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HS2

High Speed Rail (Crewe – Manchester) Environmental Statement

Volume 5: Appendix CL-002-00000

Climate change

Results of climate change assessments

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Results of climate change assessments

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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Contents

Tables

1 Introduction

1.1.1 This report is an appendix to the climate change assessment; it sets out details of the results of the in-combination climate change impact (ICCI)[1] assessment and the climate change resilience assessment (CCR).

1.1.2 This appendix should be read alongside:

- Volume 2, Community Area reports;
- Volume 3, Route-wide effects; and
- Volume 5, Appendix CL-001-00000 Climate data and information.

1.1.3 For the ICCI and CCR assessment, the relevant climate data focuses on the trends and magnitude of projected changes in climate for the construction and operation periods.

[1] The in-combination climate change impacts assessment considers the combined effect of the Proposed Scheme and potential climate change impacts on the receiving environment during construction and operation. The term in-combination climate change impacts refers to the combined effect of the impacts of the Proposed Scheme and potential climate change impacts on the receiving environment. It is not to be confused with the EIA terms 'combined effects' or 'cumulative effects'. The term 'potential climate change impacts' is not to be confused with the EIA term 'future predicted baseline'.

2 In-combination climate change impact assessment results

2.1.1 This section contains the results of the in-combination climate change impact (ICCI) assessment. It includes 16 environmental topic tables which record the process and results of the assessment and should be followed along each row from left to right. Table 1 provides a guide to the results tables describing the content of each column.

2.1.2 The aim of the assessment is to qualitatively assess the combined effect of the Proposed Scheme and potential climate change impacts on the receiving environment during construction and operation.

2.1.3 A summary of the assessment methodology can be found in the Environmental Impact Assessment Scope and Methodology Report (SMR), (see Volume 5: Appendix CT-001-00001).

2.1.4 For more detailed information about the existing mitigation measures and monitoring strategies for each topic summarised in the results tables, please see the respective sections and reports in Volume 2, Community Area reports, Volume 3, Route-wide effects and Volume 5, Appendices.

Table 1: In-combination climate change impact assessment table description

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
Each resource/receptor is identified in a new row.	The effects of the Proposed Scheme on each receptor/resource is numbered in brackets to allow for identification in later columns in the table. The Project Phases, Temporary Construction, Permanent Construction, and Operation, are assessed separately.	Each mitigation measure shows the number (in brackets) of the effect in Column 2 that it addresses. Each mitigation measure is given a new letter to allow for identification in later columns in the table.	Each in-combination climate change impact is summarised in a separate row. In-combination climate change impacts are identified under the relevant heading for impacts which have: • **direct impact on the effect** from the Proposed Scheme (these impacts are labelled with the number of the effect as identified in Column 2); and/or • **impact on the mitigation**, to affect the success of current/embedded mitigation measures, thus indirectly increasing the residual effect (these impacts are labelled with the number/letter combination used to label the mitigation, as identified in Column 3).	A "Yes" or "No" response is provided to this question. Each climate change impact relates to the number of the effect that it could impact. The letter for mitigation is also shown where it is impacted by climate change or it mitigates a direct in-combination climate change effect.	Additional mitigation measures and monitoring/future measures are identified, and reference made to the existing mitigation measure that should be improved.

Table 2: Agriculture, forestry and soils

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
Soils	Temporary effects from construction – (1) Temporary disruption (removal and reinstatement) of soils, which could lead to soil degradation, soil compaction and soil smearing (2) Increase in the area of bare ground during construction	(1a) Compliance with relevant parts of the draft Code of Construction Practice (CoCP)[2] - particularly Sections 6, 7, 15 and 16. • the requirements stated in the draft CoCP in relation to control of dust, insofar as they are applicable to the protection of agricultural crops (including grass), will also be met; • protecting agricultural land adjacent to the construction site, including provision and maintenance of appropriate stock-proof fencing and avoidance of traffic over the land leading to soil compaction; • reinstating any agricultural land which are used temporarily during	**Direct impact on effect** (1, 2) Increased frequency of dry spells may increase the sensitivity of soils when degraded as a result of the construction of the Proposed Scheme. **Impact on mitigation** (1a) Increased frequency of dry spells could make the restoration of soils to their original condition more difficult. Increased dry spells may also increase the frequency of dust generation events on areas of reduced soil quality and/or bare ground and therefore increase the need for dust suppression action to be taken as mitigation.	**No** – Increases in the frequency of dry spells could lead to drying of soils, making soils more sensitive to disruption. Consequently, it could be more difficult to reinstate soils to their original resilience and condition, avoiding any reduction in long-term capability. However, soil dryness is not considered to cause a significant issue with respect to soil handling. In addition, the use of some permanently displaced soils to restore land to agriculture or other uses with slightly deeper topsoil and subsoil layers may be undertaken where appropriate and possible. This could improve the quality of	**Additional mitigation** None required **Additional monitoring** None required

[2] Volume 5: Appendix CT-002-00000, draft Code of Construction Practice (CoCP).

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
		construction, where this is the agreed end use; • details of farm accesses which may be affected by construction, including the manner in which farm access will be maintained and avoidance of traffic over land which is used temporarily during construction; • providing a method statement for stripping, handling, storage and replacement of agricultural, forestry and woodland soils and other ecological habitats to reduce risks associated with soil degradation on areas of land to be returned to agriculture, forestry and woodland following construction. This will include any remediation measures necessary following completion of works as part of a five-year aftercare regime as set out in the HS2 Ltd Phase 2b Western Leg Information Paper E20: Maintenance of landscaped areas;[3] • the separate handling and storage of different soils, particularly topsoils and subsoils and those recovered from ancient woodlands; • handling soils that are in a suitably dry condition and not during wet weather to avoid long-term damage to soil structure from compaction; • seed for grass cover or seal medium or long-term excavated material and soil stockpiles; • the prevention of soil contamination with chemicals or other materials; and • the control of weeds on soil stores, either through treatment or removal. (1b) Compliance with Sections 5 and 16 of the draft CoCP: Contractors to monitor and manage flood risk and other extreme weather events, insofar as reasonably		agricultural land locally, for example where droughty soils are limited by soil depth, subject to the soil resource plans to be prepared during the detailed design stage. Soil reuse should consider the reuse hierarchy and achieve environmental objectives, such as reducing and/or avoiding the long-distance transport of soils. These measures are considered to be sufficient to mitigate any increases in dryness and to prevent the subsequent dust generation and need for additional dust suppression measures.	

[3] High Speed Two Ltd (2022), *Phase 2b Western Leg Information Paper E20: Maintenance of landscaped areas*.

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
		practicable, that may affect soils during construction.			
	Permanent effects from construction – (3) Soil disruption, degradation and loss affecting ability to fulfil identified function (e.g. agriculture, landscape planting, forestry) (4) Permanent removal and displacement of soils (5) Compaction and smearing of clayey, alluvial and seasonally waterlogged soils, which could affect successful reinstatement (6) Permanent loss of Best and Most Versatile Land (BMV) land or degradation to a lower classification level due to construction	(3a, 5b) Compliance with relevant parts of the draft CoCP - particularly Sections 6 and 15. • protecting agricultural land adjacent to the construction site, including provision and maintenance of appropriate stock-proof fencing and avoidance of traffic over the land leading to soil compaction; • reinstating any agricultural land which is used temporarily during construction, where this is the agreed end use; • details of farm accesses which may be affected by construction, including the manner in which farm access will be maintained and avoidance of traffic over land which is used temporarily during construction; • providing a method statement for stripping, handling, storage and replacement of agricultural, forestry and woodland soils and other ecological habitats to reduce risks associated with soil degradation on areas of land to be returned to agriculture, forestry and woodland following construction. This will include any remediation measures necessary following completion of works as part of a five year aftercare regime as set out in the HS2 Phase 2b Western Leg Information Paper E20: Maintenance of landscaped areas[3]; • the separate handling and storage of different soils, particularly topsoils and subsoils and those recovered from ancient woodlands; • handling soils that are in a suitably dry condition and not during wet weather to avoid long-term damage to soil structure from compaction; • seed for grass cover or seal medium or long-term excavated material and soil stockpiles;	**Direct impact on effect** (3, 4) Hotter and drier conditions in the summer could reduce soil moisture, thereby exacerbating the loss of soil function. (3, 4) Hotter and drier conditions in the summer could lead to drying of soils. This could increase the sensitivity of soils that are disrupted by the Proposed Scheme, thereby potentially causing them to degrade more quickly. **Impact on mitigation** (3a, 4a) Hotter and drier conditions in the summer could increase soil dryness, thereby making the reinstatement of soils to their original condition more difficult. This may reduce the effectiveness of embedded mitigation measures on reinstated soils.	**No** - Hotter and drier conditions in the summer could lead to drying of soils, making soils more sensitive to degradation once disrupted, and increasing the potential loss of soil function. Consequently, it could be more difficult to reinstate soils to their previous condition. However, soil dryness is not considered to cause a significant issue with respect to soils and soil handling. Measures to locate, seal and maintain medium and long-term stockpiles are detailed within the draft CoCP, and are considered sufficient to address the potential impacts of hotter drier conditions on stockpile maintenance. The use of some permanently displaced soils to restore land to agriculture or other uses with slightly deeper topsoil and subsoil layers may be undertaken where appropriate. This could improve the quality of agricultural land locally, for example where droughty soils are limited by soil depth, subject to the soil resource plans to be prepared during the detailed design stage. Soil reuse should consider the reuse hierarchy and achieve environmental objectives, such as reducing and/or avoiding the long-distance transport of soils. These measures are considered to be sufficient to mitigate the increased environmental effect of hotter and drier conditions due to climate change.	**Additional mitigation** None required **Additional monitoring** None required
			Direct impact on effect (3, 4, 5) Increases in the frequency of heavy rainfall events (short or long duration) could increase the risk of erosion of soils that have been disrupted or degraded as a result of the Proposed Scheme.	**No -** Increases in the frequency of heavy rainfall could increase the risk of flooding, thereby potentially leading to an increase in soil disruption and degradation through erosion. Additionally, soil handling when wet is not considered to be standard practice with respect to maintaining soil quality. Therefore,	**Additional mitigation** None required **Additional monitoring** None required

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
		• the prevention of soil contamination with chemicals or other materials; • the control of weeds on soil stores, either through treatment or removal; • surveys shall be carried out for plant pests and diseases, and measures put in place to avoid the transfer of ecologically undesirable diseased material to new areas and the spread of invasive non-native species; • the control of weeds on soil stores, either through treatment or removal; • trees which will be selected from a range of latitudes and climate zones to increase species' resilience to hotter, drier and/or wetter conditions, and landscape planting palettes which will be designed to increase species' resilience and adaptability; • ecological mitigation measures which will enable habitats to adapt to climate change by maintaining and enhancing ecological conditions and creating and restoring habitats to increase species' resilience to changes in climate; and • contractors to monitor and manage flood risk and other extreme weather events, insofar as reasonably practicable, that may affect soils during construction. (3b) A requirement in the draft CoCP for contractors to monitor and manage flood risk and other extreme weather events, insofar as reasonably practicable, that may affect soil resources. • the performance of the Proposed Scheme has been assessed against a range of design floods up to and including the 1% (1 in 100) annual probability event, including the addition of the relevant future climate change allowances in line with the latest guidance from the Environment Agency. (4a) Permanently displaced soils will be used to reinstate soil profiles to a subsoil depth of 1.2m where this depth	**Impact on mitigation** (3a, 3b, 4a, 5a) Increased frequency of heavy rainfall events present conditions that are not suitable for soil handling and therefore presents a risk that soils may be damaged should rainfall conditions persist. The restoration of soil profiles to the original condition could become more difficult. **Direct impact on effect** (6) Increased frequency of extreme weather events, such as dry spells and heavy rainfall events, could increase erosion and diminish growing conditions, thereby affecting agricultural land quality. Increased frequency of extreme weather events such as heavy rainfall events and dry spells could increase the sensitivity of BMV land to degradation from construction of the Proposed Scheme. This could increase the potential to further decrease the Agricultural Land Classification (ALC) grade of the land. **Impact on mitigation** (6a, 6b) The success of mitigation measures included in the draft CoCP outline measures for soil handling and reinstatement could be reduced as a result of extreme weather events. For example, heavy rainfall could present conditions that are not suitable for soil handling. Increased frequency of dry spells could make the reinstatement of soils to their original condition more difficult. This may reduce the effectiveness of embedded mitigation measures on reinstated soils to prevent agricultural land quality degradation to below a Grade 3a.	strict adherence to the guidelines and mitigation measures in place is advised in order to maintain the quality of soils and are considered sufficient to prevent a significant adverse effect. **No** - An increased frequency of extreme weather events, particularly heavy rainfall, could affect agricultural land quality and reduce the success of mitigation measures in place to prevent agricultural land quality degradation. However, the design and route of the Proposed Scheme avoids BMV wherever reasonably possible, as outlined within Paragraph 112 of the NPPF; avoidance of the BMV receptor is considered to be an important part in mitigating effects. Where significant development of agricultural land is demonstrated to be necessary, poorer quality land should be used in preference to higher quality land. Strict adherence to the mitigation measures in place will be undertaken in order to maintain the quality of BMV land. Where this is not possible, the amount and extent of disruption to BMV soils will be minimised by adhering to best practice as outlined within the draft CoCP and the relevant Technical Standards to prevent the loss and degradation of agricultural land. Soil Resource Plans to be prepared during the detailed design stage may be able to tailor management measures to local scale conditions, where appropriate. These mitigation measures are considered to be sufficient to prevent an increase in the significance of the effect.	**Additional mitigation** None required **Additional monitoring** None required

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
		is reasonably practicable, and the agreed end use. (5a) The principles of soil handling such as the DEFRA Code of Practice for the Sustainable Use of Soils would be followed throughout the construction period. (6a) Compliance with relevant parts of the draft CoCP - particularly Section 6. • reinstating any agricultural land which is used temporarily during construction, where this is the agreed end use; • providing a method statement for stripping, handling, storage and replacement of agricultural, forestry and woodland soils and other ecological habitats to reduce risks associated with soil degradation on areas of land to be returned to agriculture, forestry and woodland following construction. This will include any remediation measures necessary following completion of works as part of a five year aftercare regime as set out in the HS2 Phase 2b Western Leg Information Paper E20: Maintenance of landscaped areas[3]; • the separate handling and storage of different soils, particularly topsoils and subsoils and those recovered from ancient woodlands; • handling soils that are in a suitably dry condition and not during wet weather to avoid long-term damage to soil structure from compaction; • seed for grass cover or seal medium or long-term excavated material and soil stockpiles; • the prevention of soil contamination with chemicals or other materials; and • the control of weeds on soil stores, either through treatment or removal. (6b) The reinstatement of agricultural land that is used temporarily during construction to its original condition, where this is the agreed end use. Adopt best practice techniques in handling,			

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
		storing, and reinstating soils on that land.			
Agricultural Land	Temporary effects from construction – (7) Deposition of dust on agricultural land surrounding the proposed scheme	(7a) Compliance with Sections 5, 6, and 7 of the draft CoCP: • the protection of agricultural land adjacent to the construction site; • the adoption of measures to control the deposition of dust on adjacent agricultural crops; • the surfacing and maintenance of haul routes to control dust emissions as far as reasonably practicable, taking into account the contractors intended level of traffic movements; • methods to clean and suppress dust on haul routes (including watering) and in designated vehicle waiting areas. The frequency of cleaning will be suitable for the purposes of suppressing dust emissions from the site boundaries; • enforcement of speed limits on haul roads for safety reasons and for the purposes of suppressing dust emissions; • topsoil will be stripped as close as reasonably practicable to the period of excavation or other earthworks activities to avoid risks associated with runoff or dust generation; and • soil spreading, seeding, planting or sealing of completed earthworks will be undertaken as soon as reasonably practicable following completion of the earthworks.	**Direct impact on effect** (7) Increases in the frequency of dry spells (i.e. 10 or more consecutive days with no precipitation) could lead to higher levels of dust production during construction, thereby increasing dust deposition on agricultural land. **Impact on mitigation** (7a) Increased frequency of dry spells could increase the likelihood of shortages of water supply, potentially reducing the ability to use water-based systems (such as water spray and damping down) to suppress dust.	**No -** Increased frequency of dry spells could lead to higher levels of dust production, increasing the deposition of dust on agricultural land. Periods of consecutive dry days have the potential to reduce water availability that is required to suppress dust as outlined within the draft CoCP. However, other mitigation measures which do not rely on water for damping down are considered to be sufficient to prevent an increase in the significance of the effect, by preventing and reducing dust production.	**Additional mitigation** None required **Additional monitoring** None required

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
	Permanent effects from construction – (8) Permanent loss of agricultural land (9) Permanent impact on agricultural land viability as a result of construction: • disruption of drainage of agricultural land, potentially affecting crops and livestock (and overall agricultural viability); • loss of access and/or inadequate protection; • land degradation; • soil-borne crop diseases; and • presence of invasive and non-native species and weeds.	(8a) Financial compensation (9a) Compliance with relevant sections of the draft CoCP will avoid or reduce the impacts (environmental and socioeconomic) following the construction period: • the protection of agricultural land adjacent to the construction site, including the provision and maintenance of appropriate stock-proof fencing; • the control of invasive and non-native species; and the prevention of the spread of weeds generally from the construction site to adjacent agricultural land; • the adoption of measures to prevent, insofar as reasonably practicable, the spread of soil-borne, tree, crop and animal diseases from the construction area; • the adoption of measures to control the deposition of dust on adjacent agricultural crops; and • avoid bare ground wherever possible, include additional haul road damping measures.	**Direct impact on effect** (9) Increased frequency of extreme weather events, such as dry spells and heavy rainfall events, could increase erosion and diminish growing conditions, thereby affecting agricultural land viability. **Impact on mitigation** No impact identified.	**No -** Increases in the frequency of extreme weather events have the potential to increase the effect on agricultural land quality that has been affected during construction by increasing erosion and reducing the quality of growing conditions. However, monitoring and management of these impacts in line with the draft CoCP are considered to be sufficient to prevent an increase in the significance of the effect, as proper soil handling techniques throughout the construction period will ensure the quality of agricultural land is maintained**.**	**Additional mitigation** None required **Additional monitoring** None required
			Direct impact on effect (9) Increases in mean, maximum and minimum daily temperatures in winter and increased winter precipitation may extend the growing period and improve growing conditions for opportunistic, fast-growing weeds and non-native species, facilitating the spread of weeds from the construction site to surrounding agricultural land. **Impact on mitigation** No impact identified.	**No** - The impact of increases in winter temperatures and increased winter precipitation on non-native species and the embedded mitigation is considered to be negligible. Mitigation outlined within the draft CoCP, such as the control of invasive species and prevention of the spread of weeds during the construction period, is considered sufficient to prevent an increase in the significance of the effect.	**Additional mitigation** None required **Additional monitoring** None required
	Operational effects – (10) Propensity of the railway land to harbour and spread noxious weeds	(10a) Appropriate management regime that identifies and remedies areas of weed growth that might threaten adjoining agricultural land.	**Direct impact on effect** (10) Increases in extreme winds (i.e. 3-second gusts) could lead to the increase in spread of invasive and non-native species and weeds into agricultural land. **Impact on mitigation** No impact identified.	**No -** Increased wind speeds have the potential to increase the spread of invasive species along the Proposed Scheme into surrounding agricultural land, which could cause adverse effects. However, the proposed embedded mitigation and management measures (including remediation works to ensure invasive non-native species are not present and monitoring to prevent reoccurrence) are considered to be sufficient to prevent an increase in the significance of the effect and consequent threats to adjoining land of agricultural interest.	**Additional mitigation** None required **Additional monitoring** None required

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Land Holdings	Temporary effects from construction – (11) Temporary loss of land or property due to construction (12) Effects on land use and enterprises (13) Disturbance and impact on viability, principally from noise, dust and water supply	(11a, 12a) The reinstatement of agricultural land that is used temporarily during construction to agriculture, where this is the agreed end use. (11b, 12b) Financial compensation. (11c, 12c, 13a) Compliance with relevant sections of the draft CoCP: • arrangements for the maintenance of farm and field access affected by construction; • liaison and advisory arrangements with affected landowners, occupiers and agents, as appropriate; • protection of agricultural land adjacent to the construction site, including the provision and maintenance of stock-proof fencing; • the adoption of measures to control the deposition of dust on adjacent agricultural crops; • the surfacing and maintenance of haul routes to control dust emissions as far as reasonably practicable, taking into account the contractors intended level of traffic movements; • methods to clean and suppress dust on haul routes (including watering) and in designated vehicle waiting areas. The frequency of cleaning will be suitable for the purposes of suppressing dust emissions from the site boundaries; and • enforcement of speed limits on haul roads for safety reasons and for the purposes of suppressing dust emissions.	**Direct impact on effect** (11, 13) Increases in the frequency of dry spells could increase the risk of dust generation and subsequent deposition on surrounding land holdings, increasing the disturbance and impact on land holdings. **Impact on mitigation** (11a, 11c, 13a) Increased frequency of dry spells could reduce the ability to use water-based systems and mitigation measures (such as water spray and damping down) to suppress dust.	**No -** Increased frequency of dry spells could increase dust generation and deposition onto surrounding land holdings. Increases in the frequency of dry spells may also the reduce water available for dust suppression, however alternative mitigation measures such as the surfacing and maintenance of haul routes to control dust emissions and enforcement of speed limits are considered to be sufficient to prevent an increase in the significance of the residual effect.	**Additional mitigation** None required **Additional monitoring** None required
	Permanent effects from construction – (14) Effects on land use and enterprises (15) Severance of holdings (16) Permanent loss of land or property	(14-16a) Compliance with relevant sections of the draft CoCP: • Liaison and advisory arrangements with affected landowners, occupiers and agents, as appropriate, including financial compensation.	**Direct impact on effect** (14, 15, 16) None identified - where land holdings are lost permanently, it is assumed that the functionality of these areas cannot be impacted by climate change. **Impact on mitigation** No impact identified.	**No -** Climate change is not considered to increase the magnitude or sensitivity of the permanent effects on land holdings. Where land holdings are lost permanently, it is assumed that the functionality of these areas cannot be impacted by climate change. Similarly, the mitigation measure identified for this effect is to provide financial compensation to the landowner. Climate change is not considered to	**Additional mitigation** None required **Additional monitoring** None required

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
				have an impact on the effect identified or the mitigation measures implemented.	
	Operational effects – (17) Disturbance from noise (18) Propensity of linear transport infrastructure and railway land to harbour and spread noxious weeds which could affect land users, crops, and livestock and threaten agricultural interests	(17a) • Use of proven train and track technology to enable quieter operation, including aerodynamic noise of pantograph above 186mph. All noise to be reduced further away from track; • incorporate noise barriers, either earthworks and/or noise fences to reduce significant adverse airborne effects; • noise insulation measures offered for qualifying buildings, to avoid significant residual effects on health and quality of life; • stationary systems equipment used at permanent sites will be designed to avoid and minimise significant effects as far as reasonably practicable; • design of track and bed to reduce significant ground-borne noise or vibration effects; • as required by statute, noise insulation measures would be offered for qualifying buildings as defined in the Noise Insulation Regulations 1996, where noise insulation is required, ventilation will be provided so windows can be kept closed to protect internal sound levels; • noise can be generated at exits from tunnels due to pressure waves created inside the tunnel as the train enters. This is a well understood phenomenon and is mitigated by appropriate design and construction techniques; • where high levels of vibration (Rayleigh waves) could occur over soft ground, appropriate mitigation such as soil strengthening and bridging over soft ground will be incorporated; • maintenance regime specified to reduce noise effects; and	**Direct impact on effect** (18) Increases in extreme winds (i.e. 3-second gusts) could lead to the increase in spread of invasive and non-native species and weeds into adjacent land holdings. **Impact on mitigation** No impact identified.	**No** - Increased wind speeds have the potential to increase the spread of invasive species along the Proposed Scheme, into surrounding land holdings, which could cause adverse effects. However, the proposed embedded mitigation and management measures (including remediation works to ensure invasive non-native species are not present and monitoring to prevent (re)occurrence) are considered to be sufficient to prevent an increase in the significance of the effect and consequent threats to adjoining land holdings.	**Additional mitigation** None required **Additional monitoring** None required
			Direct impact on effect (18) Increases in mean, maximum and minimum daily temperatures in winter and increased winter precipitation may extend the growing period and improve growing conditions for opportunistic, fast-growing weeds and non-native species, facilitating the spread of weeds from the Proposed Scheme to surrounding land holdings during operation. **Impact on mitigation** No impact identified.	**No** - The impact of increases in winter temperatures and increased winter precipitation have the potential to extend the growing season and could have adverse impacts on non-native species. However, the proposed mitigation such as the control of invasive species during the construction period, is considered sufficient to prevent an increase in the significance of the effect.	**Additional mitigation** None required **Additional monitoring** None required

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
		• train design is assumed to be quieter than the current EU specifications. (18a) Route-wide measures will be implemented to promote bio-security and minimise the risk that invasive non-native species and diseases are spread as a consequence of the project. Should they occur, the removal of invasive species will take account of ecological best practice guidance and appropriate measures will be taken to identify and protect other features of environmental importance.			
Peat	Permanent effects from construction – (19) Permanent damage and/or removal caused by the movement of peat during construction (implications for carbon emissions and biodiversity)	(19a) - Compliance with Section 6 of the draft CoCP which denotes special provisions for handling peaty soils, as per Scottish Environment Protection Agency Guidance (SEPA); Restoration Techniques Using Peat Spoil from Construction Works (July 2011). Section 6.2.9 (draft CoCP): "Where the disturbance of soils cannot reasonably be avoided in areas of peat and peaty soils, special provisions for handling these soils will be adopted as set out in SEPA Guidance; Restoration Techniques Using Peat Spoil from Construction Works.[4]; the contractor shall conserve peat and peaty soils displaced by the Proposed Scheme as far as reasonably practicable and shall follow handling guidelines for these soils to ensure that the resource is preserved for reinstatement and similar use following construction; materials shall be stored in accordance with the guidelines and moisture	**Direct impact on effect** (19) Increases in the frequency of heavy rainfall events (short and long duration) may reduce the stability of peaty, clayey and/or seasonally waterlogged soils, and could result in peat handling and movement being undertaken during unsuitable conditions. (19) Peat that is moved and/or handled during periods of heavy rainfall (short or long duration) could be less resilient when handled and/or restored. **Impact on mitigation** (19a, 19c) Mitigation measures and best practice for peat handling and disruption could be unsuccessful if undertaken during periods of heavy rainfall.	**No** - Increased heavy rainfall events could prevent the success of the mitigation measures outlined within the draft CoCP and SEPA Guidance through handling in unsuitable conditions (i.e. deterioration of peat quality will be avoided wherever reasonably possible and handling to be undertaken during suitable weather conditions The scheme design avoids the majority of peat areas present along the route of the Proposed Scheme, however there are some very peaty soils for which avoidance is not feasible and must be replaced. Following construction, they shall be restored to a similar quality. Strict adherence to the robust mitigation and Best Practice guidance measures for peat handling are embedded within the draft CoCP, and following SEPA guidance, is considered sufficient to prevent an increase in the significance of the effect.	**Additional mitigation** None required **Additional monitoring** None required

[4] SEPA (2011), *Restoration Techniques Using Peat Spoil from Construction Works*. Available online at: https://www.sepa.org.uk/media/163263/restoration-techniques-using-peat-spoil-from-construction-works.pdf.

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
		contents of the materials checked at regular intervals to reduce degeneration of the soil resource, particularly irreversible drying and loss from wind erosion; excessive wetting of peat soils should be avoided as far as reasonably possible, periods of heavy rainfall may make this more difficult to achieve; amorphous and fibrous peat shall be stripped and stored separately from each other, where practicable. The volumes of different types of peat shall be set out in a Soil Resources Plan, based on detailed soil surveys; peat shall be stored in a condition that prevents deterioration in its quality and ensures that it will be suitable for its planned end use; an appropriate ground cover, such as that suitable for agricultural use, landscape planting or wildlife habitat shall be introduced shortly after the reinstatement of the peat to protect the ground surface from rainfall and to stabilise peat; the mitigation of damage to peat is difficult due to the nature of the receptor - once damaged it is difficult to restore back to the original state; and reducing disturbance to peat as far as reasonably possible is the main mitigation/prevention measure, where damage cannot be avoided, adherence to best practice as outlined by SEPA (and within the draft CoCP) should be followed. (19b) Design development of the Proposed Scheme would seek to reduce disturbance of any deep peat soils as far as possible. (19c) Where disturbance cannot be avoided, the peat soils would be handled with particular care to avoid compaction when wet and wind erosion when dry.	**Direct impact on effect** (19) Increases in the number of consecutive dry days (i.e. 10 or more days without precipitation) could exacerbate peat degradation through increased decomposition and mineralisation of the organic matter reducing carbon content, exacerbating the impacts of the disturbance to peat soils when disturbed/impacted by the construction of the Proposed Scheme. (19) Increases in the number of consecutive dry days (i.e. 10 or more days without precipitation) could lead to cut/disturbed peat drying out faster. **Impact on mitigation** (19a, 19c) Mitigation measures and best practice for peat handling and disruption could be unsuccessful if undertaken during periods of inappropriate weather conditions. This could cause deterioration of peat quality.	**No -** Increased frequency of dry spells could increase peat degradation and reduce the success of the mitigation measures. Peat that becomes dry cannot be re-moistened, and so strict adherence to the draft CoCP and SEPA Guidance on peat handling shall be followed. The scheme design avoids the majority of peat areas present along the route of the Proposed Scheme, however there are some very peaty soils for which avoidance is not feasible and must be replaced. They are under regular arable use, have been extensively drained and classed as best and most versatile land. Following construction they shall be restored to a similar quality. Strict adherence to the robust mitigation and guidance measures, including SEPA Guidance for peat handling, is considered sufficient to prevent an increase in the significance of the effect.	**Additional mitigation** None required **Additional monitoring** None required

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
	Operational effects – None identified	None identified.	**Direct impact on effect** None identified. **Impact on mitigation** None identified.	N/A	**Additional mitigation** None required **Additional monitoring** None required

Table 3: Air quality

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/ resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
Sensitive human and ecological receptors	Temporary effects from construction- (1) Increase in dust and particulate matter from construction activities, namely demolition, earthworks, construction and trackout, which may have temporary local effects on dust soiling, human health and ecological receptors (2) Increase in oxides of nitrogen (NO_x) including nitrogen dioxide (NO_2), and particulate matter from construction vehicles and changes in the volume, composition and/or speed of traffic on the road network, which may have temporary local effects on human health and ecological receptors (3) Increase in dust and particulate matter from mineral extraction activities, such as the use of borrow pits, which may have temporary local effects on dust soiling, human health and ecological receptors	Emissions to the atmosphere will be controlled and managed during construction through route wide implementation of the draft CoCP, with specific reference to Section 7 (Air quality) and Section 5.14 (Extreme weather events). The measures outlined in the draft CoCP may include, where appropriate: (1a, 2a, 3a) Contractors required to manage dust, air pollution, odour and exhaust emissions works as far as reasonably practicable and in accordance with best practice/best practicable means (BPM), such as Guidance on the Assessment of the Impacts of Construction on Air Quality and the Determination of their Significance (2014) produced by the Institute of Air Quality Management (IAQM). (1b, 2b, 3b) Inspection and visual monitoring to assess the effectiveness of dust and air pollution control measures.	**Direct impact on effect** (1, 3) Increased frequency of dry spells (number of consecutive days with no precipitation) could result in increased dust generation and increased ambient concentrations of dust due to lower rates of deposition. This could potentially increase adverse impacts on dust soiling, human health and ecological receptors. Increased frequency of dry spells would not be expected to impact concentrations of NO_x/NO_2 as these pollutants' concentrations are mainly determined by traffic emissions. **Impact on mitigation** (1c, 3c, 1d, 3d) Increased frequency of extreme dry spells could increase the likelihood of shortages of water supply, potentially impacting the ability to use water-based systems (such as water spray and damping down) to suppress dust.	**No** – Increased frequency of dry spells could result in increased dust generation and reduced deposition. This could increase the negative impacts to human health and ecological receptors. However, these will be managed through embedded mitigation such as those detailed in draft CoCP Section 7. For this reason, any increase in particulate matter concentrations in the air due to lower rates of deposition and increased emissions of particulate matter are considered to be negligible. In the event of a shortage of water supply, there are other mitigation measures which may be used for dust suppression such as the use of enclosures, covering stockpiles, installing hard surface roads and reducing speed limits on site to prevent an increase in the significance of the residual effect.	**Additional mitigation** Not required **Additional monitoring** Not required

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/ resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
		(1c, 2c, 3c) Cleaning of vehicle routes and designated vehicle waiting areas to suppress dust. (1d, 2d, 3d) Use water spray systems on demolition sites to dampen down emissions of fugitive dust. (1e, 2e, 3e) Keep soil stockpiles away from sensitive receptors where reasonably practicable, taking into account prevailing wind direction. (1f, 2f, 3f) Use of enclosures to contain dust emissions. (1g, 2g, 3g) Soil spreading, seeding and planting of completed earthworks as soon as reasonably practicable. (1h, 2h, 3h) Implementation of appropriate measures to control the risk of pollution due to construction works, materials and extreme weather events. (1i, 2i, 3i) Pay due consideration to the impacts of extreme weather events, using short to medium-range weather forecasting service to inform short to medium-term programme management, environmental control and impacts mitigation measures.	**Direct impact on effect (Positive)** (1, 2, 3) Increased frequency of heavy rainfall events could reduce dust generation and increase deposition from the air, resulting in decreased concentrations of dust and particulate matter. Consequently, increased frequency of heavy rainfall events could result in decreased adverse impacts of dust soiling and impacts on human health and ecological receptors. Increased frequency of heavy rainfall events would not be expected to impact concentrations of NO_x/NO_2. **Impact on mitigation** No impact identified.	**No** – The potential impact of increased frequency of heavy rainfall events on dust and particulate matter generation, and resultant effects on dust soiling, human health, ecological receptors and embedded mitigation, would be positive, as increased wet deposition would decrease concentrations of dust and particulate matter in the air.	**Additional mitigation** Not required **Additional monitoring** Not required
	Operational effects – (4) Changes in vehicle emissions of NO_2, NO_x and particulate matter, resulting from changes in the volume, composition and/or speed of road traffic, changes in road alignment and car parks which may have effects on human health and ecological receptors (5) Increased NO_2, NO_x and particulate matter emissions from stationary sources, such as combustion plant emissions associated with station buildings, which may have effects on human health and ecological receptors (6) Emissions of NO_2, NO_x and particulate matter from diesel trains used for the Rolling Stock Depot (RSD)which may have effects on human health and ecological receptors	(4a, 5a, 6a) Volume 1, Section 9 sets out the general approach to environmental monitoring during operation of the Proposed Scheme. (4b, 5b, 6b) Given that no significant air quality effects are anticipated during operation of the Proposed Scheme, no operational monitoring is required.	**Direct impact on effect** (4, 5, 6) Increased frequency of dry spells (Increase in the number of consecutive days with no precipitation) could result in increased concentrations of particulate matter due to lower rates of deposition. This could potentially increase adverse impacts on human health and ecological receptors. Increased frequency of dry spells would not be expected to impact concentrations of NO_x/NO_2. **Impact on mitigation** No impact identified.	**No** - The increased frequency of dry spells could result in lower rates of deposition of particulate matter. This could increase negative impacts to human health and ecological receptors. However, there are a number of embedded mitigation measures that minimise emissions of particulate matter during operation of the Proposed Scheme, such as ensuring that service engineering trains adhere to the latest emissions standards. For this reason, any increase in particulate matter concentrations in the air due to lower rates of deposition and increased emissions of particulate matter are considered to be negligible.	**Additional mitigation** Not required **Additional monitoring** Not required
			Direct impact on effect (Positive) (4, 5, 6) Increased frequency of heavy rainfall events could result in decreased concentrations of particulate matter due	**No** - An increase in frequency and intensity of heavy rainfall events on concentrations of particulate matter would potentially increase wet	**Additional mitigation** Not required

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/ resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
			to increased wet deposition. Therefore, increased frequency of heavy rainfall events could result in decreased adverse impacts on human health and ecological receptors. Increased frequency of heavy rainfall events would not be expected to impact concentrations of NO_x/NO_2. **Impact on mitigation** No impact identified.	deposition of particulate matter and reduce concentrations in the air. Consequently, the resultant impact would be positive.	**Additional monitoring** Not required
			Direct impact on effect (Positive) (4, 5, 6) Warmer and wetter conditions in winter (Increase in mean, max and min daily temperatures in winter and an increase in winter precipitation) could result in decreased concentrations of particulate matter, due to increased wet deposition. Furthermore, the reduced frequency of cold, dry and stable conditions, during which dispersion is low and concentrations are high, could result in decreased concentrations of particulate matter and NO_x/NO_2. Therefore, warmer and wetter conditions in winter could result in decreased adverse impacts on human health and ecological receptors. **Impact on mitigation** No impact identified.	**No** - Warmer and wetter conditions in winter could decrease concentrations of particulate matter and NO_x/NO_2, due to increased wet deposition and less periods of stable, cold and dry conditions. Consequently, the resultant impacts on human health and ecological receptors would be positive.	**Additional mitigation** Not required **Additional monitoring** Not required

Table 4: Community

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
Residents and Residential Properties	Temporary effects from construction - (1) Land required temporarily for the Proposed Scheme – residential property (including gardens) lost in part or whole to land required for construction (2) Temporary isolation of residential properties from other properties and	(1a, 2a, 3a 1b, 2b, 3b) Compliance with Section 5.1 of the draft CoCP (Community relations) stipulating the implementation of a community engagement framework to provide appropriate information and resolve community issues.	**Direct impact on effect** (2) Increased frequency of heavy rainfall events of short duration or long duration could lead to flooding of access routes which could increase the physical isolation of properties. This has the potential to increase the magnitude of	**No** – Increased frequency of heavy rainfall events of short duration or long duration could cause increased flooding to access routes which could increase the physical and psychological isolation of residential properties and residents. However, measures to prevent flooding including appropriate	**Additional mitigation** Not required **Additional monitoring** Not required

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
	infrastructure. This could be physical or psychological isolation; e.g. islanding or isolation of community resource (3) Cumulative effects – including three types of cumulative effects: • synergistic – termed 'community-wide effects' these occur where a number of individual impacts on resources come together within a location and have a wider impact on the community; • intra-project (in-combination) effects – where two or more residual significant effects from other EIA topics (Air quality, Sound, noise and vibration, heavy goods vehicle (HGV) traffic or visual impact) coincide on a community resource/receptor; and • inter-project effects – the EIA will consider the interaction between the Proposed Scheme, Phase 2a and other existing and/or approved projects in the vicinity of the Proposed Scheme which are under construction or have been consented which may give rise to significant cumulative effects.	(3b) Compliance with Section 5.3 of the draft CoCP (Construction site layout and good housekeeping) including layout of construction sites to reduce nuisance to sensitive receptors as far as possible. (1b, 2b, 3c) Compliance with Sections 5.1 and 16.3 of the draft CoCP (Community relations and water resources and flood risk respectively) including the monitoring and management of flood risk and other extreme weather events, where reasonably practicable, which may affect community resources during construction. (3d) Compliance with Sections 7.2 and 13.2 (Air quality and Sound, noise and vibration respectively) of the draft CoCP including specific measures in relation to air quality and noise will also serve to reduce impacts for the neighbouring communities including discretionary noise insulation for sensitive community resources and, in special circumstances, temporary rehousing. (1c, 2c) Compliance with Section 14.2 of the draft CoCP (Traffic and transport) including the realignment/diversion of roads to maintain access to sites. (2d) Compliance with Section 5.14 of the draft CoCP (Extreme weather events) including a short to medium-range weather forecasting service from a weather forecast provider will be used to inform short to medium-term programme management, environmental control and impact mitigation measures. (1d, 3e) Compliance with Section 12 of the draft CoCP (Landscape and visual) including the protection, inspection, maintenance and management of existing and new planting. (3f) Technical standards specify that ornamental plants shall be watered as required to maintain healthy growth following planting, during the maintenance period and subsequently in	the effect on residential properties and residents if flooding of temporary realignments/diversions as a result of construction causes islanding or isolation of community resources such as schools, health facilities, recreational facilities, open spaces, footpaths etc. (2) Increased frequency of heavy rainfall events of short duration or long duration could lead to flooding within the community that could increase the psychological isolation of residents. This has the potential to increase the sensitivity of the receptor if flooding of temporary realignments/diversions as a result of construction causes islanding or isolation of resources. For instance, psychological isolation from increased travel time due to diversions or new roads could be exacerbated if flooding events affected the community. **Impact on mitigation** No impact identified.	management of temporary changes to watercourses, construction sequencing and road realignments are considered to be sufficient to prevent an increase in the significance of the effect. Short-medium term weather forecasts and flood risk warnings will also be assessed when planning and implementing construction activities to reduce any potential effect.	
			Direct impact on effect (3) An increase in the number of consecutive days without precipitation may lead to drought, which could cause vegetation dieback, particularly under hot conditions. A reduction in existing vegetation cover (providing a screening function) could increase the magnitude of any potential effect on landscape character areas and visual setting caused by temporary construction works, thereby contributing to cumulative effects on residents. **Impact on mitigation** (1d, 3e, 3f) The effectiveness of the proposed landscaping mitigation (e.g. restoration of trees during construction, use of planting as screening to mitigate visual impact of construction compounds), could be reduced.	**No** – An increase in the number of consecutive days without precipitation may lead to drought which could cause vegetation dieback. This could potentially increase the effect of the construction activities on the landscape character areas and visual receptors, contributing to cumulative effects on residents. However, it is considered that the mitigation measures outlined in the draft CoCP, the relevant technical. standards, such as choosing plant species from a range of latitudes to increase their resilience to climate change and watering ornamental plants (trees and shrubs) as required to maintain healthy growth following planting, would mitigate any additional impact and the significance of the residual effect would not change.	**Additional mitigation** Not required **Additional monitoring** Not required

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
		cases of extreme drought. During the months of June to August, if there has been no rainfall for 5 consecutive days, watering shall be carried out twice a week until the onset of natural rainfall. (3g) Plant replacement inspections shall be made on an annual basis in August/September for the first 5 years after planting to identify dead, diseased, or dying tree stock.	**Direct impact on effect** (3) Increase in mean, max and min daily temperatures across all seasons could lead to a greater number of people having open windows, potentially leading to increased airborne noise levels experienced within properties, or uncomfortable heat within the property if windows are closed. This has the potential to increase the magnitude of the effect on residential communities. **Impact on mitigation** No impact identified.	**No** – Increase in mean, max and min daily temperatures across all seasons may lead to people opening their windows more often, leading to increased airborne noise levels within properties. However, this will not increase the significance of the effect, as the Sound, noise and vibration assessment assumes that windows will be open unless a specified noise threshold is exceeded. Where the noise threshold is exceeded, occupants will be offered alternative temporary accommodation or qualifying houses and buildings will be provided with additional sound insulation and ventilation to reduce internal sound levels and provide adequate ventilation.	**Additional mitigation** Not required **Additional monitoring** Not required
	Permanent effects from construction - (4) Residential land required permanently for the Proposed Scheme - residential property (including gardens) lost in part or whole to land required for new railway and/or the associated facilities (5) Demolition of buildings required for works to proceed (6) Permanent isolation of residential properties from other properties and infrastructure. This could be physical or psychological isolation; e.g. islanding or isolation of resource (7) Cumulative effects - including three types of cumulative effects: • synergistic – termed 'community-wide effects' these occur where a number of individual impacts on resources come together within a location and have a wider impact on the community; • intra-project (in-combination) effects – where two or more residual significant effects from other EIA topics (air quality, Sound, noise and vibration, HGV traffic or visual impact) coincide	(4a, 5a, 6a, 7a) Compliance with Section 5.1 of the draft CoCP (Community relations) stipulating the implementation of a community engagement framework to provide appropriate information and resolve community issues. (7b) Compliance with Sections 7.2 and 13.2 (Air quality and Sound, noise and vibration respectively) of the draft CoCP stipulating specific measures in relation to air quality and noise will also serve to reduce impacts for the neighbouring communities including discretionary noise insulation for sensitive community resources and, in special circumstances, temporary rehousing. (6b, 7c) Compliance with Section 14.2 of the draft CoCP (Traffic and transport) stipulating realignment/diversion of roads to maintain access to sites. (4b, 7d) Compliance with Section 12 of the draft CoCP (Landscape and visual) including the protection, inspection, maintenance and management of existing and new planting. (7e) Technical standards specify that ornamental plants shall be watered as required to maintain healthy growth	**Direct impact on effect** (6) Increased frequency of heavy rainfall events of short duration or long duration could lead to flooding of access routes which could increase the physical isolation of properties. This has the potential to increase the magnitude of the effect on residential properties and residents through islanding or isolation of community resources. (6) Increased frequency of heavy rainfall events of short duration or long duration could lead to flooding of access routes that could increase the psychological isolation of properties within the community. This has the potential to increase the sensitivity of the receptor through isolation of resources. For instance, psychological isolation from increased travel time due to diversions or new roads could be exacerbated in flooding events affecting the community. **Impact on mitigation** (6b) The effectiveness of the proposed realignment of roads to maintain access to sites could be reduced by potential	**No** – Increased frequency of heavy rainfall events of short duration or long duration could lead to flooding of access routes which could increase the physical isolation of properties. This has the potential to increase the magnitude of the effect on residential properties and residents through islanding or isolation of community resources, causing an increase in the physical and psychological isolation of residents. However, the design of drainage for new roads and changes to watercourses required to deliver the Proposed Scheme include climate change allowances for flooding and drainage. For this reason, the existing mitigation measures are considered to be sufficient to prevent an increase in the significance of the effect.	**Additional mitigation** Not required **Additional monitoring** Not required

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
	on a community resource/receptors; and • inter-project effects – the EIA will consider the interaction between the Proposed Scheme, Phase One, Phase 2a and other existing and/or approved projects in the vicinity of the Proposed Scheme which are under construction or have been consented which may give rise to significant cumulative effects.	following planting, during the 5 year maintenance period and subsequently in cases of extreme drought. During the months of June to August, if there has been no rainfall for 5 consecutive days, watering shall be carried out twice a week until the onset of natural rainfall. (7f) Plant replacement inspections shall be made on an annual basis in August/September for the first 5 years after planting to identify dead, diseased, or dying tree stock.	increased flood risk due to climate change.		
			Direct impact on effect (7) An increase in the number of consecutive days without precipitation may lead to drought, which could cause vegetation dieback, particularly under hot conditions. A reduction in existing vegetation cover (providing a screening function) could increase the magnitude of any potential effect on landscape character areas and visual setting caused by construction works, thereby contributing to cumulative effects to residents. **Impact on mitigation** (7e) The effectiveness of the proposed landscaping mitigation (e.g. use of planting to mitigate visual impact of railway line cuttings, planting of replacement habitat where existing habitat is lost due to the elements of the scheme) could be reduced.	**No** – An increase in the number of consecutive days without precipitation may lead to drought which could cause vegetation dieback. This could potentially increase the effect of the construction activities on the landscape character areas and visual receptors and reduce the effectiveness of permanent mitigation planting, contributing to cumulative effects on residents. However, it is considered that the mitigation measures outlined in the draft CoCP, the relevant technical standards, such as choosing plant species from a range of latitudes to increase their resilience to climate change and watering ornamental plants (trees and shrubs) as required to maintain healthy growth following planting, would mitigate any additional impact and the significance of the residual effect would not change.	**Additional mitigation** Not required **Additional monitoring** Not required
	Operational effects – (8) Cumulative effects - including three types cumulative effects: • synergistic – termed 'community-wide effects' these occur where a number of individual impacts on resources come together within a location and have a wider impact on the community; • intra-project (in-combination) effects – where two or more residual significant effects from other EIA topics (air quality, Sound, noise and vibration, HGV traffic or visual impact) coincide on a community resource/receptors; and • inter-project effects – the EIA will consider the interaction between the Proposed Scheme, Phase One, Phase 2a and other existing and/or approved projects in the vicinity of the Proposed Scheme which are under construction or have been consented which may	(8a) Landscape mitigation planting to mitigate impacts on landscape character and to screen the Proposed Scheme in views from residential properties. (8b) Noise fence barriers to provide acoustic screening for residential properties. (8c) Retained cuttings within the scheme design to provide noise screening for residential properties. (8d) Landscape earthworks to provide visual screening for properties. (8e) Raised earthworks and landscaping along the route to provide screening and help integrate the Proposed Scheme within the wider landscape. (8f) Moving the location of the Proposed Scheme proposed in the working draft ES to reduce Sound, noise and vibration impacts on residents. (8g) Areas designated as public realm.	**Direct impact on effect** (8) Increase in mean, max and min daily temperatures across all seasons could lead to a greater number of people having open windows, potentially leading to increased airborne noise levels experienced within properties, or uncomfortable heat within the property if windows are closed. This has potential to increase the magnitude of the effect on residential communities. **Impact on mitigation** No impact identified.	**No** – Increase in mean, max and min daily temperatures across all seasons may lead to people opening their windows more often, leading to increased airborne noise levels within properties. However, this will not impact the significance of the effect, as the Sound, noise and vibration assessment assumes that windows will be open unless a specified noise threshold is exceeded. Where the noise threshold is exceeded, occupants will be offered alternative temporary accommodation or qualifying houses and buildings will be provided with additional sound insulation and ventilation to reduce internal sound levels and provide adequate ventilation.	**Additional mitigation** Not required **Additional monitoring** Not required

