any credible EMI risk? (Y/N)	Mitigation measures
CA2-UTI-001	204+500 to 208+600	Less than 200	High pressure buried British gas pipe	Metal pipe	Potential induced voltage	60	To be determined at detailed design stage	Yes	Design, build, operate and maintain to current standards.
CA2-UTI-003	203+750 to 206+150	Varies along route	National Grid high pressure gas pipe	Metal pipe	Potential induced voltage	60	To be determined at detailed design stage	Yes	Design, build, operate and maintain to current standards.

2.3 Stone and Swynnerton (CA3)

Electromagnetic field exposure assessment (health immunity)

Table 4: Potentially affected receptors within CA3 for exposure to electromagnetic fields (health immunity)

Identifier	Approximate railway chainage km + m	Distance from route centreline (m)	Sensitive installation	Receptor	Reference	ICNIR 50Hz short term limit (μT)	Estimated emission level (A/m)	Is there any credible EMC risk? (Y/N)	Mitigation measures	Comments
CA3-006	225+700	7	Object, Stab Lane, Swynnerton, Stone	Assumed (worst case) residential/ commercial	EMI Technical Note[11] (EMF plots) and ICNIRP	200	Less than 200	N	N/A	Proposed Scheme in cutting (rail depth approximately 18m).

Electromagnetic compatibility assessment (equipment immunity)

Table 5: Potentially affected receptors within CA3 for electromagnetic compatibility assessment (equipment immunity)

Identifier	Approximate railway chainage km + m	Distance from route centreline (m)	Sensitive installation	Receptor	Reference	Immunity limit (A/m)	Estimated emission level (A/m)	Is there any credible EMC risk? (Y/N)	Mitigation measures	Comments
CA3-006	225+700	7	Object, Stab Lane, Swynnerton, Stone.	Assumed (worst case) residential/ commercial	EMI Technical Note[11] (EMF plots), BS EN 61000-6-1	3	Less than 3	N	N/A	Proposed Scheme in cutting (rail depth approximately 18m). Undertake another review at detailed design and/or testing and commissioning and replace equipment then, if necessary.

Electromagnetic interference assessment (induced voltages on cables)

2.3.1 No induced voltage risks have been identified within this community area.

2.4 Whitmore Heath to Madeley (CA4)

Electromagnetic field exposure assessment (health immunity)

Table 6: Potentially affected receptors within CA4 for exposure to electromagnetic fields (health immunity)

Identifier	Approximate railway chainage km + m	Distance from route centreline (m)	Sensitive installation	Receptor	Reference	ICNIRP 50Hz short term limit (μT)	Estimated emission level (A/m)	Is there any credible EMC risk? (Y/N)	Mitigation measures	Comments
CA4-002	232+600	0	Wyndways, Whitmore Heath, Newcastle.	Residential	EMI Technical Note[11] (EMF plots) and ICNIRP[1]	200	Less than 200	N	N/A	Proposed Scheme in tunnel (rail depth approximately 50m).
CA4-004	232+600	0	Sandy Ridge, Whitmore Heath, Newcastle.	Residential	EMI Technical Note[11] (EMF plots) and ICNIRP[1]	200	Less than 200	N	N/A	Proposed Scheme in tunnel (rail depth approximately 50m).
CA4-005	232+400	0	The Brackens, Heath Road, Whitmore, Newcastle.	Residential	EMI Technical Note[11] (EMF plots) and ICNIRP[1]	200	Less than 200	N	N/A	Proposed Scheme in tunnel (rail depth approximately 8m).
CA4-008	232+700	0	Tree Tops, Whitmore Heath, Newcastle.	Residential	EMI Technical Note[11] (EMF plots) and ICNIRP[1]	200	Less than 200	N	N/A	Proposed Scheme in tunnel (rail depth approximately 50m).
CA4-012	232+700	0	The Nook, Whitmore Heath, Newcastle.	Residential	EMI Technical Note[11] (EMF plots) and ICNIRP[1]	200	Less than 200	N	N/A	Proposed Scheme in tunnel (rail depth approximately 50m).
CA4-015	232+800	0	West Ridge, Birch Tree Lane, Whitmore, Newcastle.	Residential	EMI Technical Note[11] (EMF plots) and ICNIRP[1]	200	Less than 200	N	N/A	Proposed Scheme in tunnel (rail depth approximately 50m).

Identifier	Approximate railway chainage km + m	Distance from route centreline (m)	Sensitive installation	Receptor	Reference	ICNIRP 50Hz short term limit (μT)	Estimated emission level (A/m)	Is there any credible EMC risk? (Y/N)	Mitigation measures	Comments
CA4-033	232+800	0	West Ridge, Birch Tree Lane, Whitmore.	Residential	EMI Technical Note[11] (EMF plots) and ICNIRP[1]	200	Less than 200	N	N/A	Proposed Scheme in tunnel (rail depth approximately 50m).

