A12 Chelmsford to A120 widening scheme TR010060

6.1 ENVIRONMENTAL STATEMENT CHAPTER 15 CLIMATE

APFP Regulation 5(2)(a)

Planning Act 2008

Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009

Volume 6

August 2022

Infrastructure Planning

Planning Act 2008

A12 Chelmsford to A120 widening scheme

Development Consent Order 202[ ]

ENVIRONMENTAL STATEMENT
CHAPTER 15 CLIMATE

Regulation Reference	Regulation 5(2)(a)
Planning Inspectorate Scheme Reference	TR010060
Application Document Reference	TR010060/APP/6.1
Author	A12 Project Team & National Highways

Version	**Date**	**Status of Version**
Rev 1	August 2022	DCO Application

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15.1 Topic introduction

15.1.1 This chapter sets out the information that the Applicant is required to provide in the Environmental Statement in accordance with the Infrastructure Planning (Environmental Impact Assessment) Regulations 2017, which state that an Environmental Statement should consider both:

- The impact of the proposed scheme on climate (for example the nature and magnitude of greenhouse gas (GHG) emissions)
- The vulnerability of the proposed scheme to climate change

15.1.2 This assessment has been undertaken in accordance with the Design Manual for Roads and Bridges (DMRB) LA 114 Climate Version 0.0.1 standard (Highways England, 2021a), hereafter referred to as DMRB LA 114.

15.1.3 As per DMRB LA 114, the assessment set out in this chapter considers the impact of the proposed scheme on climate and the effects of climate on the proposed scheme during both its construction and operation.

15.1.4 This chapter is supported by the following figures [TR010060/APP/6.2]:

- Figure 15.1: Study Area for Road User GHG Emissions
- Figure 15.2: Construction Areas Used for Land Use Change GHG Emissions Calculations
- Figure 15.3: Operational Areas Used for Land Use Change GHG Emissions Calculations

15.1.5 This chapter is supported by the following appendices [TR010060/APP/6.3]:

- Appendix 15.1: Greenhouse Gas Emissions Methodology
- Appendix 15.2: Vulnerability Assessment

Impact of the proposed scheme on climate

15.1.6 The proposed scheme has the potential to affect Earth's climate by causing (either directly or indirectly) the emission of GHGs into the atmosphere, both as a result of its construction and throughout its operational life. Earth absorbs energy from the Sun and re-emits this energy as thermal infrared radiation. The GHGs in the atmosphere absorb this radiation, preventing it from escaping into space. The higher the concentration of GHGs in the atmosphere, the more heat energy is retained, and the higher global temperatures become. Due to human activities, the concentration of GHGs in the atmosphere has increased dramatically, leading to global warming. This warming leads to numerous indirect impacts (including hotter, drier summers; warmer, wetter winters; and more frequent and intense extreme weather events) as the climate responds to the increased atmospheric temperature.

15.1.7 As a result, the UK has entered into international obligations including the Paris Agreement (United Nations Framework Convention on Climate Change, 2016), which was ratified by the UK Government in 2016, after the National Networks National Policy Statement (NNNPS) (DfT, 2014) was designated in 2014. This is given effect in the UK by way of the carbon reduction 'Net Zero target' for 2050 and the carbon budgets that are set pursuant to the Climate Change Act 2008.

15.1.8 In June 2019 the Government announced a new carbon reduction ‘Net Zero target’ for 2050 which was given effect by the Climate Change Act 2008 (2050 Target Amendment Order 2019). This is a legally binding target for the Government to cut carbon emissions to net zero, against the 1990 baseline by 2050. The Climate Change Act requires five-yearly carbon budgets to be set 12 years in advance so as to meet the 2050 target. Six carbon budgets have been adopted to-date. The time periods covering the fourth, fifth and sixth budgets are 2023-2027, 2028-2032 and 2033-2037 respectively. Achieving net zero will require the UK's future GHG emissions to be aligned with these budget targets and any future new or revised carbon budget targets that may be set out by Government to achieve net zero carbon by 2050, i.e. a 100% reduction in the UK’s carbon emissions by 2050 compared with those in 1990.

15.1.9 The only statutory carbon targets are the carbon budget targets and the Net Zero 2050 target that are set at a national level i.e. they are targets for the UK as a whole. The Applicant is not aware of any relevant non-statutory targets. There are no sectoral targets (e.g. for transport), nor any targets set at a sub-national geographic scale. The Net Zero 2050 and the carbon budget targets are themselves cumulative as they are a sum of carbon emissions for a range of sectors. In addition to the absence of a sectoral or sub-national scale targets for carbon emissions, it is not possible for the Applicant to produce a baseline at such scales. Accordingly, there is no reasonable basis upon which the Applicant can assess the potential likely significant effect of the proposed scheme's carbon emissions at anything other than at national level.