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
	give rise to significant cumulative effects.	(8h) Retention of roads following realignment to provide access to residential properties.			
Community infrastructure/organisations (including community facilities and infrastructure such as education, health, emergency services, places of worship, sports and recreational facilities, publicly accessible open spaces and recreational public rights of way (PRoW)	Temporary effects from construction - (9) Land required temporarily for the Proposed Scheme from community and recreational facilities (golf clubs; places of worship etc.) and open space lost in part or whole to land required for construction of the Proposed Scheme. Temporary closure and diversion of PRoW (10) Isolation of community and recreational facilities and infrastructure from other properties and infrastructure and the severance or isolation of open space (11) Cumulative effects - including three types of cumulative effects: • synergistic – termed 'community-wide effects' these occur where a number of individual impacts on resources come together within a location and have a wider impact on the community; • intra-project (in-combination) effects – where two or more residual significant effects from other EIA topics (air quality, Sound, noise and vibration, HGV traffic or visual impact) coincide on a community resource/receptors; and • inter-project effects – the EIA will consider the interaction between the Proposed Scheme, Phase One, Phase 2a and other existing and/or approved projects in the vicinity of the Proposed Scheme which are under construction or have been consented which may give rise to significant cumulative effects.	(9a, 10a, 11a) Compliance with Section 5.1 of the draft CoCP (Community relations) stipulating the implementation of a community engagement framework to provide appropriate information and resolve community issues. (9b, 10b) Compliance with Sections 5.3 and 14.2 of the draft CoCP (Construction site layout and good housekeeping and Traffic and Transport respectively) stipulating the maintenance of PRoW during construction where reasonably practicable. (9c) Compliance with Sections 5.3 and 14.2 of the draft CoCP (Construction site layout and good housekeeping and Traffic and Transport respectively) measures to ensure that the timely maintenance and condition of public roads, cycleways and PRoW do not deteriorate due to use by the construction traffic, including monitoring arrangements with local highway authorities and procedures to be followed for the temporary or permanent closure or diversion of roads, PRoW or accesses. (9d, 10c, 11b) Compliance with Section 5.3 of the draft CoCP (Construction site layout and good housekeeping) stipulating sensitive layout of construction sites to reduce nuisance as far as possible. (9e, 10d, 11c) Compliance with Sections 5.14 and 16.3 of the draft CoCP (Community relations and water resources and flood risk respectively) stipulating the monitoring and management of flood risk and other extreme weather events, where reasonably practicable, which may affect community resources during construction.	**Direct impact on effect** (9, 10) Increased frequency of heavy rainfall events of short duration or long duration could increase the risk of flooding. This could affect the accessibility of community resource and the use of open spaces and PRoWs, which could increase the magnitude of the effect on isolation, severance and land-take of community resource. **Impact on mitigation** No impact identified	**No** – Increased frequency of heavy rainfall events of short duration or long duration could increase the risk of flooding. This could affect the accessibility of community resource and the use of open spaces and PRoWs, which could increase the magnitude of the effect on isolation, severance and land-take of community resource. However, measures to prevent flooding including appropriate management of temporary changes to watercourses, construction sequencing and road realignments are considered to be sufficient to prevent an increase in the significance of the effect. Short-medium term weather forecasts and flood risk warnings will also be assessed when planning and implementing construction activities to reduce any potential impact.	**Additional mitigation** Not required **Additional monitoring** Not required
			Direct impact on effect (11) An increase in the number of consecutive days without precipitation may lead to drought, which could cause vegetation dieback, particularly under hot conditions. A reduction in existing vegetation cover (providing a screening function) could increase the magnitude of any potential effect on landscape character areas and visual setting caused by temporary construction works, thereby contributing to cumulative effects to community facility/ infrastructure. **Impact on mitigation** (11f) The effectiveness of the proposed landscaping mitigation (e.g. restoration of trees during construction, use of planting as screening to mitigate visual impact of construction compounds), is reduced.	**No** – An increase in the number of consecutive days without precipitation may lead to drought which could cause vegetation dieback. This could potentially increase the effect of the construction activities on the landscape character areas and visual receptors, contributing to cumulative effects on community resource. However, it is considered that the mitigation measures outlined in the draft CoCP, the Plant Procurement Strategy and the Technical standard: Landscape Maintenance, Monitoring & Management Plan, such as choosing plant species from a range of latitudes to increase their resilience to climate change and watering ornamental plants (trees and shrubs) as required to maintain healthy growth following planting, would mitigate any additional impact and the significance of the residual effect would not change.	**Additional mitigation** Not required **Additional monitoring** Not required

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
		(11d) Compliance with Sections 7.2 and 13.2 (Air quality and Sound, noise and vibration respectively) of the draft CoCP stipulating specific measures in relation to air quality and noise will also serve to reduce impacts for the neighbouring communities including discretionary noise insulation for sensitive community resources and, in special circumstances, temporary rehousing. (9f, 11e) Compliance with Section 14.2 of the draft CoCP (Traffic and transport) stipulating realignment/diversion of roads to maintain access to sites. (9g, 10e) Compliance with Section 5.14 of the draft CoCP (Extreme weather events) stipulating a short to medium-range weather forecasting service from a weather forecast provider will be used to inform short to medium-term programme management, environmental control and impact mitigation measures. (11f) Compliance with Section 12 of the draft CoCP (Landscape and visual) including the protection, inspection, maintenance and management of existing and new planting. (11g) Comply with Section 14 of the draft CoCP: the avoidance of large goods vehicles operating adjacent to schools during drop off and pick up periods, where practicable. (11h) Technical standards specify that ornamental plants shall be watered as required to maintain healthy growth following planting, during the maintenance period and subsequently in cases of extreme drought. During the months of June to August, if there has been no rainfall for 5 consecutive days, watering shall be carried out twice a week until the onset of natural rainfall. (11i) Plant replacement inspections shall be made on an annual basis in August/September for the first 5 years after planting to identify dead, diseased, or dying tree stock.	**Direct impact on effect** (11) Increase in mean, max and min daily temperatures across all seasons could lead to a greater number of people having open windows, potentially leading to increased airborne noise levels experienced within community facilities (e.g. schools, hospitals), or uncomfortable heat within the facility if windows are closed. This could increase the magnitude of the effect of the construction of the Proposed Scheme on community facilities. **Impact on mitigation** No impact identified.	**No** – Increase in mean, max and min daily temperatures across all seasons may lead to people opening their windows more often, leading to increased airborne noise levels within community facilities. However, this will not impact the significance of the effect, as the Sound, noise and vibration assessment assumes that windows will be open unless a specified noise threshold is exceeded. Where the noise threshold is exceeded, occupants will be offered alternative temporary accommodation or qualifying houses and buildings will be provided with additional sound insulation and ventilation to reduce internal sound levels and provide adequate ventilation.	**Additional mitigation** Not required **Additional monitoring** Not required

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
		(10f) Compliance with relevant sections of the draft CoCP Section 16 (water resources and flood risk) including construction activities to avoid any significant increase of flood risk with appropriate measures such as keeping watercourses clear of obstructions and debris to reduce blockage risk; contractors will obtain copies of the relevant regulatory bodies' flood risk management plans, maps and strategies and prepare site specific flood risk management plans for those areas of the site at risk of flooding; Consideration of flooding when planning sites, storing materials and undertaking temporary or permanent works; Designers and contractors will be required to prepare construction and permanent works proposals that are safe and ensure that flood risk is managed appropriately. (10g) Construction sequencing and temporary works design would carefully consider and assess potential impacts on flood risk including climate change allowances.			
	Permanent effects from construction - (12) Land required permanently for the Proposed Scheme from community and recreational facilities (golf clubs; places of worship etc.) and open space lost in part or whole to land required for construction of the Proposed Scheme (13) Isolation of community and recreational facilities, and infrastructure from other properties and infrastructure/ and the severance or isolation of open space (see health) (14) Cumulative effects - including three types of cumulative effects: • synergistic – termed 'community-wide effects' these occur where a number of individual impacts on resources come together within a location and have a wider impact on the community; • intra-project (in-combination) effects – where two or more residual significant effects from other EIA topics (air	(12a, 13a, 14a) Compliance with Section 5.1 of the draft CoCP (Community relations) stipulating the implementation of a community engagement framework to provide appropriate information and resolve community issues. (14b) Compliance with Sections 7.2 and 13.2 (Air quality and Sound, noise and vibration respectively) of the draft CoCP stipulating specific measures in relation to air quality and noise will also serve to reduce impacts for the neighbouring communities including discretionary noise insulation for sensitive community resources. (13b, 14c) Compliance with Section 14.2 of the draft CoCP (Traffic and transport) stipulating realignment/diversion of roads to maintain access to sites. (13c, 14d) Compliance with Section 16 (Water resources and flood risk) Section	**Direct impact on effect** Increased frequency of heavy rainfall events of short duration or long duration could lead to flooding. This has the potential to increase travel distance and congestion on routes already affected by the Proposed Scheme which could affect the accessibility of a community resource. Furthermore, flooding could result in further land required temporarily for the Proposed Scheme and affect the use of open spaces and PRoWs. **Impact on mitigation** No impact identified.	**No** – Increased frequency of heavy rainfall events of short duration or long duration could lead to flooding. This has the potential to increase travel distance and congestion on routes already affected by the Proposed Scheme which could affect the accessibility of a community resource. Furthermore, flooding could result in further land required for the Proposed Scheme and affect the use of open spaces and PRoWs. However, the design of drainage for new roads and changes to watercourses required to deliver the Proposed Scheme include climate change allowances for flooding and drainage. For this reason, the existing mitigation measures are considered to be sufficient to prevent an increase in the significance of the effect.	**Additional mitigation** Not required **Additional monitoring** Not required

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
	quality, Sound, noise and vibration, HGV traffic or visual impact) coincide on a community resource / receptors; and • inter-project effects – the EIA will consider the interaction between the Proposed Scheme, Phase One, Phase 2a and other existing and/or approved projects in the vicinity of the Proposed Scheme which are under construction or have been consented which may give rise to significant cumulative effects.	5.14 (Extreme weather events) of the draft CoCP. (13d, 14e) Permanent works design would carefully consider and assess potential impacts on flood risk including climate change allowances. (14f) Compliance with Section 12 of the draft CoCP (Landscape and Visual) including the protection, inspection, maintenance and management of existing and new planting. (14g) Technical standards specify that ornamental plants shall be watered as required to maintain healthy growth following planting, during the maintenance period and subsequently in cases of extreme drought. During the months of June to August, if there has been no rainfall for 5 consecutive days, watering shall be carried out twice a week until the onset of natural rainfall. (14h) Plant replacement inspections shall be made on an annual basis in August/September for the first 5 years after planting to identify dead, diseased, or dying tree stock.			
	Operational effects - (15) Cumulative effects - including three types of cumulative effects: • synergistic – termed 'community-wide effects' these occur where a number of individual impacts on resources come together within a location and have a wider impact on the community; • intra-project (in-combination) effects – where two or more residual significant effects from other EIA topics (air quality, Sound, noise and vibration, HGV traffic or visual impact) coincide on a community resource / receptors; and • inter-project effects – the EIA will consider the interaction between the Proposed Scheme, Phase One, Phase 2a and other existing and/or approved projects in the vicinity of the Proposed Scheme which are under construction	(15a) Landscape mitigation planting to mitigate impacts on landscape character and to screen the Proposed Scheme for community and recreational facility users. (15b) Noise fence barriers for community resources. (15c) Raised earthworks and landscaping along the route to provide screening and help integrate the Proposed Scheme within the wider landscape. (15d) Retention of roads following realignment to provide access to community and recreational facilities. (15e) Areas designated as public realm.	**Direct impact on effect** (15) Increase in mean, max and min daily temperatures across all seasons could lead to a greater number of people having open windows, potentially leading to increased airborne noise levels experienced within community facilities (e.g. schools, hospitals), or uncomfortable heat within the community facilities if windows are closed. This could increase the magnitude of the effect of the operation of the Proposed Scheme on community resource. **Impact on mitigation** No impact identified	**No** – Increase in mean, max and min daily temperatures across all seasons may lead to people opening their windows more often, leading to increased airborne noise levels within community facilities. However, this will not impact the significance of the effect, as the Sound, noise and vibration assessment assumes that windows will be open, unless a specified noise threshold is exceeded. Where the noise threshold would be exceeded, qualifying buildings will be provided with additional sound insulation and ventilation, such as installation of mechanical vents and natural measures, to reduce internal sound levels and provide adequate ventilation.	**Additional mitigation** Not required **Additional monitoring** Not required

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
	or have been consented which may give rise to significant cumulative effects.				

Table 5: Ecology and biodiversity

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
Habitats and Wildlife Species	Temporary effects from construction – (1) Construction impacts such as noise, dust, lighting and physical disturbance causing temporary disruption effects to breeding, feeding and migration patterns of species	(1a) Temporary effects on habitats and wildlife will be controlled and managed during construction through route wide implementation of the draft CoCP, with specific reference to the following sections: Section 4.3 (Control of dust) • appropriate measures to prevent and supress dust. Section 5.4 (Lighting) • lighting will also be designed, positioned and directed so as not to unnecessarily intrude on adjacent ecological receptors. Section 9 (Ecology) • manage impacts from construction, including the timing of works, on designated sites, protected and notable species and other features of ecological importance such as ancient woodlands and watercourses; • reduce habitat loss by keeping the working area to the reasonable minimum; • reinstatement of areas of temporary habitat loss; • restoration and replacement planting; • provision of a watching brief, where relevant; • relocation or translocation of species, soil and/or plant material, as appropriate;	**Direct impact on effect** No impact identified. **Impact on mitigation** (1a) Changes in temperature and rainfall patterns could cause species to change their behaviour, potentially changing the periods during which they are susceptible (e.g. bird nesting season). This could make it more difficult to time works outside of sensitive seasons.	**No -** Changes in temperature and rainfall patterns may cause species to change their behaviour, potentially changing the periods during which they are susceptible (e.g. bird nesting season). This could make it more difficult to time works outside of sensitive seasons. However, timing of works to avoid impacts on protected and/or notable species is considered to be sufficient to prevent an increase in the significance of the effect. This would be ensured through the legal protections of certain habitats and species (e.g. the Wildlife and Countryside Act 1981 and The Conservation of Habitats and Species Regulations 2017).	**Additional mitigation** Not required **Additional monitoring** Not required
			Direct impact on effect No impact identified. **Impact on mitigation** (1a) An increased frequency of extreme weather events may delay construction works. This could make it more difficult to time works to avoid sensitive ecological periods (e.g. bird nesting season).	**No** - An increased frequency of extreme weather events may create conditions, such as flooding, that delay construction works. This could make it difficult to time works outside of sensitive ecological periods (e.g. bird nesting season). However, timing of works outside of sensitive seasons is considered to be sufficient to prevent an increase in the significance of the effect. This would be ensured through the legal protections of certain habitats and species (e.g. the Wildlife and Countryside Act 1981 and The Conservation of Habitats and Species Regulations 2017), regardless of delays in the programme due to weather.	**Additional mitigation** Not required **Additional monitoring** Not required

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
		• consultation with Natural England, the Environment Agency, local wildlife trusts and relevant planning authorities as appropriate prior to and during construction; • compliance with all wildlife licensing requirements, including those for protected and invasive species and designated sites; and • use of temporary fencing or retention of existing habitat links to reduce the risk of disturbance during construction. Section 13 (Sound, noise and vibration): • best practicable means (BPM) will be applied to minimise noise (including vibration). As part of BPM, the first mitigation measure that will be applied is noise and vibration control at source. Section 16 (Water quality, water flow and sedimentation): • appropriate measures such as bunds of non-erodible material or silt or sediment fences adjacent to watercourses.	**Direct impact on effect** (1) Increased frequency of heavy rainfall events could lead to soils and sediments exposed or disturbed during construction works being transferred into watercourses. This could increase adverse effects on aquatic ecology. **Impact on mitigation** No impact identified.	**No** - An increased frequency of heavy rainfall events, especially following drier spells, could lead to soils and sediments exposed or disturbed during construction works being transferred into watercourses. This could increase adverse effects on aquatic ecology. However, the measures to control sediment, such as use of bunds of non-erodible material or silt and sediment fences adjacent to watercourses are considered to be sufficient to prevent an increase in the significance of the effect.	**Additional mitigation** Not required **Additional monitoring** Not required
			Direct impact on effect (1) An increased frequency of dry spells (number of consecutive days with no precipitation) could increase the likelihood of shortages of water supply, potentially impacting the ability to use water-based systems (such as water spray and damping down) to suppress dust. Dust can disturb habitats and species by reducing visibility, smothering habitats and contributing to respiratory issues. **Impact on mitigation** No impact identified.	**No -** An increased frequency of dry spells (number of consecutive days with no precipitation) could increase the likelihood of shortages of water supply, potentially impacting the ability to use water-based systems (such as water spray and damping down) to suppress dust. Dust can disturb habitats and species by reducing visibility, smothering habitats and contributing to respiratory issues. However, existing measures to source water for the suppression of dust, as well as measures to suppress dust which are not water dependent (such as the use of enclosures, covering stockpiles, installing hard surface roads and reducing speed limits on site), are considered to be sufficient to prevent an increase in the significance of the effect.	**Additional mitigation** Not required **Additional monitoring** Not required
	Permanent effects from construction – (2) Loss, degradation, disturbance or severance of habitats (3) Disruption to breeding, feeding and migration patterns of species (4) Decline of species populations	(2a, 3a, 4a) Permanent effects on habitats and wildlife will be controlled and managed during construction through route wide implementation of the draft CoCP, with specific reference to Section 9 (Ecology): • reduce habitat loss by keeping the working area to the reasonable minimum; • reinstatement of areas of temporary habitat loss; • restoration and replacement planting;	**Direct impact on effect** (2, 3, 4) An increased frequency of dry spells could affect the sensitivity of habitats to disturbance or degradation thereby affecting their ability to recover. **Impact on mitigation** (2a, 2b, 2c, 2e, 2f) An increased frequency of dry spells could reduce the ability of mitigation planting (i.e. new habitats and connections between habitats) to establish, for example through reduced water availability.	**No** - An increased frequency of dry spells could increase loss, degradation, disturbance or severance of habitats and could reduce the effectiveness of mitigation planting. For example, reduced water availability could lead to changes in vegetation growth rates and limited root depth. However, existing measures to compensate for habitats affected by the scheme, including the provision of new habitats that are larger and enhance landscape connectivity, the specification of plants with a provenance from south of the	**Additional mitigation** Not required **Additional monitoring** Not required

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
		• relocation or translocation of species, soil and/or plant material, as appropriate; and • control of invasive and non-native species. (2b, 3b, 4b) New habitat creation and connectivity, including: • identification of sites along route and off route for habitat creation and enhanced landscape connectivity (i.e. culverts, viaducts and other structures to reduce severance effects); • create larger habitat areas for wildlife; providing more robust and resilient ecosystems; • design of watercourse culverts and underpasses to allow the free passage of wildlife; and • choose species and provenances appropriate to future conditions when planning. Provision of new native species will be pre-adapted to warmer conditions and more resilient to climate change. (2c, 3c, 4c) An appropriate period of monitoring and establishment for planting depending on habitat type. (2d, 3d, 4d) A qualified arboriculturist shall be involved in the planning, implementation and end product checking of felling operations in order to ensure that existing trees in 'woodland edge management zones' are undamaged, in good health and robust enough to withstand increased exposure to high winds. (2e, 3e, 4e) The specification of a proportion of plants with a provenance from south of the growing site. (2f, 3f, 4f) Ecology Site Management Plans (ESMP) will be developed for each habitat creation site. Drafts of these management plans will be discussed		growing site, and monitoring and maintaining the establishment of habitats, is considered to be sufficient to prevent an increase in the significance of the effect.	
			Direct impact on effect (2, 3, 4) An increased frequency of dry spells could reduce water levels in water dependent habitats, such as ponds and wetlands, which could affect the sensitivity of those habitats to disturbance or degradation thereby affecting their ability to recover. **Impact on mitigation** (2a, 2b, 2c, 2d, 2e, 2f) An increased frequency of dry spells could reduce the ability of water dependent habitats, provided as mitigation, to establish.	**No** - Increased frequency of dry spells, the number of consecutive days with no precipitation, could reduce water levels in water dependent habitats, such as ponds and wetlands, which could affect the ability of existing habitats to recover or new habitats to establish. However, the proposed embedded mitigation measures including the consideration of climate change when locating ponds, is considered to be sufficient to prevent an increase in the significance of the effect.	**Additional mitigation** Not required **Additional monitoring** Not required
			Direct impact on effect (2, 3, 4) Hotter and drier conditions in summer, with an increase in mean, max and min daily temperatures and a decrease in precipitation could increase the risk of fire which could affect the sensitivity of habitats to disturbance or degradation thereby affecting their ability to recover. **Impact on mitigation** (2a, 2b, 2c, 2d, 2e, 2f) Hotter and drier conditions in summer could increase the risk of fire which could reduce the ability of mitigation planting (i.e. new habitats and connections between habitats) to establish.	**No -** Hotter and drier conditions in summer could increase the risk of fire which has the potential to increase loss, degradation, disturbance or severance of existing habitats and newly created habitats. However, existing measures to protect and compensate for habitats affected by the scheme, including preventing the spread of lineside vegetation which presents a high fire risk, such as gorse and bracken, monitoring of the establishment of habitats, and replacement of dead or dying plants during the establishment period, is considered to be sufficient to prevent an increase in the significance of the effect. The physiognomy and community composition of woodland also make it a fire resilient habitat in the UK and habitats most at risk of fire such as heathland are not present.	**Additional mitigation** Not required **Additional monitoring** Not required
			Direct impact on effect (2, 3, 4) Warmer and wetter conditions in winter, with an increase in mean, maximum and minimum daily temperatures and increase in precipitation could lead to longer growing seasons. This could stimulate	**No -** Warmer and wetter conditions in winter could lead to longer growing seasons. This could stimulate increased vegetation growth where soil, water and nutrient availability allows. This could have positive or negative effects on existing and mitigation planting as	**Additional mitigation** Not required **Additional monitoring** Not required

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
		with relevant environmental bodies and Natural England. (2g, 3g, 4g) Pond creation locations should be chosen based upon their hydrological suitability, taking into account future climate change, in particular the likelihood of increased frequency and severity of drought conditions.	increased vegetation growth where soil, water and nutrient availability allows. This could affect the sensitivity of habitats to disturbance or degradation and their ability to recover, including through the spread of non-native species. **Impact on mitigation** (2a, 2b, 2c, 2d, 2e, 2f) Warmer and wetter conditions in winter, with an increase in mean, max and min daily temperatures and increase in precipitation could lead to longer growing seasons. This could stimulate increased vegetation growth where soil, water and nutrient availability allows. This could affect the ability of mitigation planting to establish (i.e. new habitats and connections between habitats), including through competition with non-native species.	well as on the spread of non-native species. However, existing measures to prevent the spread of non-native species and to manage, reinstate and monitor the establishment of habitats affected by the scheme, is considered to be sufficient to prevent an increase in the significance of the negative effect.	
			Direct impact on effect (2, 3, 4) Changes in temperature and rainfall patterns could lead to changes to species migration. This could affect the sensitivity of species to additional disruption of their migration patterns by the Proposed Scheme, thereby affecting their ability to recover. **Impact on mitigation** No impact identified.	**No** - Changes in temperature and rainfall patterns could change migration patterns of species which could make them more sensitive to disruption by the Proposed Scheme. However, measures to prevent disruption to migration patterns, such as the provision of new habitats that are larger and enhance landscape connectivity providing more robust and resilient ecosystems, is considered to be sufficient to prevent an increase in the significance of the effect.	**Additional mitigation** Not required **Additional monitoring** Not required
	Operational effects – (5) Risk of species (e.g. bats, birds and other wildlife) being struck by moving trains or harmed by turbulence	Operational effects on habitats and wildlife will be controlled and managed through the following measures. (5a) Culverts, viaducts and/or other structures to reduce severance effects. (5b) Design of watercourse culverts and underpasses to allow the free passage of wildlife. (5c) Barn owl mitigation plan.	**Direct impact on effect** (5) Changes in temperature and rainfall patterns could put additional pressure on species (e.g. bats and birds) and reduce their ability to adapt to the risk of being harmed by turbulence or struck by moving trains. **Impact on mitigation** No impact identified.	**No** - Changes in temperature and rainfall patterns could put additional pressure on species (e.g. bats and birds) and reduce their ability to adapt to the risk of being harmed by turbulence or struck by moving trains. However, measures to prevent species from coming into contact with trains, such as new habitat creation, will be sufficient to prevent an increase in the significance of the effect as new habitats will be larger, enhance landscape connectivity and include structures to reduce severance.	**Additional mitigation** Not required **Additional monitoring** Not required

Electromagnetic interference (EMI)

2.1.5 While in theory relationships exist between EMI and climate variables, any projected changes in climate are likely to have negligible impact on EMI, if any. For example, changes in temperature may affect component values of electronics designed to suppress EMI and have a small impact on their performance. Additionally, excessive rain could change earth resistivity and increase the effects of stray current. Both of these impacts would be negligible in the context of projected climate change. On this basis no formal in-combination climate change impacts assessment for the EMI topic has been undertaken.

Greenhouse gas (GHG) assessment

2.1.6 The life cycle stages for the GHG assessment are defined as follows in Table 6:

Table 6: Greenhouse Gas Assessment

Life cycle stage	Activities incorporated
Pre-construction stage (module A0)	Represents preliminary desk-based studies and works such as; strategy and brief development, architecture, design efforts, EIA and cost planning.
Product stage (modules A1-A3)	Represents the embedded carbon emissions associated with the extraction, processing and manufacturing of all materials required for the permanent assets. This includes all energy and carbon emissions from manufacturing plants, primary and secondary manufacturing stages as well as any transport emission between these stages.
Construction process stage - transport to site (module A4)	Represents transport related to carbon emissions associated with the delivery of construction material, such as concrete and steel, and construction equipment to construction sites along the Proposed Scheme from the point of production (or point of storage in the case of plant and machinery).
Construction process stage - construction and installation (module A5)	Represents carbon emissions from construction site works activities including: • temporary work, ground works and landscaping; • materials storage and any energy or otherwise need to maintain necessary environmental conditions; • transport of materials and equipment on site; • installation of materials and products into the infrastructure asset; • emissions associated with site water demand; • waste management activities (transport, processing, final disposal) associated with waste arising from the construction site; • production, transportation, and waste management of materials/products lost during works; and • land use change.
Use stage - Installed products and materials (module B1)	Represents the carbon emissions emitted directly from the fabric of products and materials once they have been installed, as well as the sequestration of emissions from trees planted as part of the Proposed Scheme.
Use stage - Maintenance (module B2)	Represents the production, transportation (to and from the site) and end of life processing of all materials required for preventative maintenance. The electricity, fuel and water for regular preventative maintenance.
Use stage - Repair (module B3)	Represents the production, transportation (to and from the site) and end of life processing of all materials required for responsive or reactive treatment to an acceptable condition. This module includes the electricity, fuel and water used for responsive or reactive treatment to an acceptable condition.
Use stage - Replacement (module B4)	Represents the production, transportation (to and from the site) and end of life processing of all materials required to replace any assets or any components within assets that have a design life of less than 120 years.

Table 7: Greenhouse gas

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
A1- A3 Embodied carbon of materials A4 - Transport to site A5 - Construction site operations B1 - Carbon emissions absorbed directly from carbon sequestration from tree planting and peatlands	Permanent effects from construction – (1) GHG emissions resulting from new materials for construction of the Proposed Scheme (A1-A3), transport (A4) and construction process (A5). This can relate to any works, including earthworks, infrastructure, structures, buildings, etc. (2) Land use change during construction process stage (A5) resulting in GHG emissions (3) Carbon emissions absorbed directly from carbon sequestration (e.g. from tree planting (B1))	(A1- A3, A4, A5) The HS2 Ltd Environmental Policy[5] aims to minimise the carbon footprint of HS2 and deliver low carbon, long distance journeys that are supported by low carbon energy". Accordingly, HS2 Ltd is applying the following carbon minimisation hierarchy: a - calculate the carbon footprint of the Proposed Scheme and use this as a tool to assess the potential to reduce carbon across the design, construction and operational phase; b - consider low carbon options in developing the detailed design of the Proposed Scheme; c - reduce embedded carbon in construction materials and carbon emissions from construction works, where practicable; d - reduce energy requirements of the Proposed Scheme and maximise the energy efficiency of operations, if reasonably practicable; e - use and/or generate low carbon energy, if reasonably practicable; and f - sequester carbon, if reasonably practicable. Carbon minimisation aims will be supported through route wide implementation of the draft CoCP, with specific reference to Section 14 (Traffic and transport), Section 5.14 (Extreme weather clause) and Section 5.9 (Temporary living accommodation).	**Direct impact on effect** (1) Increased frequency of extreme weather events, such as heatwaves, heavy rainfall or dry spells, may lead to material being damaged during construction (e.g. due to reduced ability to pour concrete in hot weather). This could lead to more material being wasted, increasing carbon emissions relating to manufacture and transport. **Impact on mitigation** No impact identified.	**No** - Increased frequency of extreme weather events may lead to material being damaged during construction or disruption of "just in time" deliveries, which could increase material wastage. However, the increases in material wastage and resulting increase in carbon emissions due to climate change are expected to be negligible and managed through processes detailed in the draft CoCP, including Section 5.14 (Extreme weather events).	**Additional mitigation** Not required **Additional monitoring** Not required
			Direct impact on effect (2) Increased frequency of heavy rainfall events of short or long duration during construction may increase the risk of travel disruption due to flooding. This may lead to increased congestion for motorised users and a resulting increase in carbon emissions associated with construction traffic. **Impact on mitigation** No impact identified.	**No** - Increases in the frequency of heavy rainfall and flooding has the potential to increase the risk of traffic disruption during construction. However, this is expected to result in a negligible increase in carbon emissions from construction traffic. Additionally, mitigation measures such as traffic management measures and road realignments will limit the extent of any effects from the Proposed Scheme. Short-medium term weather forecasts and flood risk warnings will also be assessed when planning and implementing construction activities to further reduce any potential impact, as per the draft CoCP.	**Additional mitigation** Not required **Additional monitoring** Not required
			Direct impact on effect (3) Increased frequency of dry spells can lead to vegetation die-back, which would reduce the carbon sequestration capabilities of vegetation. Additionally, carbon emissions may increase due to increased transport requirements and waste quantities. **Impact on mitigation** (3f) Increased frequency of dry spells may lead to adverse effects on mitigation planting, particularly in the	**No** - The exact effect of climate change on the carbon sink capabilities of vegetation planted as part of the Proposed Scheme are uncertain. However, the contribution of planting to the whole life carbon footprint of the scheme is small (<0.1% of the lifecycle carbon footprint). Thus, the impact of the potential changes in carbon sink capabilities	**Additional mitigation** Not required **Additional monitoring** Not required

[5] High Speed Two Ltd (2019), *Environmental Policy*. Available online at: https://www.gov.uk/government/publications/hs2-environmental-policy.

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
			first year after planting, which could mean that re-planting is required and the ability of mitigation planting to sequester carbon is reduced.	will not change the significance of the effect.	
			Direct impact on effect (Positive) (3) Warmer and wetter conditions in winter, with an increase in mean, max and min daily temperatures and increase in precipitation could lead to longer growing seasons. This could stimulate increased vegetation growth where soil, water and nutrient availability allows. **Impact on mitigation** (3f) Warmer and wetter conditions may lead to positive effects on mitigation planting, with increased growth rates increasing plantings' ability to sequester carbon.	**No** - The exact effect of climate change on the carbon sink capabilities of vegetation planted as part of the Proposed Scheme are uncertain. However, longer growing seasons could have a positive effect on the ability of plantings to sequester carbon.	**Additional mitigation** Not required **Additional monitoring** Not required
B2-B5 (Maintenance, Repair, Replacement, Refurbishment) B6 - Operational energy use B7 - Operational water use B9 - User utilisation	Operational effects – (4) Carbon emissions resulting from activities related to any works and new materials for the maintenance, repair, replacement and refurbishment of the Proposed Scheme during the use stage/operation (B2-B5) (5) Energy and fuel needed for operating the Proposed Scheme, including infrastructure as well as buildings and stations (B6, B9) (6) Carbon emissions from operational water use (B7). Includes all water used and its treatment (pre- and post-use) during the normal operation of the Proposed Scheme. For example, this includes water used in the maintenance and cleaning of the rolling stock	(B1, B2-B5, B6, B7, B9) The HS2 Ltd Environmental Policy aims to "minimise the carbon footprint of HS2 and deliver low carbon, long distance journeys that are supported by low carbon energy". Accordingly, HS2 Ltd is applying the following carbon minimisation hierarchy: a - calculate the carbon footprint of the Proposed Scheme and use this as a tool to assess the potential to reduce carbon across the design, construction and operational phase; b - consider low carbon options in developing the detailed design of the Proposed Scheme; c - reduce embedded carbon in construction materials and carbon emissions from construction works, where practicable; d - reduce energy requirements of the Proposed Scheme and maximise the energy efficiency of operations, if reasonably practicable;	**Direct impact on effect** (4) More frequent extreme weather events, such as heatwaves and heavy rainfall events, may cause accelerated deterioration of assets. As a result, more frequent maintenance may be required, leading to increased waste quantities and a resulting increase in carbon emissions. **Impact on mitigation** No impact identified.	**No** - More frequent extreme weather events may cause accelerated deterioration of assets, potentially increasing carbon emissions associated with refurbishment and renewal. However, the effect on maintenance cycles is expected to be small, leading to a negligible difference in the quantity of waste produced and thus, carbon emissions, due to climate change. Maximising opportunities to re-use materials would further reduce the impact on carbon emissions. There would therefore not be an increase in the significance of the effect.	**Additional mitigation** Not required **Additional monitoring** Not required
			Direct impact on effect (5) Increases in mean, maximum and minimum daily temperatures across all seasons could change heating and cooling requirements. In particular, increases in maximum temperatures in summer and minimum temperatures in winter would lead to more energy to cool spaces and less energy to heat spaces respectively, affecting magnitude of GHG emissions.	**No -** Increases in maximum temperatures during summer and minimum temperatures during winter would lead to more energy being required to cool spaces and less energy required to heat spaces respectively. However, as there is a change in the balance of heating and cooling it is expected that overall change in energy requirement is negligible. Additionally, climate change considerations already	**Additional mitigation** Not required **Additional monitoring** Not required

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
		e - use and/or generate low carbon energy, if reasonably practicable; and f - sequester carbon, if reasonably practicable.	**Impact on mitigation** No impact identified.	feature in the heating, cooling and ventilation design of the Proposed Scheme. There would therefore not be an increase in the significance of the effect.	
			Direct impact on effect (5) Increases in mean, maximum and minimum daily temperatures across all seasons, in particular increases in maximum summer temperatures, may lead to reduced efficiency of railway power supply and distribution equipment due to overheating. As a result, both energy use and associated carbon emissions could increase. **Impact on mitigation** No impact identified.	**No** - Increases in mean, maximum and minimum daily temperatures may lead to reduced efficiency of railway power supply and distribution equipment due to overheating. However, any expected increase in ambient temperature will be factored into the design of overhead lines and distribution equipment. Modelling will also be carried out to determine the required conductor sizes appropriate for expected electrical loads and specified operational temperature ranges. Therefore, it is expected that any increase in GHG emissions would be negligible, and there would not be an increase in the significance of the effect.	**Additional mitigation** Not required **Additional monitoring** Not required

Table 8: Health

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
People and Communities	Temporary effects from construction (1) Neighbourhood quality - Negative effects to neighbourhood quality related to the residents' experience of, and feelings about, their local environment (which have, to some degree, effects on mental health and wellbeing). Impacts could include noise emissions affecting local amenity, dust emissions from construction activities, visual impacts affecting residents' satisfaction, construction traffic on local roads causing disturbance and concerns about safety and also resulting in temporary road	Mitigation measures included in the Proposed Scheme are as follows. (1a, 2a, 3a, 4a, 5a) reducing the loss of property and community assets, as far as reasonably practicable. (1b) reducing visual intrusion and noise, as far as reasonably practicable. (1c,3b) Compliance with Section 12 of the draft CoCP (Landscape and Visual) including the incorporating landscape design and screening into the design. (2b,3c) Compliance with Section 14.2 of the draft CoCP (Traffic and transport) including the realignment and diversion	**Direct impact on effect** (1) Increases in mean, max and min daily temperatures across all seasons could lead to a greater number of people having open windows, potentially leading to increased airborne noise levels experienced within properties, or uncomfortable heat within the property if windows are closed. This has potential to increase the significance of the effect of the temporary construction works from the Proposed Scheme on neighbourhood quality potentially causing negative effects on mental health and wellbeing.	**No** - Increases in mean, max and min daily temperatures across all seasons may lead to people opening their windows more often, leading to increased airborne noise levels within properties with potential to cause negative effects on mental health and wellbeing. However, this will not increase the significance of the effect, as the Sound, noise and vibration assessment assumes that windows will be open unless a specified noise threshold is exceeded. Where the noise threshold is exceeded, occupants will be offered alternative	**Additional mitigation** Not required **Additional monitoring** Not required

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
	closures/diversions/alternative routes.). Negative effects from demolition of residential properties, landmarks and public buildings resulting in impacts to health due to loss of contacts in local area and/or a noticeable reduction in the number of people using local facilities (2) Access to services - Negative effects on access to services, health and social care impacted by temporary closures of roads and diversions and alternative routes for PRoW; reduced access from changes in journey times (3) Access to spaces - Negative effects on access to green space, recreation and physical activity impacted due to temporary closures of roads and diversions and alternative routes for PRoW; temporary loss of spaces and facilities used for physical activity; and construction traffic deterring users (walkers, cyclists, equestrians) (4) Social capital - negative effects to social capital with impacts through the introduction of temporary construction workforce altering people's perception of their communities and levels of trust. Reduced levels of community connectivity from road closures and diversions causing increased journey times between rural communities (5) Loss of land - negative effects on temporary loss of land (such as car parks)	of some PRoW and roads to maintain access.(1d) Compliance with 13.2 (Sound, noise and vibration respectively) of the draft CoCP including control of sound, noise and vibration at source, by using quiet and low vibration equipment, review of construction programme and methodology to consider quieter methods, location of equipment on site, control of working hours, the provision of acoustic enclosures and the use of less intrusive alarms, such as broadband vehicle reversing warnings. In addition, screening will be installed such as local screening of equipment, perimeter hoarding or the use of temporary stockpiles. Temporary re-housing for residential properties where it is not practicable to mitigate noise. (1e, 2c, 3d, 4b, 5b) Compliance with Section 4.2 of the draft CoCP (Local Environment Management Plans). (1f, 2d, 3e, 4c, 5c) Compliance with Section 5.1 of the draft CoCP (Community relations) which will include control measures for the construction works associated with the Proposed Scheme to ensure that the effects of the works upon people and the natural environment are reduced or avoided so far as reasonably practicable, and the [requirement] for a community engagement framework (focused on those who may be affected by construction impacts, including local residents, businesses, landowners and community resources and specific needs of protected groups (defined in Equality Act 2010)). (1g, 2e, 3f, 4d, 5d) For any loss of a community facility, options for mitigating include: • improving or altering the remaining portion of the community facility;	**Impact on mitigation** No impact identified.	temporary accommodation or qualifying houses and buildings will be provided with additional sound insulation and ventilation to reduce internal sound levels and provide adequate ventilation.	
			Direct impact on effect (1) Increased frequency of heavy rainfall events of short or long duration may lead to flooding of diversions / alternative routes in place as a result of the Proposed Scheme. This could reduce neighbourhood quality and the local environment, potentially causing negative effects on mental health and wellbeing. (2,3) Increased frequency of heavy rainfall events of short or long duration may lead to flooding which could cause additional travel delays/congestion to route's already affected by construction of the Proposed Scheme. This could lead to reduced access to services, health and social care, green space, recreation and physical activity. This could lead to increased stress for people and communities, potentially increasing the significance of the effect on health. **Impact on mitigation** No impact identified.	**No** - Increased frequency of heavy rainfall events of short or long duration may lead to flooding of routes already affected by construction of the Proposed Scheme. This could cause stress for people and communities and negative effects on neighbourhood quality through reduced access to services, health and social care, green space, recreation and physical activity. However, measures to prevent flooding including appropriate management of temporary changes to watercourses, construction sequencing and road realignments are considered to be sufficient to prevent an increase in the significance of the effect. Short-medium term weather forecasts and flood risk warnings will also be assessed when planning and implementing construction activities to reduce any potential effect.	**Additional mitigation** Not required **Additional monitoring** Not required
			Direct impact on effect (1) An increase in the number of consecutive days without precipitation may lead to drought, which could cause vegetation dieback, particularly under hot conditions. A reduction in existing vegetation cover (providing a screening function) could increase the magnitude of the effect of the Proposed Scheme on the visual setting, potentially leading to reduced neighbourhood quality and increasing the effect on the health and wellbeing of communities.	**No -** An increased frequency of dry spells could cause vegetation dieback, potentially increasing the impact of the construction effects on visual receptors. This could reduce neighbourhood quality and increase the negative effects on health and wellbeing within a community. However, it is considered that the mitigation measures outlined in the draft CoCP and relevant Technical Standards, such as choosing plant species from a range of latitudes to increase their resilience to climate change and watering ornamental	**Additional mitigation** Not required **Additional monitoring** Not required

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
		• improving other existing community facilities in the area that could reduce the effect; • improving accessibility to other community facilities; and/or • identifying land owned by the relevant local authority that could be brought into use as a community facility with its agreement. (1h ,2f, 3g, 4e, 5e) In the event of loss of a facility, mitigation includes: • improving or altering the remaining portion of the community facility; • improving other existing community facilities in the area that could reduce the effect; • improving accessibility to other community facilities; and/or • identifying land owned by the relevant local authority that could be brought into use as a community facility with its agreement. (1i, 2g, 3h, 4f, 5f) Compliance with Section 5.14 of the draft CoCP (Extreme weather events) including a short to medium-range weather forecasting service from a weather forecast provider will be used to inform short to medium-term programme management environmental control and impact mitigation measures. (1j, 2h, 3i, 4g, 5g) Compliance with Section 5.1 of the draft CoCP (Community relations) including the implementation of a community engagement framework to provide appropriate information and resolve community issues. (1k) Compliance with Sections 7.2 and 13.2 (Air quality and Sound, noise and vibration respectively) of the draft CoCP including specific measures in relation to air quality and noise will serve to reduce impacts for the neighbouring	**Impact on mitigation** (1c) The effectiveness of the proposed landscaping mitigation (e.g. restoration of trees during construction, use of planting as screening to mitigate visual impact of construction compounds), could be reduced.	plants (trees and shrubs) as required to maintain healthy growth following planting, would mitigate any additional impact and the significance of the residual effect would not change.	

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
		communities including discretionary noise insulation for sensitive community resources and, in special circumstances, temporary rehousing. (1l) Specific to Ornamental plants in the relevant Technical standard "all (ornamental) plants shall be watered as required to maintain healthy growth following planting, during the maintenance period and subsequently in cases of extreme drought. During the months of June to August, if there has been no rainfall for 5 consecutive days, watering shall be carried out twice a week until the onset of natural rainfall". (1m) Plant replacement inspections shall be made on an annual basis in August/September for the first 5 years after planting to identify dead, diseased, or dying tree stock.			
	Operational effects The introduction of the new railway (permanent assets) will have the following effects: (6) Access to services - negative effects on access to services, health and social care impacted by permanent closures of roads, diversions and alternative routes for PRoW or direct loss of a service (7) Access to spaces/facilities - Negative effects on access to green space, recreation and physical activity impacted through permanent closures of roads and diversions and alternative routes for PRoW; permanent loss of spaces and facilities due to physical activity; and permanent changes in traffic system deterring users and presence of HGV (8) Education - Negative effects through permanent impacts on educational	(6a - 9a) Compliance with Section 4.2 of the draft CoCP (Local Environment Management Plans) as related to permanent impacts. (6c - 9c) For any loss of a community facility, options for mitigating to be explored by HS2 Ltd include: • improving or altering the remaining portion of the community facility; • improving other existing community facilities in the area that could reduce the effect; • permanent realignment and diversion of some PRoW and roads to maintain access; • improving accessibility to other community facilities; and/or • identifying land owned by the relevant local authority that could be brought into use as a community facility with its agreement. (6d-9d) In the event of loss of a facility, mitigation includes:	**Direct impact on effect** None identified. **Impact on mitigation** (6e) Increased frequency of heavy rainfall events of short duration or long duration could lead to flooding of permanent diversions and access roads. This could reduce the effectiveness of realignment of roads to maintain access to sites, including services, health and social care**.**	**No -** Increased frequency of heavy rainfall events of short duration or long duration could lead to flooding of permanent diversions and access roads; this could reduce the effectiveness of realignment of roads to maintain access to sites. However, the design of drainage for new roads and changes to watercourses required to deliver the Proposed Scheme include climate change allowances for flooding and drainage. For this reason, the existing mitigation measures are considered to be sufficient to prevent any negative effects on access to sites, and therefore there would be no increase in the significance of the effect.	**Additional mitigation** Not required **Additional monitoring** Not required

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
	resources along the route (i.e. permanent closure or restricted access). (9) Social capital - Negative impact to social capital through erosion of social networks resulting from the demolition of buildings/amenities (such as residential properties, community buildings).	• improving or altering the remaining portion of the community facility; • improving other existing community facilities in the area that could reduce the effect; • improving accessibility to other community facilities; and/or • identifying land owned by the relevant local authority that could be brought into use as a community facility with its agreement. (6e-9e) Realignment of road to maintain access to sites			
	The introduction of the operational railway (trains) will have the following effect: (10) Neighbourhood quality: The operation of the new railway and associated facilities could impact neighbourhood quality; life, mental health and wellbeing of residents i.e. noise and visual impacts from operation of the Proposed Scheme. Also includes the negative effects on neighbourhood quality as related to the residents' experience of, and feelings about, their local environment (which have to some degree effects on mental health and wellbeing). Impacts could include noise emissions affecting local amenity, visual impacts affecting local amenity could result in changes of behaviours such as deterring the use of outdoor spaces, and permanent changes in traffic system from road closures/diversions/alternative route creation. Negative effects from demolition of residential properties, landmarks and public buildings resulting in impacts to health due to loss of contacts in local area and/or a noticeable reduction in the number of people using local facilities	(10a) Reducing visual intrusion and noise, as far as reasonably practicable. (10b) Incorporating landscape design and screening into the design. (10c) Incorporating noise barriers, in the form of either landscape earthworks and/or noise fence barriers to avoid or reduce significant adverse airborne noise effects. (10d) Compliance with Section 12 of the draft CoCP (Landscape and visual) including the protection, inspection, maintenance and management of existing and new planting. (10e) Specific to Ornamental plants in the relevant Technical Standard "all (ornamental) plants shall be watered as required to maintain healthy growth following planting, during the maintenance period and subsequently in cases of extreme drought. During the months of June to August, if there has been no rainfall for 5 consecutive days, watering shall be carried out twice a week until the onset of natural rainfall". (10f) Plant replacement inspections shall be made on an annual basis in August/September for the first 5 years	**Direct impact on effect** (10) Increase in mean, max and min daily temperatures across all seasons could lead to a greater number of people having open windows, potentially leading to increased airborne noise levels experienced within properties, or uncomfortable heat within the property if windows are closed. This has the potential to increase the significance of the effect on people and communities, potentially causing negative effects on mental health and wellbeing. **Impact on mitigation** No impact identified.	**No** - Increases in mean, max and min daily temperatures across all seasons may lead to people opening their windows more often, leading to increased airborne noise levels within properties. However, this will not increase the significance of the effect, as the Sound, noise and vibration assessment assumes that windows will be open unless a specified noise threshold is exceeded. Where the noise threshold is exceeded, occupants will be offered alternative temporary accommodation or qualifying houses and buildings will be provided with additional sound insulation and ventilation to reduce internal sound levels and provide adequate ventilation.	**Additional mitigation** Not required **Additional monitoring** Not required

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
		after planting to identify dead, diseased, or dying tree stock.			