Electromagnetic compatibility assessment (equipment immunity)

Table 7: Potentially affected receptors within CA4 for electromagnetic compatibility assessment (equipment immunity)

Identifier	Approximate railway chainage km + m	Distance from route centreline (m)	Sensitive installation	Receptor	Reference	Immunity limit (A/m)	Estimated emission level (A/m)	Is there any credible EMC risk? (Y/N)	Mitigation measures	Comments
CA4-002	232+600	0	Wyndways, Whitmore Heath, Newcastle.	Residential	EMI Technical Note[11] (EMF plots), BS EN 61000-6-1[4]	3	Less than 3	N	N/A	Proposed Scheme in tunnel (rail depth approximately 50m).
CA4-004	232+600	0	Sandy Ridge, Whitmore Heath, Newcastle.	Residential	EMI Technical Note[11] (EMF plots), BS EN 61000-6-1[4]	3	Less than 3	N	N/A	Proposed Scheme in tunnel (rail depth approximately 50m).
CA4-005	232+400	0	The Brackens, Heath Road, Whitmore.	Residential	EMI Technical Note[11]. (EMF plots), BS EN 61000-6-1[4]	3	Less than 3	N	N/A	Proposed Scheme in tunnel (rail depth approximately 50m).
CA4-006	232+700	14	The Willows, Whitmore Heath.	Residential	EMI Technical Note[11] (EMF plots), BS EN 61000-6-1[4]	3	Less than 3	N	N/A	Proposed Scheme in tunnel (rail depth approximately 50m).

CA4-008	232+700	0	Tree Tops, Whitmore Heath.	Residential	EMI Technical Note[11] (EMF plots), BS EN 61000-6-1[4]	3	Less than 3	N	N/A	Proposed Scheme in tunnel (rail depth approximately 50m).
CA4-012	232+700	0	The Nook, Whitmore Heath.	Residential	EMI Technical Note[11] (EMF plots), BS EN 61000-6-1[4]	3	Less than 3	N	N/A	Proposed Scheme in tunnel (rail depth approximately 50m).
CA4-015	232+800	0	West Ridge, Birch Tree Lane, Whitmore.	Residential	EMI Technical Note[11] (EMF plots), BS EN 61000-6-1[4]	3	Less than 3	N	N/A	Proposed Scheme in tunnel (rail depth approximately 50m).

Electromagnetic interference assessment (induced voltages on cables)

2.4.1 No induced voltage risks have been identified within this community area.

2.5 South Cheshire (CA5)

Electromagnetic field exposure assessment (health immunity)

2.5.1 No health immunity risks have been identified within this community area.

Electromagnetic compatibility assessment (equipment immunity)

2.5.2 No electrical equipment immunity risks have been identified within this community area.

Electromagnetic interference assessment (induced voltages on cables)

Table 8: Potentially affected receptors within CA5 for electromagnetic interference assessment (induced voltages on cables)

Identifier	Approximate railway chainage km + m	Distance from route centreline (m)	Sensitive installation	Receptor	Reference	Touch voltage limit (V)	Estimated level (V)	Is there any credible EMI risk? (Y/N)	Mitigation measures
CA5-139	243+400 to 246+400	Varies along route	London Euston to Crewe Railway, West Coast Main Line (WCML)	Railway	BS EN 50121 suite of standards apply as does BS EN 50122.	60	To be determined in detailed design stage	Unlikely	Design build, operate and maintain to current standards.

3 References

BS EN 61000-6-1 (2007), *Electromagnetic compatibility Part 6.1: Generic standards- immunity for residential, commercial and light industrial environments*.

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

BS EN 50499 (2008), *Procedure for the assessment of the exposure of workers to electromagnetic fields*.

BS EN 50121 series of standards, *Railway Applications, Electromagnetic Compatibility*, which contains the following parts:

- BS EN 50121-1:2017 Part 1: General;
- BS EN 50121-2: 2017 Part2: Emissions of the whole railway system to the outside world;
- BS EN 50121-3-2:2016 Part 3-1: Rolling stock-train and complete vehicle;
- BS EN 50121-3-2:2016 Part 3-2: Rolling stock – apparatus;
- BS EN 50121-4:2016 Part 4: Emissions and immunity of the signalling and telecommunications apparatus; and
- BS EN 50121-5:2017 Part 5: Emissions and immunity of fixed power supply installations and apparatus.

BS EN series of standards, R*ailway 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;
- BS EN 50122-2:2010 Part 2: Provisions against the effects of stray currents caused by d.c. traction systems; and
- BS EN 50122-3:2010 Part 3: Mutual Interaction of a.c. and d.c. traction systems.

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Directive 2014/30/EU on the harmonisation of the laws of the Member States relating to electromagnetic compatibility 2014. Strasbourg, European Parliament and European Council.

Directive 2006/42/EC on machinery and amending Directive 95/16/EC 2006. Strasbourg, European Parliament and European Council.

ICNIRP (2010), *Guidelines for limiting exposure to time-varying electric and magnetic fields (1Hz – 100 kHz).*

ITU (2008), *ITU-T Directives concerning the protection of telecommunication lines against harmful effects from electric power and electric lines. Volume VI. Danger, damage and disturbance.*

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