15.1.10 The transport sector (including road transport) is estimated to have accounted for approximately 27% of UK GHG emissions in 2019 (Department for Business, Energy and Industrial Strategy (BEIS), 2021a), with further GHG emissions arising from the use of materials to construct and maintain the infrastructure required to operate the strategic road network.

15.1.11 The effective assessment and management of GHG emissions offers the opportunity to reduce the impact of a project on climate by reducing the magnitude of GHG emissions, as far as practicable.

Vulnerability of the proposed scheme to climate change

15.1.12 It is important that UK infrastructure projects are designed to be resilient to changes in climate which could happen in the future (e.g. higher temperatures, heavier rainfall and more extreme weather events).

15.1.13 As a result, this chapter provides an assessment of the potential vulnerability of the proposed scheme to current and potential future climatic conditions during both its construction and operation.

15.2 Competent expert evidence

15.2.1 The assessment has been undertaken and reported by a team of competent specialists. The competent expert responsible for the assessment is a Technical Director for climate and air quality who has a BEng (Hons) in Environmental Engineering and an MSc in Geographical Information Science. The competent expert is also a member of the Institution of Environmental Science (MIEnvSci) and a Chartered Environmentalist (CEnv) and has over 19 years' experience of undertaking climate assessments for major infrastructure and linear projects, including highways, for which the process of Environmental Impact Assessment (EIA) has been required.

15.3 Stakeholder engagement

15.3.1 On 28 October 2020, a scoping request was submitted to the Planning Inspectorate. Table 15.1 identifies the key themes and feedback contained within the subsequent Scoping Opinion with regards to climate (Planning Inspectorate, 2021), and how these issues have been addressed within this aspect chapter.

Table 15.1 Key Scoping Opinion feedback for climate

Stakeholder	Comment	How this is addressed in the assessment
Planning Inspectorate	The Environmental Statement should include a description and assessment (where relevant) of the likely significant effects the proposed scheme has on climate (for example having regard to the nature and magnitude of GHG emissions) and the vulnerability of the proposed scheme to climate change.	This aspect chapter provides an assessment of the potential effects of the proposed scheme on climate (i.e. GHG emissions) and the potential vulnerability of the proposed scheme to climate change (refer to Section 15.11 of this chapter).
Planning Inspectorate	Where relevant, the Environmental Statement should describe and assess the adaptive capacity that has been incorporated into the design of the proposed scheme. This may include, for example, alternative measures such as changes in the use of materials or construction and design techniques that will be more resilient to risks from climate change.	The measures and techniques which have been applied to improve the resilience of the proposed scheme to climate change are summarised in Section 15.10 of this chapter, with further detail provided in Appendix 15.2 of the Environmental Statement [TR010060/APP/6.3].

Stakeholder	Comment	How this is addressed in the assessment
Essex County Council	Essex County Council has inaugurated an independent, cross-party Essex Climate Change Commission, the findings of which will be published in the first half of 2021. The applicant should have regard to this emerging advice within the Environmental Statement, as it is expected to impact on local policies and aspirations relevant to the proposed scheme.	The Essex Climate Change Commission published Net Zero: Making Essex Carbon Neutral in July 2021 (Essex County Council, 2021). The contents of this document are discussed further in Table 15.6 (in Section 15.4 of this chapter).
Essex County Council	Essex County Council has a commitment to formulate a Climate Action Plan to reduce carbon emissions across the county of Essex. The impact of the proposed scheme on emissions within the county and potential impact on upcoming emissions reductions goals should also be noted.	This aspect chapter provides an assessment of the potential impact of the proposed scheme on GHG emissions during construction and over a 60-year operational appraisal period in accordance with DMRB LA 114. The spatial extent over which road user GHG emissions have been assessed, which covers a large part of the county of Essex, is shown on Figure 15.1 [TR010060/APP/6.2]. There is, however, no reasonable basis upon which National Highways can assess the significance of the GHG emissions impact of a scheme at a local or regional level, nor is it required to do so by law or by the National Networks National Policy Statement (NNNPS) (Department for Transport (DfT), 2014). Estimated changes in GHG emissions have accordingly been compared to relevant UK carbon budgets in line with DMRB LA 114 (see Sections 15.5 and 15.11 of this chapter).
Essex County Council	The importance of reducing the impact of the proposed scheme to as close to ‘net zero’ as possible should be noted.	A 2050 ‘net zero’ GHG emissions target against a 1990 baseline year has been set for the UK as a whole. While there is no requirement for the proposed scheme to have ‘net zero’ GHG emissions, GHG emissions associated with the proposed scheme would be reduced to contribute to the achievement of UK GHG emissions targets.