Table 9: Historic environment

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
Built Heritage – above ground built heritage assets (e.g. Listed buildings such as farmhouses, halls, inns and non-designated assets including housing, mills, bridges)	Temporary effects from construction (1) Temporary effects to designated and non-designated heritage assets (e.g. Grade II registered park and garden), based on impacts to their historical context and rural setting due to the presence of construction	(1a) - Compliance with section 8 of the draft CoCP which sets out the measures that will be adopted, insofar as reasonably practicable, to control effects on heritage assets. This includes the introduction of management measures that will be implemented for heritage assets that are to be retained within the land required for the Proposed Scheme. (1b) Adherence to the Plant Procurement Strategy and the relevant Technical Standards.	**Direct impact on effect** (1) Increase in the number of consecutive days without precipitation may lead to drought, which could cause vegetation dieback, particularly under hot conditions. A reduction in existing vegetation cover (providing a screening function) during the construction period could increase the magnitude of any potential impact on heritage assets due to a change to their setting caused by temporary construction works for the Proposed Scheme. **Impact on mitigation** (1a, 1b) The effectiveness of the proposed landscaping mitigation (i.e. restoration of trees during construction, use of planting as screening to mitigate visual impact of construction compounds), is reduced.	**No** - An increased frequency of dry spells could cause vegetation dieback, increasing the impact of the construction effects on built heritage assets due to change to their setting. However, it is considered that the mitigation measures outlined in the draft CoCP, the Plant Procurement Strategy and the relevant Technical standards, such as choosing plant species from a range of latitudes to increase their resilience to climate change, watering ornamental plants (trees and shrubs) as required to maintain healthy growth following planting, would mitigate any additional impact and the significance of the residual effect would not change.	**Additional mitigation** Not required **Additional monitoring** Not required
	Permanent effects from construction (2) Permanent physical effects on built heritage assets or those due to change in their setting as a result of the introduction of a new element of infrastructure	(2) Management measures that will be implemented for heritage assets that are to be retained within the land required for the Proposed Scheme including: (2a) Programme of historic environment investigation and recording (including archaeology and historic buildings) to be undertaken prior to or during construction works affecting the heritage assets. (2b) Any loss of trees to be restored as part of the woodland habitat creation.	**Direct impact on effect** (2) Increases in the number of consecutive days with no precipitation, exacerbates the risks of ground settlement. This could lead to a loss of ground stability which could cause acceleration of building decay on built heritage assets already affected by the temporary construction works for the Proposed Scheme. **Impact on mitigation** None identified.	**No** - An increased frequency of dry spells may exacerbate ground settlement, increasing the impact of construction effects on built heritage features. However, there are few groundworks immediately adjacent to built heritage sites, reducing the likelihood of ground stability issues to built heritage assets. Also, any potential settlement issues will be mitigated by e.g. ground treatment measures such as injection of grout into the ground above the tunnelling to reduce ground	**Additional mitigation** Not required **Additional monitoring** Not required

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
		(2c) Avoidance; Moving a structure and reinstating post construction; Mitigation through design (that is, engineering solutions).		movement, control of ground water to avoid changes which could potentially cause ground movement (HS2 Phase 2b Western Leg Information Paper C14: Ground settlement[6]), measures which are embedded in the project and would mitigate any additional impact, therefore the significance of the residual effect would not change.	
	Operational effects (3) Noise and movement of trains affecting heritage assets by changing the setting	(3a) Noise mitigation measures have been included within the Proposed Scheme to reduce potential impacts on identified assets. (3b) Landscape planting would increasingly reduce impacts on the setting of the designated assets within the study area as it matures. (3c) Programme of replanting adjacent to train depots to act as screening.	**Direct impact on effect** None identified. **Impact on mitigation** (3b, 3c) An increase in the number of days without precipitation may lead to drought, which could cause dieback of new plantings, particularly under hot conditions. This could reduce the effectiveness of the proposed landscaping mitigation (e.g. use of planting as screening to mitigate visual impact of the proposed Scheme).	**No -** An increased frequency of dry spells could cause vegetation dieback, increasing the impact of the permanent effects on built heritage features due to a change to their setting. However, it is considered that the mitigation measures outlined in the Plant Procurement Strategy and the relevant Technical standards such as choosing plant species from a range of latitudes to increase their resilience to climate change, would mitigate any additional impact and the significance of the residual effect would not change.	**Additional mitigation** Not required **Additional monitoring** Not required
Historic landscape character	Permanent effects from construction (4) Introduction of the new railway will have negative effects on historical landscape character by introducing incongruous features	(4) Management measures that will be implemented for heritage assets that are to be retained within the land required for the Proposed Scheme, including: (4a) Route-wide principles, standards and techniques for works affecting heritage assets. (4b) Any loss of trees to be restored as part of the woodland habitat creation.	**Direct impact on effect** (4) Increase in winter temperature and precipitation could lead to a longer growing season and increased rate of vegetation growth. An increase in vegetation overgrowth would increase the impact of construction on historic landscape character. This impact may be negative or positive depending on the species of plant benefitting from the longer growth season. For instance, longer growing seasons for native species could ameliorate the impacts of vegetation dieback during the summer.	**No** - An increase in warmer wetter winters could lead to overgrowth of vegetation, and reduce the effectiveness of mitigation planting, increasing the impacts of construction on the historic landscape character. However, it is considered that the mitigation measures in relevant HS2 Ltd Technical Standards, such as: selecting planting stocks from a range of latitudes to increase climate resilience; being responsible for protection and aftercare of reinstated areas and created habitats; and the use of replacement planting, would	**Additional mitigation** Not required **Additional monitoring** Not required

[6] High Speed Two Ltd (2022), *Phase 2b Western Leg Information Paper C14: Ground settlement.*

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
			Impact on mitigation (4b) The effectiveness of replanting is reduced if pest/non-native species which are thriving in warmer wetter winters cause vegetation loss (for instance trees/hedgerow dieback) due to direct damage (i.e. eaten by bugs) or by out-competing native species.	mitigate any additional impact and the significance of the residual effect would not change.	
			Direct impact on effect (4) Increase in the number of consecutive days with no precipitation may lead to drought, which would cause dieback of existing vegetation. The reduction in vegetation cover affects landscaping which therefore increases the magnitude of any potential visual impact on historic landscape character. **Impact on mitigation** (4b) An increase in the number of days without precipitation may lead to drought, which could cause dieback of new plantings such as trees or any vegetation planted to provide screening. This could reduce the effectiveness of the proposed landscaping mitigation (e.g. use of planting as screening to mitigate visual impact of the Proposed Scheme).	**No -** An increased frequency of dry spells could cause dieback of both existing and new vegetation, potentially increasing the magnitude of any potential visual impact on the historic landscape character. However, it is considered that the mitigation measures outlined in the relevant Technical standards, such as choosing plant species from a range of latitudes to increase their resilience to climate change, would mitigate any additional impact and the significance of the residual effect would not change.	**Additional mitigation** Not required **Additional monitoring** Not required
Buried archaeology (e.g. buried remains and burial mounds) and Paleo-environmental sites and remains	Permanent effects from construction (5) Permanent physical effects on buried archaeology due to partial loss due to construction related activities (i.e. piling), and dewatering arising from construction related activities (6) Permanent physical effects on paleo-environmental remains due to partial loss due to construction related activities (i.e. piling) or dewatering arising from construction activities	(5, 6) Management measures that will be implemented for heritage assets that are to be retained within the land required for the Proposed Scheme, including: (5a, 6a) Route-wide principles, standards and techniques for works affecting heritage assets. (5b, 6b) A programme of historic environment investigation and recording (including archaeology and historic buildings) to be undertaken prior to or during construction works affecting the heritage assets.	**Direct impact on effect** (5) Increased frequency of heavy rainfall events of short duration or long duration could raise the water table. This could increase the potential magnitude of the impacts of the scheme on buried archaeology due to the combined effect of the Proposed Scheme on groundwater flows/levels and the raising of the water table. **Impact on mitigation** None identified.	**No** – The introduction of wetter conditions to remains previously preserved in a dry, oxic environment through burial could cause an adverse impact. Although the location and condition of some of these remains is currently unknown, the post-assent pre-construction archaeological works will identify any relevant archaeological features. Any impacts to these will be addressed during the construction and design process by following best practice, such designing to avoid disrupting groundwater flows, and use of piling techniques that do not disrupt groundwater flows	**Additional mitigation** Not required **Additional monitoring** Not required

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
		(5c, 6c) Recording or avoiding damage where possible.		significantly. These measures are considered to be sufficient to prevent an increase in the significance of the effect, by preventing the rise in groundwater levels from occurring.	
			Direct impact on effect (5) An increase in the number of consecutive days with no precipitation could exacerbate de-watering arising from construction activities, potentially exposing buried archaeological remains to oxic conditions. If the construction works lead to a permanent change in the water table, this could increase the magnitude of the potential impact due to greater risk of decay to waterlogged archaeological remains. **Impact on mitigation** None identified.	**No -** The introduction of drier conditions to remains previously preserved in a wet, anoxic environment through burial could cause an adverse impact. Although the location and condition of some of these remains is currently unknown, the post-assent pre-construction archaeological works will identify any relevant archaeological features. Any impacts to these will be addressed during the construction and design process. This will enable suitable mitigation (such as use of best practice piling techniques to avoid de-watering archaeological remains) to be applied depending on the specific conditions and sensitivity of the receptor. This is considered to be sufficient to prevent an increase in the significance of the effect.	**Additional mitigation** Not required **Additional monitoring** Not required
			Direct impact on effect: (5) Increased frequency of heavy rainfall events of short duration or long duration could cause flooding. This could potentially increase the magnitude of associated impacts on buried archaeological remains which are vulnerable to being exposed due to construction of the Proposed Scheme. **Impact on mitigation:** None identified.	**No -** Increased frequency of heavy rainfall events could cause flooding, potentially increasing the magnitude of the effect on archaeological remains which are vulnerable to being exposed due to construction impacts of the Proposed Scheme. However, the design of drainage and any changes to watercourses required to deliver the scheme will take into account flood risk. The embedded mitigation measures and the inclusion of climate change allowances over the design life, are considered to be sufficient to prevent an increase in the significance of the effect.	**Additional mitigation** If pre-construction archaeological works identify relevant features in proximity to water features, these should be flagged up to the detailed design team to ensure risk of flood and/or any potential changes to groundwater levels are considered, and best practice as detailed in e.g. Piling and Archaeology - guidelines and best practice (Historic England) are followed. To be finalised at Detailed Design Stage. **Additional monitoring** Not required.
			Direct impact on effect: (6) An increase in the number of consecutive days with no precipitation	**No -** The introduction of drier conditions to remains previously preserved in a wet, anoxic	**Additional mitigation**

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
			could exacerbate de-watering arising from construction activities, potentially exposing buried paleo-environmental remains toxic conditions. If the construction works lead to a permanent change in the water table, this could increase the magnitude of the potential impact due to greater risk of decay to waterlogged paleo-environmental remains. **Impact on mitigation** None identified.	environment through burial could cause an adverse impact. Although the location and condition of some of these remains is currently unknown, the post-assent pre-construction archaeological works will identify any relevant paleo-environmental features. Any impacts to these will be addressed during the construction and design process. This will enable suitable mitigation (such as use of best practice piling techniques to avoid de-watering archaeological remains) to be applied depending on the specific conditions and sensitivity of the receptor. This is considered to be sufficient to prevent an increase in the significance of the effect.	During pre-construction archaeological works, relevant PER features will be identified. Contractors will be advised of these and will be expected to follow best practice guidance in relation to any activities which risk dewatering features or permanently affecting water flows. This includes guidance in the document 'Piling and archaeology: Guidelines and best practice. (Historic England, 2007)', together with any additional mitigation identified as necessary by the Historic Environment topic. To be finalised at Detailed Design Stage.

Table 10: Land quality

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
People (Residential, Commercial and Industrial)	Temporary effects from construction: (1) Potential temporary (acute) human health impacts on-site and off-site from contaminants during construction (uptake through direct contact, ingestion and inhalation of soil/dust and fibre or vapours/gases)	(1a) Compliance with relevant sections of the draft CoCP including: • methods to control noise, waste, dust, gases and vapours (Sections 5, 7, 13 and 15 of draft CoCP); • methods to control spillage and prevent contamination of adjacent areas (Sections 5 and 16 of draft CoCP); • the management of human exposure for both construction workers and people living and working nearby (Section 11 of draft CoCP); • methods for the storage and handling of excavated materials (both contaminated and uncontaminated) (Sections 7 and 15 of draft CoCP); • management of any unexpected contamination found during construction (Section 11 of draft CoCP);	**Direct impact on effect** (1) Increases in the mean, maximum and minimum daily temperatures across all seasons may cause more volatile contaminants to vaporise where the proposed construction activities take place close to existing sources of contamination. This could increase the magnitude of the temporary human health impacts of the construction works for the Proposed Scheme on people both on-site and off-site. **Impact on mitigation** No impact identified.	**No -** Increased temperatures across all seasons may cause more volatile contaminants to vaporise from contaminated areas. Where the proposed construction activities take place close to existing sources of contamination, construction activities could result in the mobilisation of volatile contaminants which could increase the temporary human health impacts on-and off-site during the construction period. However, compliance with the mitigation measures outlined within the draft CoCP, including risk assessments, remediation and monitoring, are considered to be sufficient to prevent an increase in the significance of the effect. Any	**Additional mitigation** Not required **Additional monitoring** Not required

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
		• monitoring of groundwater/ground gases prior to, during and after construction (Section 11 of draft CoCP); • a post-remediation permit to work system (Section 11 of draft CoCP); • storage requirements for hazardous substances such as oil (Section 16 of draft CoCP); • traffic management to ensure that there is a network of designated haul roads to reduce compaction/degradation of soils (Section 14 of draft CoCP); • methods to monitor and manage flood risk and other extreme weather events which may affect land quality during construction (Section 5 of draft CoCP); and • methods to manage discovery of unknown animal burial pits (Section 6 of draft CoCP). (1b) The investigation and assessment of potentially contaminated sites would be undertaken in accordance with Environment Agency guidance and British Standards BS101759 and BS8576 and any other related guidance and regulations. A risk assessment and/or Conceptual Site Model (CSM) will be undertaken to determine what, if any, site specific remediation measures (to ensure risks to people are controlled to an acceptable level) are required to allow the Proposed Scheme to be constructed safely and to prevent harmful future migration of contaminants. (1c) The risk assessment will identify the need for a remedial options appraisal which would define the most appropriate remediation techniques. Where appropriate, this appraisal would be undertaken based on multi-criteria attribute analysis that considers environmental, resource, social and economic factors in line with the framework set out by the Sustainable Remediation Forum UK. Any remediation		contaminant mobilisation events and increases in volatility will be appropriately managed and remediated where present, regardless of changes in temperature with climate change.	
			Direct impact on effect (1) Increased frequency of dry spells (number of consecutive days with no precipitation) could increase dust generation from construction, and ambient concentrations of dust due to lower rates of deposition, in areas where the proposed construction activities take place close to existing sources of contamination. This may increase the potential to affect human health through dust inhalation, increasing the magnitude of the impact of the temporary construction works for the Proposed Scheme on people both on-site and off-site. **Impact on mitigation** (1a) Increased frequency of dry spells could increase the likelihood of shortages of water supply, potentially impacting the ability to use water-based systems (such as water spray and damping down) to suppress dust.	**No** - Increased frequency of dry spells (number of consecutive days with no precipitation) could increase dust generation from construction, and ambient concentrations of dust due to lower rates of deposition, in areas where the proposed construction activities take place close to existing sources of contamination. However, measures to manage dust such as those detailed in draft CoCP Section 7 are considered sufficient to prevent an increase the significance of the effect. In the event of a shortage of water supply, there are other mitigation measures which may be used for dust suppression such as the use of enclosures, covering stockpiles, installing hard surface roads and reducing speed limits on site to prevent an increase in the significance of the residual effect.	**Additional mitigation** Not required **Additional monitoring** Not required
			Direct impact on effect (2) Heavy rainfall events could cause flooding which could increase the risk of leaching of contaminants and run-off of sediments. This could increase the magnitude of the impact of the construction works for the Proposed Scheme on people, both on-site and off-site, by exposing them to contaminants. **Impact on mitigation** No impact identified.	**No** - An increase in the frequency of heavy rainfall events could cause flooding, increasing the risk of leaching of contaminants in areas where the proposed construction activities take place close to existing sources of contamination. This could increase the effect on people, both on-site and off-site, by exposing them to contaminants. The measures identified to prevent run-off and undertake necessary treatment of contaminated material are considered sufficient to prevent an increase in the significance of the effect.	**Additional mitigation** Not required **Additional monitoring** Not required

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
		plan will comply with HS2 Ltd's Sustainability Policy[7]. This may include considering the relative benefits of removal of contamination to enable re-use of the land for agriculture, ecological or amenity enhancements. (1d) Contaminated soils excavated within the site, where practicable, would be treated as necessary and reused within the Proposed Scheme where needed and suitable for use. Treatment techniques are likely to include stabilisation, soil washing and bio-remediation. Contaminated soil removed off-site would be taken to a soil treatment facility, another construction site (for treatment, as necessary, and reuse) or to an appropriately permitted landfill. By applying industry standard best practices to manage areas of potential contamination, HS2 Ltd will avoid any significant adverse effects to the local environment and communities. No additional measures are considered necessary to mitigate risks from land contamination during the construction stage beyond those that are set out above and/or instigated as part of the site-specific remediation strategies that will be developed at the detailed design stage, if required.			
	Permanent effects from construction – (2) Potential permanent (chronic) human health impacts from contaminants (uptake through direct contact, ingestion and inhalation of soil/dust and fibre or vapours/gases)	(2a) Compliance with relevant sections of the draft CoCP including: • methods to control noise, waste, dust, gases and vapours (Sections 5, 7, 13 and 15 of draft CoCP); • methods to control spillage and prevent contamination of adjacent areas (Sections 5 and 16 of draft CoCP); • the management of human exposure for both construction workers and people living and working nearby (Section 11 of draft CoCP); • methods for the storage and handling of excavated materials (both	**Direct impact on effect** (2) Increases in the mean, maximum and minimum daily temperatures across all seasons may cause more volatile contaminants to vaporise where the proposed construction activities take place close to existing sources of contamination. This could increase the magnitude of the human health impacts of the construction works for the Proposed Scheme on people both on-site and off-site.	**No -** Increases in the mean, maximum and minimum daily temperatures across all seasons may cause more volatile contaminants to vaporise where the proposed construction activities take place close to existing sources of contamination. This could increase the magnitude of the human health impacts of the construction works for the Proposed Scheme on people both on-site and off-site. However, compliance with the mitigation measures outlined in the draft	**Additional mitigation** Not required **Additional monitoring** Not required

[7] High Speed Two Ltd (2019), *Sustainability Policy.* Available online at: https://www.gov.uk/government/publications/hs2-sustainability-policy.

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
		contaminated and uncontaminated) (Sections 7 and 15 of draft CoCP); • management of any unexpected contamination found during construction (Section 11 of draft CoCP); • monitoring of groundwater/ground gases prior to, during and after construction (Section 11 of draft CoCP); • a post-remediation permit to work system (Section 11 of draft CoCP); • storage requirements for hazardous substances such as oil (Section 16 of draft CoCP); • traffic management to ensure that there is a network of designated haul roads to reduce compaction / degradation of soils (Section 14 of draft CoCP); • methods to monitor and manage flood risk and other extreme weather events which may affect land quality during construction (Section 5 of draft CoCP); and • methods to manage discovery of unknown animal burial pits (Section 6 of draft CoCP). (2b) The investigation and assessment of potentially contaminated sites would be undertaken in accordance with Environment Agency guidance and British Standards BS101759 and BS8576 and any other related guidance and regulations. A risk assessment and/or CSM will be undertaken to determine what, if any, additional site specific permanent remediation measures (to ensure risks to people are controlled to an acceptable level) are required to allow the Proposed Scheme to be constructed safely and to prevent harmful future migration of contaminants. (2c) The risk assessment will identify the need for a remedial options appraisal which would define the most appropriate remediation techniques. Where appropriate, this appraisal would be undertaken based on multi-criteria	**Impact on mitigation** No impact identified.	CoCP, including risk assessments, remediation and monitoring are considered to be sufficient to prevent an increase in the significance of the effect. Any increases in volatility will be appropriately managed and remediated where present, regardless of changes in temperature with climate change.	
			Direct impact on effect (2) Hotter and drier conditions in summer have the potential to increase desiccation and cracking at the surface of landfill clay caps that have been restored as a result of severance and/or disruption where the proposed construction activities take place close to existing and historic landfill sites. This may result in new pathways for the release of landfill gas to the atmosphere. **Impact on mitigation** (2a) Clay caps are installed at landfill sites as a remediation/contamination prevention measure, and will be reinstated if severed by the construction of the Proposed Scheme. If the integrity of these barriers is degraded through the effects of climate change, their ability to mitigate the release of contaminants/landfill gas may be reduced.	**No -** Hotter and drier conditions in summer have the potential to increase desiccation and cracking at the surface of landfill clay caps that have been restored as a result of severance and/or disruption where the proposed construction activities take place close to existing and historic landfill sites. Cracked clay caps could cause the release of landfill gas into the surrounding environment and associated adverse health impacts. However, compliance with the mitigation measures outlined in the draft CoCP are considered to be sufficient to prevent an increase in the significance of the effect.	**Additional mitigation** Not required **Additional monitoring** Not required
			Direct impact on effect (2) Extreme weather events can cause rapid changes in atmospheric pressure resulting in the release of ground gas, in particular from landfills. With an increased frequency of extreme weather events the risk of ground gas release and asphyxiation could increase. **Impact on mitigation** (2d) An increased frequency of extreme weather events could cause the effectiveness of measures to control or prevent the release of ground gas to be	**No -** An increased frequency of extreme weather events could cause rapid changes in atmospheric pressure, causing the release of ground gases into the surrounding environment. This increases the risk to human health including asphyxiation. However the mitigation measures, such as installation of cover systems and gas collection systems, are considered sufficient to prevent an increase in the significance of the effect.	**Additional mitigation** Not required **Additional monitoring** Not required

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
		attribute analysis that considers environmental, resource, social and economic factors in line with the framework set out by the Sustainable Remediation Forum UK. Any remediation plan will comply with HS2 Ltd.'s sustainability policy. This may include considering the relative benefits of removal of contamination to enable re-use of the land for agriculture, ecological or amenity enhancements. (2d) Additional site-specific permanent remediation measures, that could focus on source removal, pathway breakage or receptor protection, would be developed during the detailed design stage if required. These measures would ensure that risks to people and property from gas and vapours in the ground will be controlled to an acceptable level. Any remediation plan will comply with HS2 Ltd.'s sustainability policy. This may include considering the relative benefits of removal of contamination to enable re-use of the land for agriculture, ecological or amenity enhancements. (2e) Contaminated soils excavated within the site, where practicable, would be treated as necessary and reused within the Proposed Scheme where needed and suitable for use. Treatment techniques are likely to include stabilisation, soil washing and bio-remediation. Contaminated soil removed off-site would be taken to a soil treatment facility, another construction site (for treatment, as necessary, and reuse) or to an appropriately permitted landfill. (2f) By applying industry standard best practices to manage areas of potential contamination, HS2 Ltd will avoid any significant adverse effects to the local environment and communities. No additional measures are considered necessary to mitigate risks from land contamination during the construction stage beyond those that are set out above and/or established as part of the site specific remediation strategies that	impaired or reduce its effective design life.		

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
		will be developed at the detailed design stage, if required.			
Groundwater	Temporary effects from construction – (4) Potential temporary effects to groundwater quality from leaching during construction; vertical and lateral migration from contaminated soils and waters	(4a) Compliance with relevant sections of the draft CoCP including: • management of any unexpected contamination found during construction (Section 11 of draft CoCP). (4b) The investigation and assessment of potentially contaminated sites would be undertaken in accordance with Environment Agency guidance and British Standards BS101759 and BS8576. A risk assessment and/or CSM will be undertaken to determine the contamination risks and what, if any, site specific remediation measures are required to allow the Proposed Scheme to be constructed safely. Remediation measures will be identified that could focus on source removal, pathway breakage or receptor protection. These would be developed during the detailed design stage, if required. Any remediation plan will comply with HS2 Ltd.'s sustainability policy. This may include considering the relative benefits of removal of contamination to enable re-use of the land for agriculture, ecological or amenity enhancements.	**Direct impact on effect** (4) Increased frequency of heavy rainfall events could increase groundwater levels locally, and could mobilise contaminants where the proposed construction activities take place close to existing sources of contamination, resulting in negative effects on groundwater quality. **Impact on mitigation** (4a) An increased frequency of heavy rainfall events and a change in groundwater levels could reduce the effectiveness of mitigation measures designed to maintain the same hydrogeological conditions, making mobilisation of contaminants more likely.	**No** - Increases in the frequency of heavy rainfall events could increase groundwater levels locally, and could mobilise contaminants where the proposed construction activities take place close to existing sources of contamination, resulting in negative effects on groundwater quality. However, compliance with the mitigation measures outlined within the draft CoCP, including risk assessments, remediation and monitoring, are considered sufficient to prevent an increase in the significance of the effect.	**Additional mitigation** Not required **Additional monitoring** Not required
			Direct impact on effect (4) Increased frequency of heavy rainfall events could increase the risk of contaminant leaching into groundwater bodies, where the proposed construction activities take place close to existing sources of contamination. **Impact on mitigation** (4a) Increased frequency of heavy rainfall events could reduce the effectiveness of mitigation measures designed to prevent contaminated water pooling under certain rainfall levels, making the mobilisation and leaching of contaminants more likely.	**No** - Increases in the frequency of heavy rainfall events have the potential to increase the risk of sediment and contaminant leaching into surrounding groundwater bodies during construction where the proposed construction activities take place close to sources of contamination. However, compliance with the mitigation measures outlined within the draft CoCP, including risk assessments, remediation and monitoring, are considered sufficient to prevent an increase in the significance of the effect.	**Additional mitigation** Not required **Additional monitoring** Not required
	Operational effects – (5) Potential impact to bedrock aquifers through the operation of the trains which may give rise to minor contamination through leakage of hydraulic or lubricating oils (6) Unintentional release of coolant from an auto-transformer station, feeder stations and substations	(5a, 6a) Maintenance and operation of the Proposed Scheme would be in accordance with environmental legislation and good practice. Spillage and pollution response procedures similar to those to be outlined in the draft CoCP would be established for all high risk activities and employees would be trained in responding to such incidents. Where appropriate, the	**Direct impact on effect** (5, 6) Increased frequency of heavy rainfall events could increase the risk of contaminant leaching into groundwater bodies, resulting in negative impacts on groundwater quality. **Impact on mitigation** No impact identified.	**No** - Increased frequency of heavy rainfall events have the potential to increase the risk of contaminant leaching into surrounding groundwater causing negative impacts on groundwater quality. However the operation of the Proposed Scheme is not anticipated to give rise to significant contamination events and	**Additional mitigation** Not required **Additional monitoring** Not required

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
	through accidental discharge causing contamination	transformers will incorporate secondary containment appropriate to the level of risk to minimise external leakage/spillage. However, such leakage or spillage is expected to be very small and unlikely to result in significant contamination.		measures such as safe storage of potential contaminants, are considered to be sufficient to prevent an increase in the significance of the effect by preventing pollutants from leaching into groundwater bodies.	
Surface Water	Temporary effects from construction – (7) Potential impact to surface waters including canals, rivers, brooks, ponds and drains from existing contaminants (lateral migration through groundwater and direct run - off from site)	(7a) Compliance with relevant sections of the draft CoCP including: • methods to control noise, waste, dust, gases and vapours (Sections 5, 7, 13 and 15 of draft CoCP); • methods to control spillage and prevent contamination of adjacent areas (Sections 5 and 16 of draft CoCP); • methods for the storage and handling of excavated materials (both contaminated and uncontaminated) (Sections 7 and 15 of draft CoCP); • management of any unexpected contamination found during construction (Section 11 of draft CoCP); • a post-remediation permit to work system (Section 11 of draft CoCP); • storage requirements for hazardous substances such as oil (Section 16 of draft CoCP); • traffic management to ensure that there is a network of designated haul roads to reduce compaction / degradation of soils (Section 14 of draft CoCP); • methods to monitor and manage flood risk and other extreme weather events which may affect land quality during construction (Section 5 of draft CoCP); and • methods to manage discovery of unknown animal burial pits (Section 6 of draft CoCP). (7b) The investigation and assessment of potentially contaminated sites would be undertaken in accordance with Environment Agency guidance and British Standards BS101759 and BS8576. A risk assessment and/or CSM will be undertaken to determine what, if any,	**Direct impact on effect** (7) Increased frequency of heavy rainfall events could increase the risk of sediment and contaminant run-off into surrounding surface waters, where the proposed construction activities take place close to existing sources of contamination. **Impact on mitigation** No impact identified.	**No -** Increased frequency of heavy rainfall events could increase the risk of sediment and contaminant run-off into surrounding surface waters, where the proposed construction activities take place close to existing sources of contamination, resulting in negative impacts on surface quality. The measures identified to prevent run-off and undertake necessary treatment of contaminated material are considered sufficient to prevent an increase in the significance of the effect.	**Additional mitigation** Not required **Additional monitoring** Not required

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
		additionally site-specific remediation measures are required to allow the Proposed Scheme to be constructed safely and to prevent harmful future migration of contaminants. Remediation measures will be identified that could focus on source removal, pathway breakage or receptor protection, would be developed during the detailed design stage if required. These measures would ensure that risks to people and property from gas and vapours in the ground, the principal risk in this area, would be controlled to an acceptable level. (7c) The risk assessment will identify the need for a remedial options appraisal which would define the most appropriate remediation techniques. Where appropriate, this appraisal would be undertaken based on multi-criteria attribute analysis that considers environmental, resource, social and economic factors in line with the framework set out by the Sustainable Remediation Forum UK. Any remediation plan will comply with HS2 Ltd.'s sustainability policy. This may include considering the relative benefits of removal of contamination to enable re-use of the land for agriculture, ecological or amenity enhancements. (7d) Contaminated soils excavated within the site, where practicable, would be treated as necessary and reused within the Proposed Scheme where needed and suitable for use. Treatment techniques are likely to include stabilisation, soil washing and bio-remediation. Contaminated soil removed off-site would be taken to a soil treatment facility, another construction site (for treatment, as necessary, and reuse) or to an appropriately permitted landfill.			
	Operational effects – (8) The operation of the trains may give rise to minor contamination through leakage of hydraulic of lubricating oils	(8a, 9a) Maintenance and operation of the Proposed Scheme would be in accordance with environmental legislation and good practice. Spillage and pollution response procedures	**Direct impact on effect** (8, 9) Increased frequency of heavy rainfall events could increase the risk of transportation of contaminant run-off	**No -** Increased frequency of heavy rainfall events has the potential to increase the risk of contaminants being washed into surrounding surface water causing negative	**Additional mitigation** Not required **Additional monitoring**

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
	(9) Unintentional release of coolant from an auto-transformer station, feeder stations and substations through accidental discharge causing contamination	similar to those to be outlined in the draft CoCP would be established for all high risk activities and employees would be trained in responding to such incidents. Where appropriate, the transformers will incorporate secondary containment appropriate to the level of risk and would be included in the installed design to minimise external leakage/spillage. However, such leakage or spillage is expected to be very small and unlikely to result in significant contamination.	into surface water, resulting in negative impacts on surface water quality, particularly after a long, dry spell. **Impact on mitigation** No impact identified.	impacts on surface water quality. However the operation of the Proposed Scheme is not anticipated to give rise to significant contamination events and measures such as safe storage of potential contaminants, are considered to be sufficient to prevent an increase in the significance of the effect by preventing pollutants from contaminating surface water bodies.	Not required
Ecological Designations	Temporary effects from construction – (10) Potential impact to ecological designations from contaminants on-site and off-site (direct contact with soils and water or exposure to ground gases or vapours)	(10a) Compliance with the draft CoCP including: • methods to control noise, waste, dust, gases and vapours (Sections 5, 7, 13 and 15 of draft CoCP); • methods to control spillage and prevent contamination of adjacent areas (Sections 5 and 16 of draft CoCP); • methods for the storage and handling of excavated materials (both contaminated and uncontaminated) (Sections 7 and 15 of draft CoCP); • management of any unexpected contamination found during construction (Section 11 of draft CoCP); • a post-remediation permit to work system (Section 11 of draft CoCP); • storage requirements for hazardous substances such as oil (Section 16 of draft CoCP); • traffic management to ensure that there is a network of designated haul roads to reduce compaction/degradation of soils (Section 14 of draft CoCP); • methods to monitor and manage flood risk and other extreme weather events which may affect land quality during construction (Section 5 of draft CoCP); and • methods to manage discovery of unknown animal burial pits (Section 6 of draft CoCP).	**Direct impact on effect** (10) Increased frequency of dry spells (number of consecutive days with no precipitation) could increase dust generation from construction, and ambient concentrations of dust due to lower rates of deposition, in areas where the proposed construction activities take place close to existing sources of contamination. Contaminated dust could disturb ecological designations. **Impact on mitigation** (10a) Increased frequency of dry spells (number of consecutive days with no precipitation) could increase dust generation from construction and therefore increase the need for dust suppression action to be taken as mitigation. The availability of water to be used for dust suppression mitigation measures may not be sufficient or available to prevent contaminated dust from being generated and/or deposited on surrounding ecological designations.	**No -** Increased frequency of dry spells (number of consecutive days with no precipitation) could increase dust generation from construction, and ambient concentrations of dust due to lower rates of deposition, in areas where the proposed construction activities take place close to existing sources of contamination. Contaminated dust could disturb ecological designations. However, measures to manage dust such as those detailed in draft CoCP Section 7 are considered sufficient to prevent an increase the significance of the effect. In the event of a shortage of water supply, there are other mitigation measures which may be used for dust suppression such as the use of enclosures, covering stockpiles, installing hard surface roads and reducing speed limits on site to prevent an increase in the significance of the effect.	**Additional mitigation** Not required **Additional monitoring** Not required
			Direct impact on effect (10) Increases in the mean, maximum and minimum daily temperatures across all seasons may cause more volatile contaminants to vaporise where the proposed construction activities take place close to existing sources of contamination. This could	**No** - Increases in the mean, maximum and minimum daily temperatures across all seasons may cause more volatile contaminants to vaporise where the proposed construction activities take place close to existing sources of contamination. This could	**Additional mitigation** Not required **Additional monitoring** Not required

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
		(10b) The investigation and assessment of potentially contaminated sites would be undertaken in accordance with Environment Agency guidance and British Standards BS101759 and BS8576. A risk assessment and/or CSM will be undertaken to determine what, if any, site specific remediation measures are required to allow the Proposed Scheme to be constructed safely and to prevent harmful future migration of contaminants. Remediation measures will be identified that could focus on source removal, pathway breakage or receptor protection, would be developed during the detailed design stage if required. These measures would ensure that risks to people and property from gas and vapours in the ground, the principal risk in this area, would be controlled to an acceptable level. (10c) Where significant contamination is encountered, a remedial options appraisal would be undertaken to define the most appropriate remediation techniques. Where appropriate, this appraisal would be undertaken based on multi-criteria attribute analysis that considers environmental, resource, social and economic factors in line with the framework set out by the Sustainable Remediation Forum UK. Any remediation plan will comply with HS2 Ltd.'s Sustainability policy. This may include considering the relative benefits of removal of contamination to enable re-use of the land for agriculture, ecological or amenity enhancements. (10d) Contaminated soils excavated within the site, where practicable, would be treated as necessary to remove or render contamination inactive and reused within the Proposed Scheme where needed and suitable for use (environmental earthwork mitigation). Treatment techniques are likely to include stabilisation, soil washing and bio-remediation. Contaminated soil removed off-site would be taken to a soil	increase the magnitude of the temporary impacts of the construction works for the Proposed Scheme on ecological designations. **Impact on mitigation** No impact identified.	increase the magnitude of the temporary impacts of the construction works for the Proposed Scheme on ecological designations. However, compliance with the mitigation measures outlined within the draft CoCP, including risk assessments, remediation and monitoring, are considered to be sufficient to prevent an increase in the significance of the effect. Any contaminant mobilisation events and increases in volatility will be appropriately managed and remediated where present, regardless of changes in temperature with climate change.	
			Direct impact on effect (10) Increased heavy rainfall events could increase the risk of contaminant and sediment run-off into surrounding ecological designations, resulting in negative impacts on ecological designations. **Impact on mitigation** No impact identified.	**No** - Increased frequencies of heavy rainfall events have the potential to increase the risk of run-off of sediments into surrounding ecological designations. However, the mitigation measures outlined within the draft CoCP during construction of the proposed scheme will remediate contaminated land as far as reasonably possible, and there would therefore not be an increase in the significance of the effect.	**Additional mitigation** Not required **Additional monitoring** Not required

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
		treatment facility, another construction site (for treatment, as necessary, and reuse) or to an appropriately permitted landfill.			
	Operational effects – (11) The operation of the trains may give rise to minor contamination through leakage of hydraulic lubricating oils (12) Unintentional release of coolant from an auto-transformer station, feeder stations and substations through accidental discharge causing contamination	(11a, 12a) Maintenance and operation of the Proposed Scheme would be in accordance with environmental legislation and good practice. Spillage and pollution response procedures similar to those to be outlined in the draft CoCP would be established for all high-risk activities and employees would be trained in responding to such incidents. Where appropriate, the transformers will incorporate secondary containment appropriate to the level of risk would be included in the installed design to minimise external leakage/spillage. However, such leakage or spillage is expected to be very small and unlikely to result in significant contamination. (11b, 12b) Additional site-specific permanent remediation measures, that could focus on source removal, pathway breakage or receptor protection, would be developed during the detailed design stage if required. These measures would ensure that risks to people and property from gas and vapours in the ground will be controlled to an acceptable level: any remediation plan will comply with HS2 Ltd.'s Sustainability policy. This may include considering the relative benefits of removal of contamination to enable re-use of the land for agriculture, ecological or amenity enhancements.	**Direct impact on effect** (11, 12) Increased frequency of heavy rainfall events could increase the risk of contaminated run-off, which could affect ecological designations during operation. **Impact on mitigation** No impact identified.	**No** - Increased frequencies of heavy rainfall events have the potential to increase contaminant run-off into surrounding ecological designations. However, the operation of the trains is not anticipated to give rise to significant contamination events, and remediation of contaminated land during construction will reduce the risks of contaminant run-off during operation. Route-wide permanent adverse impacts on land quality arising during operation would be avoided or mitigated through measures included in the design, and monitoring works may continue to demonstrate the effectiveness of any remedial works at specific sites. There would therefore not be an increase in the significance of the effect.	**Additional mitigation** Not required **Additional monitoring** Not required
Geological Resources	Permanent effects from construction – (13) Loss of national Geological Resources as a result of the Proposed Scheme	(13a) The effects of the construction of the Proposed Scheme will either remove a geological resource entirely, or not affect it at all. Therefore no mitigation is required for this receptor.	**Direct impact on effect** None identified. **Impact on mitigation** None identified.	**N/A**	**Additional mitigation** Not required **Additional monitoring** Not required
Built Environment	Permanent effects from construction – (14) Potential impact to underground structures and buried services from contaminated land	(14a, 15a) Compliance with the draft CoCP including: • methods to control noise, waste, dust, gases and vapours (Sections 5, 7, 13 and 15 of draft CoCP);	**Direct impact on effect** (14, 15) Extreme weather events can cause rapid changes in atmospheric pressure resulting in the release of ground gas, in particular from landfills.	**No -** An increased frequency of extreme weather events could cause rapid changes in atmospheric pressure, causing the release of ground gases into the surrounding built environment. This increases	**Additional mitigation** Not required **Additional monitoring** Not required

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
	(15) Potential impact on property receptors on-site and off-site (direct contact with contaminated soil and water, and underground receptors)	• methods to control spillage and prevent contamination of adjacent areas (Sections 5 and 16 of draft CoCP); • methods for the storage and handling of excavated materials (both contaminated and uncontaminated) (Sections 7 and 15 of draft CoCP); • management of any unexpected contamination found during construction (Section 11 of draft CoCP); • a post-remediation permit to work system (Section 11 of draft CoCP); • monitoring of groundwater/ground gases prior to, during and after construction (Section 11 of draft CoCP); • storage requirements for hazardous substances such as oil (Section 16 of draft CoCP); • traffic management to ensure that there is a network of designated haul roads to reduce compaction/degradation of soils (Section 14 of draft CoCP); • methods to monitor and manage flood risk and other extreme weather events which may affect land quality during construction (Section 5 of draft CoCP); and • methods to manage discovery of unknown animal burial pits (Section 6 of draft CoCP). (14b, 15b) The investigation and assessment of potentially contaminated sites would be undertaken in accordance with Environment Agency guidance and British Standards BS101759 and BS8576. A risk assessment and/or CSM will be undertaken to determine what, if any, site specific remediation measures are required to allow the Proposed Scheme to be constructed safely and to prevent harmful future migration of contaminants. Remediation measures will be identified that could focus on source removal, pathway breakage or receptor protection, would be developed during the detailed design stage if	With an increased frequency of extreme weather events the risk of ground gas release and explosion which would damage the built environment could increase. **Impact on mitigation** (14e, 15e) An increased frequency of extreme weather events could cause the effectiveness of measures to control or prevent the release of ground gas to be impaired or reduce its effective design life.	the risk of explosion which could cause damage. However the mitigation measures, such as installation of cover systems and gas collection systems, are considered sufficient to prevent an increase in the significance of the effect.	

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
		required. These measures would ensure that risks to people and property from gas and vapours in the ground, the principal risk in this area, would be controlled to an acceptable level. (14c, 15c) Where significant contamination is encountered, a remedial options appraisal would be undertaken to define the most appropriate remediation techniques. Where appropriate, this appraisal would be undertaken based on multi-criteria attribute analysis that considers environmental, resource, social and economic factors in line with the framework set out by the Sustainable Remediation Forum UK. Any remediation plan will comply with HS2 Ltd.'s sustainability policy. This may include considering the relative benefits of removal of contamination to enable re-use of the land for agriculture, ecological or amenity enhancements. (14d, 15d) Contaminated soils excavated within the site, where practicable, would be treated as necessary to remove or render contamination inactive and reused within the Proposed Scheme where needed and suitable for use (environmental earthwork mitigation). Treatment techniques are likely to include stabilisation, soil washing and bio-remediation. Contaminated soil removed off-site would be taken to a soil treatment facility, another construction site (for treatment, as necessary, and reuse) or to an appropriately permitted landfill. (14e, 15e) Additional site-specific permanent remediation measures, that could focus on source removal, pathway breakage or receptor protection, would be developed during the detailed design stage if required. These measures would ensure that risks to people and property			

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
		from gas and vapours in the ground, a further principal risk in this area, will be controlled to an acceptable level. Any remediation plan will comply with HS2 Ltd.'s sustainability policy. This may include considering the relative benefits of removal of contamination to enable re-use of the land for agriculture, ecological or amenity enhancements.			
Mining and Mineral Resources	Permanent effects from construction – (16) Permanent sterilisation of resources (including peat) within land required for construction of the Proposed Scheme (e.g. direct excavation, severance, isolation of resources) (17) Borrow pit extraction resulting in use of mineral resources	(16a) Mitigation of the effects on mineral resources could include extraction of the resource. (17a) Landowner to be compensated for the loss of mineral resource. Following extraction the land would be restored to a condition suitable for the previous land use.	**Direct impact on effect** None identified. **Impact on mitigation** None identified.	**N/A**	**Additional mitigation** Not required **Additional monitoring** Not required

Table 11: Landscape and visual

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
Landscape Character Areas and Visual receptors	Temporary effects from construction Temporary effects on landscape character areas and visual receptors due to changes in landscape character and views because of: (1) - Presence of construction sites, plant, compounds, haul roads, soils and material storage and stockpiling, lighting (2) - Excavation of tunnels and cuttings; construction of embankments; temporary structures (3) - The removal of existing landscape elements such as woodland, trees and hedgerows (4) - Closure and diversion of existing public highways and PRoW (5) - Loss of buildings and structures	(1a, 2a, 3a, 4a, 5a) Compliance with Section 12 of the draft CoCP (Landscape and Visual) including the following: • Prevention of damage to landscape features adjacent to the construction sites due to movement of construction vehicles. (3b) Where appropriate, a proportion of ancient woodland soil with its associated seed bank will be salvaged and translocated to respective pre-prepared ecological compensation areas. (3c) Woodland translocation will take place in the dormant season in autumn/early winter under normal weather conditions.	**Direct impact on effect** (1, 2, 3) Increases in the number of consecutive days without precipitation may lead to the creation and distribution of dust in areas of bare ground, exacerbating the visual impacts of construction compounds and roads on the landscape character and visual receptors. **Impact on mitigation** (1b, 2b, 3j, 5b) Increased frequency of dry spells could increase the likelihood of shortages of water supply, potentially reducing the ability to use water-based systems (such as water spray and damping down) to suppress dust.	**No -** An increased frequency of dry spells could lead to increased creation and distribution of dust on bare ground, increasing the impact of the construction effects on the landscape character and visual receptors. However, it is considered that the mitigation measures in the draft CoCP, e.g. use of water for dust suppression, would mitigate any additional impact and the significance of the residual effect would not change. In the event of a shortage of water supply, there are other mitigation measures included in the draft CoCP which may be used for dust suppression e.g. covering stockpiles, use of enclosures, installing hard surface roads and reducing speed limits on	**Additional mitigation** Not required **Additional monitoring** Not required

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
		(3d) In order to increase resilience to climate change of the plantings, 1/3 of all planting stock should be from the same region of provenance as the site, 1/3 from up to 2" latitude south of the site and 1/3 from 2"-5" latitude south of the site (with some exceptions in relation to ancient woodland compensation and planting in areas such as Site of Special Scientific Interest (SSSI). (3e) Species selection will also take account of tree and shrub species for climate change using advice from sources such as the Forestry Commission. (3f) Plant species which are adaptable to climate change, in particular the projected increase in temperature and changing hydrological regime should be selected wherever possible for the various wetland/aquatic habitats. (3g) All ornamental plants shall be watered as required to maintain healthy growth following planting, during the 5 year maintenance period and subsequently in cases of extreme drought. During the months of June to August, if there has been no rainfall for 5 consecutive days, watering shall be carried out twice a week until the onset of natural rainfall". (3h) Plant replacement inspections shall be made on an annual basis in August/September for the first 5 years after planting to identify dead, diseased, or dying tree stock. (3i) The management, maintenance and monitoring requirements for all of areas of habitat and landscape shall be carried out in line with the following principles (among others): where possible, ensure that planting is maintained in a		site, which would mitigate any additional impact and the significance of the residual effect would not change.	
			Direct impact on effect (1, 2, 3, 4, 5) An increase in the frequency of short or long duration heavy rainfall events may lead to increased creation and distribution of mud (e.g. washout of mud onto haul roads, mud in combination with movement of construction vehicles on roads), therefore increasing the visual impacts of construction on the landscape character and visual receptors. **Impact on mitigation** None identified.	**No -** Increased frequency of heavy rainfall events, combined with construction vehicle movements, could cause an increase in the creation and distribution of mud, increasing the impact of the construction effects on the landscape character and visual receptors. However, it is considered that the mitigation measures outlined in the draft CoCP, e.g. use of vehicle wash-down points to clean vehicle wheels, appropriate wheel-cleaning measures to prevent the transfer and accumulation of mud, would mitigate any additional impact, and the significance of the residual effect would not change.	**Additional mitigation** Not required **Additional monitoring** Not required
			Direct impact on effect (1,2,3) Increases in the number of consecutive days without precipitation may lead to drought, which could cause vegetation dieback, particularly under hot conditions. A reduction in existing vegetation cover (which provides a screening function) may increase the magnitude of any potential impact on landscape character areas and visual setting caused by temporary construction works for the Proposed Scheme. **Impact on mitigation** (1a) The effectiveness of the proposed landscaping mitigation (e.g. restoration of trees during construction, use of planting as screening to mitigate visual impact of construction compounds), could be reduced.	**No -** An increased frequency of dry spells could cause vegetation dieback, increasing the impact of the construction effects on the landscape character areas and visual receptors. However, it is considered that the mitigation measures outlined in the draft CoCP, relevant procurement strategies and Technical Standards, such as choosing plant species from a range of latitudes to increase their resilience to climate change and watering ornamental plants (trees and shrubs) as required to maintain healthy growth following planting, would mitigate any additional impact and the significance of the residual effect would not change.	**Additional mitigation** Not required **Additional monitoring** Not required

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
		productive and economical way; maintain a planting character consistent with that of the surrounding landscape and thereby aid integration of HS2. (3j) The "Right Trees for London's Changing Climate Project" database should be referred to during species selection. (1b, 2b, 3j, 5b) Compliance with Section 7 of the draft CoCP (Air quality) including the following: • BPM to be implemented to control dust emissions from construction works. (1c, 2c, 3k, 4c, 5c) Compliance with Section 5.14 of the draft CoCP (Extreme weather events).			
	Operational effects - (6) Change in landscape character areas, visual receptors and reduced tranquillity due to the presence of the railway line and associated elements, specifically: • Cuttings and embankments, viaducts; • The loss of vegetation and landscape features such as ponds, streams, soils, changes to landform and introduction of newly built features such as overbridges, underbridges, auto-transformer stations, and feeder stations, overhead power equipment; and • Loss of buildings and structures.	(6a) Design of earthworks to tie the engineering earthworks for embankments and cuttings into their wider landscape context and to mitigate views of structures and overhead power equipment from sensitive receptors, where reasonably practicable. Earthworks design also takes account of the relationship to surrounding land uses and management, such as agriculture. (6b) Compensatory woodland planting in areas of loss, using the same species composition and planting types (and appropriate planting density), such as woodland planting to compensate for the partial loss of woodland, and to provide habitat connectivity, enhanced landscape/green infrastructure connectivity, as well connectivity of historic landscape features, where reasonably practicable, and to soften appearance of embankments and viaduct abutments. (6c) Species may also be selected for their resilience to climate change,	**Direct impact on effect** (6) An increase in the frequency of consecutive days with no rain can lead to vegetation dieback. A reduction in existing vegetation cover (providing a screening function) could affect landscaping, therefore increasing the magnitude of any potential impact on landscape character areas and visual setting caused by the Proposed Scheme. **Impact on mitigation** (6c) The effectiveness of the proposed landscaping mitigation (e.g. use of planting to mitigate visual impact of railway line cuttings, planting of replacement habitat where existing habitat is lost due to the elements of the scheme) could be reduced.	**No -** An increased frequency of dry spells could cause vegetation dieback, increasing the impact of the scheme effect on landscape character areas and visual receptors. However, it is considered that the mitigation measures outlined in the draft CoCP, relevant procurement strategies and Technical Standards, such as choosing plant species from a range of latitudes to increase their resilience to climate change, watering ornamental plants (trees and shrubs) as required to maintain healthy growth following planting, would mitigate any additional impact and the significance of the residual effect would not change.	**Additional mitigation** Not required **Additional monitoring** Not required
			Direct impact on effect None identified **Impact on mitigation** (6b) The effectiveness of the proposed landscaping mitigation (e.g. planting	**No -** Increased frequency of heavy rainfall events could impact on the establishment of landscape planting used as e.g. screening, reduce its effectiveness. However, it is considered that the mitigation measures outlined in the	**Additional mitigation** Not required **Additional monitoring** Not required

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
		particularly in urban areas. Species with a known low resilience to diseases will not be planted unless there is a specific reason to do so. (6d) In order to increase climate change resilience, 1/3 of all planting stock should be from the same region of provenance as the site, 1/3 from up to 2" latitude south of the site and 1/3 from 2"-5" latitude south of the site (with some exceptions in relation to ancient woodland compensation and planting in areas such as SSSI). (6e) Species selection will also take account of tree and shrub species for climate change using advice from sources such as the Forestry Commission. (6f) Plant species which are adaptable to climate change, in particular the increase in temperature and changing hydrological regime should be selected wherever possible for the various wetland/aquatic habitats. (6g) "Right Trees for London's Changing Climate Project" database should be referred to. (6h) Hedgerow replacement and restoration in areas of loss to restore connectivity and landscape pattern, where reasonably practicable, and using an appropriate palette of hedgerow types and species to tie the Proposed Scheme mitigation into the wider landscape character. (6i) Compensation for loss of field ponds with new wetlands, ecological ponds and biodiversity wetland features and wetland enhancement.	used as screening to mitigate visual impacts) could be reduced due to an increase in heavy rainfall events, which can damage plants or cause waterlogging of planted areas, leading to increased failure rates. **Direct impact on effect** (6) An increase in the frequency of consecutive days with no rain can cause stress to wetland and other habitats, therefore increasing the magnitude of any scheme impacts on existing wetlands. **Impact on mitigation** None identified.	relevant procurement strategies and Technical Standards e.g. being responsible for all protection, monitoring and aftercare of reinstated areas and created habitats, including remedial works as required, and carrying out plant replacement inspections on an annual basis for the first 5 years after planting to identify dead, diseased, dying tree stock; and ensuring that standing and fallen dead trees are removed and replacements made when identified; would mitigate any additional impact and the significance of the residual effect would not change. **No** - An increased frequency of dry spells could weaken existing habitats including wetland habitat areas, increasing the impact of the scheme's effect on existing habitats, impacting landscape character areas and visual receptors. However, it is considered that the mitigation measures outlined in the relevant procurement strategies and Technical Standards, such as use of replacement planting, selection of planting species from a range of latitudes to ensure climate resilience, being responsible for all protection, monitoring and aftercare of reinstated areas and created habitats, including remedial works as required, carrying out plant replacement inspections on an annual basis for the first 5 years after planting to identify dead, diseased, dying tree stock; and ensuring that standing and fallen dead trees are removed and replacements made when identified; would mitigate any additional impact and the significance of the residual effect would not change.	**Additional mitigation** Not required **Additional monitoring** Not required

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
		(6j) Pond creation locations should be chosen based upon their hydrological suitability, taking into account future climate change, in particular the likelihood of increased frequency and severity of drought conditions. (6k) Pond creation and enhancement measures should consider future climate change, in particular the likelihood of increased frequency and severity of drought conditions. (6l) Provision of new areas of informal semi natural greenspace to compensate for loss of existing greenspace. (6m) Linear belts of planting will be provided to create strong linkages between habitat fragments and islands, particularly in response to climate change. (6n) Public realm interventions to integrate and connect the stations into its immediate and wider townscape context with new street planting, where reasonably practicable, including introduction of green infrastructure. (6o) Avoidance of unnecessary tree and vegetation removal, and protection of existing trees in accordance with BS 5837: Trees in relation to design, demolition and construction. (6p) Specific to Ornamental plants in the relevant Technical Standard "all (ornamental) plants shall be watered as required to maintain healthy growth following planting, during the maintenance period and subsequently in cases of extreme drought. During the months of June to August, if there has been no rainfall for 5 consecutive days, watering shall be carried out twice a week until the onset of natural rainfall".			

Table 12: Major accidents and natural disasters

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
Members of the public and local communities; Infrastructure and the built environment; The natural environment, including ecosystems, land and soil quality, air quality, surface and groundwater resources and landscape; and The historic environment, including archaeology and built heritage.	Temporary effects from construction (1) Impact upon emergency response/evacuation (including for hazardous facilities) - Emergency response routes and evacuation procedures are unusable, leading to injury or fatality to members of public and/or damage to sensitive environmental receptors	(1a) Managed via CDM: Consultation with the Health and Safety Executive, local authorities and utility providers to understand locations of hazardous sites/assets, information fed into design and definition of required mitigation; Early engagement with emergency services and operators of affected facilities to be undertaken so that emergency response strategies can be revised, if required; Appropriate diversions/alternative routes and access points to be identified, communicated and agreed with the relevant parties and implemented; All major utilities that interface with the Proposed Scheme infrastructure to be diverted away from the Proposed Scheme prior to commencing early works, where possible and appropriate to do so; and Overarching controls outlined in the draft (CoCP which states that route-wide, local area and site-specific traffic management measures will be implemented during the construction of the Proposed Scheme on or adjacent to public roads, bridleways, footpaths and other PRoW affected by the Proposed Scheme as necessary.	**Direct impact on effect** (1) Increased frequency of heavy rainfall events could increase the risk of flooding during construction. This could lead to traffic disruption, further increasing the potential disruption to emergency services. **Impact on mitigation** (1a) Increased frequency of heavy rainfall could increase the risk of flooding along proposed alternative routes, thereby reducing the effectiveness of the mitigation.	**No** - Increased frequency of heavy rainfall could increase the risk of flooding which has the potential to increase disruption to emergency services, as well as potentially reducing the effectiveness of the proposed mitigation by disrupting alternative routes. However, where emergency routes are allocated as part of the proposed design, this will be done following close consultation with local emergency services to ensure that flood risk resulting from periods of heavy rainfall is accounted for in the selection of alternative emergency routes. These measures are considered sufficient to ensure that emergency routes should remain effective throughout the construction period and are therefore considered sufficient to prevent an increase in the significance of the effect.	**Additional mitigation** Not required **Additional monitoring** Not required
	Permanent effects from construction (2) Spillage or longer-term seepage of pollutants into groundwater or surface water due to construction activities - causing irreversible damage to environmental receptor (watercourse) or contamination and/or loss of drinking supply (3) Fire, explosion, release or exposure to harmful gas/materials as a result of construction activities adjacent to/over/striking hazard sources for example former landfill sites; ground gas; unexploded ordnance (UXO); gas	(2a, 4a) • Locations of below ground conditions and assets identified and fed into the design and construction; • Consultation with utility providers, local authorities, landfill owners and operators and the Environment Agency to manage interfaces and define appropriate control measures; • Limited storage of hazardous substances at construction sites; and • The management of risk related to leaks and spills impacting upon water features is considered within the Water	**Direct impact on effect** (2, 4) Changes in temperature and rainfall patterns may increase the sensitivity of environmental receptors, thereby increasing the severity of accidental damage from construction related activities. For example, increased temperatures could cause degradation of aquatic habitats and stressed fauna would be more likely to be negatively affected by a pollution event.	**No** – Changes in temperature and rainfall patterns could lead to alteration in surface and groundwater conditions. However, changes in groundwater conditions will be small over the construction period. Therefore, these changes are not considered to be significant enough to change the validity of the pre-construction investigations or to significantly increase the sensitivity of the receptors, and there would not be an increase in the significance of the effect.	**Additional mitigation** Not required **Additional monitoring** Not required

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
	pipeline route- causing fatality/injury to member of the public; irreversible damage to environmental receptor (listed building, ecological site, watercourse etc.); or structural damage to buildings and/or infrastructure (4) Physical damage or contamination of aquifer or water abstraction point due to construction activities (e.g. disturbance of contaminated ground) - leading to pollution of groundwater/surface water receptors	resources and flood risk sections of the ES. (3a) • Locations of below ground hazard/risk (e.g. Unexploded Ordnance (UXO)) identified and fed into the design and construction; • All major utilities that interface with the Proposed Scheme infrastructure to be diverted away from the Proposed Scheme prior to commencing early works, where possible and appropriate to do so; • Consultation with appropriate stakeholders such as utility providers, cavern owners/operators and Environment Agency to manage interfaces and define appropriate control measures; and • The draft CoCP includes specific requirements to prevent fire, carry out risk assessments for the possibility of UXO.	**Impact on mitigation** (2a, 4a) Changes in temperature and rainfall patterns could lead to alteration in surface and groundwater conditions, which could affect the validity of pre-construction investigations (for example, conclusions from geotechnical investigations).		
			Direct impact on effect (3) Hotter and drier conditions in summer may increase the risk of wildfires as well as the potential extent of a fire, increasing the magnitude of the effect. Drier vegetation would be more susceptible to fire, potentially increasing the effect of a fire event related to the Proposed Scheme. **Impact on mitigation** None identified.	**No** – Hotter and drier conditions in summer may increase the risk of wildfires as well as the potential extent of fires when they do occur. These conditions may also lead to drier vegetation which is more susceptible to the effects of a fire originating from construction activities. However, the embedded mitigation measures, including appropriate control measures which shall be put in place following consultation with appropriate stakeholders and requirements within the draft CoCP, are considered to be sufficient to ensure that there is no increase in the significance of the effect.	**Additional mitigation** Not required **Additional monitoring** Not required
	Operational effects (5) Fire and/or explosion (and associated emergency response activities), cause either direct or indirect harm, due to for example	(5a) Tunnels have been designed to relevant industry standards, including HS2's fire strategy. A tunnel fire risk assessment must be carried out under legislation, to ensure	**Direct impact on effect** (5) Hotter and drier conditions in summer may increase the risk of wildfires as well as the potential extent	**No** – Hotter and drier conditions in summer may increase the risk of wildfires as well as the potential extent of fires when they do occur. These conditions may also lead to drier vegetation which is more	**Additional mitigation** Not required **Additional monitoring** Not required

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
	depot activities; fire in or adjacent to HS2 facilities causing drift of fire to/from facility (6) Impact upon emergency response/evacuation (including for hazardous facilities) - emergency response routes are permanently closed/diverted , leading to injury or fatality to members of public and/or irreversible damage to sensitive environmental receptors	the safety of the occupants of the tunnel and those in the immediate vicinity who are at risk. A fire management strategy for tunnels will be drawn up during detailed design in line with the Technical Specifications for Interoperability. HS2 rolling stock is electric—no flammable fuels. The Proposed Scheme shall not carry hazardous (combustible/explosive) freight. However, it is expected that off route sections associated with the Proposed Scheme (will carry freight, alongside HS2 services. However, in these instances freight will be carried on Network Rail owned and operated infrastructure, and as such falls under Network Rails operating licence and safety plans. The fire safety objectives of the Proposed Scheme include the protection of the environment. Any drainage contaminated by firefighting operations will be discharged into a balancing pond and discharged safely in agreement with the Environment Agency, avoiding sensitive environmental receptors. (6a) Consultation with the emergency services, Transport for Greater Manchester, owners/operators of the hazardous facilities, the Health and Safety Executive, local authorities and utility providers to understand locations of hazardous sites/assets, mitigation incorporated into design as appropriate. Operational conflicts to be avoided or minimised where possible. Early engagement with emergency services and affected sites so that emergency response strategies can be revised, if required. Permanent diversions/alternative routes to be identified, communicated and agreed with the relevant parties and implemented.	of a fire, increasing the magnitude of the effect. Drier vegetation would be more susceptible to fire, potentially increasing the effect of a fire event related to the Proposed Scheme. **Impact on mitigation** None identified.	susceptible to the effects of a fire originating from operation of the Proposed Scheme. However, the embedded mitigation measures, such as designing assets in accordance with relevant industry standards, fire strategy and fire safety objectives of the Proposed Scheme, are considered to be sufficient to ensure that there is no increase in the significance of the effect.	
			Direct impact on effect (6) Increased frequency of heavy rainfall events could increase the risk of flooding during operation. This could lead to traffic disruption, further increasing the potential disruption to emergency services. **Impact on mitigation** (6a) Increased frequency of heavy rainfall could increase the risk of flooding along the permanent diversions/alternative routes of the Proposed Scheme, thereby reducing the effectiveness of the mitigation.	**No** – Heavy rainfall and the resulting increase in flood risk has the potential to increase disruption to emergency services, as well as potentially reducing the effectiveness of the proposed mitigation by disrupting alternative routes. However, where emergency service routes are designed as part of the scheme, these are designed to HS2 flood risk standards, which include climate change. Where emergency routes are allocated as part of the proposed design, this will be done following close consultation with local emergency services to ensure that flood risk resulting from periods of heavy rainfall is accounted for in the selection of alternative emergency routes. These measures are considered sufficient to ensure that emergency routes are resilient and remain effective throughout the operation period, and are therefore considered sufficient to prevent an increase in the significance of the effect.	**Additional mitigation** Not required **Additional monitoring** Not required

Table 13: Socio-economics

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
Resources (those assets and facilities which are impacted): • property units; and • businesses. Receptors (the operators, users or beneficiaries of the resources listed above): People in employment associated with a resource including: • employees in employment; • sole traders; and partners.	Temporary effects from construction - (1) Direct impacts on employment opportunities as a result of construction (2) Indirect impacts on the economy as a result of the construction phase due to multiplier effects on other construction sector projects, demand for construction sector jobs, and change in opportunities for local employment (3) Combined environmental effects on level of employment/wellbeing experienced by receptors and potential loss of trade for affected businesses (noise and vibration; HGV construction traffic; air quality; water; and visual impacts) (4) Isolation of infrastructure from receptors resulting in an impact on businesses and organisations	(1a) The construction of the Proposed Scheme offers considerable opportunities to businesses and residents along the line of route in terms of supplying goods and services and obtaining employment. HS2 Ltd is committed to working with its suppliers to build a skilled workforce that promotes further economic growth across the UK. (3a) Reducing nuisance through sensitive layout of construction sites (Section 5 of the draft CoCP). (3b) Applying best practicable means (BPM) during construction works to reduce noise (including vibration). As part of BPM, mitigation applied in following order: 1. noise and vibration control at source; 2. screening; and 3. noise insulation or temporary re-housing. (3c) Lead contractors will obtain prior consent from local authorities, setting out BPM, working hours and assessment of construction noise. (3d) Contractors will undertake monitoring to demonstrate compliance with noise commitments. (3e) Contractors will comply with draft CoCP (Section 13) and Environmental Protection Act 1990 (EPA). (3f) Monitor and manage flood risk and other extreme weather events that may affect socio-economic resources during construction, including: • Obtain copies of the relevant regulatory bodies' flood risk management plans, maps and strategies and prepare site specific flood risk management plans for those areas of the site at risk of flooding; and • Designers and contractors will be required to prepare construction and	**Direct impact on effect** (3) Increase in mean, max and min daily temperatures across all seasons would lead to a greater number of employees / workers having open windows in business premises, potentially leading to increased airborne noise levels experienced within buildings, or uncomfortable heat within the property if windows remain closed. This increased noise level could impact on productivity in some economic activities. **Impact on mitigation** (3a, 3b) Mitigation measures such as screening and noise insulation could be less effective in a hotter climate because people's exposure to the noise will be increased because they are more likely have their windows opened.	**No** – Increase in mean, max and min daily temperatures across all seasons may lead to employees/businesses opening their windows more often, leading to increased airborne noise levels within properties. However, this will not impact the significance of the effect, as the Sound, noise and vibration assessment assumes that windows will be open unless a specified noise threshold is exceeded. Where the noise threshold is exceeded, employees/workers will be offered alternative temporary areas or qualifying buildings will be provided with additional sound insulation and ventilation to reduce internal sound levels and provide adequate ventilation.	**Additional mitigation** Not required **Additional monitoring** Not required
			Direct impact on effect (2,3) Increased frequency of heavy rainfall events could cause flooding of routes that have been realigned or permanently diverted as a result of the Proposed Scheme. This could then increase the duration of disruption and congestion, affecting employees, workers and nearby businesses. **Impact on mitigation** (3g) Increased frequency of heavy rainfall events may reduce the effectiveness of the mitigation measures (such as traffic management measures to limit disruption), as heavy rainfall/flooding could cause further disruption and road closures to already disrupted traffic and on diverted/realigned routes.	**No –** Increase in frequency of heavy rainfall and flooding has the potential to increase the duration of disruption, travel distance and congestion on routes, which could affect employees and nearby businesses. However, mitigation measures such as traffic management measures, road realignments, procedures to address any highway incidents or vehicle breakdowns relating to construction traffic, especially at peak times, and the use of rail or water transport to limit transport by road where practicable will limit the significance of any effects from the Proposed Scheme. Therefore it is unlikely that these impacts would cause programme delays as the construction programme and method statements account for	**Additional mitigation** Not required **Additional monitoring** Not required

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
		permanent works proposals that are safe and ensure that flood risk (including that to third parties and the proposed works) is managed appropriately (Section 13 and 16 of the draft CoCP). (3g) Site specific traffic management measures including requirements relating to the movement of traffic from business and commercial operators of road vehicles, including goods vehicles and procedures to address any highway incidents or vehicle breakdowns relating to construction traffic, especially at peak times (Section 14 of the draft CoCP). (4a) Maintaining access to businesses for the duration of construction works where reasonably practicable (Section 14 of the draft CoCP).		extreme weather events such as heavy rainfall. Furthermore, drainage design for new roads included as part of Proposed Scheme include climate change allowances for flooding and drainage. For this reason the existing mitigation measures are considered to be sufficient to prevent an increase in the significance of the effect.	
	Permanent effects from construction - (5) Businesses lost or impaired due to land required for the Proposed Scheme	(5a) Businesses displaced by the Proposed Scheme would be compensated in accordance with the Compensation Code. HS2 Ltd recognises the importance of businesses that are displaced from their existing premises being able to relocate to suitable alternative premises and would, therefore, offer additional support over and above statutory requirements to facilitate this process.	**Direct impact on effect** None identified. **Impact on mitigation** None identified.	**N/A**	**Additional mitigation** Not required **Additional monitoring** Not required
	Operational effects – (6) Direct employment opportunities associated with the operations phase (7) Indirect impacts on the economy as a result of the operational phase due to multiplier effects: further economic activity (jobs, expenditure or income) associated with additional local income, local supplier purchases and longer-term development effects (8) Combined environmental effects on level of employment/wellbeing experienced by receptors and potential loss of trade for affected businesses (noise and vibration; traffic; air quality; water; and visual impacts) Roads:	(8a) Use of proven train and track technology to enable quieter operation, including aerodynamic noise of pantograph above 186mph. All noise to be reduced further away from track. (8b) Incorporate noise barriers, either earthworks and/or noise fences to reduce significant adverse airborne effects. (8c) Noise insulation measures offered for qualifying buildings, to avoid significant residual effects on health and quality of life. (8d) Stationary systems equipment used at permanent sites will be designed to avoid significant effects and minimise effects as far as reasonably practicable.	**Direct impact on effect** (8) Increase in mean, max and min daily temperatures across all seasons would lead to a greater number of employees/businesses having open windows, potentially leading to increased airborne noise levels experienced within buildings, or uncomfortable heat within the property if windows remain closed. **Impact on mitigation** None identified.	**No –** Increase in mean, max and min daily temperatures across all seasons may lead to workers/employees opening their windows more often, leading to increased airborne noise levels within properties. However, this will not impact the significance of the effect, as the Sound, noise and vibration assessment assumes that windows will be open unless a specified noise threshold is exceeded. Where the noise threshold would be exceeded, qualifying buildings will be provided with additional sound insulation and ventilation to reduce internal sound levels and provide adequate	**Additional mitigation** Not required **Additional monitoring** Not required

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
	(9) Permanent diversions, closures and realignment of routes, and loss of parking, loading and lay-bys, may result in increased travel distance, journey time, congestion and delays at a local level. However, at a route-wide level the scheme is expected to provide a beneficial effect on forecasts for future road congestion through the provision of increased capacity of the rail network (10) Additional vehicle movements due to traffic associated with new stations, as well as staff, servicing and operational traffic for any Infrastructure Maintenance Depot, potentially resulting in increased congestion, delays and accident risk Rail: (11) Possessions, blockades and speed restrictions on the National Rail network may result in increased disruption to conventional rail services at a local level. However, at a route-wide level the scheme is expected to provide a beneficial effect on long distance, medium and local routes through the provision of increased capacity of the rail network	(8e) Design of track and bed to avoid significant ground-borne noise or vibration effects. (8f) As required by statute, noise insulation measures would be offered for qualifying buildings as defined in the Noise Insulation and ventilation will be provided so windows can be kept closed to protect internal sound levels. (8g) Noise can be generated at exits from tunnels due to pressure waves created inside the tunnel as the train enters. This is a well understood phenomenon and is mitigated by appropriate design and construction techniques. (8h) Maintenance regime specified to reduce noise effects. (8i) Train design is assumed to be quieter than the current EU specifications. (8j) Noise and vibration impact shall be assessed and mitigated through design and protection on the basis of a passenger only railway for the planned operational hours with maintenance and engineering activities outside of those times. (HS2 Project Specification January 2012). (9a) Reinstatement of roads on or close to their existing alignments, where reasonably practicable. (9b,11a) HS2 will work with businesses to mitigate any parking and loading effects where reasonably practicable. (10a) Travel Plans for HS2 stations and depots to mitigate the impacts of traffic and transport movements associated with stations, maintenance and operation. (10b) Depots operate a shift pattern, with changeover times that would not coincide with the morning and evening peak periods. There will also only be limited operational traffic. (9c, 10c) Building mitigation into the design, with highways and road junctions designed to accommodate the level of traffic forecast.		ventilation. Additional mitigation measures would include the installation of mechanical vents, where necessary, and natural measures to reduce noise pollution.	
			Direct impact on effect (9) Increased frequency of heavy rainfall events could cause flooding of routes that have been realigned or permanently diverted as a result of the Proposed Scheme. This could potentially increase travel distance or cause increased congestion and delays to workers/employees. **Impact on mitigation** None identified.	**No –** The increase in frequency of heavy rainfall events could result in flooding, which has the potential to increase travel distance and congestion on routes already affected by the Proposed Scheme thereby affecting employees and businesses. However, drainage design for new roads included as part of Proposed Scheme include climate change allowances for flooding and drainage. For this reason the existing mitigation measures are considered to be sufficient to prevent an increase in the significance of the effect.	**Additional mitigation** Not required **Additional monitoring** Not required

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
		(9d) Drainage design for the railway, and new roads included as part of Proposed Scheme, include climate change allowances for flooding and drainage.			

Table 14: Sound, noise and vibration

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
Residential properties and non-residential community facilities and commercial properties (Assessment receptors at building facades)	Temporary effects from construction - (1) Airborne noise from construction activities having adverse effects on occupants of properties (2) Airborne noise from construction traffic on local roads potentially having adverse effects on occupants of properties (3) Ground-borne construction vibration (including indirect construction traffic) affecting occupants of properties	(1a, 2a, 3a) Temporary effects on residential and non-residential properties will be controlled and managed during construction through route wide implementation of the draft CoCP, with specific reference to Section 13. (1b, 2b, 3b) Contractors will comply with the draft CoCP (Section 13) and Environmental Protection Act 1990 (EPA). The draft CoCP requires that Best practicable means (BPM) will be applied to minimise noise (including vibration). As part of BPM, mitigation measures will be applied in following order: 1. noise and vibration control at source; 2. screening; and 3. noise insulation with appropriate ventilation, or temporary re-housing. (1c, 2c, 3c) Lead contractors will obtain prior consent from local authorities, setting out BPM, working hours and assessment of construction noise. (1d, 2d, 3d) Contractors will undertake monitoring to demonstrate compliance with noise commitments.	**Direct impact on effect** (1, 2, 3) Increase in mean, max and min daily temperatures across all seasons could lead to a greater number of people having open windows, potentially leading to increased airborne noise levels experienced within properties, or uncomfortable heat within the property if windows are closed. **Impact on mitigation** (1a-1d, 2a-2d, 3a-3d) Mitigation measures such as screening and noise insulation could be less effective in a hotter climate because people's exposure to the noise will be increased because they are more likely have their windows opened.	**No** - Increase in mean, max and min daily temperatures across all seasons may lead to people opening their windows more often, leading to increased airborne noise levels within properties. However, this will not impact the significance of the effect, as the Sound, noise and vibration assessment assumes that windows will be open unless a specified noise threshold is exceeded. Where the noise threshold is exceeded, occupants will be offered alternative temporary accommodation or qualifying houses and buildings will be provided with additional sound insulation and ventilation to reduce internal sound levels and provide adequate ventilation.	**Additional mitigation** Not required **Additional monitoring** Not required
	Operational effects – (4) Airborne noise from railway operations potentially having adverse effects on occupants of properties	Operational effects on residential and non-residential properties will be controlled and managed through the following measures.	**Direct impact on effect** (4, 5, 6) Increase in mean, max and min daily temperatures across all seasons would lead to a greater number of people having open windows,	**No** - Increase in mean, max and min daily temperatures across all seasons may lead to people opening their windows more often, leading to increased airborne noise	**Additional mitigation** Not required **Additional monitoring**

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
	(5) Increased train services, especially during peak hours, would help reduce traffic congestion for commuters; this would be is a positive effect as this reduces congestion, causing a reduction in noise (6) Ground-borne noise and vibration present at properties in close proximity to the alignment and tunnels, affecting occupants of properties	(4a, 5a) Use of proven train and track technology to enable quieter operation, including aerodynamic noise of pantograph above 186mph. All noise to be reduced further away from track. (4b, 5b) Incorporate noise barriers, either earthworks and/or noise fences to reduce significant adverse airborne effects. (4c, 5c) Other engineering structures along route to reduce visual effects. (4d, 5d) Noise insulation measures offered for qualifying buildings, to avoid significant residual effects on health and quality of life. (4e, 5e) Stationary systems equipment used at permanent sites will be designed to avoid significant effects and minimise effects as far as reasonably practicable. (4f, 5f, 6a) Design of track and bed to avoid significant ground-borne noise or vibration effects. (4g, 5g, 6b) As required by statute, noise insulation measures would be offered for qualifying buildings as defined in the Noise Insulation Regulations 1996, where noise insulation is required, ventilation will be provided so windows can be kept closed to protect internal sound levels. (4h, 5h) Noise can be generated at exits from tunnels due to pressure waves created inside the tunnel as the train enters. This is a well understood phenomenon and is mitigated by appropriate design and construction techniques. (6c) Where high levels of vibration (Rayleigh waves) could occur over soft ground, appropriate mitigation such as soil strengthening and bridging over soft ground will be incorporated. (4i, 5i) Maintenance regime specified to reduce noise effects. (4j, 5j) Train design is assumed to be quieter than the current EU specifications.	potentially leading to increased airborne noise levels experienced within properties, or uncomfortable heat within the property if windows remain closed. **Impact on mitigation** No impact identified.	levels within properties. However, this will not impact the significance of the effect, as the Sound, noise and vibration assessment assumes that windows will be open, unless a specified noise threshold is exceeded. Where the noise threshold would be exceeded, qualifying houses and buildings will be provided with additional sound insulation and ventilation to reduce internal sound levels and provide adequate ventilation. Additional mitigation measures would include the installation of mechanical vents, where necessary, and natural measures to reduce noise pollution.	Not required

Table 15: Traffic and transport

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
Users of all forms of motorised traffic and transport	Temporary Effects of Construction Roads: (1) Temporary diversions, closures and realignment of routes, and loss of parking, loading and lay-bys. This may result in increased travel distance/time, congestion and delays for motorists and bus users. There may also be an increased accident risk (2) Additional site-related traffic, including construction vehicle movements to and from the various construction compounds. This may result in increased congestion and delays for motorists and bus users. There may also be an increased accident risk Rail: (3) Possessions, blockades and speed restrictions on the National Rail network. This may result in increased disruption to conventional rail services. Also impacts to users of existing stations using the car park and drop off due to construction work e.g. delays Waterways and canals: (4) Temporary diversions, closures and realignment of waterways, which may cause disruption for users	(1a, 2a) New highways/roads would, where reasonably practicable, be constructed and operational prior to permanent closure of existing highways/roads. Highway measures, including junction improvements, passing places and carriageway widening provided, as required, to manage safe passing of construction vehicles. (1b) The use of local road network for Heavy Goods Vehicles limited to site set-up, surveys and servicing, where reasonably practicable. (1c, 2b) Traffic management measures to limit disruption. (1d, 2c) Road closures restricted to overnight, weekends and bank holidays where reasonably practicable to reduce the number of users affected. (1e, 2d, 3a, 4a) Compliance with the draft CoCP: • Section 14 (Traffic and Transport); • Section 5.14 (Extreme weather clause); and • Section 5.9 (Temporary living accommodation). (2e) Reuse of excavated material along route. (2f) On-site welfare provided to reduce daily travel by workers. (2g) Borrow pits would limit the volume of construction traffic on the road network. (3b) Programming the construction works to coincide with the possessions that are required and planned by Network Rail for the general maintenance of their railway. Where works potentially affect Network Rail assets, disruption to travelling passengers and freight movements would be reduced as far as reasonably practicable. (3c, 4a) Compliance with Section 14 of the draft CoCP which specifies the production of a route-wide traffic	**Direct impact on effect** (1, 2, 3, 4) Increased frequency of heavy rainfall events of short or long duration may cause travel delays/congestion and therefore lengthened traffic impacts. This could then cause programme delays and reduced productivity in construction activities as well as congestion for motorised users. **Impact on mitigation** (1b, 2b, 1f, 2f) Increased frequency of heavy rainfall events may reduce the effectiveness of the mitigation measures (such as traffic management measures to limit disruption), as heavy rainfall/flooding could cause further disruption and road closures to already disrupted traffic and on diverted or realigned routes.	**No** - Increases in the frequency of heavy rainfall and flooding has the potential to increase in the duration of disruption to road users and therefore cause programme delays. However, mitigation measures such as traffic management measures, road realignments and onsite welfare will limit the significance of any effects from the Proposed Scheme. It should also be noted that the programme is flexible. Therefore it is unlikely that these impacts would cause programme delays as the construction programme and method statements account for extreme weather events such as heavy rainfall. Increased delays and congestion caused by flooding are likely to be localised impacts that will not increase the significance of the effect. Short-medium term weather forecasts and flood risk warnings will also be assessed when planning and implementing construction activities to reduce any potential impact.	**Additional mitigation** Not required **Additional monitoring** Not required

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
		management plan (RTMP) which will include procedures to be followed to obtain consent to work on or over railways, highways and canals.			
	Operational effects: Roads: (5) Permanent diversions, closures and realignment of routes, and loss of parking, loading and lay-bys, may result in increased travel distance, journey time, congestion and delays at a local level. However, at a route-wide level the scheme is expected to provide a beneficial effect on forecasts for future road congestion through the provision of increased capacity of the rail network (6) Additional vehicle movements due to traffic associated with new stations, as well as staff, servicing and operational traffic for any Infrastructure Maintenance Depot, potentially resulting in increased congestion, delays and accident risk Rail: (7) Possessions, blockades and speed restrictions on the National Rail network may result in increased disruption to conventional rail services at a local level. However, at a route-wide level the scheme is expected to provide a beneficial effect on long distance, medium and local routes through the provision of increased capacity of the rail network Waterways and canals: (8) Permanent diversions, closures and realignment of waterways, which may cause disruption for users	(5a) Reinstatement of roads on or close to their existing alignments, where reasonably practicable. (5b,7a) HS2 will work with businesses to mitigate any parking and loading effects where reasonably practicable. (6a) Travel Plans for HS2 stations and depots to mitigate the impacts of traffic and transport movements associated with stations, maintenance and operation. (6b) Depots operate a shift pattern, with changeover times that would not coincide with the morning and evening peak periods. There will also only be limited operational traffic. (5c, 6c) Building mitigation into the design, with highways and road junctions designed to accommodate the level of traffic forecast. (5d) Drainage design for the railway, and new roads included as part of Proposed Scheme, include climate change allowances for flooding and drainage.	**Direct impact on effect** (5, 6) Increased frequency of heavy rainfall events could cause flooding of routes that have been realigned or permanently diverted as a result of the Proposed Scheme. This could potentially increase travel distance or cause increased congestion and delays. **Impact on mitigation** No impact identified.	**No** – The increase in frequency of heavy rainfall events could result in flooding, which has the potential to increase travel distance and congestion on routes already affected by the Proposed Scheme. However, drainage design for new roads included as part of Proposed Scheme include climate change allowances for flooding and drainage. For this reason, the existing mitigation measures are considered to be sufficient to prevent an increase in the significance of the effect.	**Additional mitigation** Not required **Additional monitoring** Not required
Pedestrian, cyclists and equestrians	Temporary effects of construction: (7) Realignments and closures of footpaths, PRoW and pavements, which may increase journey distance, time and risk of accident (8) Increased traffic related severance for non-motorised users	(7a) Temporary alternative routes for PRoW during construction where practicable, where existing or final route not available. (7b, 8a) Compliance with the draft CoCP: • Section 14 (Traffic and Transport); and • Section 5.14 (Extreme weather clause).	**Direct impact on effect** (7, 8) Increased frequency of heavy rainfall events could increase the risk of accidents and increase the duration of the impact on non-motorised users. This could lead to programme delays and reduced productivity in construction activities. In severe cases,	**No** - Increased frequency of heavy rainfall and flooding events has the potential to increase the duration of disruption to non-motorised users, causing programme delays. However, increased delays and congestion caused by flooding are likely to be localised impacts that will not	**Additional mitigation** Not required **Additional monitoring** Not required

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
			flooding of roads could cause increased disruption to PRoW users. **Impact on mitigation** (7a, 8a) Increased frequency of heavy rainfall events may potentially disrupt the temporary alternative route of PRoW.	increase the significance of the effect. Short-medium term weather forecasts and flood risk warnings will also be assessed when planning and implementing construction activities to reduce any potential impact. Therefore it is unlikely that these impacts would cause programme delays as the construction programme and method statements account for extreme weather events such as heavy rainfall.	

Table 16: Waste and material resources

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
Non-hazardous, inert and hazardous waste landfills	Permanent effects from construction – (1) Non-Hazardous Waste Landfill - excavation waste, demolition waste and construction waste to be disposed to non-hazardous landfill (2) Inert Waste Landfill -excavation waste to be disposed to inert waste landfill (3) Hazardous Waste Landfill - excavation waste and demolition waste to be disposed to hazardous waste landfill (All construction effects are permanent as they relate to the available space in landfill. There are no temporary waste effects during construction)	(1a, 2a, 3a) Management of all potential waste generated through construction of the Proposed Scheme (i.e. excavated material, demolition and construction wastes and worker accommodation site waste) will be dealt with in line with the Government's waste hierarchy, which is a guide to sustainable waste and material resource management. It advocates the use of landfill only as a last resort and all other opportunities for prevention, reuse, recycling or recovery will be assessed to minimise the amount of waste sent to landfill. (1b, 2b, 3b) Opportunities to prevent waste production by 'designing out' waste will form an integral part of the ongoing design development and construction process for the Proposed Scheme. (1c, 2c, 3c) Compliance with the draft CoCP: • Section 15 (Waste and Materials); and	**Direct impact on effect:** (1, 2, 3) An increase in the frequency of heavy rainfall events could contribute to increased slope stability risks and increased erosion of bunds and capping layers. These effects may all contribute to a decrease in the available landfill capacity leading to an increase in the magnitude of this effect. **Impact on mitigation** No impact identified.	**No** - An increase in the frequency of heavy rainfall events could contribute to structural and stability risks at landfills leading to a reduction in available landfill capacity. However, the decrease in landfill capacity is considered to be negligible and would not require additional landfill capacity to be found. This small risk would be managed by the respective landfill operators, to identify engineering solutions to prevent loss of landfill capacity. These measures are sufficient to prevent an increase in the significance of the effect.	**Additional mitigation** Not required **Additional monitoring** Not required
			Direct impact on effect: (1, 2, 3) Increased frequency of heavy rainfall events of short or long duration, may lead to increased flooding. Flooding could disrupt 'just in time' deliveries, which may lead to wastage of materials. Furthermore, flood events may disrupt transport	**No** - The resulting increase in wastage of construction material due to increases in travel disruption due to flooding is expected to be negligible and managed through processes detailed in the draft CoCP, including Section 5.14 (Extreme	**Additional mitigation** Not required **Additional monitoring** Not required

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
		• Section 5.14 (Extreme weather events).	infrastructure which would in turn impact on the delivery of waste to treatment centres. **Impact on mitigation** No impact identified.	weather events). These measures are sufficient to prevent an increase in the significance of the effect.	
			Direct impact on effect: (1, 2, 3) Increased frequency of extreme weather events, such as dry spells and heavy rainfall events, may lead to loss and reduction in quality of available waste and material resources. For example, stockpiles of material destined for reuse or recovery may become unsuitable, resulting in more waste being disposed of and increasing the magnitude of the effect. **Impact on mitigation** No impact identified.	**No** - The potential increase in wastage of stockpiles of material due to increased frequency of extreme weather events during construction is expected to be negligible. This would be adequately managed through the embedded mitigation, including Section 5.14 of the draft CoCP (Extreme weather events). These measures are sufficient to prevent an increase in the significance of the effect.	**Additional mitigation** Not required **Additional monitoring** Not required
	Operational effects – (4) Railway station (all stations) and train waste (at terminus stations only) will require disposal to non-hazardous waste landfill (5) Maintenance waste related to rolling stock and asset maintenance (6) Ancillary infrastructure waste will require disposal to non-hazardous waste landfill in 2034	(4a) Provision of public realm litter and recycling bins for train passengers and other users of railway stations. Waste will be managed in accordance with the waste hierarchy by the train operating company. (4b, 5a, 6a) A circular economy approach will be applied with regards to waste and material management during operation, to maximise waste prevention, reuse and recycling so that the need to landfill waste are minimised. (5b) Provision of secure containers for use by train operating companies and railway station tenants; and use of compactors and bailing equipment to improve collection payloads and facilitate opportunities to derive revenue streams for large quantities of recyclable material such as cardboard. Waste will be managed in accordance with the waste hierarchy by the fleet maintenance contractor. (5c, 6b) Waste generated by track maintenance and other ancillary infrastructure will be managed in	**Direct impact on effect:** (4) Increased mean, max and min daily temperatures can alter organic waste decomposition rates at landfill sites. This impact is uncertain, as higher temperatures and less moisture in the organic waste could reduce decomposition rate, but higher temperatures with sufficient moisture in the organic waste could increase decomposition rate. **Impact on mitigation** No impact identified.	**No** – The exact impact of increased mean, max and min daily temperatures on decomposition rates of organic waste is uncertain. However, due to the relatively small quantities of organic waste produced in operation the impact on the effect is expected to be negligible, and there would not be an increase in the significance of the effect.	**Additional mitigation** Not required **Additional monitoring** Not required
			Direct impact on effect: (5, 6) More frequent extreme weather events, such as dry spells and heavy rainfall events, may cause accelerated deterioration of assets. As a result, more frequent maintenance may be required, leading to increased waste quantities.	**No** – It is not expected that maintenance cycles will need to change substantially enough to make a notable difference in the quantity of waste produced due to climate change. Additionally, the overall quantity of waste generated from maintenance is expected to be small. Any increase	**Additional mitigation** Not required **Additional monitoring** Not required

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
		accordance with the waste hierarchy by Network Rail and/or the train operating company.	**Impact on mitigation** No impact identified.	in volume of waste material as a result of increased asset deterioration rates due to climate change is therefore expected to be negligible, and there would not be an increase in the significance of the effect.	

Table 17: Water resources and flood risk

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
Surface Water	Temporary effects from construction – (1) Accidental release of pollution, silts or sediments to surface water affecting water quality (2) Alterations to surface water resource availability for abstraction (3) Alterations to hydrological regime (e.g. high flows/levels and low flows/levels) due to temporary channel realignments, temporary channel diversions and changes in hydromorphology	(1a, 2a, 3a, 4a) Compliance with relevant sections of the draft CoCP: Section 16 (water resources and flood risk): • compliance with relevant, pollution prevention guidelines and Construction Industry Research and Information Association (CIRIA) publications as far as reasonably practicable; • provision of maps showing sensitive areas and buffer zones where no pollutants are to be stored or used; • preparation of method statements for silt management, site drainage at compounds and satellite compounds, for the storage and control of oils and chemicals and the prevention of accidental spillages; • the avoidance of discharges of site runoff to the water environment without the prior approval of the appropriate authority; • measures to prevent silt-laden runoff and other pollutants entering the water environment; such as use of bunds of non-erodible material or silt or sediment fences adjacent to watercourses;	**Direct impact on effect:** (1) An increased frequency of dry spells could reduce flows in watercourses increasing sensitivity to pollutant and sediment inputs which could increase the negative effect on water quality. **Impact on mitigation:** No impact identified.	**No** – An increased frequency of dry spells could reduce flows in watercourses increasing sensitivity to pollutant and sediment inputs which could increase the negative effect on water quality. However, measures such as safe storage of oils and chemicals and silt fences, are considered to be sufficient to prevent an increase in the significance of the effect by preventing pollutants and sediments from entering watercourses.	**Additional mitigation** Not required **Additional monitoring** Not required
			Direct impact on effect: (1) An increased frequency of heavy rainfall events could increase surface water runoff and soil erosion, which could increase the transfer of pollutants and sediment into watercourses, thereby increasing the negative effect on water quality. **Impact on mitigation:** An increased frequency of heavy rainfall events could reduce the effectiveness of mitigation measures to prevent the release of contaminants	**No** - An increased frequency of heavy rainfall events could increase negative effects on water quality by increasing surface water runoff which can transfer pollutants and sediments into watercourses and reduce the effectiveness of mitigation. However, measures to contain sediments and pollutants such as bunds, silt traps, and oil interceptors are considered to be sufficient to prevent an increase in the significance of the effect by preventing pollutants and sediments from reaching watercourses.	**Additional mitigation** Not required **Additional monitoring** Not required

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
		• restrictions or controls on excavation within (and close to) watercourses to limit effects on water quality, sedimentation, fisheries and aquatic ecology; • procedures for monitoring groundwater levels and quality at abstraction boreholes and wells to enable adverse effects on quality or levels to be identified; • response procedures to be implemented in the event of works affecting groundwater levels or quality with subsequent adverse effects on abstractions, watercourses or water bodies. Section 5.14 (extreme weather events): • use of weather forecasting and flood warning services to inform programme management, environmental control and impact mitigation measures. Section 5.12 (pollution control) • emergency response measures for pollution incidents; and • up to date site drainage plans and flood risk management plans. (1b, 2b, 3b) Compliance with the Water Framework Directive (WFD) to limit effects on surface water resources by avoiding sensitive receptors (such as floodplain areas, water dependent habitats and surface water abstractions) wherever reasonably practical. (1c, 2c, 3c) Method statements describing how potential changes to flood risk, water quality, and channel hydro morphology will be managed during the establishment, use and decommissioning of site haul roads. (2d) Promoting water recycling on site for water uses which do not require potable water, such as dust suppression. A water source hierarchy will be employed; water recycled on site is at the top of the hierarchy, followed by water abstracted or captured locally. Potable mains water is at the bottom of the hierarchy and	and sediments into the water environment.		
			Direct impact on effect: (2) An increased frequency of dry spells could lead to reduced water availability, increasing the sensitivity of surface water resources, such as abstractions, to temporary construction activities which could have a negative effect on surface water flows and levels. **Impact on mitigation:** No impact identified.	**No** - An increased frequency of dry spells could lead to reduced water availability increasing the sensitivity of surface water resources, such as abstractions, to temporary construction activities which could have a negative effect on surface water flows and levels. However, the proposed embedded mitigation measures (including, monitoring of water levels, water reuse, water efficiency measures and compliance with EA abstraction licence conditions/limitations in times of drought) are considered to be sufficient to prevent an increase in the significance of the effect.	**Additional mitigation** Not required **Additional monitoring** Not required
			Direct impact on effect: (3) An increased frequency of heavy rainfall events could alter the hydraulic conditions of temporary channel realignments and diversions resulting in the channel design being inappropriate for the future flow regime. **Impact on mitigation:** (1a) An increased frequency of heavy rainfall events could reduce the effectiveness of temporary channel realignments and diversions.	**No** - An increased frequency of heavy rainfall events could alter the hydraulic conditions of temporary channel realignments and diversions resulting in the channel design being inappropriate for the future flow regime. However, design, monitoring and adaptive management of temporary channel realignments and diversions are considered to be sufficient to prevent an increase in the significance of the effect because where there is a risk of flooding the design technical standards incorporate climate change allowances.	**Additional mitigation** Not required **Additional monitoring** Not required

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
		shall only be used where unavoidable i.e. for drinking water or where no other source of water is reasonably practicable. (2e) A Water Resources Plan shall be produced which will determine water requirements and propose options for prevention, reduction and reuse of water to comply with the water source hierarchy. (3d) A robust pre- and post- diversion or realignment monitoring strategy (covering hydro-morphological and ecological elements) to address the design risks presented by climate change to assess the success of the watercourse diversions and realignments and the respective design elements allowing adaptive management.			
	Permanent effects from construction- (4) Alterations to surface water resource availability for abstraction (5) Alterations to hydrological regime (e.g. high flows/levels and low flows/levels) due to permanent channel realignments, permanent channel diversions and changes in hydromorphology (6) Disruption of water dependent habitats	(4a, 5a, 6a) Compliance with WFD to limit effects on surface water resources by avoiding sensitive receptors (such as floodplain areas, water dependent habitats and surface water abstractions) wherever reasonably practical. (4b, 5b, 6b) Where permanent water course diversions or re-alignments are proposed the aim will be to design these with equivalent hydraulic capacity to the existing channels. (4c, 5c, 6c) Where water courses are natural channels, the design will aim to incorporate appropriate features to retain and where reasonably practicable enhance their hydro-morphological status, provided this is compatible with their flood risk and land drainage functions. (4d, 5d, 6d) Avoidance, of channels and floodplain areas, where reasonably practicable. (4e, 5e, 6e) Avoidance, where reasonably practicable, of water dependent habitats, including natural springs that can play a key role in the hydrology and hydrogeology of such ecosystems. (4f, 5f, 6f) Avoidance, where reasonably practicable, of major public water	**Direct impact on effect:** (4) An increased frequency of dry spells could lead to reduced water availability, increasing the sensitivity of surface water resources (such as abstractions) to permanent construction, which could have an effect on surface water flows and levels. **Impact on mitigation:** No impact identified.	**No** – An increased frequency of dry spells could lead to reduced water availability increasing the sensitivity of surface water resources (such as abstractions) to permanent construction, such as new structures, which could have an effect on surface water flows and levels. However, embedded mitigation measures (including, avoiding sensitive receptors such as water dependent habitats and adaptive management informed by monitoring before and after construction to address the design risks posed by climate change) are considered to be sufficient to prevent an increase in the significance of the effect.	**Additional mitigation** Not required **Additional monitoring** Not required
			Direct impact on effect: (5) An increased frequency of heavy rainfall events could alter the hydraulic conditions of permanent channel realignments and diversions resulting in the channel design being inappropriate for the future flow regime.	**No** – An increased frequency of heavy rainfall events could alter the hydraulic conditions of permanent channel realignments and diversions resulting in the channel design being inappropriate for the future flow regime. However, the design of permanent surface water channel realignments and diversions is considered to be	**Additional mitigation** Not required **Additional monitoring** Not required

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
		supplies and smaller licensed and unlicensed abstractions of surface water. (4g, 5g, 6g) Watercourse diversions have been avoided wherever possible. (4h, 5h, 6h) Adapt field subsurface drainage systems to discharge into new channels. (4i, 5i, 6i) Position of piers to maximise the distance between watercourse banks and the pier, and where necessary, include scour protection to manage erosion. (4j, 5j, 6j) Design of certain features to be developed further in consultation with the Environment Agency and the Lead Local Flood Authorities with a view to further mitigation being embedded. (4k, 5k, 6k) Drop inlet culverts and inverted siphons have been avoided. (4l, 5l, 6l) Watercourse realignments at culverts have been reduced as far as is reasonably practicable. Culvert lengths have been reduced as far as is reasonably practicable. (4m, 5m, 6m) Invert levels will be set below the firm bed of the watercourse to allow a natural substrate to develop along the bed of the culvert. (4n, 5n, 6n) Steep gradients have been avoided wherever reasonably practicable. (4o, 5o, 6o) A robust pre- and post-diversion or realignment monitoring strategy (covering hydro-morphological and ecological elements) to address the design risks presented by climate change to assess the success of the watercourse diversions and realignments and the respective design elements allowing adaptive management.	**Impact on mitigation:** (5) An increased frequency of heavy rainfall events could reduce the effectiveness of permanent temporary channel realignments and diversions.	sufficient to prevent an increase in the significance of the effect because where there is a risk of flooding the design technical standards incorporate climate change allowances.	