Stakeholder	Comment	How this is addressed in the assessment
Essex County Council and Feering Parish Council	All GHGs (not just carbon dioxide (CO_2)) should be considered.	Where it is practical and proportionate to do so (e.g. where industry recognised emission factors are available), this aspect chapter has considered emissions of the seven GHGs that contribute to climate change (i.e. carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), nitrogen trifluoride (NF_3) and sulphur hexafluoride (SF_6)). As required by DMRB LA 114, these GHG emissions have been expressed throughout this aspect chapter as emissions of carbon dioxide equivalent (CO_2e).

15.3.2 The full Scoping Opinion, as well as the Applicant's response regarding how and where comments have been addressed in the Environmental Statement and draft Development Consent Order (DCO), is included within Appendix 5.1 [TR010060/APP/6.3] of the Environmental Statement.

15.3.3 The proposed scheme held a period of statutory consultation between 22 June to 16 August 2021. Table 15.2 identifies the key feedback received from the statutory consultation process with regards to climate, together with how such issues have been addressed within this aspect chapter. All comments raised during the statutory consultation, as well as the Applicant's responses, are included in the Consultation Report [TR010060/APP/5.1].

Table 15.2 Key statutory consultation feedback for climate

Stakeholder	Comment	How this is addressed in the assessment
Essex County Council	Essex County Council welcomes the benefit that the proposed scheme can have on benefiting climate change but is equally concerned to see that material provisions are made in the development proposal that mitigate the carbon emissions generated from the construction and operation of the proposal and its associated development. Essex County Council note that adequate provision should be made for the reduction and offsetting of carbon emissions, both embedded and operational, in order to reduce the development's carbon footprint and mitigate the effects of climate change.	As described in Section 15.10 of this chapter, a number of mitigation measures have been embedded within the proposed scheme in order to reduce GHG emissions. Standard mitigation measures are also proposed in order to reduce GHG emissions during construction of the proposed scheme. In addition, a number of opportunities for enhancement have been identified to further reduce GHG emissions associated with the proposed scheme going forwards.

Stakeholder	Comment	How this is addressed in the assessment
	The proposed scheme, which will be carbon heavy in its construction, needs to show a commitment and methodology to offset the carbon footprint of the development and make it carbon net neutral.	There is no requirement for UK infrastructure projects to be 'carbon net neutral'. Indeed, there is no requirement for the UK's transportation sector to achieve net zero 2050 itself. Instead, and as required by DMRB LA 114, the magnitude of the GHG emissions associated with the proposed scheme would be reduced as far as practicable through the implementation of embedded and standard mitigation (as described in Section 15.10 of this chapter). In addition, some of the GHG emissions associated with the proposed scheme would be offset over the longer term by proposed tree planting within the Order Limits.
	Essex County Council recommend the measuring of the carbon footprint of the whole development throughout its life cycle, with the yearly disclosure of this information in aid of pursuing low carbon targets through the Carbon Plan. Essex County Council note that this is an omission from the proposal which would provide considerable support in monitoring, reducing, mitigating, as well as offsetting carbon emissions associated with the construction and operation of the development. In order to achieve national targets of net zero carbon by 2050, and to reduce the carbon footprint of Essex, the need to decarbonise large infrastructure developments in Essex is significant. Essex County Council note that any measuring should be made available yearly and reviewed going forward.	As per DMRB LA 114, and as summarised in Table 5.7 of this chapter, GHG emissions have been considered across the life cycle of the proposed scheme, including during construction and over a 60 year operational period. As described in Section 15.12 of this chapter, and as required by DMRB LA 114, quarterly GHG emission returns would be reported to National Highways during the construction and operational phases of the proposed scheme using the National Highways Carbon Tool (National Highways, 2021a). The data would be evaluated to inform any ongoing monitoring of GHG emissions by National Highways and by Government.

Stakeholder	Comment	How this is addressed in the assessment
	Any consented DCO submission should work towards specific and measurable targets around proposed benefits to the environment, waste, greening the development and offsetting against pollution impacts. The solution would potentially be to set carbon targets which could be monitored throughout the construction and operation of the proposed scheme.	Carbon management processes and procedures have been implemented, with reference to Publicly Available Specification (PAS) 2080:2016 Carbon Management in Infrastructure (British Standards Institution, 2016), in an attempt to achieve a voluntary project goal of a 30% reduction in project related embodied carbon within the final scheme design. It should be noted that this voluntary 30% reduction will be measured against a 'baseline' which will be determined at the detailed design stage (e.g. based on more detailed design information), which may therefore differ from the estimates of embodied carbon presented within this chapter.