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
	Operational effects – (7) Accidental release of pollution to surface water courses and associated water bodies affecting water quality	(7a) Considered in a route-wide assessment in Volume 3. (7b) A draft operation and maintenance plan for water resources and flood risk will be provided. Climate Change Design Impact Assessments (CCDIA) for scheme elements/assets are used to inform the Operation and Maintenance Plans. (7c) Sustainable drainage systems (SuDS) will be used where reasonably practicable. These will help to remove any suspended material within runoff from the Proposed Scheme through filtration, vegetative adsorption or settlement. (7d) An assessment of spillage and routine runoff pollution is being undertaken using the Highways England Water Risk Assessment Tool (HEWRAT) as set out in LA 113 Road Drainage and the Water Environment Revision of the Design Manual for Roads and Bridges (DMRB), to inform the pollution risks associated with highways operation to inform the selection of appropriate mitigation. (7e) Operation and maintenance plan for water resources and flood risk.	**Direct impact on effect:** (7) An increased frequency of dry spells could reduce flows in watercourses increasing sensitivity to pollutant and sediment inputs which could increase the negative effect on water quality. **Impact on mitigation:** No impact identified.	**No** – An increased frequency of dry spells could reduce flows in watercourses increasing sensitivity to pollutant and sediment inputs which could increase the negative effect on water quality. However, measures to prevent pollutants from entering watercourses are considered to be sufficient to prevent an increase in the significance of the effect by preventing pollutants and sediments from reaching watercourses.	**Additional mitigation** Not required **Additional monitoring** Not required
			Direct impact on effect: (7) An increased frequency of dry spells could increase the build-up of pollutants in roadside drainage systems. The first flush of the drainage system by rainfall after a dry spell could lead to a pollutant release into the water environment which could increase the negative effect on water quality. **Impact on mitigation:** No impact identified.	**No** – An increased frequency of dry spells could increase the build-up of pollutants in roadside drainage systems. The first flush of the drainage system by rainfall after a dry spell could lead to a pollutant release into the water environment which could increase the negative effect on water quality. However, measures to prevent pollutants from entering watercourses (including use of SuDS) are considered to be sufficient to prevent an increase in the significance of the effect.	**Additional mitigation** Not required **Additional monitoring** Not required
			Direct impact on effect: (7) An increased frequency of heavy rainfall events could increase surface water runoff and soil erosion, which could increase the transfer of pollutants and sediment into watercourses, which could increase the negative effects on water quality. (7) An increased frequency of heavy rainfall events could increase flows in watercourses decreasing sensitivity to pollutant and sediment inputs which could reduce the negative effect on water quality. **Impact on mitigation:** (7c) An increased frequency of heavy rainfall events could reduce the effectiveness of mitigation measures,	**No** – An increased frequency of heavy rainfall events could increase negative effects on water quality by increasing surface water runoff which can transfer pollutants and sediments into watercourses and reduce the effectiveness of mitigation. However, measures to manage sediments and pollutants such as through the use of SuDS, where required, will take account of climate change and are therefore considered to be sufficient to prevent an increase in the significance of the effect. An increased frequency of heavy rainfall events could increase flows in watercourses decreasing	**Additional mitigation** Not required **Additional monitoring** Not required

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
			such as SuDS, to prevent the release of contaminants and sediments into the water environment.	sensitivity to pollutant and sediment inputs which could reduce the negative effect on water quality.	
Groundwater resources	Temporary effects from construction – (8) Accidental release of pollution to groundwater affecting water quality (9) Alterations to groundwater flows, baseflows and levels during dewatering and groundworks (such as excavation and construction of foundations, tunnels and cuttings) could affect groundwater resource availability for abstractions and springs	(8a) Compliance with relevant sections of the draft CoCP: Section 16 (water resources and flood risk) • compliance with relevant, pollution prevention guidelines and CIRIA publications as far as reasonably practicable; • provision of maps showing sensitive areas and buffer zones where no pollutants are to be stored or used; • preparation of method statements for silt management, site drainage at compounds and satellite compounds, for the storage and control of oils and chemicals and the prevention of accidental spillages; • the avoidance of discharges of site runoff to the water environment without the prior approval of the appropriate authority; • restrictions or controls on excavation within (and close to) watercourses to limit effects on water quality, sedimentation, fisheries and aquatic ecology; • procedures for monitoring groundwater levels and quality at abstraction boreholes and wells to enable adverse effects on quality or levels to be identified; and	**Direct impact on effect:** (8) An increased frequency of dry spells could lead to lower groundwater flows and levels which could change groundwater sensitivity to pollutants resulting from temporary construction activities, which could increase or decrease effects on water quality. **Impact on mitigation:** No impact identified.	**No** – An increased frequency of dry spells could lead to lower groundwater flows and levels which could change groundwater sensitivity to pollutants resulting from temporary construction activities, which could increase or decrease effects on water quality. However, measures such as safe storage of oils and chemicals, are considered to be sufficient to prevent an increase in the significance of the effect by preventing pollutants from reaching groundwater bodies.	**Additional mitigation** Not required **Additional monitoring** Not required
			Direct impact on effect: (9) An increased frequency of dry spells could lead to reduced water availability increasing sensitivity of groundwater resources such as abstractions and springs to temporary construction activities which could have a negative effect on groundwater flows and levels. **Impact on mitigation:** No impact identified.	**No** – An increased frequency of dry spells could lead to reduced water availability increasing sensitivity of groundwater resources such as abstractions and springs to temporary construction activities which could have an effect on groundwater flows and levels. The proposed embedded mitigation measures (including, monitoring of ground water levels, water reuse, water efficiency measures and compliance with EA abstraction licence conditions / limitations in times of drought) are considered to be sufficient to prevent an increase in the significance of the effect.	**Additional mitigation** Not required **Additional monitoring** Not required

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
		• response procedures to be implemented in the event of works affecting groundwater levels or quality with subsequent adverse effects on abstractions, watercourses or water bodies. Section 5.14 (extreme weather events) • use of weather forecasting and flood warning services to inform programme management, environmental control and impact mitigation measures. Section 5.12 (pollution control) • emergency response measures for pollution incidents; and • up to date site drainage plans and flood risk management plans. (9a) Installation of cut-off structures around excavations. (9b) Ensuring cut-off structures are driven to sufficient depths to meet an underlying strata or zone of lower permeability. (9c) Promoting groundwater recharge, such as discharging pumped water to recharge trenches around excavations to maintain baseline groundwater and surface water conditions. (9d) Incorporating passive bypasses within the design, which could comprise a 'blanket' of permeable material, such as gravel, placed around temporary structures allowing groundwater to bypass the below-ground works, without a rise in groundwater levels on the upstream side. (9e) The Tunnel Boring Machine (TBM) will be operated in a closed face mode when tunnelling within water bearing strata and the tunnel lining will be designed to reduce leakage rates as far as is reasonably practicable, thereby reducing the requirements for dewatering and drainage. (9f) A wider buffer strip, or shallower batter on excavations. (9g) Creation of temporary sections of lined channel.	**Direct impact on effect:** (9) An increased frequency of heavy rainfall events (particularly long duration events) could increase groundwater recharge, and alter ground water flows and levels, which could reduce the sensitivity of receptors such as abstractions and springs. **Impact on mitigation:** No impact identified	**No** – An increased frequency of heavy rainfall events (particularly long duration events) could increase groundwater recharge, and alter ground water flows and levels, which could reduce the sensitivity of receptors such as abstractions and springs. However, as this impact would be variable (although generally beneficial from a groundwater resource perspective) there is no change to the significance of the residual effect.	**Additional mitigation** Not required **Additional monitoring** Not required

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
		(9h) recirculation of treated water back to the watercourses at an appropriate rate and location. (9i) Promoting water recycling on site for water uses which do not require potable water, such as dust suppression. A water source hierarchy will be employed; water recycled on site is at the top of the hierarchy, followed by water abstracted or captured locally. Potable mains water is at the bottom of the hierarchy and shall only be used where unavoidable i.e. for drinking water or where no other source of water is reasonably practicable. (9j) A Water Resources Plan shall be produced which will determine water requirements and propose options for prevention, reduction and reuse of water to comply with the water source hierarchy.			
	Permanent effects from construction- (10) Disruption, damage, removal, or replacement of natural springs, boreholes, monitoring points, major public water supplies and smaller licensed and unlicensed abstractions of groundwater, leading to disruption in water availability for resource users, changes to hydrogeology, and changes in pollution pathways (11) Permanent alterations to groundwater flows, baseflows and levels could affect groundwater resource availability for abstractions and springs	(10a, 11a) Compliance with relevant sections of the draft CoCP: • Section 16 (water resources and flood risk); • Section 5.14 (extreme weather events); and • Section 5.12 (pollution control). (10b, 11b) Avoidance, where reasonably practicable, of water dependent habitats, including natural springs that can play a key role in the hydrology and hydrogeology of such ecosystems. (10c, 11c) Existing groundwater abstraction boreholes or monitoring points would be protected from physical damage, insofar as reasonably practicable, including appropriate decommissioning of abandoned boreholes in order to prevent pollution pathways. (10d, 11d) Permanent drainage measures to ensure baseflows are maintained. (10e, 11e) Wherever reasonably practicable, the design will aim to recreate affected spring features nearby.	**Direct impact on effect:** (10, 11) An increased frequency of dry spells could lead to reduced groundwater availability which could increase the sensitivity of receptors such as abstractions and springs to disruption, damage or groundwater flow effects. **Impact on mitigation:** (10d ,11d) An increased frequency of dry spells could make reinstating boreholes and springs more difficult due to reduced water availability.	**No** – An increased frequency of dry spells could lead to reduced groundwater flows which could increase the sensitivity of receptors such as existing or reinstated abstractions and springs to disruption, damage or groundwater flow effects. The proposed embedded mitigation measures (including, avoiding sensitive receptors such as major public water supplies, water dependent habitats, and adaptive management informed by monitoring before and after construction to address the design risks posed by climate change) are considered to be sufficient to prevent an increase in the significance of the effect.	**Additional mitigation** Not required **Additional monitoring** Not required
			Direct impact on effect: (10,11) An increased frequency of heavy rainfall events (particularly long duration events) could increase groundwater recharge, and alter ground water flows and levels which would reduce the sensitivity of	**No** – An increased frequency of heavy rainfall events (particularly long duration events) could increase groundwater recharge, and alter ground water flows and levels which would reduce the sensitivity of receptors such as abstractions and springs. However, as this	**Additional mitigation** Not required **Additional monitoring** Not required

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
		(10f, 11f) A robust pre- and post-diversion or realignment monitoring strategy (covering hydro-morphological and ecological elements) to address the design risks presented by climate change to assess the success of the watercourse diversions and realignments and the respective design elements allowing adaptive management.	receptors such as abstractions and springs. **Impact on mitigation:** No impact identified.	impact would be variable (although generally beneficial from a groundwater resource perspective) there is no change to the significance of the residual effect.	
	Operational effects – (12) Accidental release of pollution to groundwater affecting water quality.	(12a) Considered in a route-wide assessment in Volume 3. (12b) Operation and maintenance plan for water resources and flood risk. (12c) Sustainable drainage systems will be used where reasonably practicable. These will help to remove any suspended material within runoff from the Proposed Scheme through filtration, vegetative adsorption or settlement. (12d) Adherence to NPPF6 policies to ensure the Proposed Scheme is safe from flooding. The Proposed Scheme aligns with the Sequential Test and Exception Test policies in NPPF. It will be safe from flooding over its lifetime, without increasing flood risk to vulnerable receptors elsewhere.	**Direct Impact on Effect:** (12) An increased frequency of dry spells could lead to lower groundwater flows and levels which could change groundwater sensitivity to pollutants which could increase or decrease effects on water quality. **Impact on mitigation:** No impact identified.	**No** – An increased frequency of dry spells could lead to lower groundwater flows and levels which could change groundwater sensitivity to pollutants, for example from an accidental spillage from operation of rail and roads associated with the scheme, which could increase or decrease effects on water quality. However, measures to contain pollutants from entering watercourses are considered to be sufficient to prevent an increase in the significance of the effect by preventing pollutants from reaching groundwater bodies.	**Additional mitigation** Not required **Additional monitoring** Not required
			Direct Impact on Effect: (12) An increased frequency of heavy rainfall events could increase surface water runoff and soil erosion, which could increase the transfer of pollutants into groundwater bodies, which could increase the negative effects on water quality. (12) An increased frequency of heavy rainfall events could increase groundwater flows and levels which could change groundwater sensitivity to pollutants which could increase or decrease effects on water quality. **Impact on mitigation:** (12c) An increased frequency of heavy rainfall events could reduce the effectiveness of SuDS at preventing the transfer of pollutants into groundwater bodies.	**No** – An increased frequency of heavy rainfall events could increase negative effects on groundwater quality by increasing surface water runoff which can transfer pollutants into groundwater bodies and reduce the effectiveness of mitigation. However, measures to contain pollutants are considered to be sufficient to prevent an increase in the significance of the effect by preventing pollutants and sediments from reaching groundwater bodies. An increased frequency of heavy rainfall events could increase flows in watercourses decreasing sensitivity to pollutants which could reduce the negative effect on water quality.	**Additional mitigation** Not required **Additional monitoring** Not required

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
Flood risk and land drainage	Temporary effects from construction – (13) Temporary changes to drainage systems, water storage and water flows within watercourses and their floodplains during construction affecting flood risk. For example haul roads, topsoil stockpiling, temporary watercourse crossings and location of construction compounds	(13a) Compliance with relevant sections of the draft CoCP: Section 16 (water resources and flood risk) • construction activities will be undertaken having regard to the requirements to avoid any significant increase of flood risk with appropriate measures such as keeping watercourses clear of obstructions and debris to reduce blockage risk; • the contractors will obtain copies of the relevant regulatory bodies' flood risk management plans, maps and strategies and prepare site specific flood risk management plans for those areas of the site at risk of flooding; • consideration of flooding when planning sites, storing materials and undertaking temporary or permanent works; and • designers and contractors will be required to prepare construction and permanent works proposals that are safe and ensure that flood risk (including that to third parties and the proposed works) is managed appropriately. Section 5.14 (extreme weather events) • use of weather forecasting and flood warning services to inform programme management, environmental control and impact mitigation measures. (13b) Construction sequencing and temporary works design would carefully consider and assess potential impacts on flood risk including climate change allowances (All Proposed Scheme permanent watercourse crossings shall be designed to convey the 1 in 100-year return period flow, including an additional flow allowance for climate change). All critical systems infrastructure shall be designed to remain operational during a 1 in 1000-year return period flood event (i.e. no additional allowance for climate change),	**Direct impact on effect:** (13) An increased frequency of heavy rainfall events during construction could increase the magnitude of the scheme's effect on flood risk. **Impact on mitigation:** (13b) An increased frequency of heavy rainfall events could reduce the effectiveness of mitigation to drain and store water.	**No** – An increased frequency of heavy rainfall events during construction could increase the magnitude of the scheme's effect on flood risk and reduce the effectiveness of mitigation to drain and store water. However, measures to prevent flooding including appropriate management of temporary changes to watercourses, construction sequencing and the management of the construction work sites, including haul roads, are considered to be sufficient to prevent an increase in the significance of the effect, because water flows will be appropriately managed to reduce the risk of flooding to an acceptable level.	**Additional mitigation** Not required **Additional monitoring** Not required

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
		with 1 metre of freeboard to top of rail level). (13c) Method statements detailing how these works would be undertaken will be produced by the nominated undertaker in consultation with the Environment Agency and the Lead Local Flood Authority (LLFA). (13d) Preparation of flood risk assessments and method statements for temporary works, including main construction and satellite compound drainage, watercourse crossings and realignments and temporary realignments in consultation with the Environment Agency, and where applicable, the LLFA and other relevant regulators. (13e) Location of storage, machinery, equipment and temporary buildings outside flood risk areas where reasonably practicable. (13f) Construction of outfalls during periods of low flow to reduce the risk of scour and erosion. (13g) Design of temporary watercourse realignments with equivalent hydraulic capacity to the existing channels, ensuring that field subsurface drainage systems can be adapted to discharge into the new channel. (13h) Having regard to the requirement for construction activities to avoid any increases in flood risk to vulnerable receptors. (13i) Where reasonably practicable, runoff from the cuttings would be drained to the balancing ponds within the natural catchment to which this water would naturally drain, avoiding transfer of water from one water body to another.			
	Permanent effects from construction – (14) Permanent changes to drainage systems, water storage and water flows within watercourses and their	(14a) Compliance with relevant sections of the draft CoCP Section 16 (water resources and flood risk)	**Direct impact on effect:** (14) An increased frequency of heavy rainfall events could increase the magnitude of scheme's effect on flood risk.	**No** – An increased frequency of heavy rainfall events could increase the magnitude of the scheme's effect on flood risk and reduce the effectiveness of mitigation to drain and store water. However, the	**Additional mitigation** Not required **Additional monitoring** Not required

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
	floodplains following completion of construction affecting flood risk	• designers and contractors will be required to prepare construction and permanent works proposals that are safe and ensure that flood risk (including that to third parties and the proposed works) is managed appropriately. (14a) Permanent works design would carefully consider and assess potential impacts on flood risk including climate change allowances (All Proposed Scheme permanent watercourse crossings shall be designed to convey the 1 in 100 year return period flow, including an additional flow allowance for climate change. All critical systems infrastructure shall be designed to remain operational during a 1 in 1000 year return period flood event (i.e. no additional allowance for climate change), with 1 metre of freeboard to top of rail level. (14b) Floodplain avoidance strategy. (14c) Provision of replacement floodplain storage areas along the route of the Proposed Scheme. (14d) Provision has been made to pass surface water runoff and land drainage flows beneath sections of raised embankment that would cross surface water flow paths, where reasonably practicable. (14e) Perimeter drainage and culverts, with their inverts set below the likely level of any upstream field subsurface drainage systems. (14f) In locations where the route of the Proposed Scheme would cross watercourses, the design aim is for structures to accommodate flood flows up to and including the 1 in 100 (1%) annual probability flood with an allowance for climate change based on latest guidance issued by the Environment Agency. (14g) Balancing ponds for new sections of highway and railway drainage have been sized on a precautionary basis, pending more detailed information	**Impact on mitigation:** (14) An increased frequency of heavy rainfall events could reduce the effectiveness of mitigation to drain and store water.	design of drainage and changes to watercourses required to deliver the scheme will take into account flood risk. The design process, the measures to be incorporated, and the inclusion of climate change allowances over the design life, are considered to be sufficient to prevent an increase in the significance of the effect.	
			Direct impact on effect: No impact identified. **Impact on mitigation:** (14) An increased frequency of dry spells could lead to clay lined balancing ponds drying up, resulting in an increase in the cracking of the clay lining, reducing the balancing ponds effectiveness as mitigation to store water.	**No** – An increased frequency of dry spells could lead to clay lined balancing ponds drying up, resulting in an increase in the cracking of the clay lining, reducing the balancing ponds effectiveness as mitigation to store water. However, considering the minor consequence to pond attenuation should cracking occur, and the measures such as ensuring that a suitable balancing pond liner is chosen based on the role of the pond, it is considered there is no change to the significance of the residual effect.	**Additional mitigation** Not required **Additional monitoring** Not required

1. Resources/receptors potentially impacted by the Proposed Scheme	2. Project phase and effects of Proposed Scheme on receptors/resources	3. Existing/embedded mitigation measures	4. Climate change trend and potential in-combination climate impact on: (i) Proposed Scheme effect (Column 2) and/or (ii) effectiveness of existing/embedded mitigation (Column 3)	5. Are additional/amended mitigation measures/monitoring required? (to address potential increase in the significance of the residual effect due to climate change)	6. Additional/amended mitigation measures/monitoring to address adverse effects on resources and receptors as a result of climate change (as identified in Column 4)
		about the permeability and runoff characteristics of existing and proposed ground surfaces. (14h) Location of confluence of any combined flows to be downstream of any proposed crossing and any potential loss in existing channel capacity will be mitigation. (14i) Elements of proposed structures (i.e. piers and abutments) have been located, where practicable, outside of the existing channel and functional floodplains, and provision made for vertical clearance above the floodplain.			
Off-Route Works Annandale Depot Hotspot: Surface water resources	Operational effects – (15) Release of treated waste water to surface water courses and associated water bodies affecting water quality	(15a) Considered in a route-wide assessment in Volume 3. (15b) A draft operation and maintenance plan for water resources and flood risk will be provided. CCDIA for scheme elements/assets are used to inform the Operation and Maintenance Plans. (15c) SuDS will be used where reasonably practicable. These will help to remove any suspended material within runoff from the Proposed Scheme through filtration, vegetative adsorption or settlement. (15d) An assessment of spillage and routine runoff pollution is being undertaken using the Highways England Water Risk Assessment Tool (HEWRAT) as set out in LA 113 Road Drainage and the Water Environment Revision of the Design Manual for Roads and Bridges (DMRB), to inform the pollution risks associated with highways operation to inform the selection of appropriate mitigation. (15e) Operation and maintenance plan for water resources and flood risk.	**Direct impact on effect:** (15) An increased frequency of dry spells could reduce flows in watercourses increasing sensitivity to pollutant inputs from waste water treatment discharge works which could increase the negative effect on water quality. **Impact on mitigation:** No impact identified.	**Yes** – An increased frequency of dry spells could reduce flows in watercourses increasing sensitivity to waste water treatment discharges which could increase the negative effect on water quality. Although measures to prevent pollutants from entering watercourses will help to prevent an increase in the significance of the effect, additional mitigation may be needed to reduce the risk at this hotspot.	**Additional mitigation** Not required **Additional monitoring** Not required

3 Climate change resilience assessment results

3.1.1 This section contains the results of the climate change resilience (CCR) assessment. It includes 17 asset specific risk assessment tables, which record the process and results of the assessment and should be followed along each row from left to right. Table 18 provides a guide to the result table describing the content of each column.

3.1.2 The aim of the assessment is to ensure that climate change resilience is being considered throughout the design, construction and operation of the Proposed Scheme and, through consultation and collaboration with engineering and design teams, ensure any resilience measures already defined are robust to potential climate change impacts, and that additional resilience measures can be identified and designed where appropriate.

3.1.3 A summary of the assessment methodology can be found in the EIA SMR (see Volume 5: Appendix CT-001-00001).

Table 18: Climate change resilience assessment table description

Climate change trend	Potential impact on HS2 Ltd asset group	Existing/embedded mitigation	Likelihood of impact on HS2 Ltd asset group	Consequence of impact on HS2 Ltd asset group	Risk level	Additional mitigation measures
Column 1 contains the projected climate change trend which poses a potential impact on the specific asset group. e.g. increase in frequency of extreme rainfall events or increase in maximum summer temperatures.	Column 2 details the potential impact upon the specific asset group as a result of climate change. e.g. flooding of track or overheating of electrical equipment.	Column 3 summarises key existing/embedded measure(s) to be implemented though the design process and/or during the construction and operational stages of the Proposed Scheme to mitigate the impact of climate change.	Column 4 scores the likelihood of the impact (Column 2) occurring considering the design life of the asset and existing/embedded mitigation (Column 3): • Unlikely; Possible; Likely Justification of scoring is included here.	Column 5 scores the consequence of the impact (Column 2) occurring considering the design life of the asset and existing/embedded mitigation (Column 3): • Very high; High; Medium; Low; Very low Justification of scoring is included here.	Column 6 states the resulting risk level to the specific asset group: • 'High', 'Medium' or 'Low' The risk level considers the likelihood (Column 4) of the impact occurring and the magnitude of impact consequence (Column 5).	Column 7 describes any additional mitigation measures proposed. Additional mitigation is only proposed where the resulting risk level is 'High' as stated in Column 6.

Table 19: Fencing, walls and noise barriers

Climate change trend	Potential impact on HS2 Ltd asset group	Existing/embedded mitigation	Likelihood of impact on HS2 Ltd asset group	Consequence of impact on HS2 Ltd asset group	Risk level	Additional mitigation measures
Increase in mean temperature across all seasons. Increased frequency of heatwaves.	Higher temperatures (and associated carbon dioxide levels) would increase the rate of chloride and carbonation induced reinforcement corrosion to the structural components of the asset for example, concrete posts.	During the detailed design stage, the impacts associated with climate change on chloride and carbonation induced reinforcement corrosion rates will be managed through the development of asset-specific technical specification documents, which will set-out appropriate durability requirements for materials to ensure that appropriate climatic conditions are incorporated in the design process. These documents will be informed by HS2 Ltd Technical Standards and best practice e.g. British Standards. During the operational stage, a regular programme of maintenance will be undertaken including general inspection, monitoring and replacement of the asset where necessary.	**Likelihood level: Unlikely** During higher temperatures, the rate in which concrete corrosion occurs is unlikely to increase over the design life (30 years for fencing and 120 years for walls) due to the appropriate selection of materials. In addition, regular maintenance should help to ensure asset quality over the design life of the asset.	**Consequence level: Very Low** The consequence of the climate change impact is very low due to the selection of appropriate materials. In the unlikely event of greater asset degradation occurring e.g. corrosion of fence posts, very low costs will be incurred associated with additional remedial/replacement works of asset components prior to the structural stability of the asset being compromised.	**Low**	No additional resilience measures required
Increase in mean winter rainfall. Increased frequency of heavy rainfall events.	Wetter winters along with more frequent rainfall events would lead to elevated groundwater levels and flooding. Saturated ground conditions could lead to the deterioration of below ground structural elements of masonry walls and wooden fencing.	During the detailed design stage, the impacts associated with flooding and saturated ground conditions will be managed through the development of asset-specific technical specification documents, which will specify the selection of materials with appropriate durability requirements. This could also include requirements for membranes, damp-proof courses and copings to mitigate against penetration and accumulation of moisture in vulnerable elements of the asset, such as brickwork. These documents will be informed by HS2 Ltd Technical Standards and best practice e.g. British Standards. During the operational stage, a regular programme of maintenance will be undertaken including general inspection and replacement of the asset where necessary.	**Likelihood level: Unlikely** The climate change impact on the asset is unlikely due to the appropriate selection of resilient materials and resistant mitigation such as membranes, damp-proof courses and copings. In addition, regular maintenance and adaptive management should help to ensure asset quality over the design life of the asset (30 for fences, 60 years for traditional masonry walls and 120 years for other wall materials).	**Consequence level: Very Low** The consequence of the climate change impact is very low due to the selection of appropriate materials. In the unlikely event of greater asset degradation occurring e.g. deterioration of below ground structural elements, very low costs will be incurred associated with additional remedial/replacement works of asset components prior to the structural stability of the asset being compromised.	**Low**	No additional resilience measures required
Increase in mean winter rainfall.	Whilst mean temperatures are expected to increase across all seasons, cold weather events will still occur with freeze/thaw cycles	During the detailed design stage, the impacts associated with cold temperatures and freeze thaw will be managed through the development of asset-specific technical specification documents, which will specify the selection of appropriate materials e.g. non-frost susceptible materials or the use of traditional masonry systems	**Likelihood level: Unlikely** The climate change impact on the asset is unlikely due to the appropriate selection of resilient materials. In addition, regular	**Consequence level: Very Low** The consequence of the climate change impact is very low due to the selection of appropriate materials. In the unlikely event of greater asset degradation	**Low**	No additional resilience measures required

Climate change trend	Potential impact on HS2 Ltd asset group	Existing/embedded mitigation	Likelihood of impact on HS2 Ltd asset group	Consequence of impact on HS2 Ltd asset group	Risk level	Additional mitigation measures
Decreased frequency of cold weather events (e.g. snow and ice).	resulting in deterioration and damage to the structural components of masonry or concrete walls.	should be restricted to structures with a maximum 60 years design life. These documents will be informed by HS2 Ltd Technical Standards and best practice e.g. British Standards. During the operational stage, a regular programme of maintenance will be undertaken including general inspection, monitoring and replacement of the asset where necessary.	maintenance should help to ensure asset quality over the design life of the asset (30 years for fences, 60 years for traditional masonry walls and 120 years for other wall materials).	occurring e.g. freeze thaw impacts, very low costs will be incurred associated with additional remedial/replacement works of asset components prior to the structural stability of the asset being compromised.		
Increased frequency of windstorm events in the second half of the 21st Century.	More frequent windstorm events will lead to an increased likelihood of direct damage to fencing, walls and noise barriers.	During the detailed design stage, the impacts associated with extreme wind events will be managed through the development of asset-specific technical specification documents, which will set-out appropriate materials and wind loading thresholds, for example, fencing, walls and noise barriers in proximity to the track will be designed to incorporate appropriate wind loading factors accounting for wind turbulence effects caused by the passage of trains. These documents will be informed by HS2 Ltd Technical Standards and best practice, for example British Standards. During the operational stage, a regular programme of maintenance will be undertaken including general inspection and replacement of the asset where necessary. When replacing the asset, wind loading thresholds taking account of the climate parameters at the time of asset replacement, will be taken into consideration.	**Likelihood level: Unlikely** The climate change impact is only projected within the second half of the 21st century and is unlikely to impact on fencing or noise barriers due appropriate wind loading factors specified over the asset design life. Impermeable fences, walls and noise barriers that could be more vulnerable to wind loading will be designed to withstand air pressures from passing trains, and therefore are not expected to be affected by small increases in wind speeds due to climate change.	**Consequence level: Low** The consequence of the climate change impact is low. Impermeable assets such as walls will be designed to withstand higher wind loading without failure. Assets such as security fences and noise barriers may have lower thresholds; however, the consequence of failure is low, with additional low costs incurred to repair or replace failed assets following extreme wind events.	**Low**	No additional resilience measures required
Increase in mean winter rainfall. Increased frequency of dry spells. Increased frequency of heatwaves.	An increased likelihood of wetter winters followed by hotter drier summers can result in fluctuating soil moisture content. This can lead to shrink-swell and soil creep processes in areas with susceptible soils, and subsequent damage to the structural components of masonry walls.	During the detailed design stage, geotechnical analysis will be undertaken to establish the geological conditions across the route and any localised constraints or risks. In accordance with HS2 Ltd Technical Standards, allowances would be made for the effects of weathering and climate change (see Table 25) and used to inform design, for example foundation design for the asset. During the operational stage, a regular programme of maintenance will be undertaken including general inspection, monitoring and replacement of the asset where necessary allowing for preventative maintenance (or asset replacement) before a service-disrupting failure occurs.	**Likelihood level: Unlikely** The climate change impact on shrink/swell processes and damage to the asset is unlikely to occur as the geotechnical investigations will be sufficient to inform the design and allow for additional (or different) ground works if required, taking account of current and future ground conditions, over the asset design life (30 years for fences, 60 years for traditional masonry walls and 120 years for other wall materials).	**Consequence level: Very Low** The consequence of the climate change impact is very low. The resultant impact could lead to the very low cost of repair and maintenance associated with additional inspections and remedial works.	**Low**	No additional resilience measures required

Table 20: Tracks

Climate change trend	Potential impact on HS2 Ltd asset group	Existing/embedded mitigation	Likelihood of impact on HS2 Ltd asset group	Consequence of impact on HS2 Ltd asset group	Risk level	Additional mitigation measures
Increase in mean daily maximum temperatures. Increased frequency of heatwaves.	Higher temperatures and more frequent heatwaves would lead to an increased likelihood of track buckling and/or associated misalignment problems.	During the detailed design stage, the impacts associated with higher temperatures will be managed in accordance with HS2 Ltd Technical Standards, which specify that rails will be designed to an appropriate stress-free temperature (SFT) of 27 degrees, (consistent with UK Rail Industry Standards for SFT) for either slab or ballasted track, to provide adequate lateral stability to the track system. To achieve the level of performance required in different locations across the route, the type of track will also be considered (ballasted track vs slab track), with slab track providing additional resilience as it can withstand higher loads and therefore reducing track misalignment during high temperatures. For specific environmental conditions at certain locations, such as bridges and tunnels, the optimum SFT shall be assessed based on the ambient temperatures to manage rail stress effectively and/or the incorporation of rail expansion devices in the case of certain long bridges. High Speed Rail also requires a larger rail cross-section and larger sleepers (for ballast track) than conventional rail, giving higher resilience against the possibility of any track misalignment during periods of high temperatures. Additional measures will be incorporated into the design where required. For example, treating the rails with UV protection at manufacturing stage or applying a coating or white paint to the rails in situ reduces the expansion rate and minimises the occurrence of track buckling. During the operational stage, automated Asset Condition Monitoring (ACM) by train-borne equipment supplemented with on-track monitoring systems at critical locations will facilitate identifying both temperature and the relative rail and track slab position. Alarm systems will indicate if the Critical Rail Temperature (CRT) is likely to be reached, allowing for action to be taken such as temporary speed restrictions. In the event that rail temperatures may reach a critical temperature, re-stressing of the rails to give a higher SFT is possible in situ, prioritised at those locations where misalignment is more likely e.g. bends. Whilst the design life for the Track system as a whole is 60 years, the typical service life of the rails is only 20 years. At the time of rail replacement, the appropriate SFT would be reviewed based on the prevailing climate at that time.	**Likelihood level: Unlikely** The design and installation of the rails will give a SFT in accordance with UK Rail Industry (and HS2 Ltd) standards. In addition to this, other factors such as: the relatively short service life for the rails (20 years); the resilient nature of the design (large rail cross-section and larger sleepers for ballasted track than conventional rail); the use of slab track at higher risk locations; and track monitoring systems, will all contribute to the resilience of the track. Additionally, measures such as coated rails and temporary speed restrictions, and the ability to alter the SFT of the rails in situ if necessary, provides further operational resilience. These factors result in it being unlikely that there will be track buckling or rail misalignment as a result of high temperatures or heatwaves.	**Consequence level: Medium** The consequence of the climate change impact is medium. In the unlikely event that the CRT is exceeded by future higher temperatures, there are opportunities to manage this risk at the operational stage, such as re-stressing the rails to a higher SFT, and temporary speed restrictions. This will ensure consequences are limited to delays lasting less than 1 day until temperatures fall or remedial/replacements works occur, and costs associated with additional maintenance activities are low. Rail replacement every 20 years allows the optimum SFT to be re-considered at each asset replacement cycle.	**Low**	No additional resilience measures required
Increase in mean daily maximum temperatures. Increased frequency of heatwaves.	Higher temperatures and more frequent heatwaves would lead to an increased likelihood of rail expansion joints failure.	During the detailed design stage, the impacts associated with higher temperatures will be managed through the development of asset-specific technical specification documents. Where expansion joints are necessary, such as for viaducts and bridges longer than 100 metres, these documents will set out the operating temperature thresholds. Additionally, the rails will be designed to an optimised SFT, to provide adequate lateral stability to the track system minimising the likelihood of rail expansion and increased pressure on the expansion joint. At the design stage, the specified expansion joints will have residual capacity for several reasons including to allow some redundancy in the temperature range assumption.	**Likelihood level: Possible** Selection of an appropriate expansion joint capacity and locally optimised SFT shall be in accordance with best practice and will ensure that the rail is capable of withstanding rail temperatures; measures implemented at operational stage will help further manage the likelihood of track buckling and any associated impacts on the expansion joints. Regular monitoring and maintenance should help to ensure expansion	**Consequence level: Low** The consequence of the climate change impact is Low. At each renewal of the device the installation will be optimised for the foreseen temperature ranges. If temperatures beyond the capacity of the devices are exceeded in the future, measures implemented at operational stage, such as temporary speed restrictions, will help ensure consequences are limited to delays to journey time and low costs associated with additional maintenance activities	**Low**	No additional resilience measures required

Climate change trend	Potential impact on HS2 Ltd asset group	Existing/embedded mitigation	Likelihood of impact on HS2 Ltd asset group	Consequence of impact on HS2 Ltd asset group	Risk level	Additional mitigation measures
		During the operational stage, automated ACM by train-borne equipment supplemented with fixed monitoring systems at critical expansion joint locations will monitor several parameters including displacements. Alarm systems will be used to indicate if thresholds are likely to be exceeded, allowing for preventative maintenance before a service-affecting failure occurs.	joints achieve their service life (15 years) and are replaced prior to failure.	which should limit impacts on RED to delays in journey times, lasting less than 1 day until temperatures fall or remedial/replacements works occur on damaged expansion joints in extreme cases.		
Decreased frequency of cold weather events (e.g. snow and ice).	Although cold weather events will become less frequent, they will still occur, potentially resulting in the build-up of ice or snow on switches and crossings leading to switch and crossing (S&C) failure.	During the detailed design stage, the impact associated with low temperatures will be mitigated through the development of an asset-specific technical specifications documents. These documents will set-out the operating temperature thresholds for materials and will include below freezing temperatures in addition to information on future maintenance provision, such as the ability for S&C to be heated to prevent the build-up of ice or snow. During the operational stage, automated ACM and alarm systems will be used to indicate potential equipment degradation or failure, allowing for preventative maintenance before a service-affecting failure occurs. In the event of forecasted ice and snow conditions, preventative maintenance measures such as the running of ghost trains, heating of S&C and staff patrols will be undertaken.	**Likelihood level: Unlikely** Although cold weather events will become less frequent, they will still occur; however, the impact is unlikely to occur over the service life of the rails (15-25 years) due to the setting of appropriate temperature thresholds within the product specification documents. During extreme low temperature events, monitoring and alarm systems and preventative maintenance measures will help reduce the likelihood of failure.	**Consequence level: Very Low** The consequence of the climate change impact is very low. Appropriate temperature thresholds and monitoring and alarm systems will help keep consequences very low with preventative maintenance measures carried out prior to any service-disrupting impact occurring.	**Low**	No additional resilience measures required
Increase in mean winter rainfall. Increased frequency of heavy rainfall events.	Wetter winters and more frequent heavy rainfall events would lead to an increased likelihood of track flooding.	During the outline design stage, the alignment of the track will be located outside areas at risk of flooding. Where this is not achievable, the risk of flooding will be managed in accordance with the HS2 Ltd Technical Standards, which state that the railway will be protected against the 1 in 1,000 year (0.1%) annual probability design event, with a minimum of 1 metre of freeboard to top of rail level. Slab track will also be designed with the appropriate cross falls to prevent pooling of water and flood conveyance and drainage assets will further manage surface and groundwater to ensure the continual and safe running and operation of the HS2 Ltd rolling stock (see Table 28). During the operational stage, inspection and maintenance will be carried out on flood mitigation measures including surface water drainage to ensure these are operating effectively.	**Likelihood level: Unlikely** In areas at risk of flooding, the climate change impact is unlikely to occur due to the high flood design standards (current 1 in 1,000 (0.1%) annual probability design event) and associated freeboard being applied. The risk of flooding is expected to increase with time due to the impact of climate change; however, in high flood risk locations, consideration will be given to adapting the design (e.g. increasing freeboard levels) or taking other precautions (e.g. warnings and temporary line closures) to ensure the likelihood of the impact remains low over the design life of the asset.	**Consequence level: Medium** The consequence of the climate change impact is medium. Whilst flood and drainage design standards will help reduce the risk of flooding over the design life of the asset, any flooding exceeding these standards could have notable consequences including delayed services. Contingency plans and ongoing inspection and maintenance regimes will help to ensure residual risks are managed and consequences are limited.	**Low**	No additional resilience measures required
Increased frequency of windstorm events in the second half of the 21st Century.	More frequent windstorm events will increase the likelihood of vegetation and leaves being blown on to the track causing loss of traction, and/or damage or track.	During the outline design stage, the impacts associated with extreme wind events and wind borne debris will be managed in accordance with the HS2 Ltd Technical Standards that specifies that a 'zone of influence', which provides a minimum of 10metre offset around the track, will be implemented to manage future vegetation encroachment and prevent impacts on railway operations e.g. falling branches and trees. Additionally, resilient vegetation will be selected (for example, those with stable root systems) (see Table 27). During the operational stage, ongoing maintenance of vegetation (including checks for tree health) will be undertaken in addition to a regular programme of track maintenance to clear any debris (for example leaf fall) from the track.	**Likelihood level: Likely** The zone of influence will help reduce the likelihood of larger debris falling on the track due to high winds. However, leaves on the line will always occur, but it is unlikely to increase due to the impacts of climate change.	**Consequence level: Very Low** The consequence of the climate change impact is very low, linked to the low costs associated with more frequent vegetation maintenance or localised replacement of failed vegetation. The implementation of the Zone of Influence around the track will help to prevent impacts on railway operations however the resultant impact will lead to very low delays.	**Medium**	No additional resilience measures required

Climate change trend	Potential impact on HS2 Ltd asset group	Existing/embedded mitigation	Likelihood of impact on HS2 Ltd asset group	Consequence of impact on HS2 Ltd asset group	Risk level	Additional mitigation measures
Increase in mean temperature across all seasons. Increased frequency of dry spells. Increase in mean winter rainfall.	An increased likelihood of wetter winters followed by longer or more frequent dry spells would result in greater fluctuations in soil moisture content. This can lead to shrink-swell processes in areas with susceptible soils, and subsequent damage to the track geometry.	During the detailed design stage, geotechnical analysis will be undertaken to establish the geological conditions across the route and any localised constraints or risks. In accordance with HS2 Ltd Technical Standards, allowances to be made for the effects of weathering and climate change (see Table 25) will be utilised to inform design. For example, ground movement at the formation level and the timescale and rates of the movement will be analysed (for example through determination of the plasticity / swell potential of soils) and will be assessed against HS2 Ltd railway earth structure performance requirements. This will feed into the track alignment design. Additionally, the design will accommodate for track form transition arrangements, i.e. ballast to slab track to be located on constant track geometry. During the operational stage, a regular programme of maintenance will be undertaken including general inspection and monitoring, for example, through level monitoring or extensometer measurement, allowing for preventative maintenance (or asset replacement) to occur before a service-disrupting failure occurs.	**Likelihood level: Unlikely** The climate change impact on shrink/swell processes and damage to the asset is unlikely to occur as the geotechnical investigations will be sufficient to inform the design and allow for additional (or different) ground works if required, taking account of current and future ground conditions, over the asset design life (120 years).	**Consequence level: Low** The consequence of the climate change impact is low. The resultant impact could lead to the low cost of repair and maintenance associated with additional inspections and remedial works following damage to structural elements. This could also result in speed restrictions, whilst post event works are being undertaken which could have a low impact upon journey times resulting in delays.	**Low**	No additional resilience measures required

Table 21: Stations

Climate change trend	Potential impact on HS2 Ltd asset group	Existing/embedded mitigation	Likelihood of impact on HS2 Ltd asset group	Consequence of impact on HS2 Ltd asset group	Risk level	Additional mitigation measures
Increase in mean daily maximum temperature. Increased frequency of heatwaves.	Higher temperatures and more frequent heatwaves would lead to an increased likelihood of electrical equipment overheating and failing.	During the detailed design stage, stations will be designed as a minimum to meet Building Research Establishment Environmental Assessment Method (BREEAM) "Excellent Rating", which will consider thermal comfort and ventilation arrangements. Areas of the station considered to be more vulnerable to overheating, will be designed to maximise passive cooling, for example transformer rooms will be designed with louvre doors to aid ventilation of electrical equipment during normal operations. Heating, ventilation and air conditioning (HVAC) systems will also be incorporated into the station design to provide additional cooling in periods of higher temperatures. HVAC systems will be sized appropriately using thermal modelling taking account of future maximum temperature ranges as a result of climate change. During the operational stage, station buildings will be monitored and fed into an Engineering Management System which will be monitored by the infrastructure maintainer. Alarm systems will indicate potential equipment failure or if thresholds are likely to be exceeded. This will allow for preventative maintenance (or asset replacement) to be actioned before a service-disrupting failure occurs.	**Likelihood level: Unlikely** The impact is unlikely to occur due to the provision of adequately sized HVAC systems to be utilised during periods of high temperatures. Additionally, monitoring systems will allow for action to be taken prior to stations overheating which will prevent secondary impacts on railway operations.	**Consequence level: Low** The consequence of the impact will be low. Low costs will be incurred associated with the additional remedial/replacement works to repair failed (HVAC) equipment.	**Low**	No additional resilience measures required
Increase in mean daily maximum temperature.	Higher temperatures and more frequent heatwaves would lead to an increased likelihood of passenger discomfort and unsafe working environments,	During the detailed design stage, stations will be designed as a minimum to meet BREEAM "Excellent Rating", which will consider thermal comfort and ventilation arrangements. For example, HVAC systems will provide additional cooling to public waiting areas in periods of higher temperatures and canopies on the station concourses to provide shading to passengers and staff. HVAC systems	**Likelihood level: Unlikely** The impact is unlikely to occur due to the provision of adequately sized HVAC systems and health and safety procedures to reduce heat stress risk	**Consequence level: Low** The consequence of the impact will be low. Low costs will be incurred associated with the additional remedial/replacement works to repair failed (HVAC) equipment.	**Low**	No additional resilience measures required

Climate change trend	Potential impact on HS2 Ltd asset group	Existing/embedded mitigation	Likelihood of impact on HS2 Ltd asset group	Consequence of impact on HS2 Ltd asset group	Risk level	Additional mitigation measures
Increased frequency of heatwaves.	resulting in potential health impacts for example heat stress.	will be sized appropriately using thermal modelling taking account of future maximum temperature ranges as a result of climate change. During the operational stage, the risk of heat stress to the public and staff is mitigated through HS2 Ltd health and safety procedures. For example, appropriate announcements will be provided within stations and risks to staff working outdoors will be managed through HS2 Ltd health and safety procedures, which will include Dynamic Risk Assessments, and specify adaptive management procedures for example, provision of appropriate Personal Protective Equipment (PPE) for personnel working outside.	to the public and workers during higher temperatures.			
Decreased frequency of cold weather events (e.g. snow and ice).	Whilst cold weather events will become less frequent, they will still occur, with extreme low temperatures leading to snow and hail loading on structures causing stability issues.	During the detailed design stage, stations will be designed to take into account snow loading through the selection of materials with appropriate durability requirements, in accordance with the HS2 Ltd Technical Standards and best practice e.g. British Standards and Eurocodes. During the operational stage, a regular programme of maintenance will be undertaken including general inspection and monitoring of the asset where necessary.	**Likelihood level: Unlikely** The impact is unlikely to occur due to the appropriate structural design and selection of materials. In addition, regular monitoring and maintenance should help to ensure asset quality in maintained.	**Consequence level: Low** The consequence of the climate change impact is low. In the unlikely event of damage of the asset structure occurring, low costs will be incurred associated with additional remedial/replacement works of asset components prior to the structural stability of the asset being compromised.	**Low**	No additional resilience measures required
	Although cold weather events will become less frequent, they will still occur, with low temperatures leading to passenger discomfort and unsafe working environments, resulting in potential health impacts for example cold stress.	During the detailed design stage, stations will be designed as a minimum to BREEAM "Excellent Rating". When considering thermal comfort specifications to size the HVAC systems, thermal modelling will be undertaken taking account of temperature ranges as a result of climate change. In addition, climate-controlled waiting areas will be provided within public areas and canopies which will provide cover for passengers and staff in adverse weather conditions. During the operational stage, the risk of cold stress to the public and staff is mitigated through HS2 Ltd health and safety procedures. For example, appropriate announcements will be provided within stations and risks to staff working outdoors will be managed through HS2 Ltd health and safety procedures, which will include Dynamic Risk Assessments, and specify adaptive management procedures for example, provision of appropriate PPE for personnel working outside.	**Likelihood level: Unlikely** The impact is unlikely to occur due to the provision of adequate HVAC systems, waiting areas and health and safety procedures to protect the public and workers during cold temperatures.	**Consequence level: Low** The consequence of the impact will be low. Low costs will be incurred associated with the additional remedial/replacement works to repair failed (HVAC) equipment.	**Low**	No additional resilience measures required
Increase in mean winter rainfall. Increased frequency of heavy rainfall events.	Wetter winters and more frequent extreme rainfall events would lead to an increased likelihood of flooding in station assets including platforms, buildings, access and car parks.	During the outline design stage, flood risks will be managed in accordance with the HS2 Ltd Technical Standards which require critical assets such as stations to be protected to the a 1 in 1000 year (0.1%) annual probability design event. In addition, on site drainage will be designed to manage the risk of surface water flooding, with drainage designed to include an allowance of 40% to the peak rainfall intensity (see Table 28). During the operational stage, inspection and maintenance will be carried out on flood mitigation measures including surface water drainage to ensure these are operating effectively. In the event of a flood, post event inspections and maintenance will be carried out where necessary and contingency plans will be in place to minimise disruption to the network operation.	**Likelihood level: Unlikely** In areas at risk of flooding, the climate change impact is unlikely to occur due to the high flood design standards (current 1 in 1,000 (0.1%) annual probability design event). In addition, the provision of appropriately sized and maintained drainage will reduce the likelihood of flooding. The risk of flooding is expected to increase with time due to the impact of climate change; however, in high flood risk locations, consideration will be given to adapting the design (e.g. increasing freeboard levels) to ensure	**Consequence level: Medium** The consequence of the climate change impact is medium. Whilst flood and drainage design standards will help reduce the risk of flooding over the design life of the asset, any flooding exceeding these standards could have notable consequences due to the nature of the station and possible interdependencies. Consequences could include delayed services causing negative passenger experiences. Contingency plans and ongoing inspection and maintenance regimes will help to ensure residual risks	**Low**	No additional resilience measures required

Climate change trend	Potential impact on HS2 Ltd asset group	Existing/embedded mitigation	Likelihood of impact on HS2 Ltd asset group	Consequence of impact on HS2 Ltd asset group	Risk level	Additional mitigation measures
			the likelihood of the impact remains low over the design life of the asset.	are managed and consequences are limited.		
Increase in mean winter rainfall. Increased frequency of heavy rainfall events.	More frequent heavy rainfall events would lead to an increased likelihood of health and safety incidents during wet conditions for example, slips, trips and falls.	At the detailed design stage, appropriate selection of flooring materials will be undertaken to prevent slips, trips and falls during wetter weather. During the operational stage, the risk of slips, trips and falls to staff working outdoors will be managed through HS2 Ltd health and safety procedures, for example, use of signage and appropriate footwear.	**Likelihood level: Possible** Although appropriate material selection and health and safety procedures will be in place to help protect passengers and workers, slips, trips and falls are still possible, however incidents are unlikely to increase due to climate change.	**Consequence level: Low** Appropriate design and health and safety procedures will help to manage the low consequence of the climate change impact. Any impacts are likely to be short term on persons affected such as lost time injury or medical treatment.	**Low**	No additional resilience measures required
Increased frequency of windstorm events in the second half of the 21st Century.	More frequent windstorm events would lead to increased likelihood of structural damage to buildings and/or unsafe working environments.	During the detailed design stage, the structural design of stations, including the selection of durable materials, will take into account future wind loading through the use of wind modelling where appropriate, in accordance with the HS2 Ltd Technical Standards and best practice, for example, British Standards and Eurocodes. During the operational stage, a regular programme of maintenance will be undertaken including general inspection and monitoring of the asset where necessary. The risk to staff working outdoors will be managed through HS2 Ltd health and safety procedures which will include Dynamic Risk Assessments that specify adaptive management procedures for example, work will be curtailed or cancelled if high winds are forecast.	**Likelihood level: Unlikely** The impact is unlikely to occur due to the appropriate design and selection of materials e.g. through the use of wind modelling to design for appropriate wind loading. In addition, regular monitoring and maintenance should help to ensure asset quality to prevent failure.	**Consequence level: Low** The consequence of the climate change impact is low. Low costs will be incurred associated with additional remedial/replacement works of asset components prior to the structural stability of the asset being compromised.	**Low**	No additional resilience measures required
Increased frequency of lightning events in the second half of the 21st Century.	More frequent lightning events would lead to an increased likelihood of lightning strikes and direct damage to stations.	During the detailed design stage, following local and regional lightning risk assessments, standard lightning protection, such as lightning rods, will be specified. The frequency of lightning strikes will not affect the effectiveness of the mitigation. During the operational stage, the lightning protection system will be place, which will be effective at protecting stations irrespective of the number of lightning strikes. Risks to staff working outdoors will be managed through HS2 Ltd health and safety procedures, which will include Dynamic Risk Assessments that specify adaptive management procedures for example, work will be curtailed or cancelled if lightning is forecast.	**Likelihood level: Unlikely** The impact is unlikely to occur due to standard lightning protection being implemented.	**Consequence level: Very Low** During a lightning event and the unlikely event of a strike on station infrastructure, lightning protection will mitigate the impact and any resulting consequence will be very low.	**Low**	No additional resilience measures required
Increase in mean winter rainfall. Increased frequency of dry spells. Increase in mean winter rainfall.	An increased likelihood of wetter winters followed by hotter drier summers can result in fluctuating soil moisture content. This can lead to shrink-swell and soil creep processes in areas with susceptible soils, and subsequent damage to the structural components of masonry walls.	During the detailed design stage, geotechnical analysis will be undertaken to establish the geological conditions across the route and any localised constraints or risks. In accordance with HS2 Ltd Technical Standards, allowances would be made for the effects of weathering and climate change (see earthworks CCR assessment) and used to inform design e.g. foundation design for the asset. During the operational stage, a regular programme of maintenance will be undertaken including general inspection, monitoring and replacement of the asset where necessary allowing for preventative maintenance (or asset replacement) before a service-disrupting failure occurs.	**Likelihood level: Unlikely** The climate change impact on shrink/swell processes and damage to the asset is unlikely to occur as the geotechnical investigations will be sufficient to inform the design and allow for additional (or different) ground works if required, taking account of current and future ground conditions, over the asset design life (30 years for fences, 60 years for traditional masonry walls and 120 years for other wall materials).	**Consequence level: Very Low** The consequence of the climate change impact is very low. The resultant impact could lead to the very low cost of repair and maintenance associated with additional inspections and remedial works.	**Low**	No additional resilience measures required

Table 22: Rolling stock

Climate change trend	Potential impact on HS2 Ltd asset group	Existing/embedded mitigation	Likelihood of impact on HS2 Ltd asset group	Consequence of impact on HS2 Ltd asset group	Risk level	Additional mitigation measures
Increase in mean daily maximum temperature. Increased frequency of heatwaves.	Higher temperatures and more frequent heatwaves would lead to an increased likelihood of maximum operating thresholds being exceeding and the systems tripping. This could lead to overheating of carriages and passenger and staff discomfort and potential health impacts, for example, heat stress.	During the development of the Train Technical Specification the specifications and sizing of the heating, ventilation, and air conditioning systems (HVAC), used to control the interior temperature range of rolling stock carriages, will be informed by future ambient air temperatures. These conditions will be developed from European Standards, for example, the Zone III (United Kingdom) summer climatic conditions specified in EN 13129 will be selected and include an uplift to take account of the impacts of climate change. The HVAC systems will be designed to automatically pre-cool carriages to the desired interior temperature prior to operational use. The Train Technical Specification document specifies that the HVAC system performance will be monitored by a diagnostics system on board the train. Alarm systems, which will indicate potential equipment failure or if thresholds are likely to be exceeded during the operations, will trigger additional measures such as asset maintenance or the distribution of water to passengers to reduce the risk of heat stress.	**Likelihood level: Unlikely** The impact is unlikely to occur due to the appropriate sizing and automation of HVAC systems. Monitoring systems will allow for remedial action to be taken for example, distribution of water supplies to manage impacts on staff and passengers prior to rolling stock heating to a temperature that will affect the safety of wellbeing of passengers.	**Consequence level: Low** The consequence of the climate change impact will be low, with issues associated with the HVAC system likely leading to passenger discomfort or delays. Additional measures, such as the distribution of water, will help to manage the consequences.	**Low**	No additional resilience measures required
Decreased frequency of cold weather events (e.g. snow and ice).	Although cold weather events will become less frequent, they will still occur to leading to passenger and staff discomfort and potential impacts, for example, cold stress.	During the development of the Train Technical Specification, the specifications and sizing of the HVAC systems used to control the interior temperature range of rolling stock carriages, will be informed in part by external climate conditions including ambient air temperatures. These conditions are developed from European Standards, for example, the Zone I (United Kingdom) winter climatic conditions specified in EN 13129. The HVAC systems will be designed to automatically pre-heat carriages to the desired interior temperature prior to operational use. The Train Technical Specification specifies that the HVAC system performance will be monitored by a diagnostics system on board the train. Alarm systems, which will indicate potential equipment failure or if thresholds are likely to be exceeded during the operations, will trigger additional measures such as asset maintenance.	**Likelihood level: Unlikely** With cold weather events becoming less frequent, the climate change impact is unlikely to occur with HVAC systems designed to be resilient to current weather conditions. Monitoring systems will also allow for remedial action to be taken prior to rolling stock cooling to a temperature that will affect the safety or wellbeing of passengers.	**Consequence level: Low** The consequence of the climate change impact will be low associated with passenger discomfort or delays whilst maintenance activities occur.	**Low**	No additional resilience measures required
	Although cold weather events will become less frequent, they will still occur, potentially leading to ice build-up underneath rolling stock leading to issues during coupling / uncoupling operations.	The Train Technical Specification specifies that rolling stock unit shall be specified to be resistant to the build-up of snow and ice accumulation underneath the rolling stock unit. In addition, couplers will be designed with covers and heating systems to prevent ice build-up during operations. During the operational stage, the Train Technical Specification specifies that a regular programme of maintenance will be undertaken including general inspection and monitoring of the asset where necessary.	**Likelihood level: Unlikely** The climate change impact is unlikely to occur due to the appropriate design of rolling stock and coupler mechanisms.	**Consequence level: Very Low** The consequence of the climate change impact is very low. In the unlikely event of ice build-up on the coupler mechanism, low costs and delays will be incurred whilst couplers are heated.	**Low**	No additional resilience measures required
	Although cold weather events will become less frequent, they will still occur potentially leading to the build-up of snow and ice	During the development of the Train Technical Specifications, the rolling stock will be required to remain operational in snow depths of up to 200mm above the rail level in line with the UK Rule Book. However further operational measures may be implemented before these limits are reached as a result of health and safety.	**Likelihood level: Possible** The design of the rolling stock will ensure that the unit will remain operational during snowfall (up to design limits) however it is possible that temporary speed restrictions will	**Consequence level: Medium** The consequence of the climate change impact is medium. Whilst the rolling stock specification and mitigation measures such as the operation of ghost trains will help to	**Medium**	No additional resilience measures required

Climate change trend	Potential impact on HS2 Ltd asset group	Existing/embedded mitigation	Likelihood of impact on HS2 Ltd asset group	Consequence of impact on HS2 Ltd asset group	Risk level	Additional mitigation measures
	which could affect operations.	During the operational stage, in the event of forecasted ice and snow conditions, preventative measures such as the continuous running of ghost trains will be undertaken along with maintenance of the track (see Table 20). During an ice and snow event visual inspections of the track will be undertaken by the on-board Train Captain, and action taken for example, precautionary measures such as temporary speed restrictions may be implemented.	be implemented for operational safety reasons.	reduce ice and snow build up on tracks, speed restrictions may be implemented. Consequences could include delayed services causing negative passenger experiences.		
	Although cold weather events will become less frequent, they will still occur, and would lead to ice build-up around the bogie and bolster. This could lead to ice detaching at high speed and causing damage to the underframe equipment.	During the development of the Train Technical Specifications document, the rolling stock unit (including underframe) shall be specified to be resistant to the build-up of snow and ice whilst in operation. This is to prevent secondary damage to the rolling stock in the event of ice detachment from parts of the underframe such as the bogie and bolster. During an ice and snow event visual inspections of the track will be undertaken and action taken for example, precautionary measures such as temporary speed restrictions may be implemented. Additionally, general inspection and monitoring of the rolling stock will be undertaken and remedial action taken as required for example, damaged components will be replaced.	**Likelihood level: Unlikely** The climate change impact is unlikely to occur due to the appropriate rolling stock design. In addition, regular monitoring and maintenance should help to ensure asset quality is maintained.	**Consequence level: Very Low** The consequence of the climate change impact is very low linked to delays or additional costs associated with more frequent inspections or remedial works of the rolling stock.	**Low**	No additional resilience measures required
Increased frequency of heavy rainfall events.	More frequent heavy rainfall events would lead to an increased likelihood of track flooding which would impact on the ability of the train to operate.	During outline design stage, the vertical track alignment will also be designed above the current 1 in 1,000 (0.1%) annual probability design event, with a minimum of 1 metre freeboard to the top of the rail (see Table 20). During the development of the Train Technical Specifications, the rolling stock will be required to remain operational until water reaches the track railhead, which is in line with the UK Rule Book. However further operational measures may be implemented before these limits are reached as a result of health and safety. During the operational stage, in the event of forecasted heavy rain conditions, precautionary measures such as temporary speed restrictions may be implemented.	**Likelihood level: Possible** The high flood design standards (current 1 in 1,000 (0.1%) annual probability design event) and associated freeboard and track drainage will help to reduce the likelihood of flood events and water reaching the railhead, however it is possible that speed restrictions will be implemented during operation for health and safety.	**Consequence level: Medium** The consequence of the climate change impact is medium. Whilst track flood and drainage design standards will help reduce the risk of flooding, any flooding exceeding these standards could have notable consequences on rolling stock. Consequences could include delayed services causing negative passenger experiences.	**Medium**	No additional resilience measures required
	More frequent heavy rainfall events would lead to an increased likelihood of health and safety incidents during wet conditions when entering the train carriages, for example, slips, trips and falls.	During the development of the Train Technical Specifications, appropriate selection of durable flooring materials will be undertaken to prevent slips, trips and falls during wetter weather. For example, removable barrier mats will be provided in door wells.	**Likelihood level: Possible** Although appropriate material selection and health and safety procedures will be in place to help protect passengers and workers, slips, trips and falls are still possible, however incidents are unlikely to increase due to climate change.	**Consequence level: Low** Appropriate design and health and safety procedures will help to manage the low consequence of the impact. Any impacts are likely to be short term impacts on persons affected such as lost time injury or medical treatment.	**Low**	No additional resilience measures required
Increased frequency of windstorm events in the second half of the 21st Century.	More frequent windstorm events would increase the likelihood of object strikes on rolling stock e.g. tree branches, gravel.	During the outline design stage, a zone of influence surrounding the track will be incorporated into the design in accordance with the HS2 Ltd Technical Standards to reduce the risk of falling branches and trees during high winds affecting the railway (see Table 27). During the development of the Train Technical Specifications, the selection of rolling stock components, for example windows and bodyshell with appropriate durability requirements will be specified to minimise direct damage from foreseeable items (e.g. ballast strike and gravel) striking the rolling stock.	**Likelihood level: Possible** The zone of influence will help reduce the likelihood of larger debris falling on the track due to high winds. However, impacts from windborne debris from outside of HS2 Ltd influence are possible, but unlikely to increase due to the impacts of climate change.	**Consequence level: Low** The consequence of the climate change impact is low linked to delays or additional costs associated with more frequent inspections or remedial works following strikes by wind borne debris.	**Low**	No additional resilience measures required

Climate change trend	Potential impact on HS2 Ltd asset group	Existing/embedded mitigation	Likelihood of impact on HS2 Ltd asset group	Consequence of impact on HS2 Ltd asset group	Risk level	Additional mitigation measures
		During the operational stage, in the event of object strikes the rolling stock will be checked and remedial action taken as required for example, damaged components will be replaced.				
	More frequent windstorm events would increase the likelihood of crosswinds leading to disruption to operations for example, implementation of speed restrictions.	During the development of the Train Technical Requirements Specifications, rolling stock will be specified to accommodate loading associated with crosswinds. For example, characteristic wind curves will be utilised during the design of rolling stock along with wind tunnel measurements in more vulnerable locations. In addition, in areas at risk of cross winds developing, the civil design of the railway will be designed to accommodate the physical and operational constraints. For example, wind barriers may be provided to reduce potential impacts on operations. During the operational stage, in the event of high winds and storminess, precautionary measures such as temporary speed restrictions may be implemented before a service-affecting failure occurs.	**Likelihood level: Possible** The design of the rolling stock, and civils design will include mitigation such as wind barriers at vulnerable locations to reduce the impact of crosswinds. However, in windstorm events it is possible that speed restrictions will be implemented during operation for health and safety.	**Consequence level: Low** The consequence of the climate change impact is low linked to delays or additional costs associated with more frequent inspections or remedial works following strikes by wind borne debris.	**Low**	No additional resilience measures required
Decreased frequency of fog events in the second half of the 21st Century.	Although fog events will become less frequent in the second half of the 21st Century, they will still occur, leading to reduced visibility of signals and disruption to operations for example, implementation of speed restrictions.	During the development of the Train Technical Specifications, rolling stock will be specified with a new signalling and train driving system called the European Train Control System (ETCS), which is a train protection system and includes elements on the track and the train and removes the need for any lineside signals and therefore the need for direct line of sight. During the operational stage, in the event of fog conditions, precautionary measures such as temporary speed restrictions may be implemented.	**Likelihood level: Possible** The appropriate specification of control, command signalling and rolling stock systems (ETCS) will remove the need for a clear line of sight however it is possible that within fog conditions, temporary speed restrictions will be implemented during operation for health and safety.	**Consequence level: Low** During fog conditions, automatic operator mode will be in operation however consequences could include delayed services causing negative passenger experiences.	**Low**	No additional resilience measures required
Increased frequency of lightning events in the second half of the 21st Century.	More frequent lightning events would lead to an increased likelihood of lightning strikes and direct damage to rolling stock.	The HS2 Ltd Technical Standards will specify that a lightning protection system will be place, which will be effective at protecting rolling stock irrespective of the number of lightning strikes. If a train is struck by lightning, it will be checked upon arrival at the depot and remedial action will be taken.	**Likelihood level: Unlikely** The impact is unlikely to occur due to standard lightning protection being implemented.	**Consequence level: Low** During a lightning event and the unlikely event of a strike on rolling stock, lightning protection will mitigate the impact and any resulting consequence will be low, limited to delays lasting hours whilst the train is checked.	**Low**	No additional resilience measures required

Table 23: Overbridges, underbridges and viaducts

Climate change trend	Potential impact on HS2 Ltd asset group	Existing/embedded mitigation	Likelihood of impact on HS2 Ltd asset group	Consequence of impact on HS2 Ltd asset group	Risk level	Additional mitigation measures
Increase in mean daily maximum temperature. Increased frequency of heatwaves.	Higher temperatures and more frequent heatwaves would lead to an increased likelihood of greater thermal loading resulting in overstressed bearings and movement joints that could eventually compromise structural stability of the asset.	During the detailed design stage, the impacts associated with climate change on thermal loading will be managed through the selection of materials with appropriate durability requirements, informed by HS2 Ltd Technical Standards and best practice for example, British Standards and Eurocodes, which utilise isotherms to ensure that appropriate climatic conditions are incorporated in the design process. In general, integral bridges will be adopted to avoid the need for elements vulnerable to high temperatures such as bearings and movement joints. During the operational stage, the condition of viaducts and multi-span bridge assets will be monitored by remote technologies and by regular measurement, to detect deterioration and inform maintenance and renewal cycles and allowing for preventative maintenance (or asset replacement) of sub-elements of the asset before the structural stability of the asset is compromised.	**Likelihood level: Unlikely** During high temperatures, the impacts associated with thermal loading on the asset group are unlikely to occur due to the avoidance of vulnerable asset components (e.g. movement joints) and the appropriate selection of materials. In addition, regular monitoring and maintenance should help to ensure vulnerable asset components achieve their design life (25 years for bearings and expansion joints) and are replaced prior to failure.	**Consequence level: Very Low** The consequence of the climate change impact is very low. In the unlikely event of degradation of the asset occurring, very low costs will be incurred associated with additional remedial/replacement works of asset components e.g. bearings, prior to the structural stability of the asset being compromised.	**Low**	No additional resilience measures required
Increase in mean temperature across all seasons.	Higher temperature and carbon dioxide levels would lead to increased impact on chloride and carbonation induced reinforcement corrosion of concrete asset components.	During the detailed design stage, the climate change impacts on chloride and carbonation induced reinforcement corrosion rates will be managed through the selection of materials with appropriate durability requirements, informed by HS2 Ltd Technical Standards and best practice for example, British Standards and Eurocodes. A durability assessment report for concrete segments of bridges will be undertaken. During the operational stage, a regular programme of maintenance will be undertaken including general inspection and monitoring of the asset where necessary allowing for preventative maintenance (or asset replacement) before a service-disrupting failure occurs.	**Likelihood level: Unlikely** During higher temperatures, the rate in which concrete corrosion occurs is unlikely to increase over the design life (120 years for the bridge parapets and superstructure of the bridge) due to the appropriate selection of materials e.g. weathering steel. In addition, regular monitoring and maintenance should help to ensure asset quality to prevent failure.	**Consequence level: Very Low** The consequence of the climate change impact is very low. In the unlikely event of degradation of the asset occurring for example corrosion of bearings, very low costs will be incurred associated with additional remedial/replacement works of asset components prior to the structural stability of the asset being compromised.	**Low**	No additional resilience measures required
Decreased frequency of cold weather events (e.g. snow and ice).	Although cold weather events will become less frequent, they will still occur. The spreading of de-icing salts on overbridges will continue to be undertaken as part of regular maintenance activities increasing the likelihood of corrosive action, and over the long term, impacting the durability of bridge components.	During the detailed design stage, the selection of materials will ensure that corrosion rates take account of climate change through the provision of durability enhancement measures following British Standards. This includes the consideration of chloride induced corrosion of embedded steel in concrete e.g. weathering steel shall not be used in structures subject to de-icing salts. In addition, a durability assessment report for concrete segments of the bridges will be undertaken. During the operational stage, a regular programme of maintenance will be undertaken including general inspection and monitoring of the asset where necessary allowing for preventative maintenance (or asset replacement) before a service-disrupting failure occurs.	**Likelihood level: Unlikely** The likelihood of this impact on the asset is unlikely to occur, due to appropriate material selection. In addition, regular monitoring and maintenance should help to ensure vulnerable asset components achieve their design life (for example 25 years for bearings, where used) and are replaced prior to failure.	**Consequence level: Very Low** The consequence of the climate change impact is very low. In the unlikely event of degradation of the asset occurring, for example, corrosion of bearings, very low costs will be incurred associated with additional remedial/replacement works of asset components prior to the structural stability of the asset being compromised.	**Low**	No additional resilience measures required
Increased frequency of heavy rainfall events. Increase in mean winter rainfall.	Whilst mean temperatures are expected to increase across all seasons, cold weather events will still occur resulting in a risk of freezing drainage features leading to flooding and potential structural damage. The risk is greatest where asset components are inaccessible.	During the detailed design stage, the flood conveyance and drainage systems will be designed to ensure adequate drainage of the bridge superstructure, taking account of climate change (see Table 28). The impacts associated with extreme cold weather events will be managed through the selection of materials with appropriate durability requirements, informed by HS2 Ltd Technical Standards and best practice e.g. British Standards and Eurocodes. In addition, bridge drainage features will be designed to be accessible where possible to help ensure maintenance access.	**Likelihood level: Unlikely** The likelihood of this climate change impact is unlikely due to appropriate material selection and appropriate drainage design, taking account of design life (60 years for drainage pipes).	**Consequence level: Low** The consequence of the climate change impact is low. In the unlikely event of extreme low temperatures freezing drainage components, resultant blockages could result in localised flooding. This could incur low costs and delays to journey times. Additional costs will also be incurred associated with additional	**Low**	No additional resilience measures required

Climate change trend	Potential impact on HS2 Ltd asset group	Existing/embedded mitigation	Likelihood of impact on HS2 Ltd asset group	Consequence of impact on HS2 Ltd asset group	Risk level	Additional mitigation measures
		During the operational stage, a regular programme of maintenance will be undertaken including general inspection, monitoring and replacement of the asset where necessary allowing for preventative maintenance (or asset replacement) before a service-disrupting failure occurs.		remedial/replacement works of asset components.		
Increased frequency of heavy rainfall events. Increase in mean winter rainfall.	Wetter winters and more frequent heavy rainfall events, leading to greater and more frequent flood flows, would increase the likelihood of scouring action on bridge piers and abutments.	During the detailed design stage, piers and abutments located within the floodplain will be avoided. Where it is not possible to locate these assets outside of the flood zone, the impacts associated with climate change on flood flows and potential scouring of vulnerable bridge structures will be assessed through a scour assessment. This will consider risks associated with natural processes (channel migration/degradation), contraction (increases in velocity from channel narrowing) and local (piers and abutments) scour, with calculations based upon a range of flood design events up to the current 1 in 200 (0.5%) annual probability design event. The scour assessment will then inform the foundation and piles design, the selection of materials and other protection measures. For example, the selection of reinforced and waterproofed material will be used to strengthen abutments and piers taking account of durability requirements, informed by HS2 Ltd Technical Standards and best practice, for example, British Standards and Eurocodes. During the operational stage, a regular programme of maintenance will be undertaken including general inspection, monitoring and replacement of the asset where necessary allowing for preventative maintenance (or asset replacement) before a service-disrupting failure occurs. In the event of a flood, post event inspections and remedial maintenance will be carried out where necessary.	**Likelihood level: Unlikely** The climate change impact resulting in scouring of the bridge superstructure is unlikely to occur as the scour assessment will consider the potential impacts of climate change of flood flows and appropriate scour mitigation will be designed. Regular maintenance and post event inspections should also ensure remedial action prior to degradation or failure of the protection measures.	**Consequence level: Low** The consequence of the climate change impact is low. Following an extreme flood event, additional maintenance activities could be undertaken including remedial works and replacement of scour mitigation measures which will result in additional low costs being incurred. This could also result in speed restrictions, whilst post event works are being undertaken which could have a low impact upon journey times resulting in delays.	**Low**	No additional resilience measures required
Increased frequency of heavy rainfall events.	More frequent heavy rainfall events would lead to an increased likelihood of flooding and/or flood debris blocking the bridge structure.	During the detailed design stage, the impacts associated with flooding and potential blocking of the bridge structure with debris will be managed in accordance with the HS2 Ltd Technical Standards, which require the bridge soffit level (and bearings) to be set above the 1 in 100 (1%) annual probability design event, including an additional allowance for climate change and the provision of a 600mm freeboard. This will also accommodate for 10-50% blockage of the bridge. During the operational stage, a regular programme of maintenance will be undertaken including general inspection, monitoring and replacement of the asset where necessary allowing for preventative maintenance (or asset replacement) before a service-disrupting failure occurs. In the event of a flood, post event inspections and maintenance will be carried out where necessary.	**Likelihood level: Unlikely** The climate change impact resulting in flood of the bridge structure is unlikely to occur as the setting of the bridge soffit level will take into account the impact of climate change on peak river flows over the design life of the asset (120 years for the bridge parapets and superstructure of the bridge) and potential impacts of blockages. Regular maintenance should ensure conveyance of water through the bridge structure and in the event of a flood, post event inspections and maintenance will be carried out where necessary.	**Consequence level: Low** The consequence of the climate change impact is low. The resultant impact could lead to the low cost of repair and maintenance associated with additional inspections and remedial works following a flood event. This could also result in speed restrictions, whilst post event works are being undertaken which could have a low impact upon journey times resulting in delays.	**Low**	No additional resilience measures required
Increase in mean winter rainfall.	Wetter winters would lead to higher groundwater levels and greater porewater pressures, which could result in flotation of foundations of the bridge superstructure and structural issues.	During the detailed design stage, geotechnical analysis will be undertaken to establish the geological and groundwater conditions across the route and any localised constraints or risks. In accordance with HS2 Ltd Technical Standards, allowances would be made for the effects of weathering and climate change, (see Table 25) and used to inform design e.g. foundation design and bridge superstructure. The impacts associated with porewater pressure will also be managed	**Likelihood level: Unlikely** The impact on the asset is unlikely to occur over the design life of the asset (120 years for bridges) due to mitigation measures implemented, for example, geotechnical analysis to ensure that groundwater levels are	**Consequence level: Low** The consequence of the climate change impact is low. The resultant impact could lead to the low cost of repair and maintenance associated with additional inspections and remedial works. This could also result	**Low**	No additional resilience measures required

Climate change trend	Potential impact on HS2 Ltd asset group	Existing/embedded mitigation	Likelihood of impact on HS2 Ltd asset group	Consequence of impact on HS2 Ltd asset group	Risk level	Additional mitigation measures
		through the selection of materials with appropriate durability requirements. During the operational stage, a regular programme of maintenance will be undertaken including general inspection and ground remediation actions where necessary.	designed for in the bridge and foundation design. A regular programme of bridge inspection and maintenance will help ensure that the impact is unlikely to occur and ground remedial actions are undertaken.	in speed restrictions, whilst post event works are being undertaken which could have a low impact upon journey times resulting in delays.		
Increased frequency of windstorm events in the second half of the 21st Century.	More frequent windstorm events would increase the likelihood of structural damage or stability issues associated with lightweight structures such as footbridges.	During the detailed design stage, the selection of materials and design of bridges will take into account the impacts associated with wind loading, informed by HS2 Ltd Technical Standards and best practice e.g. British Standards, Eurocodes and DMRB. During the operational stage, a regular programme of maintenance will be undertaken including general inspection, monitoring and replacement of the asset components where necessary allowing for preventative maintenance (or asset replacement) before a service-disrupting failure occurs.	**Likelihood level: Unlikely** The climate change impact is only projected within the second half of the 21st century and is unlikely to impact on the asset (120 years for bridges) due to the mitigation measures implemented e.g. incorporating wind loading into the bridge design, and the small increase in extreme winds that is projected, compared to the current climate.	**Consequence level: Low** The consequence of the climate change impact is low. The resultant impact could lead to the low cost of repair and maintenance associated with additional inspections and remedial works following an extreme wind event. This could also result in restricted pedestrian access and speed restrictions, whilst post event works are being undertaken which could have a low impact upon journey times resulting in delays.	**Low**	No additional resilience measures required
Increase in mean temperature across all seasons. Increased frequency of dry spells. Increase in mean winter rainfall.	An increased likelihood of wetter winters followed by longer or more frequent dry spells would result in greater fluctuations in soil moisture content. This can lead to shrink-swell processes in areas with susceptible soils, and subsequent damage to the structural elements of the asset.	During the detailed design stage, geotechnical analysis will be undertaken to establish the geological conditions across the route and any localised constraints or risks. In accordance with HS2 Ltd Technical Standards, allowances would be made for the effects of weathering and climate change (see Table 25) and used to inform structural design for the asset, for example taking into account the settlement of natural soil. During the operational stage, a regular programme of maintenance will be undertaken including general inspection, monitoring and replacement of the asset where necessary allowing for preventative maintenance (or asset replacement) before a service-disrupting failure occurs.	**Likelihood level: Unlikely** The climate change impact on shrink/swell processes and damage to the asset is unlikely to occur as the geotechnical investigations will be sufficient to inform the design and allow for additional (or different) ground works if required, taking account of current and future ground conditions, over the asset design life (120 years for the bridge parapets and superstructure of the bridge).	**Consequence level: Low** The consequence of the climate change impact is low. The resultant impact could lead to the low cost of repair and maintenance associated with additional inspections and remedial works following damage to structural elements. This could also result in speed restrictions, whilst post event works are being undertaken which could have a low impact upon journey times resulting in delays.	**Low**	No additional resilience measures required

Table 24: Tunnels (civils)

Climate change trend	Potential impact on HS2 Ltd asset group	Existing/embedded mitigation	Likelihood of impact on HS2 Ltd asset group	Consequence of impact on HS2 Ltd asset group	Risk level	Additional mitigation measures
Increase in mean temperature across all seasons.	Higher temperature and carbon dioxide levels would lead to increased impact on chloride and carbonation induced reinforcement corrosion of concrete asset components.	During the detailed design stage, the climate change impacts on chloride and carbonation induced reinforcement corrosion rates will be managed through the selection of materials with appropriate durability requirements, informed by HS2 Ltd Technical Standards and best practice for example, British Standards and Eurocodes. A durability assessment report for concrete segments of the tunnels will be undertaken. Increased temperatures within the tunnels will also be managed through appropriate tunnel ventilation design (see Table 32). During the operational stage, a regular programme of maintenance will be undertaken including general inspection and monitoring of the asset where necessary.	**Likelihood level: Unlikely** The climate change impact is unlikely to occur over the design life of the asset (120 years) due to the selection of appropriate materials.	**Consequence level: Very Low** The consequence of the climate change impact is very low with regular asset inspections and maintenance ensuring repair works are carried out without causing lasting delays.	**Low**	No additional resilience measures required
Increase in mean winter rainfall.	Wetter winters could lead to higher groundwater levels and greater hydraulic pressures, which could increase the likelihood of failures and groundwater ingress into the tunnel.	During the detailed design stage, the climate change impacts on groundwater levels (and therefore potential ingress) will be managed through consideration of: a high water table (1m below ground level); changes in groundwater levels and pore water pressures associated with the maximum flood water level (including maximum groundwater pressure) and minimum foreseeable groundwater pressure; and the selection of materials. For example, segmented tunnels (which include cast in place linings, waterproof sheet membrane and double gaskets) will be designed to include a surcharge load and will be watertight in accordance with leakage criteria in the HS2 Ltd Technical Standards and British Tunnel Society specifications. During the operational stage, monitoring will be undertaken to verify long term movement of tunnel linings, with water tightness and sump pump arrangements allowing any (minor) water seepage into the tunnels to be collected and discharged.	**Likelihood level: Unlikely** The climate change impact is unlikely to occur as tunnels are designed to be watertight regardless of groundwater levels over its 120 year design life.	**Consequence level: Low** , The consequence of the climate change impact is low with regular asset inspections and maintenance ensuring remedial, repair or replacement works are undertaken, which could include low cost replacement of linings or sheet membranes.	**Low**	No additional resilience measures required
Increase in mean winter rainfall. Increased frequency of heavy rainfall events.	Wetter winters and more frequent extreme rainfall events could lead to an increased likelihood of flooding and/or water ingress into tunnels and surface structures (e.g. headhouses and portals).	During the outline design stage, surface features such as portals and shafts will be located outside of areas at risk of flooding. Portals will be designed to be porous and will incorporate flood risk reduction measures such as appropriate sealing and drainage systems (see Table 28). Where tunnel shafts are required, the risk of flooding will be managed in accordance with the HS2 Ltd Technical Standards, which require the level of shaft entrances to be raised above the current 1 in 1,000 (0.1%) annual probability design event plus 300mm freeboard and/or additional risk reduction measures such as appropriate sealing, flood barriers, sump pump arrangement and appropriate drainage. During the operational stage, inspection and maintenance will be carried out on flood mitigation measures include surface water drainage to ensure these are operating effectively.	**Likelihood level: Unlikely** In areas at risk of flooding, the climate change impact is unlikely to occur due to the high flood design standards (current 1 in 1,000 (0.1%) annual probability design event) and associated freeboard being applied. The risk of flooding is expected to increase with time due to the impact of climate change; however, in high flood risk locations, consideration will be given to adapting the design (e.g. increasing freeboard levels) or taking other precautions (e.g. warnings and temporary line closures) to ensure the likelihood of the impact remains low over the design life of the asset.	**Consequence level: Medium** The consequence of the climate change impact is medium. The flood design and drainage standards adopted would limit flooding to extreme events that exceed these design standards or due to drainage blockages however this could result in localised flooding causing delays of up to a day. Ongoing inspection and maintenance will however manage these residual risks with consequences limited to low costs and limited delays to journey time.	**Low**	No additional resilience measures required

Climate change trend	Potential impact on HS2 Ltd asset group	Existing/embedded mitigation	Likelihood of impact on HS2 Ltd asset group	Consequence of impact on HS2 Ltd asset group	Risk level	Additional mitigation measures
Decreased frequency of cold weather events (e.g. snow and ice).	Although cold weather events will become less frequent, build-up of ice on the inside of tunnels and at portal entrances will still occur, increasing the likelihood of damage to tunnel linings.	During the detailed design stage, all structural elements, sealing materials and waterproof membranes shall be designed to withstand the environmental and operational conditions including from the effects of freeze/ thaw actions for the design life. Excess water entering the tunnels and causing formation of ice will be managed by appropriate drainage strategy. During the operational stage, a regular programme of maintenance will be undertaken including general inspection, monitoring and remedial works for example, re-sealing/grouting of seals where necessary allowing for preventative maintenance before a service-disrupting failure occurs.	**Likelihood level: Unlikely** Damage from build-up of ice is unlikely to occur over the design life of the asset due to the fact that the design life has been considered in the specification of material - the tunnel lining is difficult to replace (120 year design life), and the design, monitoring and maintenance of the drainage system will reduce the likelihood of ice formation. The current design is more resilient than traditional tunnel construction through the use of a fibre reinforced concrete design.	**Consequence level: Very Low** The consequence of the climate change impact is very low. The resultant impact could lead to the cost of repair and maintenance associated with the replacement of tunnel lining and could cause delays lasting several hours. This impact can be further managed by carrying out maintenance outside of peak times to minimise disruption to operation with limited consequences.	**Low**	No additional resilience measures required
Increase in mean temperature across all seasons. Increased frequency of dry spells. Increase in mean winter rainfall.	An increased likelihood of wetter winters followed by hotter drier summers can result in fluctuating moisture content. This can lead to shrink-swell processes in areas with susceptible ground conditions, and subsequent damage to the structural elements of the tunnel.	During the detailed design stage, geotechnical analysis will be undertaken to establish the geological conditions across the route and any localised constraints or risks. In accordance with HS2 Ltd Technical Standards, allowances would be made for the effects of weathering and climate change (see Table 25) and used to inform design e.g. foundation and structural design. During the operational stage, a regular programme of maintenance will be undertaken including general inspection, monitoring, remedial works, or replacement of damaged sub-assets where necessary. HS2 Ltd shall undertake long term structural health monitoring for a number of tunnel rings/tunnel structures through the use of laser technology. In addition, the internal conditions of the tunnel bore will be monitored to ensure detection of any surface defects or irregularities, which may be a manifestation of ground movements.	**Likelihood level: Unlikely** The climate change impact on shrink/swell processes and damage to the asset is unlikely to occur as the geotechnical investigations will be sufficient to inform the design and allow for additional ground remediation if required, taking account of current and future ground conditions, over the asset design life.	**Consequence level: Very Low** The consequence of the climate change impact is very low with regular asset inspections and maintenance ensuring remedial, repair or replacement works are undertaken prior to the asset failing and causing larger consequences.	**Low**	No additional resilience measures required

Table 25: Earthworks

Climate change trend	Potential impact on HS2 Ltd asset group	Existing/embedded mitigation	Likelihood of impact on HS2 Ltd asset group	Consequence of impact on HS2 Ltd asset group	Risk level	Additional mitigation measures
Increased frequency of heatwaves.	More frequent drought conditions would lead to an increased likelihood of earthwork planting failure/loss due to a lack of sufficient water availability, causing earthwork stability issues.	During the outline design stage, earthworks will not be designed to rely upon the effects of vegetation for stability. A zone of influence surrounding the track will be incorporated which includes the avoidance of tree and shrub planting within earthworks, in accordance with the HS2 Technical Standards (see Table 27). This will avoid any impacts on structural integrity as a result of planting failures. During the operational stage, routine inspections and maintenance of embankments will be undertaken, including vegetation management and health checks of adjacent trees to ensure vegetation does not encroach into the earthworks.	**Likelihood level: Unlikely** By avoiding planting on earthworks, the risk of instability issues due to planting failure will be avoided. Regular maintenance and the removal of any unwanted vegetation from earthworks will mean that the climate change impact is unlikely to occur.	**Consequence level: Very Low** Monitoring and maintenance strategies will ensure unwanted vegetation does not encroach onto embankments keeping the consequence of the climate change impact very low.	**Low**	No additional resilience measures required
Increase in mean daily maximum temperature.	Higher temperatures and more frequent heatwaves would lead to an increased likelihood of instability and weakening of the geosynthetic reinforced layers of earthworks leading to tensile creep and rupture.	During the detailed design stage, geosynthetics will be specified in line with HS2 Ltd Technical Standards and guidance contained within the British Standard for strengthened/reinforced soils (BS8006) to ensure that the selection of materials is suitable for future design temperatures. The geosynthetics to be specified are used in many countries, including those already significantly warmer than the UK (e.g. throughout Europe). Geosynthetics reinforced layers (e.g. geo-grids) will also be buried within earthworks to avoid exposure to sunlight and therefore their exposure to future temperature fluctuations will be limited. During the operational stage, monitoring and maintenance strategies include the regular inspection of the earthworks. This will inform asset maintenance requirements before a service-disrupting failure of the earthworks occurs.	**Likelihood level: Unlikely** The climate change impact is unlikely to occur over the design life of the asset (120 years) as a result of detailed materials durability specifications for the synthetic layers of the earthworks.	**Consequence level: Low** The consequence of the climate change impact is low, due to the material specifications taking into account higher temperatures Low costs may be incurred associated with additional inspections and preventative maintenance works which would be carried out to help mitigate the impact of earthwork distortions, before a service-disrupting failure would occur. Maintenance works will preferentially be undertaken during the overnight maintenance period to avoid consequences associated with delays.	**Low**	No additional resilience measures required
Increased frequency of heavy rainfall events.	Wetter winters and more frequent rainfall events, leading to greater and more frequent flood flows would lead to an increased likelihood of scouring action and erosion of earthworks and slope material.	During the outline design stage, the placement of earthworks within the floodplain will be avoided, where viaducts will be used to carry the track alignment in these locations. Earthworks will be designed with perimeter drainage at the toe of the embankment or crest of a cutting, in addition to the track drainage, which will capture and convey surface water away from the earthworks, thereby reducing the risk of scouring. The design standard for drainage features will include an allowance for climate change (see Table 28). Where earthworks remain at risk of erosion (e.g. in Flood Zones) scour protection shall be included. During the operational stage, a regular programme of maintenance will be undertaken including general inspections (including inspections following a flood event) of the earthworks and drainage features, allowing for preventative maintenance such as the clearing of perimeter drainage.	**Likelihood level: Unlikely** The climate change impact resulting in scouring of embankments is unlikely to occur over the design life of the earthworks (120 years) due to avoidance of earthworks within floodplains and appropriate drainage design taking into account climate change. During extreme events that exceed flood risk design standard, monitoring and maintenance will allow for preventative measures before the impact of scour and erosion of the earthworks would occur.	**Consequence level: Low** Avoidance of earthworks within the floodplain alongside drainage design taking into account climate change will keep consequences of scouring to the earthworks low. Low costs may be incurred associated with additional inspections and preventative maintenance works which would be carried out to help mitigate the impact of scour before a service-disrupting failure would occur. Maintenance works will preferentially be undertaken during the overnight maintenance period to avoid consequences associated with delays.	**Low**	No additional resilience measures required