15.3.4 No changes to the scope or methodology compared to that set out in the Environmental Scoping Report (ESR) (Highways England, 2020a) for this aspect have been required as a result of the stakeholder engagement process.

15.4 Legislative and policy framework

Legislation

15.4.1 On 12 December 2020, the UK communicated its new Nationally Determined Contribution under the Paris Agreement to the United Nations Framework Convention on Climate Change. The Nationally Determined Contribution commits the UK to reducing economy-wide GHG emissions by at least 68% by 2030, compared to 1990 levels (UK Government, 2020).

15.4.2 The UK's Climate Change Act 2008 commits the UK to reducing carbon emissions to 'net zero' by 2050. The Climate Change Act 2008 also requires the Secretary of State to set legally binding carbon budgets over five-year periods and to ensure that net UK carbon emissions do not exceed these budgets.

15.4.3 The UK Government carbon budgets which have been set to-date and that are relevant to the proposed scheme are as follows:

- The fourth carbon budget: 2023–2027 (defined within The Carbon Budget Order 2011) – 1,950 million tons of carbon dioxide equivalent ($MtCO_2e$), equivalent to a 36% reduction in annual emissions from a 1990 baseline.
- The fifth carbon budget: 2028–2032 (defined within The Carbon Budget Order 2016) – 1,725$MtCO_2e$, equivalent to a 57% reduction in annual emissions from a 1990 baseline.

- The sixth carbon budget: 2033–2037 (defined within The Carbon Budget Order 2021) – 965MtCO_2e, equivalent to a 78% reduction in annual emissions from a 1990 baseline. It is also the first budget which is in line with the 2050 net zero carbon target.

National policy

National Policy Statements

15.4.4 The National Networks National Policy Statement (NNNPS) (DfT, 2014) sets out the Government's policies to deliver the development of Nationally Significant Infrastructure Projects (NSIPs) on the national road and rail networks in England. The Secretary of State uses the NNNPS as the primary basis for making decisions on DCO applications.

15.4.5 Key policy from the NNNPS relevant to this aspect is set out in Table 15.3.

Table 15.3 NNNPS requirements for climate

NNNPS paragraph	NNNPS requirement	How this is addressed in the assessment
Paragraph 4.40	This paragraph of the NNNPS states that '*New national networks infrastructure will be typically long-term investments which will need to remain operational over many decades, in the face of a changing climate. Consequently, applicants must consider the impacts of climate change when planning location, design, build and operation. Any accompanying environment statement should set out how the proposal will take account of the projected impacts of climate change.'*	In accordance with paragraphs 3.26 to 3.45 of DMRB LA 114, possible future changes in climate over a 60-year appraisal period, and potential impacts on the proposed scheme associated with these climatic changes, have been considered. Measures to mitigate these potential impacts, which are embedded within the design of the proposed scheme, are identified within this aspect chapter and residual risks assessed (see Sections 15.8 to 15.11 of this chapter).
Paragraph 4.41	This paragraph of the NNNPS states that '*Where transport infrastructure has safety-critical elements and the design life of the asset is 60 years or greater, the applications should apply the UK Climate Projections 2009 (UKCP09) high emissions scenario (high impact, low likelihood) against the 2080 projections at the 50% probability level*.'	In accordance with paragraph 3.28 of DMRB LA 114, the latest available projections (i.e. UK Climate Projections 2018 (UKCP18)) have been used for the high emissions (i.e. RCP8.5) scenario against the 2080 projections at the 50% probability level. UKCP18 supersede UKCP09 and are considered to provide a better estimate of future climate conditions.