Climate change trend	Potential impact on HS2 Ltd asset group	Existing/embedded mitigation	Likelihood of impact on HS2 Ltd asset group	Consequence of impact on HS2 Ltd asset group	Risk level	Additional mitigation measures
Increase in mean winter rainfall.	Wetter winters and more frequent rainfall events would lead to an increased likelihood of earthwork failure (e.g. slips and slumps).	During the detailed design stage, geotechnical analysis will be undertaken in accordance with HS2 Ltd Technical Standards to develop the earthworks design and to mitigate the effects of geohazards that impact on slope stability. This shall consider hazards relating to extreme wet weather conditions including groundwater levels, artesian and sub-artesian conditions, location of springs, and seasonal variations of these including allowances for the effects of climate change. This shall be used to ensure robust embankment design for example the selection of appropriate fill material types / subdivisions, slope grading, and crest or toe drainage. During the operational stage, routine monitoring and maintenance strategies will be undertaken without disruption to the rail operation and will include inspection of drainage and signs of movement following prolonged or heavy rainfall events.	**Likelihood level: Unlikely** The climate change impact is unlikely to occur over the design life of the asset (120 years) due to the detail design work, which includes a detailed assessment of slope stability that takes into account rainfall extremes and climate change.	**Consequence level: Low** Detailed design assessments along with monitoring and maintenance strategies, will keep the consequences of climate change impacts low. Low costs may be incurred associated with additional inspections and preventative maintenance works, such as soil nails or micropiles, which would be carried out to help mitigate the impact of earthwork slips, before a service-disrupting failure would occur. Maintenance works will preferentially be undertaken during the overnight maintenance period to avoid consequences associated with delays.	**Low**	No additional resilience measures required
	Wetter winters and more frequent rainfall events would increase the likelihood of sinkholes where ground conditions permit, leading to earthwork failure.	During the detailed design stage, geotechnical analysis will be undertaken in accordance with HS2 Ltd Technical Standards to develop the earthworks design. Detailed ground investigations will identify local areas of risk, relating to geotechnical characteristics of the in-situ ground including specific risks associated with particular geological units that are susceptible to sinkholes forming and subsidence. Where these are identified, mitigation through ground improvement or another appropriate stabilisation will be considered. During the operational stage, routine inspections, monitoring and maintenance will be undertaken including the regular inspection of the earthworks and drainage to ensure they are performing as designed. Where ground movement instrumentation has been installed this will be used to monitor settlements.	**Likelihood level: Unlikely** The climate change impact is unlikely to occur over the design life of the asset (120 years) due to the detailed design and construction activities, which considers slope stability and preparatory ground improvement works.	**Consequence level: Low** Detailed design assessments, ground improvement works, slope stability measures, and monitoring and maintenance strategies, will keep consequences low. Low costs may be incurred associated with additional inspections and preventative maintenance works which would be carried out to help mitigate the impact of earthwork distortions, before a service-disrupting failure would occur. Maintenance works will preferentially be undertaken during the overnight maintenance period to avoid consequences associated with delays.	**Low**	No additional resilience measures required
	Wetter winters and more frequent heavy rainfall events would lead to an increased likelihood of earthwork planting failure due to groundwater saturation in the root zone. This would increase the likelihood of instability within the earthwork, increasing its vulnerability to erosion.	During outline design stage, embankment slopes shall be designed to ensure their stability and reliability given the effect of any existing nearby trees or vegetation. Planting of any new trees and shrubs within earthworks will be avoided in accordance with HS2 Ltd Technical Standards (see Table 27) and earthworks will be designed not to rely upon the effects of vegetation for stability. During the operational stage, routine inspections and maintenance of embankments will be undertaken, including vegetation management and health checks of adjacent trees to ensure vegetation does not encroach into the earthworks.	**Likelihood level: Unlikely** By designing earthworks not to rely upon the benefits of vegetation for stability and avoiding planting on earthworks altogether, the risk of erosion due to planting failure will be avoided. Regular maintenance and the removal of any unwanted vegetation from earthworks will mean that the climate change impact is unlikely to occur.	**Consequence level: Very Low** Monitoring and maintenance strategies will ensure unwanted vegetation does not encroach onto embankments keeping the consequence of the climate change impact very low.	**Low**	No additional resilience measures required

Climate change trend	Potential impact on HS2 Ltd asset group	Existing/embedded mitigation	Likelihood of impact on HS2 Ltd asset group	Consequence of impact on HS2 Ltd asset group	Risk level	Additional mitigation measures
	Wetter winters would result in rising groundwater levels, which would increase the likelihood of seepage from cuttings, causing loss of strength and stability through saturation of the material.	During the detailed design stage, geotechnical analysis will be undertaken in accordance with HS2 Ltd Technical Standards to develop the earthworks design and to mitigate the effects of geohazards that impact on slope stability. This shall consider hazards relating to extreme wet weather conditions including groundwater levels, artesian and sub-artesian conditions and seasonal variations of these including allowances for the effects of climate change. This shall be used to ensure robust design of cuttings and where potential seepages are identified, cutting slopes will include drainage. During the operational stage, routine monitoring and maintenance strategies will include the regular inspection of the earthworks in cuttings. This will inform asset maintenance requirements (e.g. drain clearance) before a service-disrupting failure of the earthworks occur.	**Likelihood level: Unlikely** The climate change impact is unlikely to occur over the design life of the asset (120 years) as a result of detailed groundwater and slope stability assessments and appropriate drainage design taking into account climate change.	**Consequence level: Low** Due to the detailed slope stability calculations, the consequence of the climate change impact is low. Low costs may be incurred associated with additional inspections and preventative maintenance works which would be carried out to help mitigate the impact of seepage, before a service-disrupting failure would occur. Maintenance works will preferentially be undertaken during the overnight maintenance period to avoid consequences associated with delays.	**Low**	No additional resilience measures required
Decreased frequency of cold weather events (e.g. snow and ice).	Although cold weather events will become less frequent, they will still occur, leading to embankment heave or degradation due to frost. This, coupled with thaw-weakening when the frost subsides, would increase the likelihood of stability issues.	During the detailed design stage, the effects of frost on the stability of the surface of cutting and embankment slopes through their design life will be undertaken in accordance with HS2 Ltd Technical Standards, which prohibit movement of the track from frost-heave. Therefore, materials will be selected to ensure the provision of non-frost susceptible materials within the earthworks. During the operational stage, monitoring and maintenance strategies include ground movement monitoring instrumentation built into embankments in areas considered of high risk to monitor earthwork reliability and long-term stability and settlement. This will inform asset maintenance requirements before a service-disrupting failure of the earthwork occurs.	**Likelihood level: Unlikely** As a result of detailed materials selection and durability specifying only non-frost susceptible materials, the climate change impact of frost heave is unlikely to occur.	**Consequence level: Low** Due to the material specifications taking into account higher temperatures, the consequence of the climate change impact is low. Low costs may be incurred associated with additional inspections and preventative maintenance works which would be carried out to help mitigate the impact of earthwork distortions, before a service-disrupting failure would occur. Maintenance works will preferentially be undertaken during the overnight maintenance period to avoid consequences associated with delays.	**Low**	No additional resilience measures required
Increase in mean temperature across all seasons. Decrease in mean summer rainfall.	An increased likelihood of wetter winters followed by longer or more frequent dry spells would result in greater fluctuations in soil moisture content. This can lead to shrink-swell processes in areas of susceptible soils, causing instability within the earthwork through a reduction in soil strength and cohesion. Hotter, drier summers would lead to increased evaporation and consequent shrinkage of susceptible soil.	During the detailed design stage, geotechnical analysis will be undertaken in accordance with HS2 Ltd Technical Standards to develop the earthworks design and to mitigate the effects of geohazards that impact on slope stability. This shall consider groundwater levels and/or pressures at all possible extremes taking into account climatic and seasonal variations (e.g. adverse weather conditions, such as prolonged periods of precipitation or prolonged drought) including allowances for the effects of climate change. This shall be used to ensure robust embankment design for example the selection of appropriate earthwork materials (i.e. those not susceptible to shrink swell) and crest or toe drainage. During the operational stage, a regular programme of maintenance (e.g. drain clearance and vegetation management) will be undertaken	**Likelihood level: Unlikely** The climate change impact on shrink/swell process and subsequent stability impacts to the earthworks is unlikely to occur over the design life of the asset as the geotechnical investigations will be sufficient to inform the design, taking account of current and future ground conditions, and asset design life.	**Consequence level: Low** Due to the detailed ground investigations informing localised ground improvements in areas susceptible to shrink/swell, the consequence of the climate change impact is low. Low costs may be incurred associated with additional inspections and preventative maintenance works which would be carried out to help mitigate the impact of shrink/swell, before a service-disrupting failure would occur. Maintenance works will preferentially be undertaken during the overnight	**Low**	No additional resilience measures required

Climate change trend	Potential impact on HS2 Ltd asset group	Existing/embedded mitigation	Likelihood of impact on HS2 Ltd asset group	Consequence of impact on HS2 Ltd asset group	Risk level	Additional mitigation measures
Increase in mean winter rainfall.	This would lead to an increased likelihood of desiccation cracking, causing instability within the earthworks. Wetter winters could then result in infiltration of water into the earthworks causing further instability issues.	including and general inspection and ground movement monitoring where necessary.		maintenance period to avoid consequences associated with delays.		
Increased frequency of windstorm events in the second half of the 21st Century.	More frequent windstorm events would increase the likelihood of direct wind erosion on exposed faces of earthworks slopes and indirect stability issues by consequent falling trees.	During the detailed design stage, all embankments will be designed to be stable and shall be finished to meet the landscape requirements in line with HS2 Ltd Technical Standards. For example, earth structure slopes will be grass seeded, minimising the susceptibility of the earthworks to wind erosion. In accordance with the HS2 Technical Standards, a zone of influence surrounding the track will also prevent planting in areas that could affect earthworks, which will remove any risk from falling trees. During the operational stage, routine inspections and maintenance will be undertaken without disruption to the rail operation, for example inspections following storm events will identify any erosion to inform maintenance requirements.	**Likelihood level: Unlikely** The climate change impact resulting in earthworks erosion is unlikely to occur due to the specified zone of influence, grass seeding, and maintenance regimes.	**Consequence level: Very Low** Grass-seeded earthworks and the inclusion of a zone of influence preventing tree planting within earthworks will keep consequences of wind erosion very low. Very low consequences associated with delays will be further managed by undertaking maintenance works overnight.	**Low**	No additional resilience measures required

Table 26: Retaining structures

Climate change trend	Potential impact on HS2 Ltd asset group	Existing/embedded mitigation	Likelihood of impact on HS2 Ltd asset group	Consequence of impact on HS2 Ltd asset group	Risk level	Additional mitigation measures
Increase in mean winter rainfall.	Wetter winters would result in rising groundwater levels increasing the likelihood of hydrostatic build-up behind retaining structures and causing stability issues.	During the detailed design stage, geotechnical analysis will be undertaken in accordance with HS2 Ltd Technical Standards. This shall consider hazards relating to extreme wet weather conditions including groundwater levels, artesian and sub-artesian conditions and seasonal variations of these including allowances for the effects of climate change. Where necessary, further mitigation such as weepholes will be provided to reduce pore water pressure behind the retaining structures. During the operational stage, a regular programme of inspections (including post flood event inspections) and maintenance of the retaining structure and drainage features will be undertaken, allowing for preventative maintenance such as the clearing of drainage.	**Likelihood level: Unlikely** The climate change impact is unlikely to occur over the design life of the retaining structure (120 years) due to groundwater and geotechnical analysis (that take climate change into account) used to inform the design and the provision of embedded mitigation such as appropriate drainage.	**Consequence level: Low** Maintenance and monitoring strategies will keep consequences low. Low costs may be incurred associated with additional inspections and preventative maintenance works which would be carried out before a service-disrupting failure would occur, for example additional drainage clearance. Maintenance works will preferentially be undertaken during the overnight maintenance period to avoid consequences associated with delays.	**Low**	No additional resilience measures required
Increased frequency of heavy rainfall events.	Wetter winters and more frequent heavy rainfall events, leading to greater and more frequent flood flows would lead to an increased likelihood of scouring action and erosion of retaining structures and slope material.	During the outline design stage, the placement of retaining structures within the floodplain will be avoided, instead viaducts will be used to carry the track alignment in these locations. During the detailed design stage, retaining structures (in addition to the track) will be designed with perimeter drainage to capture and convey surface water away from the retaining structures and reduce the effects of scour due to surface water flow. The design of drainage features will include an allowance for climate change (see Table 28).	**Likelihood level: Unlikely** The climate change impact is unlikely to occur over the design life (120 years) due to the avoidance of retaining structures within floodplains, with provision for appropriate drainage design and materials selection taking into account durability and climate change.	**Consequence level: Low** Maintenance and monitoring strategies will keep consequences low. Low costs may be incurred associated with additional inspections and preventative maintenance works which would be carried out to help mitigate the impact of scour, before a service-disrupting failure would occur,	**Low**	No additional resilience measures required

Climate change trend	Potential impact on HS2 Ltd asset group	Existing/embedded mitigation	Likelihood of impact on HS2 Ltd asset group	Consequence of impact on HS2 Ltd asset group	Risk level	Additional mitigation measures
		Structure materials not susceptible to scour will also be selected (e.g. reinforced soils) but if scour remains a residual risk, then concrete or steel walls will be considered. During the operational stage, a regular programme of maintenance and general inspections (including inspections following a flood event) of the retaining structures and drainage features will be undertaken, allowing for preventative maintenance such as the clearing of perimeter drainage.		for example additional drainage clearance. Maintenance works will preferentially be undertaken during the overnight maintenance period to avoid consequences associated with delays.		
Increase in mean temperature across all seasons.	Higher temperature and carbon dioxide levels would lead to increased impact on chloride and carbonation induced reinforcement corrosion of concrete asset components.	During the detailed design stage, the climate change impacts on chloride and carbonation induced reinforcement corrosion rates will be managed through the selection of materials with appropriate durability requirements, informed by HS2 Ltd Technical Standards and best practice for example, British Standards and Eurocodes. A durability assessment report for concrete segments of retaining structures will be undertaken. During the operational stage, a regular programme of maintenance will be undertaken including general inspection and monitoring of the asset where necessary.	**Likelihood level: Unlikely** During higher temperatures, the rate in which concrete corrosion occurs is unlikely to increase over the design life (120 years) due to the appropriate selection of materials e.g. weathering steel. In addition, regular monitoring and maintenance should help to ensure asset quality to prevent failure.	**Consequence level: Very Low** The consequence of the climate change impact is very low. In the unlikely event of degradation of the asset occurring, very low costs will be incurred associated with additional remedial/replacement works of asset components prior to the structural stability of the asset being compromised.	**Low**	No additional resilience measures required
Increased frequency of heatwaves. Decrease in mean summer rainfall.	More frequent drought conditions would lead to an increased likelihood of earthwork planting failure/loss due to a lack of sufficient water availability, causing non-uniform settlement of foundations and instability.	During outline design, a zone of influence surrounding the track will be incorporated which includes the avoidance of tree and shrub planting within retaining earthworks or adjacent to retaining walls, in accordance with the HS2 Ltd Technical Standards. This will avoid any impacts on structural integrity of the retaining structures as a result of tree and shrub planting failures. Retaining structures will also be designed not to be sensitive to moisture changes from vegetation. During the operational stage, routine inspections and maintenance of retaining structures will be undertaken, including vegetation management to ensure vegetation does not encroach into retaining structures.	**Likelihood level: Unlikely** By avoiding planting on or adjacent to retaining structures the risk of instability issues due to planting failure will be avoided. Regular maintenance and the removal of any unwanted vegetation from earthworks will result in the climate change impact being unlikely to occur.	**Consequence level: Very Low** Monitoring and maintenance strategies will ensure unwanted vegetation does not encroach onto embankments keeping the consequence of the climate change impact very low.	**Low**	No additional resilience measures required
Increase in mean temperature across all seasons. Decrease in mean summer rainfall. Increase in mean winter rainfall.	An increased likelihood of wetter winters followed by longer or more frequent dry spells would result in greater fluctuations in soil moisture content. This can lead to shrink-swell processes in areas with susceptible soils, causing foundation settlement and deformation of the retaining walls.	During the detailed design stage, geotechnical analysis will be undertaken in accordance with HS2 Ltd Technical Standards to develop the structure design and to mitigate the effects of shrinkage (including cracking) and swelling in natural clay soils. This shall consider groundwater levels and/or pressures at all possible extremes taking into account climatic and seasonal variations (e.g. adverse weather conditions, such as prolonged periods of precipitation or prolonged drought) including allowances for the effects of climate change. Backfills to retaining structures will use materials which are not susceptible to shrink-swell behaviours. During the operational stage, routine inspections and maintenance (e.g. drain clearance and vegetation management) will be undertaken without disruption to the rail operation, including ground movement monitoring where necessary.	**Likelihood level: Unlikely** The climate change impact on shrink/swell process and subsequent stability impacts to the retaining structure is unlikely to occur as the geotechnical investigations will be sufficient to inform the design, taking account of current and future ground conditions, and asset design life.	**Consequence level: Low** Due to the detailed ground investigations informing localised ground improvements in areas susceptible to shrink/swell, the consequence of the climate change impact is low. Low costs may be incurred associated with additional inspections and preventative maintenance works which would be carried out to help mitigate the impact of shrink/swell, before a service-disrupting failure would occur. Maintenance works will preferentially be undertaken during the overnight maintenance period to avoid consequences associated with delays.	**Low**	No additional resilience measures required

Climate change trend	Potential impact on HS2 Ltd asset group	Existing/embedded mitigation	Likelihood of impact on HS2 Ltd asset group	Consequence of impact on HS2 Ltd asset group	Risk level	Additional mitigation measures
Decreased frequency of cold weather events (e.g. snow and ice). Increase in mean temperature across all seasons. Increase in mean winter rainfall.	Although cold weather events will become less frequent, they will still occur, potentially leading to freeze-thaw cycles and weathering of retaining walls.	During the detailed design stage, materials used for retaining walls are specified as reinforced concrete walls which are not susceptible to freeze-thaw impacts in accordance with HS2 Ltd Technical Standards. In addition, concrete mix designs and nominal reinforcement cover width are based on exposure conditions of the local environment as stated in British Standard 8500-01 (specifying concrete guidance), taking into account future climate change such as an increase in mean winter rainfall. During the operational stage, monitoring and maintenance strategies include inspection of the retaining structures during regular asset inspections.	**Likelihood level: Unlikely** The climate change impact is unlikely to occur due to appropriate materials durability selection and concrete design, taking into account environmental conditions, and because cold weather events are expected to decrease in frequency. Monitoring and maintenance regimes will identify areas of defects or minor drainage allowing for any repairs to be undertaken well before significant damage occurs to the retaining structure.	**Consequence level: Low** Maintenance and monitoring strategies will help keep consequences low. Low costs may be incurred associated with additional inspections and preventative maintenance works which would be carried out to help mitigate the impact of freeze-thaw before a service-disrupting failure would occur, for example localised reinforcement works. Maintenance works will preferentially be undertaken during the overnight maintenance period to avoid consequences associated with delays.	**Low**	No additional resilience measures required

Table 27: Soft landscaping and planting

Climate change trend	Potential impact on HS2 Ltd asset group	Existing/embedded mitigation	Likelihood of impact on HS2 Ltd asset group	Consequence of impact on HS2 Ltd asset group	Risk level	Additional mitigation measures
Increase in mean temperature across all seasons.	Higher temperatures would lead to a change in the composition of the vegetation specified as part of the soft landscape, for example, introduction and spread of invasive species or disease, which could compromise the design.	During the detailed design stage, vegetation will be specified and planted in accordance with the HS2 Ltd Technical Standards which specify the selection of species resilient to higher future temperatures for example, those of more southerly provenance. During the construction stage, vegetation should be grown in controlled conditions to prevent the spread of invasive species and species that have a low resilience to disease will be avoided. A Biosecurity Management Plan will be produced and will identify appropriate measures to prevent potential spread of invasive non-native species. Additionally, where required, a review of biosecurity issues relating to protected and/or notable species should be carried out to prevent the spread of disease, for example, tree species vulnerable to virulent tree pathogens. During the operational stage, ongoing maintenance of vegetation will be undertaken to ensure invasive and undesired species are managed appropriately for example, through the use of herbicides. Ongoing maintenance of vegetation (including checks for tree health to identify diseased or dying tree stock) will be undertaken and action taken as required, for example, any planting found to be defective will be replaced.	**Likelihood level: Unlikely** The introduction and spread of invasive species as a result of an increase in mean temperatures will be managed through the selection of resilient species and the implementation of a biosecurity plan which should prevent the spread of disease. Therefore, it is unlikely that this will impact upon the effectiveness of the soft landscaping design.	**Consequence level: Very Low** The consequence of the climate change impact is considered to be very low, linked to the low costs associated with more frequent vegetation maintenance or localised replacement of failed vegetation.	**Low**	No additional resilience measures required
	Higher temperatures would lead to a change in the growth rate of the vegetation which could compromise the design and impact upon railway operations.	During the detailed design stage, vegetation will be specified and planted in accordance with the HS2 Ltd Technical Standards which specify the selection of resilient species informed by an assessment of tree species growth rate. Additionally, a 'zone of influence', which provides a minimum of 10metre offset around the track, will be implemented to manage future vegetation encroachment and prevent impacts on railway operations.	**Likelihood level: Unlikely** Changes in the growth rate of vegetation as a result of an increase in mean temperatures, will be managed through the selection of resilient species and through ongoing operational management e.g. cutting and pruning of vegetation. Therefore, it is unlikely that this will impact on the	**Consequence level: Very Low** The consequence of the climate change impact is considered to be very low, linked to the low costs associated with more frequent vegetation maintenance or localised replacement of failed vegetation.	**Low**	No additional resilience measures required

Climate change trend	Potential impact on HS2 Ltd asset group	Existing/embedded mitigation	Likelihood of impact on HS2 Ltd asset group	Consequence of impact on HS2 Ltd asset group	Risk level	Additional mitigation measures
		During the operational stage, ongoing vegetation maintenance will be undertaken to prevent vegetation encroaching on the zone of influence. In addition, maintenance such as cutting of grassland will be undertaken and adjusted dependent upon growth rates throughout the season. Weed control will be monitored and managed as necessary for example, through the use of herbicides.	soft landscaping design. Additionally, ongoing maintenance of vegetation within the zone of influence around the tracks will be undertaken to prevent impacts on railway operations.			
Increase in mean temperature across all seasons. Increased frequency of dry spells. Increased frequency of heatwaves.	Higher temperatures and extended periods of hot days would lead to a change in the composition of the vegetation and soft landscaping features, which could include for example, species that present a higher fire risk increasing the vulnerability to wildfire/heathland fires.	During the detailed design stage, vegetation will be specified and planted in accordance with the HS2 Ltd Technical Standards which stipulate the avoidance of species that pose a high fire risk for example, eucalyptus. During the operational stage, ongoing maintenance of vegetation will be undertaken to ensure undesired species for example, bracken and gorse, are managed appropriately through pruning or coppicing to prevent a build-up of woody debris and leaf litter, which could pose a fire risk.	**Likelihood level: Possible** Whilst the avoidance of high fire risk specifies within the landscape design and future maintenance will help reduce the risk of fires in soft landscaping areas, the climate change impact would still increase the risk of fires outside of HS2 Ltd's area of influence, which if close enough, could impact on HS2 operations.	**Consequence level: Very Low** The climate change impact would result in additional costs associated with more frequent maintenance over the design life of the soft landscaping features. Any climate change impact resulting in incidents of fire outside of HS2 Ltd's area of influence could result in very low consequences to HS2 Ltd operations including delays to journey times.	**Low**	No additional resilience measures required
Decreased frequency of cold weather events (e.g. snow and ice).	Although cold weather events will become less frequent, they will still occur. Cold temperatures and frost conditions could result in planting failure.	During the detailed design stage, vegetation will be specified and planted in accordance with the HS2 Ltd Technical Standards which specify that planting of vegetation and seeding will be undertaken at a suitable time of the year to avoid periods of prolonged cold weather and reduce the risk of failure to germinate/establish. Additionally, translocation of vegetation should be undertaken avoiding frost/snow conditions. During the operational stage, ongoing maintenance of vegetation (including checks for tree health and ensuring tree pits drainage systems are effective and functional) will be undertaken and action taken as required, for example, any planting found to be defective will be replaced.	**Likelihood level: Unlikely** Failure of vegetation due to cold weather and frost conditions is unlikely, since vegetation translocation or seeding will be avoided during vulnerable periods. Regular inspections and maintenance will also help to ensure vegetation health is managed before widespread failure occurs.	**Consequence level: Very Low** The consequence of the climate change impact is considered to be very low, linked to the low costs associated with more frequent vegetation maintenance or localised replacement of failed vegetation.	**Low**	No additional resilience measures required
Increase in mean winter rainfall. Increased frequency of heavy rainfall events.	Wetter winters and more frequent heavy rainfall events would lead to an increased likelihood of planting failure due to groundwater saturation in the root zone.	During the detailed design stage, vegetation will be specified and planted in accordance with the HS2 Ltd Technical Standards which specify the selection of resilient vegetation (for example, those with stable root systems) to current and future groundwater levels as informed by site investigations and soil suitability surveys. Additionally, planting of vegetation and seeding will be undertaken at a suitable time of the year to avoid periods of high rainfall and reduce the risk of failure to germinate/establish. During the operational stage, ongoing maintenance of vegetation (including checks for tree health and ensuring tree pits drainage systems are effective and functional) will be undertaken and action taken as required, for example, any planting found to be defective will be replaced.	**Likelihood level: Unlikely** Failure of vegetation due to groundwater saturation is unlikely to occur due to the selection of resilient vegetation in vulnerable locations. Regular inspections and maintenance will also help to ensure vegetation health is managed before failure occurs.	**Consequence level: Very Low** The consequence of the climate change impact is considered to be very low, linked to the low costs associated with more frequent vegetation maintenance or localised replacement of failed vegetation.	**Low**	No additional resilience measures required
Increase in mean winter rainfall.	Wetter winters and more frequent heavy rainfall events would lead to an increased likelihood of	During the detailed design stage, vegetation will be specified and planted in accordance with the HS2 Ltd Technical Standards which specify the selection of resilient riparian vegetation (for example, those with stable root systems) along riverbanks or compensatory	**Likelihood level: Possible** Planting will still be undertaken in flood prone areas, and whilst mitigation, such as the use of geotextiles, will be	**Consequence level: Very Low** The consequence of the climate change impact is considered to be very low as, failure or loss of planting	**Low**	No additional resilience measures required

Climate change trend	Potential impact on HS2 Ltd asset group	Existing/embedded mitigation	Likelihood of impact on HS2 Ltd asset group	Consequence of impact on HS2 Ltd asset group	Risk level	Additional mitigation measures
Increased frequency of heavy rainfall events.	planting failure/loss due to high velocity flood flows.	wetland habitats. Additionally, mitigation such as geotextiles will be used to prevent washout during flood flows. During the operational stage, ongoing maintenance of vegetation (including checks for tree health) will be undertaken and action taken as required. Following large flood events, planting found to have failed or lost will be replaced.	implemented to reduce the likelihood of planting failure or loss due to high velocity flood flows, failure of planting during flood events is still possible.	due to high velocity flood flows will be limited to isolated locations, with a very low cost associated with additional maintenance or replacement.		
Increased frequency of dry spells.	More frequent drought conditions would lead to an increased likelihood of planting failure/loss due to a lack of sufficient water availability.	During the detailed design stage, vegetation will be specified and planted in accordance with the HS2 Ltd Technical Standards which specify the selection of resilient vegetation (including the avoidance of high-water demand species), and that seeding and planting should not be undertaken during periods of drought. Additionally, planting in more vulnerable locations will be subject to a site-specific risk assessment that will consider soil depth, rain shadow and gradient, with a preference for optimising passive water retention. During the operational stage, ongoing maintenance of vegetation (including checks for tree health) will be undertaken and action taken as required, for example, any planting found to be defective will be replaced. In addition, during the maintenance period and in the event of extreme drought, watering should be carried out until the onset of natural rainfall to minimise vegetation failure.	**Likelihood level: Possible** The likelihood of planting failure due to more frequent dry weather is possible. Whilst mitigation will be implemented such as the avoidance of vulnerable species and watering during prolonged dry weather, issues associated with cost or provision of water may prevent this from occurring if a larger geographical area is affected.	**Consequence level: Very Low** The consequence of the climate change impact is considered to be very low, linked to the low costs associated with more frequent vegetation maintenance or localised replacement of failed vegetation.	**Low**	No additional resilience measures required
	More frequent drought conditions would lead to an increased likelihood of waterbodies drying out which could compromise the design.	During the detailed design and construction stage, waterbodies/ponds creation locations will be specified in accordance with the HS2 Ltd Technical Standards. This includes locating species based upon hydrological suitability, particularly the likelihood of increased frequency and severity of drought conditions. During the operational stage, ongoing maintenance of waterbodies or ponds will be undertaken including the monitoring or pond quality and water regime.	**Likelihood level: Unlikely** The likelihood of waterbodies and ponds drying out is unlikely to occur due to the location of features based upon their hydrological suitability. Regular inspections and maintenance will also help to ensure waterbodies are managed before failure occurs.	**Consequence level: Very Low** Due to the mitigation measures implemented, drying out wetlands and ponds due to more frequent dry weather events, will be limited to isolated locations, with a very low cost associated with additional maintenance. Where failure occurs, the habitat will be replaced as it will be environmental mitigation.	**Low**	No additional resilience measures required
Increased frequency of windstorm events in the second half of the 21st Century.	More frequent windstorm events will increase the likelihood of damage or stability issues to vegetation.	During the detailed design stage, vegetation will be specified and planted in accordance with the HS2 Ltd Technical Standards which specify the selection of resilient vegetation (for example, those with stable root systems). An assessment of wind tolerance and the ability of existing trees within woodland edge management zones to withstand high winds will be undertaken. Additionally, a 'zone of influence', which provides a minimum of 10 metre offset around the track, will be implemented to manage future vegetation encroachment and prevent impacts on railway operations for example, falling branches and trees. During the operational stage, ongoing maintenance of vegetation (including checks for tree health) will be undertaken and action taken as required to avoid planting failure for example, ornamental planting will be inspected for wind firmness and firmed as necessary through underground guying and plant ties.	**Likelihood level: Possible** During windstorms, planting failure is possible, however regular inspections and maintenance will help to ensure vegetation health is managed before failure occurs.	**Consequence level: Very Low** The consequence of the climate change impact is considered to be very low, linked to the low costs associated with more frequent vegetation maintenance or localised replacement of failed vegetation. The implementation of the Zone of Influence around the track will help to prevent impacts on railway operations.	**Low**	No additional resilience measures required

Climate change trend	Potential impact on HS2 Ltd asset group	Existing/embedded mitigation	Likelihood of impact on HS2 Ltd asset group	Consequence of impact on HS2 Ltd asset group	Risk level	Additional mitigation measures
Increased frequency of lightning events in the second half of the 21st Century.	More frequent lightning events would lead to increased likelihood of lightning strikes and direct damage to trees potentially resulting in secondary impacts on HS2 Ltd's assets.	During the detailed design stage, vegetation will be specified and planted in accordance with the HS2 Ltd Technical Standards which specify the selection of resilient vegetation (for example, those with stable root systems to prevent the tree uprooting). Additionally, a 'zone of influence', which provides a minimum of 10metre offset around the track, will be implemented to manage future vegetation encroachment and prevent impacts on railway operations, for example, falling branches and trees. During the operational stage, ongoing maintenance of vegetation (including checks for tree health) will be undertaken as required, for example, any planting found to be defective will be replaced.	**Likelihood level: Possible** Due to the zone of influence around the track, secondary impacts of trees uprooting and affecting HS2 Ltd assets will be mitigated. However, as a result of lightning strikes on vegetation, direct planting failure is still possible.	**Consequence level: Very Low** The consequence of the climate change impact is considered to be very low, linked to the low costs associated with more frequent vegetation maintenance or localised replacement of failed vegetation. The implementation of the Zone of Influence around the track will help to prevent impacts on railway operations.	**Low**	No additional resilience measures required

Table 28: Drainage and flood conveyance systems

Climate change trend	Potential impact on HS2 Ltd asset group	Existing/embedded mitigation	Likelihood of impact on HS2 Ltd asset group	Consequence of impact on HS2 Ltd asset group	Risk level	Additional mitigation measures
Increase in mean daily maximum temperature. Increased frequency of heatwaves.	Higher temperatures and more frequent heatwaves would lead to an increased likelihood of damage to exposed drainage elements, for example cracking of pipes.	During the detailed design stage, the impacts associated with higher temperatures will be managed through the selection of materials with appropriate durability requirements, informed by HS2 Ltd Technical Standards and best practice, for example, British Standards and Eurocodes. The durability design will take account of the criticality and design life of drainage elements and asset drainage will be designed to be accessible where possible to help ensure maintenance access. During the operational stage, a regular programme of maintenance will be undertaken including general inspection, monitoring and replacement of the asset where necessary.	**Likelihood level: Unlikely** The likelihood of the climate change impact is unlikely due to appropriate material selection and drainage design, taking account of design life of the drainage element (120 years for inaccessible elements 60 years for non-critical accessible elements).	**Consequence level: Low** The consequence of the climate change impact is low. The resultant impact could lead to the low cost of repair and maintenance associated with additional inspections and replacement of drainage elements in the event of damage.	**Low**	No additional resilience measures required
Increase in mean temperature across all seasons.	Higher temperatures would lead to a change in the growth rate of the vegetation, which could compromise the design of soft landscape drainage features.	During the detailed design stage, soft landscape drainage elements (for example swales) will be specified and planted in accordance with the HS2 Ltd Technical Standards, which specify the selection of resilient species informed by an assessment of tree species growth rates (see Table 27). During the operational stage, ongoing vegetation maintenance such as cutting of soft landscape grassland will be undertaken and adjusted dependent upon growth rates throughout the season.	**Likelihood level: Unlikely** The likelihood of the climate change impact is unlikely. Whilst more resilient species will be selected, any changes in vegetation growth rate as a result of an increase in mean temperatures, will be managed through operational management, for example, more frequent cutting and pruning of vegetation.	**Consequence level: Very Low** The consequence of the climate change impact is considered to be very low, linked to the low costs associated with more frequent vegetation maintenance of soft landscaped drainage features, for example more frequent cutting and pruning of vegetation.	**Low**	No additional resilience measures required
Decreased frequency of cold weather events (e.g. snow and ice).	Although cold weather events will become less frequent, they will still occur resulting in a risk of freezing drainage features leading to blockages or damage of drainage elements, for example cracking of pipes.	During the detailed design stage, the impacts associated with cold temperatures will be managed through the selection of materials with appropriate durability requirements, informed by HS2 Ltd Technical Standards and best practice for example, British Standards and Eurocodes. In addition, the drainage elements will be designed to an appropriate gradient to prevent standing water and will be designed with an appropriate cover level to prevent freezing of water within pipes from low air temperatures, for example, the minimum cover from top of sub-ballast to top of pipe shall be 800mm.	**Likelihood level: Unlikely** The likelihood of this climate change impact is unlikely due to appropriate material selection and drainage design, taking account of design life of the drainage element (120 years for inaccessible elements 60 years for non-critical accessible elements).	**Consequence level: Very Low** The consequence of the climate change impact is low. The resultant impact could lead to the low cost of repair and maintenance associated with additional inspections and repair or replacement of drainage elements in the event of damage and could lead to journey time delays depending on the drainage asset affected.	**Low**	No additional resilience measures required

Climate change trend	Potential impact on HS2 Ltd asset group	Existing/embedded mitigation	Likelihood of impact on HS2 Ltd asset group	Consequence of impact on HS2 Ltd asset group	Risk level	Additional mitigation measures
		The durability design will take account of the criticality and design life of drainage elements and asset drainage will be designed to be accessible where possible to help ensure maintenance access. During the operational stage, a regular programme of maintenance will be undertaken including general inspection, monitoring and replacement of the asset where necessary.				
Increase in mean winter rainfall. Increased frequency of heavy rainfall events.	Wetter winters and more frequent heavy rainfall events, would lead to an increased likelihood of overwhelmed drainage features resulting in direct damage (e.g. scour) of the drainage elements. Direct damage could lead to failure and/or reduced drainage capacity leading to secondary impacts associated with localised flooding and possible inundation of adjacent assets. (For assets potentially affected by these secondary impacts, see asset specific CCR assessments).	During the detailed design stage, drainage elements will be water compatible and designed to accommodate rainfall intensities factored to include climate change allowances in accordance with HS2 Ltd Technical Standards and best practice such as, Environment Agency guidance and British Standards. For example, the performance of runoff attenuation elements for building and facility drainage will be assessed using a peak rainfall intensity allowance of 30% to take account of climate change and the performance of track drainage and runoff attenuation elements will be assessed using a peak rainfall intensity allowance of 40% to take account of climate change. During the operational stage, a regular programme of maintenance will be undertaken including general inspection, monitoring, repair and replacement of the asset where necessary. In the event of flooding, post event inspections of the drainage assets (and adjacent assets) and maintenance will be carried out where necessary.	**Likelihood level: Possible** Although drainage elements have been designed to include an uplift for climate change, it is possible that elements could become overwhelmed during the design life of the asset (120 years for inaccessible elements and 60 years for non-critical accessible elements). This could lead to scour around some assets as a result of design exceedance events. In the event of flooding, post event inspections and maintenance will be carried out where necessary.	**Consequence level: Low** The consequence of the climate change impact is low. The resultant impact could lead to low costs associated with additional inspections and repair or replacement of drainage elements in the event of damage and could lead to journey time delays depending on the drainage asset affected.	**Low**	No additional resilience measures required
Increase in mean winter rainfall. Increased frequency of heavy rainfall events.	Wetter winters would lead to an increased likelihood of higher groundwater levels, which if inundate drainage features, affect drainage performance (e.g. reduced drainage capacity). Groundwater inundation could lead to secondary impacts including localised flooding and possible inundation of other HS2 Ltd assets. (For assets potentially affected by these secondary impacts, see asset specific CCR assessments).	During the detailed design stage, drainage elements will be water compatible and Sustainable Drainage Systems (SuDS) will be designed to accommodate peak flows including climate change allowances in accordance with HS2 Ltd Technical Standards and best practice such as, Environment Agency guidance and British Standards. Where elevated groundwater levels may result in ingress into the drainage system, the system will be sensitivity tested to ensure sufficient capacity. During the construction stage, consideration would be given to the use of special boring and construction techniques to avoid obstruction of groundwater flows, particularly in Source Protection Zones (SPZ). During the operational stage, a regular programme of maintenance will be undertaken including general inspection, monitoring, repair and replacement of the asset where necessary. In the event of flooding, post event inspections of the drainage assets and maintenance will be carried out where necessary.	**Likelihood level: Possible** It is possible that groundwater ingress into drainage elements will occur, however given the consideration of climate change and embedded mitigation in the design, the resultant impact is likely to be limited to reduced capacity in the system for surface water (resulting in localised flooding or pooling of water).	**Consequence level: Low** The consequence of the climate change impact is low. The resultant impact could lead to low costs associated with additional inspections and repair or replacement of drainage elements in the event of damage and could lead to journey time delays depending on the drainage asset affected.	**Low**	No additional resilience measures required
Increase in mean winter rainfall.	More frequent heavy rainfall events would lead to an increased likelihood of flood	During the detailed design stage, the impacts associated with the potential blocking of drainage elements with debris will be managed in accordance with the HS2 Ltd Technical Standards. For example, track drainage will be sized appropriately, and the design will make	**Likelihood level: Likely** Blockage risk is included in the design of more vulnerable assets and will allow the probability of critical events	**Consequence level: Low** The consequence of the climate change impact is low. The resultant impact could lead to the low costs	**Medium**	No additional resilience measures required

Climate change trend	Potential impact on HS2 Ltd asset group	Existing/embedded mitigation	Likelihood of impact on HS2 Ltd asset group	Consequence of impact on HS2 Ltd asset group	Risk level	Additional mitigation measures
	debris damaging or blocking drainage elements features. Both direct damage and blockages could lead to secondary impacts associated with localised flooding and possible inundation of other HS2 Ltd assets. (For assets potentially affected by these secondary impacts, see asset specific CCR assessments).	provision for routing of flood waters away from the track in the event of blockage of drainage systems. A culvert / drainage blockage risk assessment will form part of the design for more vulnerable assets to inform the freeboard allowance. During the operational stage, a regular programme of maintenance will be undertaken including general inspection, monitoring and replacement of the asset where necessary. In the event of flooding, post event inspections of the drainage assets and maintenance will be carried out where necessary.	to be minimised. Blockage of various flood conveyance and drainage assets at a local level may still occur occasionally during an extreme flood event (over a design life of 120 years) as debris is transported towards flood conveyance and drainage asset inlets. In the event of flooding, post event inspections and maintenance will be carried out where necessary.	associated with additional inspections and repair or replacement of drainage elements in the event of damage and could lead to journey time delays depending on the drainage asset affected.		
Increased frequency of heavy rainfall events.						
Increase in mean temperature across all seasons.	An increased likelihood of wetter winters followed by longer or more frequent dry spells would result in greater fluctuations in soil moisture content. This can lead to shrink-swell processes in areas with susceptible soils, and subsequent damage to the structural elements of the asset.	During the detailed design stage, geotechnical analysis will be undertaken to establish the geological conditions across the route and any localised constraints or risks. In accordance with HS2 Ltd Technical Standards, allowances would be made for the effects of weathering and climate change (see Table 25) and used to inform design e.g. foundation and structural design. Heave and settlement will be considered when designing trackside filter and carrier drains in deep excavations or on embankments to ensure there is no displacement causing defects. During the operational stage, a regular programme of maintenance will be undertaken including general inspection, monitoring and replacement of the asset where necessary allowing for preventative maintenance (or asset replacement) before a service-disrupting failure occurs.	**Likelihood level: Unlikely** The climate change impact on shrink/swell processes and damage to the asset is unlikely to occur as the geotechnical investigations will be sufficient to inform the design and allow for additional (or different) ground works if required, taking account of current and future ground conditions, over the drainage element design life.	**Consequence level: Low** The consequence of the climate change impact is low. The resultant impact could lead to the low cost of repair and maintenance associated with additional inspections and replacement of drainage elements in the event of damage. Additional impacts from localised flooding could result in delays to journey times depending on the asset affected.	**Low**	No additional resilience measures required
Increased frequency of dry spells.						
Increase in mean winter rainfall.						

Table 29: Lineside equipment (signalling, telecommunications and lighting)

Climate change trend	Potential impact on HS2 Ltd asset group	Existing/embedded mitigation	Likelihood of impact on HS2 Ltd asset group	Consequence of impact on HS2 Ltd asset group	Risk level	Additional mitigation measures
Increase in mean daily maximum temperature.	Higher temperatures and more frequent heatwaves would lead to an increased likelihood of lineside equipment overheating and failing. This could also result in secondary impacts such as lineside fires.	During the detailed design stage, the impacts associated with higher temperatures will be managed through the development of asset-specific technical specification documents. These documents will set out the operating temperature thresholds taking into account climate change over the design life of the asset (30 years for equipment such as the signalling and telecommunications boxes). More vulnerable asset components for example cabling will be sized accordingly, taking into account de-rating factors of Low Voltage (LV) power cables (BS7671)[8], which will be informed by projected future temperatures.	**Likelihood level: Unlikely** Overheating of equipment is unlikely to occur over the design life of the asset (30 years) due to the setting of appropriate temperature thresholds within the product specification documents. During extreme events that exceed temperature thresholds,	**Consequence level: Very Low** Appropriate temperature thresholds and monitoring and alarm systems will help keep consequences very low with works carried out prior to any service-disrupting impact occurring. Consequences will be further	**Low**	No additional resilience measures required

[8] British Standard (2018), *BS 7671: 2018 Requirements for Electrical Installations, IET wiring Regulations.*

Climate change trend	Potential impact on HS2 Ltd asset group	Existing/embedded mitigation	Likelihood of impact on HS2 Ltd asset group	Consequence of impact on HS2 Ltd asset group	Risk level	Additional mitigation measures
Increased frequency of heatwaves.		During the operational stage, automated ACM and alarm systems will indicate potential equipment failure if thresholds are likely to be exceeded, allowing for preventative maintenance, such as mechanical cooling or asset replacement, before a service-disrupting failure occurs. At the end of the asset design life, the specification of operating temperatures will be reassessed to take into account current climate projections at that time.	monitoring and alarm systems will help reduce the likelihood of failure.	managed by undertaking maintenance works overnight		
Decreased frequency of cold weather events (e.g. snow and ice).	Although cold weather events will become less frequent, they will still occur. This would lead to an increased likelihood of freezing of M&E equipment and failure.	During the detailed design stage, the impact associated with low temperatures will be mitigated through the development of an asset-specific technical specifications documents. These documents will set-out the operating temperature thresholds of the equipment and will include below freezing temperatures. During the operational stage, automated ACM and alarm systems will be used to indicate potential equipment failure due to periods of low or freezing temperatures, allowing for preventative maintenance, such as anti-condensation heating or asset replacement, before a service-disrupting failure occurs.	**Likelihood level: Unlikely** Freezing of M&E equipment during cold weather events is considered unlikely to occur over the design life of the asset (30 years) due to the setting of appropriate temperature thresholds within the product specification documents. During extreme low temperature events, monitoring and alarm systems will help reduce the likelihood of failure.	**Consequence level: Very Low** Appropriate temperature thresholds and monitoring and alarm systems will help keep consequences very low with works carried out prior to any service-disrupting impact occurring. Consequences will be further managed by undertaking maintenance works overnight.	**Low**	No additional resilience measures required
	Although cold weather events will become less frequent, ice and snow will still occur reducing driver visibility of signals, potentially leading to service disruptions.	During the outline design, fully automatic signalling equipment will be chosen so that operations do not rely on the train driver's visibility of signalling.	**Likelihood level: Unlikely** The visibility of signals does not impact on the effectiveness of the automatic signalling equipment and as a result the impact on the asset is unlikely to occur.	**Consequence level: Very Low** The implementation of automatic signalling equipment will mitigate this impact and keep any resultant consequences very low.	**Low**	No additional resilience measures required
Increase in mean winter rainfall. Increased frequency of heavy rainfall events.	Wetter winters and more frequent rainfall events would lead to an increased likelihood of flooding and/or water ingress into lineside equipment.	During the detailed design stage, track and perimeter drainage will be designed to convey peak flood flows and volumes, taking into account climate change within the flood design standards, to help protect the equipment (see CCR assessment for flood conveyance and drainage). The lineside equipment cabinets will be designed to be watertight (to the specified Ingress Protection (IP) rating) to prevent water ingress. During the operational stage, regular inspections will allow for preventative maintenance, such as the replacement of asset components (for example, IP rated equipment box seals) before failure occurs allowing water ingress to the equipment during flood events.	**Likelihood level: Unlikely** Flooding of lineside equipment is unlikely to occur due to the resistant measures of the IP rated equipment boxes. This will prevent water ingress into the equipment.	**Consequence level: Very Low** In the unlikely event that the flood design standards are exceeded, the resistant measures (e.g. equipment box seals) will prevent water ingress, where regular maintenance of these will keep consequences very low.	**Low**	No additional resilience measures required
Increased frequency of lightning events in the second half of the 21st Century.	More frequent lightning events would lead to an increased likelihood of lightning strikes and direct damage to lineside equipment and associated cables.	During the detail design stage, following local and regional lightning risk assessments, standard lightning protection, such as lightning rods, will be specified. The frequency of lightning strikes will not affect the effectiveness of the mitigation. During the operational stage, the lightning protection system will be place, which will be effective at protecting buildings and depots irrespective of the number of lightning strikes.	**Likelihood level: Unlikely** Standard lightning protection implemented on vulnerable assets will mitigate against the impact. Additionally, more frequent lightning events are not predicted to occur until the second half of the 21st Century; therefore, the climate change impact is unlikely to occur during the design life of the asset (30 years). Upgraded lightning protection (as necessary) would be provided at asset replacement.	**Consequence level: Very Low** During a lightning event and the unlikely event of a strike on the lineside equipment, lightning protection will mitigate the impact and any resulting consequence will be very low.	**Low**	No additional resilience measures required

Climate change trend	Potential impact on HS2 Ltd asset group	Existing/embedded mitigation	Likelihood of impact on HS2 Ltd asset group	Consequence of impact on HS2 Ltd asset group	Risk level	Additional mitigation measures
Decreased frequency of fog events in the second half of the 21st Century.	Although fog events will become less frequent in the second half of the 21st Century, they will still occur, leading to reduced visibility of signals, potentially leading to service disruptions.	During the outline design, fully automatic signalling equipment will be chosen so that operations do not rely on the train driver's visibility of signalling.	**Likelihood level: Unlikely** The visibility of signals does not impact on the effectiveness of the automatic signalling equipment and as a result the impact on the asset is unlikely to occur.	**Consequence level: Very Low** The implementation of automatic signalling equipment will mitigate this impact and keep any resultant consequences very low.	**Low**	No additional resilience measures required

Table 30: Overhead Contact System

Climate change trend	Potential impact on HS2 Ltd asset group	Existing/embedded mitigation	Likelihood of impact on HS2 Ltd asset group	Consequence of impact on HS2 Ltd asset group	Risk level	Additional mitigation measures
Increase in mean daily maximum temperature. Increased frequency of heatwaves.	Higher temperatures and more frequent heatwaves would lead to an increased likelihood of the Overhead Contact System (OCS) loosening or sagging, potentially resulting in a disconnect from the pantograph or a reduction in efficiency.	During the detailed design stage, the impacts associated with higher temperatures will be managed through the development of asset-specific technical specification documents. These documents will set out the operating temperature thresholds taking into account climate change over the design life of the asset. During the operational stage, automated ACM and alarm systems will indicate potential equipment failure if thresholds are likely to be exceeded, allowing for preventative maintenance (or asset replacement) before a service-disrupting failure occurs. At the end of the design life, the specification of operating temperatures will be reassessed to take into account current climate projections at that time.	**Likelihood level: Unlikely** During high temperatures, sagging and eventual disconnect of the Overhead Line (OHL) from the pantograph is unlikely to occur over the design life of the asset (30 years) due to the setting of appropriate temperature thresholds within the product specification documents. During extreme hot weather events that exceed temperature thresholds, monitoring and alarm systems will trigger a response before a complete disconnect occurs.	**Consequence level: Very Low** Appropriate temperature thresholds and monitoring and alarm systems will help keep consequences very low, where maintenance works can be carried out prior to any service-disrupting impact occurs. In response to warnings from monitoring, this will be further managed by undertaking maintenance works overnight.	**Low**	No additional resilience measures required
Decreased frequency of cold weather events (e.g. snow and ice).	Although cold weather events will become less frequent, they will still occur. Snow and/or ice build-up on the OCS would cause structural damage to the pantograph, increasing the likelihood of poor electrical contact, electrical arcing, and power surges.	During the detailed design stage, the impacts associated with low and freezing temperatures will be managed through the development of asset-specific technical specification documents. These documents will set-out the operating temperature thresholds, including the maximum allowable thickness of ice on the OLE, taking into account climate change over the design life of the asset. During the operational stage, automated ACM and alarm systems will indicate potential equipment failure including changes in the tensioning system due to snow or ice loading, allowing for preventative maintenance (or asset replacement) before a service-disrupting failure occurs. In response to alarm systems, there is a provision to run ghost trains to maintain electrical load through the OLE, preventing ice build-up.	**Likelihood level: Unlikely** During cold weather events, structural damage to the pantograph and/or potential electrical arcing and power surges is unlikely to occur due to the setting of appropriate temperature thresholds within the product specification documents. The monitoring and alarm systems that will trigger further mitigation to help prevent ice build-up, such as the running of ghost trains.	**Consequence level: Very Low** Monitoring and alarm systems will help keep consequences very low, where maintenance works can be carried out prior to any service-disrupting impact occurs. This will be further managed by undertaking maintenance works overnight.	**Low**	No additional resilience measures required
Increased frequency of windstorm events in the second half of the 21st Century.	More frequent windstorm events would lead to an increased likelihood of direct damage to the OCS, or indirect damage by windborne debris or falling objects. These impacts would be exacerbated if coupled with ice loading on the OCS.	During the detailed design stage, the impacts associated with high winds will be managed through the development of asset-specific technical specification documents. These documents will set out the wind loading requirements of assets such as the OCS, which includes the OHL. This will help prevent the pantograph from losing contact with rolling stock during windstorm events. Landscape planting is restricted within a zone of influence surrounding the route to reduce the risk of falling branches and trees affecting the OCS in accordance with the HS2 Ltd Technical Standards	**Likelihood level: Likely** Despite the mitigation implemented to help enable the OCS to withstand high wind loading and direct impact of windstorm events, indirect damage from windborne debris from out with the HS2 Ltd zone of influence is likely to occur could still impact the OCS multiple times over the design life of the asset.	**Consequence level: Low** Due to the implementation of the zone of influence, consequences associated with larger falling trees or debris will be managed; however, windblown debris could still result in low consequences associated with costs and delays to journey times, whilst maintenance works are ongoing.	**Medium**	No additional resilience measures required

Climate change trend	Potential impact on HS2 Ltd asset group	Existing/embedded mitigation	Likelihood of impact on HS2 Ltd asset group	Consequence of impact on HS2 Ltd asset group	Risk level	Additional mitigation measures
		(see CCR assessment for Soft Landscaping and Planting). Wind-blown debris from outside of the railway envelope will be difficult to mitigate, but also has a lower likelihood of occurrence due to the distance from the OCS. During the operational stage, automated ACM and alarm systems will be used to detect any early signs of deterioration in the tensioning system which could occur as a result of excessive windy conditions, allowing for preventative maintenance before a service-disrupting failure occurs.				
Increased frequency of lightning events in the second half of the 21st Century.	More frequent lightning events would lead to an increased likelihood of lightning strikes and direct damage to and/or faults to the OCS.	During the detail design stage, following local and regional lightning risk assessments, standard lightning protection, such as lightning rods, will be specified. The frequency of lightning strikes will not affect the effectiveness of the mitigation. During the operational stage, the lightning protection system will be place, which will be effective at protecting the OCS irrespective of the number of lightning strikes.	**Likelihood level: Unlikely** Standard lightning protection implemented on vulnerable assets will help to mitigate the impact from occurring. Additionally, more frequent lightning events are not predicted to occur until the second half of the 21st Century; therefore, the climate change impact is unlikely to occur during the design life of the asset (30 years). Upgraded lightning protection (as necessary) would be provided at asset replacement.	**Consequence level: Very Low** During a lightning event and the unlikely event of a strike on the lineside equipment, lightning protection will mitigate the impact and any resulting consequence associated with additional inspections and maintenance costs will be very low.	**Low**	No additional resilience measures required
Increase in mean temperature across all seasons. Increased frequency of dry spells. Increase in mean winter rainfall.	An increased likelihood of wetter winters followed by longer or more frequent dry spells would result in greater fluctuations in soil moisture content. This can lead to shrink-swell processes in areas with susceptible soils, and subsequent damage to the structural elements of the OCS.	During the detailed design stage, geotechnical analysis will be undertaken to establish the geological conditions across the route and any localised constraints or risks. In accordance with HS2 Ltd Technical Standards, allowances would be made for the effects of weathering and climate change (see CCR assessment for earthworks) and used to inform design e.g. foundation and structural design. During the operational stage, a regular programme of maintenance will be undertaken including general inspection, monitoring and replacement of the asset where necessary allowing for preventative maintenance (or asset replacement) before a service-disrupting failure occurs.	**Likelihood level: Unlikely** The climate change impact on shrink/swell processes and damage to the asset is unlikely to occur as the geotechnical investigations will be sufficient to inform the design and allow for additional ground remediation if required, taking account of current and future ground conditions over the asset design life (30 years).	**Consequence level: Very Low** Due to the mitigation measures implemented, the consequence of the climate change impact is very low associated with costs and delays whilst regular asset inspections and maintenance works are undertaken prior to the asset failing and causing larger consequences.	**Low**	No additional resilience measures required.

Table 31: Auto-transformer Feeder Systems (ATFS)

Climate change trend	Potential impact on HS2 Ltd asset group	Existing/embedded mitigation	Likelihood of impact on HS2 Ltd asset group	Consequence of impact on HS2 Ltd asset group	Risk level	Additional mitigation measures
Increase in mean daily maximum temperature.	Higher temperatures and more frequent heatwaves would lead to an increased likelihood of railway power supplies and distribution	During the detailed design stage, the impacts associated with higher temperatures will be managed through the development of asset-specific technical specification documents. These documents will set out the operating temperature thresholds taking into account climate change over the design life of the asset.	**Likelihood level: Unlikely** Overheating of equipment is unlikely to occur over the design life of the asset (40 years) due to the setting of appropriate temperature thresholds	**Consequence level: Very Low** Appropriate temperature thresholds and monitoring and alarm systems will help keep consequences very low and works are carried out prior to any	**Low**	No additional resilience measures required

Climate change trend	Potential impact on HS2 Ltd asset group	Existing/embedded mitigation	Likelihood of impact on HS2 Ltd asset group	Consequence of impact on HS2 Ltd asset group	Risk level	Additional mitigation measures
Increased frequency of heatwaves.	equipment overheating or failing.	During the operational stage, automated ACM and alarm systems will indicate potential equipment failure if thresholds are likely to be exceeded, allowing for preventative maintenance (or asset replacement) before a service-disrupting failure occurs. At the end of the design life, the specification of operating temperatures will be reassessed to take into account current climate projections at that time.	within the product specification documents. During extreme events that exceed temperature thresholds, monitoring and alarm systems will help to make the impact unlikely to occur.	service-disrupting impact occurs. In response to warnings from monitoring, this will be further managed by undertaking maintenance works overnight.		
Increase in mean winter rainfall. Increased frequency of heavy rainfall events.	Wetter winters and more frequent extreme rainfall events would lead to an increased likelihood of flooding and/or water ingress into railway power supply and distribution equipment.	During the outline design stage, flood vulnerable equipment will be preferentially located within areas at lower risk of flooding. Where this is not achievable, during the detailed design stage, the risk of flooding will be managed in accordance with the HS2 Ltd Technical Standards, which require that all infrastructure be protected against the current 1 in 1,000 (0.1%) annual probability design event from any source of flooding plus an appropriate freeboard allowance. During the operational stage, automated ACM and alarm systems will indicate potential equipment failure due to rainwater ingress, allowing for preventative maintenance (or asset replacement) before a service-disrupting failure occurs.	**Likelihood level: Unlikely** The climate change impact resulting in flooding of the railway power supply and distribution equipment is unlikely to occur over the design life of the asset (40 years) due high design standards. The probability of flooding will increase with time due to the impact of climate change; however, flood protection measures will be reassessed to take into account of latest predicted flood levels and climate projections at that time of asset replacement.	**Consequence level: Low** In the unlikely event that the flood design standards are exceeded, the consequence of the impact will be low, with flooding to railway power supply and distribution equipment likely to result in delays to journey times by hours rather than days where maintenance procedures are followed. Furthermore, monitoring and alarm systems enabling the identification of maintenance measures to be undertaken before service-disrupting consequence occurs.	**Low**	No additional resilience measures required
Increased frequency of lightning events in the second half of the 21st Century.	More frequent lightning events would lead to increased likelihood of lightning strikes and direct damage to and/or faults on the railway power supply and distribution network.	During the detail design stage, following local and regional lightning risk assessments, standard lightning protection, such as lightning rods, will be specified. The frequency of lightning strikes will not affect the effectiveness of the mitigation. During the operational stage, the lightning protection system will be place, which will be effective at protecting buildings and depots irrespective of the number of lightning strikes.	**Likelihood level: Unlikely** Standard lightning protection implemented on vulnerable assets will help to mitigate the impact from occurring. Additionally, more frequent lightning events are not predicted to occur until the second half of the 21st Century; therefore, the climate change impact is unlikely to occur during the design life of the asset (40 years). Upgraded lightning protection (as necessary) would be provided at asset replacement.	**Consequence level: Very Low** During a lightning event and the unlikely event of a strike on the lineside equipment, lightning protection will mitigate the impact and any resulting consequence will be very low.	**Low**	No additional resilience measures required
Increase in mean temperature across all seasons. Increased frequency of dry spells. Increase in mean winter rainfall.	An increased likelihood of wetter winters followed by longer or more frequent dry spells would result in greater fluctuations in soil moisture content. This can lead to shrink-swell processes in areas with susceptible soils, and subsequent damage to the structural elements of the asset.	During the detailed design stage, geotechnical analysis will be undertaken to establish the geological conditions across the route and any localised constraints or risks. In accordance with HS2 Ltd Technical Standards, allowances would be made for the effects of weathering and climate change (see CCR assessment for earthworks) and used to inform design e.g. foundation and structural design. During the operational stage, a regular programme of maintenance will be undertaken including general inspection, monitoring and replacement of the asset where necessary allowing for preventative maintenance (or asset replacement) before a service-disrupting failure occurs.	**Likelihood level: Unlikely** The climate change impact on shrink/swell processes and damage to the asset is unlikely to occur as the geotechnical investigations will be sufficient to inform the design and allow for additional ground remediation if required, taking account of current and future ground conditions over the asset design life (40 years).	**Consequence level: Very Low** Due to the mitigation measures implemented, the consequence of the climate change impact is very low, with regular asset inspections and maintenance ensuring remedial, repair or replacement works are undertaken prior to the asset failing and causing larger consequences.	**Low**	No additional resilience measures required

Table 32: Tunnels (M&E)

Climate change trend	Potential impact on HS2 Ltd asset group	Existing/embedded mitigation	Likelihood of impact on HS2 Ltd asset group	Consequence of impact on HS2 Ltd asset group	Risk level	Additional mitigation measures
Increase in mean daily maximum temperature. Increased frequency of heatwaves.	Higher temperatures and more frequent heatwaves would increase the likelihood of tunnels overheating leading to reduced effectiveness of the natural tunnel ventilation system and increased use of the mechanical ventilation.	During the outline design stage, tunnel ventilation analysis has been undertaken using climate change projections to inform the ventilation capacity requirements to effectively cool and ventilate the tunnels in normal, congestion, and fire scenarios. The assessments concluded that temperatures within the tunnel during normal operations will be effectively managed through the design to maximise natural ventilation, for example the use of bypass chambers and night-time cooling. HS2 Ltd Technical Standards ensure internal tunnel air temperatures will not exceed 35° C in normal conditions and 43° C in congestion conditions, no more than 1% of the year. Mechanical ventilation will be installed into the tunnels to serve congestion and fire scenario operations, with the provision of standby jet fans, where there is opportunity to utilise this capacity during normal operations if required with increased frequency of heatwaves and higher temperatures. The impact of high tunnel temperatures on the operation of the rolling stock air conditioning is assessed in the CCR assessment for Rolling Stock. During the operational phase, real time monitoring of temperature at tunnel portals will inform the Ventilation Control System (VCS) to the requirements of mechanical ventilation and bypass shaft operation in the event of rising tunnel temperatures. The VCS operates regular automatic testing of the ventilation system, supplemented by ACM and alarm systems to indicate potential equipment failure, allowing for preventative maintenance (for example, asset replacement) before a service-disrupting failure occurs.	**Likelihood level: Likely** The climate change impact is likely over the design life of the tunnel ventilation (40 years) due to the tunnel ventilation analysis allowing for exceedances no more than 1% of the year, requiring mechanical ventilation. This use of the mechanical ventilation will increase with climate change to effectively cool the tunnels.	**Consequence level: Low** The tunnel ventilation analysis informs the design of the natural and mechanical ventilation systems, which will help keep the consequences of overheating in the tunnel low. There will be low costs associated with the more frequent operation of mechanical ventilation, in addition to the cost of replacement of assets if the mechanical ventilation is utilised more than expected.	**Medium**	No additional resilience measures required
	Higher temperatures and more frequent heatwaves would increase the likelihood of mechanical and electrical (M&E) equipment in headhouses and control rooms overheating and failing. This could also result in secondary impacts such as tunnel fires.	During the detailed design stage, the impacts associated with higher temperatures will be managed through the development of asset-specific technical specification documents for M&E equipment. These documents will set out the operating temperature thresholds taking into account climate change over the design life of the asset. Ventilation analysis has also been undertaken using climate change projections to inform HVAC requirements for below-ground equipment control rooms and above-ground headhouses. The HVAC systems will maintain room temperatures to those specified within HS2 Ltd Technical Standards, controlled to a maximum of 40°C. During the operational stage, real time monitoring of temperature within equipment control rooms will inform the VCS to the HVAC requirements. ACM and alarm systems will indicate potential equipment failure, allowing for preventative maintenance (for example, fan or drive replacement) before a service-disrupting failure occurs. At the end of the design life (40 years), the specification of operating temperatures will be reassessed to take into account current climate projections at that time.	**Likelihood level: Unlikely** The climate change impact is unlikely to occur over the design life of the asset (40 years) due to the setting of appropriate temperature thresholds within the product specification documents. During extreme events that exceed temperature thresholds, monitoring and alarm systems will reduce the likelihood of the impact occurring.	**Consequence level: Very Low** Appropriate HVAC system design taking account of future climate, design life and operating temperature thresholds, and monitoring and alarm systems will help keep consequences very low. Maintenance works would be carried out prior to any service-disrupting impact occurring. In response to warnings from monitoring, this will be further managed by undertaking maintenance works overnight.	**Low**	No additional resilience measures required

Climate change trend	Potential impact on HS2 Ltd asset group	Existing/embedded mitigation	Likelihood of impact on HS2 Ltd asset group	Consequence of impact on HS2 Ltd asset group	Risk level	Additional mitigation measures
Increase in mean winter rainfall. Increased frequency of heavy rainfall events.	Wetter winters and more frequent rainfall events would increase the likelihood of flooding and/or water ingress into tunnels and surface structures (e.g. headhouses and portals) or overload the tunnel drainage systems, resulting in damage and failure of M&E equipment.	During the detailed design stage, the tunnel portals and shafts will be designed to prevent water ingress (see CCR assessment for Tunnel (Civils). Localised tunnel flooding could still occur, e.g. fire water, however the M&E equipment will be placed at a high level and cabling will be sealed to withstand any localised tunnel flooding. Additionally, sump pumps and drainage will be placed at tunnel low points. During the operational stage, the ACM will identify excessive water ingress through automated monitoring and alarm systems, and early detection of defects with the tunnel pumping / drainage system. This is supplemented by a regular programme of visual inspections and replacement of the asset where necessary.	**Likelihood level: Unlikely** Flooding of the tunnels and thus water ingress into M&E equipment is unlikely to occur due to the low probability of the flood design standard being exceeded over the design life of the asset (120 years). The probability of flooding will increase with time due to the impact of climate change; however, equipment is placed at a high level within the tunnel with appropriate sump pump and drainage provisions.	**Consequence level: Low** The consequence of flooding within the tunnel is low based on the low associated costs and delays that would result from the required maintenance to tunnel drainage.	**Low**	No additional resilience measures required
Increased frequency of windstorm events in the second half of the 21st Century.	Increased frequency of windstorm events would increase the likelihood of direct damage to M&E equipment at portal entrances and hinder the performance of mechanical ventilation during its operation.	During the outline design stage, the orientation of the tunnel portal will be designed taking into account the effect of the prevailing wind on the portals, reducing the likelihood of winds hindering the performance of the mechanical ventilation within the tunnel. During the detailed design stage, the M&E equipment installed in the tunnels will be designed to withstand the impacts of high wind speeds produced by the piston effect of trains, and therefore the small changes to wind speeds associated with windstorm events resulting from climate change. During the operational stage, real time monitoring of the air velocity inside the tunnel will inform the requirement of additional ventilation capacity to counter adverse wind forces associated with wind gusts, to ensure continued performance of the tunnel ventilation in normal, congestion, and fire scenarios. The ACM will ensure early detection of defects through automated monitoring and alarm systems, supplemented by a regular programme of visual inspections and replacement of the asset where necessary.	**Likelihood level: Unlikely** The climate change impact is unlikely to occur over the design life of the asset (40 years) due to the appropriate siting of tunnels taking into account prevailing winds and air velocity monitoring informing ventilation requirements responding to wind gusts associated with climate change.	**Consequence level: Very Low** Reducing train speeds through the tunnel during windstorm events to prevent the tunnel ventilation system from reaching capacity will result in a very low consequence to journey times.	**Low**	No additional resilience measures required

Table 33: Maintenance buildings and depots

Climate change trend	Potential impact on HS2 Ltd asset group	Existing/embedded mitigation	Likelihood of impact on HS2 Ltd asset group	Consequence of impact on HS2 Ltd asset group	Risk level	Additional mitigation measures
Increase in mean daily maximum temperature.	Higher temperatures and more frequent heatwaves would lead to an increased likelihood of electrical equipment overheating and failing which could lead to secondary impacts such as disruption to maintenance operations.	During the detailed design stage, staffed maintenance buildings and depots will be designed to BREEAM "Excellent Rating", which will consider thermal comfort and ventilation arrangements. HVAC systems will be incorporated into maintenance buildings and depots where necessary to provide additional cooling in periods of higher temperatures. HVAC systems will be sized appropriately using thermal modelling taking account of future maximum temperature ranges as a result of climate change. During the operational stage, the humidity and temperature of critical lineside buildings and staffed buildings will be monitored through remote data collection, which will feed into an Engineering Management System which will be monitored by the infrastructure maintainer. Alarm systems will indicate potential equipment failure or if thresholds are likely to be exceeded. This will allow for preventative maintenance (or asset replacement) to be actioned before a service-disrupting failure occurs.	**Likelihood level: Unlikely** The impact is unlikely to occur due to the provision of adequately sized HVAC systems. Additionally, monitoring systems will allow for action to be taken prior to buildings overheating which will prevent secondary impacts on railway operations.	**Consequence level: Low** The consequence of the impact will be low. Low costs will be incurred associated with the additional remedial/replacement works to repair failed heating, ventilation and air conditioning (HVAC) equipment.	**Low**	No additional resilience measures required
Increase in mean daily maximum temperature. Increased frequency of heatwaves.	Higher temperatures and more frequent heatwaves would lead to an increased likelihood of staff discomfort within maintenance buildings and depots, and unsafe working environments resulting in potential health impacts for example heat stress.	During the detailed design stage, staffed maintenance buildings and depots will be designed to BREEAM "Excellent Rating", which will consider thermal comfort and ventilation arrangements. For example, this will include HVAC systems to provide additional cooling to critical staffed areas in periods of higher temperatures. HVAC systems will be sized appropriately using thermal modelling taking account of future maximum temperature ranges as a result of climate change. During the operational stage, the risk of heat stress to staff will be mitigated through HS2 Ltd health and safety procedures which will include Dynamic Risk Assessments, and specify adaptive management procedures for example, provision of appropriate PPE for personnel working outside.	**Likelihood level: Unlikely** The impact is unlikely to occur due to the provision of adequately sized air conditioning systems and health and safety procedures to protect workers working outside during higher temperatures. Additionally, monitoring systems will allow for action to be taken prior to buildings overheating.	**Consequence level: Low** The consequence of the impact will be low, with higher temperatures potentially disrupting maintenance activities over the short-term. Adaptive maintenance procedures such as altering shift patterns and operational procedures and PPE will help to manage consequences.	**Low**	No additional resilience measures required
Decreased frequency of cold weather events (e.g. snow and ice).	Whilst cold weather events will become less frequent, they will still occur. This would lead to an increased likelihood of unsafe working environments and potential health impacts for example, cold stress.	During the detailed design stage, staffed maintenance buildings and depots will be designed to BREEAM "Excellent Rating". When considering thermal comfort specifications to size the HVAC systems, thermal modelling will be undertaken taking account of temperature ranges as a result of climate change. During the operational stage, critical lineside buildings and staffed buildings will be monitored and feed into an Engineering Management System which will be monitored by the infrastructure maintainer. Additionally, the risk of cold stress to staff working outdoors will be managed through HS2 Ltd health and safety procedures, which will specify adaptive management procedures for example, provision of appropriate PPE.	**Likelihood level: Unlikely** The impact is unlikely to occur due to the provision of adequately sized heating systems and health and safety procedures to protect workers during cold temperatures. Additionally, monitoring systems will allow for action to be taken to protect workers during cold temperatures.	**Consequence level: Low** The consequence of the impact will be low, with cold temperatures potentially disrupting maintenance activities over the short-term. Adaptive maintenance procedures such as altering shift patterns and operational procedures and PPE will help to manage consequences.	**Low**	No additional resilience measures required
	Whilst cold weather events will become less frequent, they will still occur, with extreme low temperatures leading to snow loading on	During the detailed design stage, maintenance buildings and depot structures will be designed to take into account snow loading through the selection of materials with appropriate durability requirements, in accordance with the HS2 Ltd Technical Standards and best practice e.g. British Standards and Eurocode.	**Likelihood level: Unlikely** The impact is unlikely to occur due to the appropriate structural design and selection of materials. In addition, regular monitoring and maintenance	**Consequence level: Low** The consequence of the climate change impact is low. In the unlikely event of damage of the asset structure occurring, low costs will be	**Low**	No additional resilience measures required

Climate change trend	Potential impact on HS2 Ltd asset group	Existing/embedded mitigation	Likelihood of impact on HS2 Ltd asset group	Consequence of impact on HS2 Ltd asset group	Risk level	Additional mitigation measures
	structures causing stability issues.	During the operational stage, a regular programme of maintenance will be undertaken including general inspection and monitoring of the asset where necessary.	should help to ensure asset quality in maintained.	incurred associated with additional remedial/replacement works of asset components prior to the structural stability of the asset being compromised.		
Increase in mean winter rainfall. Increased frequency of heavy rainfall events.	Wetter winters and more frequent extreme rainfall events would lead to an increased likelihood of flooding to depots and maintenance buildings.	During the outline design stage, the impacts associated with flooding will be managed in accordance with HS2 Ltd Technical Standards, which requires infrastructure to be protected against the current 1 in 1,000 (0.1%) annual probability design event. In addition, building drainage systems will be designed to include an uplift on peak rainfall to account for climate change, which will help reduce the risk of drainage systems overflowing and causing localised flooding during extreme rainfall events (see CCR assessment for Flood Conveyance and Drainage). During the operational stage, a regular programme of maintenance will be undertaken including general inspection and monitoring of the drainage systems where necessary allowing for preventative maintenance (or component replacement) before a service-disrupting failure occurs. In the event of a flood, post event inspections and maintenance will be carried out where necessary and contingency plans will be in place to minimise disruption to the network operation.	**Likelihood level: Unlikely** Flooding of maintenance buildings and depots is unlikely to occur due to the low probability of the flood design standard being exceeded over the design life of the asset (60 years for depot sheds and 120 year for brick or in situ construction). The risk of flooding is expected to increase with time due to the impact of climate change; however, in high flood risk locations, consideration will be given to adapting the design (e.g. increasing freeboard levels) to ensure the likelihood of the impact remains low over the design life of the asset.	**Consequence level: Medium** The consequence of flooding is medium. The flood design and drainage standards adopted would limit flooding to extreme events that exceed these design standards or due to drainage blockages. This could result in localised flooding causing delays of up to a day. Ongoing inspection and maintenance will however manage these residual risks with consequences limited to low costs and limited delays to journey time.	**Low**	No additional resilience measures required
	More frequent heavy rainfall events would lead to an increased likelihood of health and safety incidents during wet conditions for example, slips, trips and falls.	At the detailed design stage, appropriate selection of flooring materials will be undertaken to prevent slips, trips and falls during wetter weather. During the operational stage, the risk of slips, trips and falls to staff working outdoors will be managed through HS2 Ltd health and safety procedures, for example, use of signage and appropriate footwear.	**Likelihood level: Possible** Although appropriate material selection and health and safety procedures will be in place to help protect workers, slips, trips and falls are still possible, however incidents are unlikely to increase due to climate change.	**Consequence level: Low** Appropriate design and health and safety procedures will help to manage the low consequence of the impact. Any impacts are likely to be short term impacts on persons affected such as lost time injury or medical treatment.	**Low**	No additional resilience measures required
Increased frequency of windstorm events in the second half of the 21st Century.	More frequent windstorm events would lead to increased likelihood of greater wind loading on maintenance buildings and depots, which could lead to structural damage or stability issues and/or unsafe working environments.	During the detailed design stage, the structural design of maintenance buildings and depots, including the selection of durable materials, will take into account future wind loading in accordance with the HS2 Ltd Technical Standards and best practice e.g. British Standards and Eurocodes. During the operational stage, a regular programme of maintenance will be undertaken including general inspection and monitoring of the asset where necessary. The risk to staff working outdoors will be managed through HS2 Ltd health and safety procedures which will include Dynamic Risk Assessments that specify adaptive management procedures for example, work will be curtailed or cancelled if high winds are forecast.	**Likelihood level: Unlikely** The impact is unlikely to occur due to the appropriate design and selection of materials. In addition, regular monitoring and maintenance should help to ensure asset quality to prevent failure.	**Consequence level: Low** The consequence of the climate change impact is low, as wind loading including climate change will be taken into account in the design stage. However, costs may still be incurred associated with remedial/replacement works to assets due to over-design events.	**Low**	No additional resilience measures required
Increased frequency of lightning events in the second half of the 21st Century.	More frequent lightning events would lead to increased likelihood of lightning strikes and direct damage to maintenance buildings and depots and/or	During the detail design stage, following local and regional lightning risk assessments, standard lightning protection, such as lightning rods, will be specified. The frequency of lightning strikes will not affect the effectiveness of the mitigation. During the operational stage, the lightning protection system will be place, which will be effective at protecting buildings and depots	**Likelihood level: Unlikely** The impact is unlikely to occur due to standard lightning protection being implemented.	**Consequence level: Very Low** During a lightning event and the unlikely event of a strike, lightning protection will mitigate the impact and any resulting consequence will be very low.	**Low**	No additional resilience measures required

Climate change trend	Potential impact on HS2 Ltd asset group	Existing/embedded mitigation	Likelihood of impact on HS2 Ltd asset group	Consequence of impact on HS2 Ltd asset group	Risk level	Additional mitigation measures
	unsafe working environments.	irrespective of the number of lightning strikes. Risks to staff working outdoors will be managed through HS2 Ltd health and safety procedures, which will include Dynamic Risk Assessments that specify adaptive management procedures for example, work will be curtailed or cancelled if lightning is forecast.				
Increase in mean winter rainfall. Increased frequency of dry spells. Increase in mean winter rainfall.	An increased likelihood of wetter winters followed by hotter drier summers can result in fluctuating soil moisture content. This can lead to shrink-swell and soil creep processes in areas with susceptible soils, and subsequent damage to the structural components of masonry walls.	During the detailed design stage, geotechnical analysis will be undertaken to establish the geological conditions across the route and any localised constraints or risks. In accordance with HS2 Ltd Technical Standards, allowances would be made for the effects of weathering and climate change (see CCR assessment for earthworks) and used to inform design e.g. foundation and structural design. During the operational stage, a regular programme of maintenance will be undertaken including general inspection, monitoring and replacement of the asset where necessary allowing for preventative maintenance (or asset replacement) before a service-disrupting failure occurs.	**Likelihood level: Unlikely** The climate change impact on shrink/swell processes and damage to the asset is unlikely to occur as the geotechnical investigations will be sufficient to inform the design and allow for additional (or different) ground works if required, taking account of current and future ground conditions, over the asset design life (30 years for fences, 60 years for traditional masonry walls and 120 years for other wall materials).	**Consequence level: Low** The consequence of the climate change impact is low. The resultant impact could lead to the low cost of repair and maintenance associated with additional inspections and remedial works following damage to structural elements.	**Low**	No additional resilience measures required

Table 34: Construction period

Climate change trend	Potential impact on HS2 Ltd asset group	Existing/embedded mitigation	Likelihood of impact on HS2 Ltd asset group	Consequence of impact on HS2 Ltd asset group	Risk level	Additional mitigation measures
Increase in mean daily maximum temperature. Increased frequency of heatwaves.	Higher temperatures and more frequent hot weather events would increase the likelihood of programme delays due to the restrictions placed on certain construction activities during this period. For example, the pouring of concrete during higher temperatures can reduce the strength and durability of the finished product.	During the construction period, the impact of more frequent hot weather events will be managed through the timing and flexibility of the construction programme and the development of Risk Assessment Method Statements (RAMS) for each construction activity. The RAMS will set out activity-specific mitigation, for example, the provision of shading, possible use of concrete curing agents where applicable, and avoiding concrete pours during the hottest part of hot days.	**Likelihood level: Possible** Restriction of certain construction activities due to higher temperatures is possible during the construction period; however, the flexibility of the construction programme and the use of activity-specific RAMS will reduce the extent of any notable programme delays.	**Consequence level: Very Low** The consequence of the climate change impact is very low associated with additional costs incurred as a result of delays within the construction programme.	**Low**	No additional resilience measures required
	More frequent hot weather events would lead to an increased likelihood of unsafe working environments and potential health impacts, for example, heat stress on construction staff.	During the construction period, the impacts associated with higher temperatures will be managed through the Construction (Design and Management) Regulations, which specify that adequate welfare facilities will be provided for construction staff. The implementation of HS2 Ltd health and safety procedures will also specify mitigation during hot weather events, for example, altering shift patterns for construction staff to help avoid long periods of outdoor working, the provision of appropriate PPE, and ongoing toolbox talks to raise awareness of the health impact of working in hot weather.	**Likelihood level: Unlikely** The climate change impact is unlikely to occur during the construction period due to the health and safety procedures in place which are there to minimise exposure of construction staff working outdoors during higher temperatures.	**Consequence level: Very Low** HS2 Ltd health and safety procedures will reduce the consequences of health impacts to the workforce through the provision of adequate welfare facilities and altered shift patterns, reducing the risk before harm or injury could occur, keeping the consequence very low.	**Low**	No additional resilience measures required
Increased frequency of dry spells.	Hotter and drier weather would increase the likelihood of dust creation from construction activities	During the construction period, the creation of dust associated with hotter and drier weather will be managed through the implementation of the draft CoCP. This document sets out appropriate dust mitigation and management measures for	**Likelihood level: Unlikely** The climate change impact is unlikely to occur during the construction period due to mitigation set out in the	**Consequence level: Very Low** HS2 Ltd health and safety procedures and dust mitigation measures will reduce the consequences of health	**Low**	No additional resilience measures required

Climate change trend	Potential impact on HS2 Ltd asset group	Existing/embedded mitigation	Likelihood of impact on HS2 Ltd asset group	Consequence of impact on HS2 Ltd asset group	Risk level	Additional mitigation measures
	leading to potential health impacts on construction workers. Dust can also affect vehicles, machinery and equipment, causing failures or breakdowns.	construction activities, which will be transposed into the RAMS for each construction activity. The impact of dust on the health of construction workers will be managed through the health and safety procedures, for example, the provision of appropriate PPE.	draft CoCP and RAMS minimising dust creation and protecting the workforce from the health impacts of dust.	impacts to the workforce to very low, where the mitigation is implemented before harm or injury could occur.		
Increased frequency of heavy rainfall events. Increase in mean winter rainfall.	Wetter winters and more frequent extreme rainfall events would lead to an increased likelihood of flooding to temporary assets such as working platforms and compounds and to construction activities such as excavations and temporary cuttings / embankments. This would cause direct and indirect impacts to temporary works and assets under construction, and place construction workers at risk.	During outline design, temporary assets and construction activities will be preferentially located outside of areas at risk of flooding. Flood risk / drainage management plans will be produced to inform mitigation, for example, the placement of flood defence bunds, raised working platforms, and sizing of attenuation ponds. A site drainage plan will be produced for all locations, detailing how surface water will be managed in terms of flow, volume and water quality for each compound. Flooding events preventing access routes for deliveries will be managed by the timing and flexibility of the construction programme, and alternative access points with adjoined service road alongside the construction length will be utilised. During the construction period, the impacts associated with high rainfall and extreme weather events will be managed through the implementation of the HS2 Ltd draft CoCP. This document sets out the requirement to register with the Environment Agency's Floodline Warnings Direct service. Activity-specific RAMS will consider the impacts of extreme weather when planning forthcoming construction activities, for example stockpiling of materials and compound area for plant. Following periods of high rainfall and subsequent flooding, health and safety procedures will stipulate the inspection of, for example, working platforms, and a review of safety permits before works can recommence.	**Likelihood level: Possible** Flooding of site compounds and other working areas which cannot be placed outside areas at risk of flooding remains possible during the construction period; however, the provision of temporary flood risk management measures, site drainage, appropriate method statements and good site management will reduce the extent, duration and impact of flooding on site and disruption to construction activities.	**Consequence level: Low** Although flooding of construction sites and compounds, and disruption to activities during the construction period is possible, mitigation measures will keep consequences low, where works will not resume until the site is considered safe for the workforce following an event.	**Low**	No additional resilience measures required
	Wetter winters would increase the likelihood of programme delays as certain activities would be restricted, such as earthworks and the pouring of surface materials including concrete and asphalt. Pouring concrete in wet weather would reduce the strength and durability of the finished product.	During the outline design stage, the construction programme will be developed to ensure vulnerable activities such as earthworks, which are on the critical path, will be undertaken outside of winter months reducing the likelihood of wet weather delays to these activities. During the construction period, the impacts associated with prolonged wet weather or extreme rainfall events will be managed through the timings of the construction programme and the development of RAMS for each construction activity. The RAMS will set out activity-specific mitigation, for example, the provision of temporary coverings.	**Likelihood level: Possible** Restriction of certain construction activities due to increased rainfall is possible during the construction period; however, the flexibility of the construction programme and the use of activity-specific RAMS will reduce the extent of any notable programme delays.	**Consequence level: Very Low** The consequence of the climate change impact is very low associated with additional costs incurred as a result of delays within the construction programme, activity specific mitigation or the mobilisation of alternative construction activities.	**Low**	No additional resilience measures required
Decreased frequency of cold weather events (e.g. snow and ice).	Although cold weather events will become less frequent, they will still occur. Cold weather events could result in programme delays as certain activities would be restricted, such as the pouring of concrete. Pouring concrete in low temperatures can reduce	During the construction period, the impact of cold weather events will be managed through the timing and flexibility of the construction programme and the development of RAMS for each construction activity. The RAMS will set out activity-specific mitigation, for example, preparatory works for a planned concrete pour occurring below 5°C, including the use of tented and heated enclosures, the heating of aggregate, or the supply of steam into the concrete. If this is not practicable, the pour will be delayed.	**Likelihood level: Possible** Restriction of certain construction activities due to cold weather events is possible during the construction period; however, the flexibility of the construction programme and the use of activity-specific RAMS will reduce the extent of any notable programme delays.	**Consequence level: Very Low** The consequence of the climate change impact is very low associated with additional costs incurred as a result of delays within the construction programme, activity specific mitigation or the mobilisation of alternative construction activities.	**Low**	No additional resilience measures required

Climate change trend	Potential impact on HS2 Ltd asset group	Existing/embedded mitigation	Likelihood of impact on HS2 Ltd asset group	Consequence of impact on HS2 Ltd asset group	Risk level	Additional mitigation measures
	the strength and durability of the finished product.					
	Although cold weather events will become less frequent, they will still occur and would lead to unsafe working environments and potential health impacts to construction staff e.g. slips during icy conditions, and health impacts such as hypothermia.	During the construction phase, the impacts associated with low temperatures will be managed through the implementation of health and safety procedures. These documents will set out mitigation to reduce icy environments within the working area such as de-icing measures and ongoing toolbox talks to raise awareness of the health impacts of working in low temperatures.	**Likelihood level: Unlikely** The climate change impact is unlikely to occur during the construction period with the implementation of the health and safety procedures.	**Consequence level: Very Low** HS2 Ltd health and safety procedures including mitigation such as de-icing measures will reduce the consequences of health and safety impacts to the workforce to very low, where the mitigation is implemented before harm or injury could occur.	**Low**	No additional resilience measures required
	Although cold weather events will become less frequent, they will still occur and would lead to snow loading on temporary structures, increasing the likelihood of stability issues.	During detailed design, temporary works design will consider the impact of snow loading on the temporary structures.	**Likelihood level: Unlikely** The climate change impact is unlikely to occur during the construction period due to robust temporary works design that will take account of snow loading.	**Consequence level: Very Low** The consequence of this impact is very low, temporary works design will fully consider snow loading.	**Low**	No additional resilience measures required
Increased frequency of windstorm events in the second half of the 21st Century.	Windstorm events would increase the likelihood of programme delays due to the restrictions placed on certain construction activities during this period. For example, activities which require the use of cranes for lifting operations.	During the construction phase, the impact of windstorm events will be managed through the timing and flexibility of the construction programme and the development of RAMS for each construction activity. The RAMS will set out activity-specific mitigation, for example, lifting activities will not be conducted during times of high winds.	**Likelihood level: Possible** Restriction of certain construction activities due to windstorm events is possible during the construction period; however, the flexibility of the construction programme and the use of activity-specific RAMS will reduce the extent of any notable programme delays.	**Consequence level: Very Low** The consequence of the climate change impact is very low associated with additional costs incurred as a result of delays within the construction programme.	**Low**	No additional resilience measures required
	Windstorm events would lead to an increased likelihood of an unsafe working environments and potential safety impacts, for example, wind-borne debris or wind loading on structures causing stability issues.	During detailed design, temporary works design will consider the impact of wind loading on the temporary structures. During the construction phase, the impacts associated with wind will be managed through the implementation of health and safety procedures. These documents will set out procedures to reduce working in windy environments.	**Likelihood level: Unlikely** The climate change impact is unlikely to occur during the construction period due to robust temporary works design that will take account of wind loading.	**Consequence level: Very Low** The consequence of the climate change impact is very low associated with additional costs incurred as a result of delays within the construction programme.	**Low**	No additional resilience measures required
Decreased frequency of fog events in the second half of the 21st Century.	Although fog events will become less frequent, they will still occur and would lead to an increased likelihood of an unsafe working environment and potential safety impacts, for example, reduced visibility for plant and machinery drivers.	During the construction period, the impact of fog events will be managed through the timing and flexibility of the construction programme and the development of RAMS for each construction activity. The RAMS will set out activity-specific mitigation, for example, the movement of plant and machinery will not occur during fog events.	**Likelihood level: Possible** Restriction of certain construction activities due to fog events is possible during the construction period; however, the flexibility of the construction programme and the use of activity-specific RAMS will reduce the extent of any notable programme delays.	**Consequence level: Very Low** The consequence of the climate change impact is very low associated with additional costs incurred as a result of delays within the construction programme.	**Low**	No additional resilience measures required

Table 35: Emergency and maintenance access

Climate change trend	Potential impact on HS2 Ltd asset group	Existing/embedded mitigation	Likelihood of impact on HS2 Ltd asset group	Consequence of impact on HS2 Ltd asset group	Risk level	Additional mitigation measures
Increase in mean daily maximum temperature. Increased frequency of heatwaves.	Higher temperatures and more frequent heatwaves would increase the rate of degradation of access road surface material, such as asphalt.	During the detailed design stage, an asset-specific technical specification document for maintenance and emergency access roads will be prepared, which will specify appropriate material durability requirements for surfacing material informed by future ambient temperatures and solar radiation exposure. During the operational stage, a regular programme of inspection and maintenance will be undertaken, including local repairs and improvement of degrading surfaces. At the end of the design life of paved roads (40 years), the surfacing material durability specification will be reassessed to take into account climate projections at that time.	**Likelihood level: Unlikely** The climate change impact is unlikely to occur over the design life of the asset (40 years) due to the setting of appropriate material durability specifications that take account of future temperatures.	**Consequence level: Very Low** The consequence of the climate change impact is very low, with additional costs incurred associated with more frequent inspections and remedial works costs over the design life of the asset.	**Low**	No additional resilience measures required
Increase in mean temperature across all seasons.	Higher temperatures would lead to a change in the growth rate of the vegetation, which could impact upon the accessibility of the access road.	During the operational stage, ongoing vegetation maintenance will be undertaken to prevent vegetation encroaching on the access road. In addition, maintenance such as grass cutting will be undertaken and adjusted dependent upon growth rates throughout the season. Weed control will be monitored and managed as necessary for example, through the use of herbicides.	**Likelihood level: Unlikely** It is unlikely that the climate change impact will result in accessibility issues along access road due to ongoing maintenance of vegetation undertaken.	**Consequence level: Very Low** The consequence of the climate change impact is considered to be very low, with additional costs incurred associated with more frequent vegetation maintenance.	**Low**	No additional resilience measures required
Increase in mean winter rainfall. Increased frequency of heavy rainfall events.	Wetter winters and more frequent heavy rainfall events would lead to an increased likelihood of flooding of access roads, potentially leading to road closures and inaccessibility for emergency or maintenance vehicles along preferred access routes.	During the outline design stage, access roads have been preferentially located within areas at a lower risk of flooding. To provide resilience, access points will be regularly spaced whereby the maximum lineside walking distance to any access point will not exceed 1km. Emergency access points will be accessible by emergency vehicles and by helicopter, where the frequent spacing of access points allows emergency access to always be available if flooding along certain routes occurs during operation. During the detail design stage, drainage for emergency and maintenance access roads will be designed to ensure no flooding of the running carriageway during a 1 in 5 (20%) annual probability design event including an allowance for climate change and surface water flows will be captured in a flood conveyance feature attenuated to the 1 in 100 (1%) annual probability design event including an allowance for climate change, using ground investigation data. During the operational stage, a regular programme of maintenance will be undertaken including general inspections of the access roads and drainage features, allowing for preventative maintenance such as the clearing of perimeter drainage. Maintenance activities will be scheduled to take into account current weather conditions, such as high rainfall events.	**Likelihood level: Possible** Although access roads have been preferentially located in areas of lower risk of flooding, it is possible that localised flooding could still occur and prevent access along the preferred route. However, alternative accesses will be available, and the sizing of drainage will reduce the likelihood of surface flooding.	**Consequence level: Low** The consequence of the climate change impact is low, associated with more frequent delays and potential health and safety or cost impacts due to rerouting emergency vehicles via alternative access routes, or rescheduling maintenance activities.	**Low**	No additional resilience measures required
Increase in mean winter rainfall. Increased frequency of heavy rainfall events.	Wetter winters and more frequent heavy rainfall events would lead to an increased likelihood of flooding of access roads, resulting in subsidence, rutting and heave of the bound road surface material,	During the outline design stage, access roads will be preferentially located within areas at a lower risk of flooding but will remain at grade with the surrounding area. During the detail design stage, durable surface materials will be chosen based on the asset technical specification documents to reduce the risk of damage due to floodwater, whilst access roads will also be designed to include cross-falls and rolling crowns to help prevent standing water, reducing the possibility of rutting.	**Likelihood level: Unlikely** The climate change impact is unlikely to occur over the design life of the asset (40 years) due to the setting of material durability technical specifications and provision of drainage to avoid standing water. Inspection and maintenance strategies	**Consequence level: Low** The consequence of the climate change impact is low, associated with costs incurred to undertake additional inspections and remedial works due to local flood damage and/or rutting.	**Low**	No additional resilience measures required

Climate change trend	Potential impact on HS2 Ltd asset group	Existing/embedded mitigation	Likelihood of impact on HS2 Ltd asset group	Consequence of impact on HS2 Ltd asset group	Risk level	Additional mitigation measures
Increase in mean temperature across all seasons.	and the washout of unbound surface material. This process is accelerated by higher humidity and warmer conditions.	During the operational stage, a regular programme of inspection and maintenance will be undertaken, allowing for preventative maintenance such as repairs prior to excessive degradation of the road surface. At the end of the design life of paved roads (40 years), the specification will be reassessed to take into account current climate projections at that time.	will further reduce the likelihood of significant degradation of the access roads.			
Increase in mean temperature across all seasons. Decrease in mean summer rainfall. Increase in mean winter rainfall.	An increased likelihood of wetter winters followed by longer or more frequent dry spells would result in greater fluctuations in soil moisture content. This can lead to shrink-swell and soil creep processes in areas with susceptible soils, and subsequent damage to the bound road surfacing.	During the detailed design stage, geotechnical analysis will be undertaken to establish the geological conditions across the route and any localised constraints or risks. In accordance with HS2 Ltd Technical Standards, allowances would be made for the effects of weathering and climate change (see CCR assessment for earthworks) and used to inform design, for example, foundation/subgrade design for the road, taking into account frequency of use. In areas of poor ground conditions a more resilient infill material will be used in the capping layer. During the operational stage, a regular programme of inspection and maintenance will be undertaken, allowing for preventative maintenance such as repairs prior to excessive degradation of the road surface.	**Likelihood level: Unlikely** The climate change impact is unlikely to occur as the geotechnical investigations will be sufficient to inform the design and allow for additional ground remediation if required, taking account of current and future ground conditions over the asset design life. Maintenance strategies will further reduce the likelihood of substantial degradation of the access roads.	**Consequence level: Very Low** Due to the mitigation measures implemented, the consequence of the climate change impact is very low, associated with costs incurred due to additional asset inspections and maintenance works undertaken prior to the asset failing.	**Low**	No additional resilience measures required
Decreased frequency of cold weather events (e.g. snow and ice). Increase in mean winter rainfall.	Although cold weather events will become less frequent, they will still occur, leading to freeze-thaw cycles resulting in degradation of bound road surface material.	During the detailed design stage, the impacts associated with cold temperatures and freeze thaw will be managed through the development of asset-specific technical specification documents. These documents will set out the use of non-frost susceptible materials within 450mm of the bound surface. Additionally, appropriate drainage design will ensure conveyance of standing water from the access road material, to reduce infiltration into the surface material. During the operational stage, a regular programme of inspection and maintenance will be undertaken, allowing for preventative maintenance such as repairs prior to excessive degradation of the road surface.	**Likelihood level: Unlikely** The climate change impact is unlikely to occur as a result of the appropriate material selection for road surface material and provision of drainage to avoid standing water. Inspection and maintenance strategies will further reduce the likelihood of significant degradation of the access roads.	**Consequence level: Very Low** The consequence of the climate change impact is very low, associated with cost incurred due to additional inspections and remedial works due to local damage.	**Low**	No additional resilience measures required