NNNPS paragraph	NNNPS requirement	How this is addressed in the assessment
Paragraph 4.42	This paragraph of the NNNPS states that '*The applicant should take into account the potential impacts of climate change using the latest UK Climate Projections available at the time and ensure any environment statement that is prepared identifies appropriate mitigation or adaptation measures. This should cover the estimated lifetime of the new infrastructure.'*	The UKCP18 projections are the latest available and have been used to understand possible changes in climate over the lifetime of the proposed scheme (i.e. up to the 2080s), as per paragraphs 3.31 and 3.32 of DMRB LA 114. Based on these possible changes in climate, mitigation measures embedded within the design of the proposed scheme have been identified and presented within this assessment (see Section 15.10 of this chapter).
Paragraph 4.43	This paragraph of the NNNPS states that '*The applicant should demonstrate that there are no critical features of the design of new national networks infrastructure which may be seriously affected by more radical changes to the climate beyond that projected in the latest set of UK climate projections. Any potential critical features should be assessed taking account of the latest credible scientific evidence on, for example, sea level rise (e.g. by referring to additional maximum credible scenarios such as from the Intergovernmental Panel on Climate Change or Environment Agency) and on the basis that necessary action can be taken to ensure the operation of the infrastructure over its estimated lifetime through potential further mitigation or adaptation.'*	DMRB LA 114 states that climate assessments should use the H++ climate scenarios to test the sensitivity of vulnerable safety-critical features, to ensure that such features would not be affected by more radical changes to the climate beyond that projected in the latest set of UK Climate Projections. The H++ scenarios cover heat waves, cold snaps, low and high rainfall, droughts, floods and windstorms. However, of these climate related events, the greatest risks to safety critical features (e.g. structures) are considered likely to be those associated with flooding. The H++ scenarios were developed using a set of climate change projections which have since been superseded (i.e. UKCP09); however, the Met Office does not propose to update these scenarios using UKCP18. Following the publication of updated guidance on climate change allowances, the H++ scenarios are no longer used to inform peak river flow allowances on highway schemes. As discussed in Chapter 14: Road drainage and the water environment, of the Environmental Statement [TR010060/APP/6.1], however, consideration has been given to potential changes to the risk of flooding should more radical changes in climate occur. This analysis identified no locations where the maximum credible climate change allowance published at that time (i.e. a 65% climate change allowance for peak river flow) would result in a risk of flooding to the carriageway due to the freeboard (i.e. the difference between the design flood level

NNNPS paragraph	NNNPS requirement	How this is addressed in the assessment
		and the soffit level of a bridge/culvert) at all watercourse crossings. Since this analysis was undertaken, however, the recommended maximum credible climate change allowance for peak river flow has been increased from 65% to 72%. As there is significant freeboard for each of the main rivers considered, and generally small, modelled changes in flood depth due to the additional allowances for climate change considered, the risk of flooding to the proposed scheme with even a 72% climate change allowance is considered low.
Paragraph 4.44	This paragraph of the NNNPS states that '*Any adaptation measures should be based on the latest set of UK Climate Projections, the Government's national Climate Change Risk Assessment and consultation with statutory consultation bodies. Any adaptation measures must themselves also be assessed as part of any environmental impact assessment and included in the environment statement, which should set out how and where such measures are proposed to be secured.'*	The UKCP18 projections are the latest available and have been used to understand possible changes in climate over the lifetime of the proposed scheme (i.e. up to the 2080s) within this chapter. The Independent Assessment of UK Climate Risk (Climate Change Committee, 2021a), which provides advice to Government to inform the UK's third Climate Change Risk Assessment (CCRA3), has also been reviewed as part of this assessment (see Section 15.8 of this chapter). As noted in Chapter 14: Road drainage and the water environment, of the Environmental Statement [TR010060/APP/6.1], relevant climate change allowances, which have been agreed in consultation with relevant stakeholders (e.g. the Environment Agency), have informed the design of the proposed scheme. Based on the above, mitigation measures embedded within the design of the proposed scheme have been identified and presented within this chapter, along with standard mitigation measures, which are secured in the Register of Environmental Actions and Commitments (REAC), within the first iteration of the Environmental Management Plan (EMP) [TR010060/APP/6.5] (see Section 15.10 of this chapter).

NNNPS paragraph	NNNPS requirement	How this is addressed in the assessment
Paragraph 5.17	This paragraph of the NNNPS states that '*Where the development is subject to EIA, any Environmental Statement will need to describe an assessment of any likely significant climate factors in accordance with the requirements in the EIA Directive. It is very unlikely that the impact of a road project will, in isolation, affect the ability of Government to meet its carbon reduction plan targets. However, for road projects applicants should provide evidence of the carbon impact of the project and an assessment against the Government's carbon budgets.*'	Prior to this DCO application, changes in operational road user GHG emissions (i.e. carbon impacts) have been considered as part of the appraisal of scheme options in accordance with Transport Analysis Guidance (TAG) Unit A3, Section 4 (DfT, 2021a). In accordance with paragraphs 3.11 to 3.20 of DMRB LA 114, changes in GHG emissions associated with the construction and operation of the proposed scheme have been estimated and compared to relevant UK carbon budgets in order to assess their significance (see Section 15.11 of this chapter).
Paragraph 5.19	This paragraph of the NNNPS outlines states that '*Evidence of appropriate mitigation measures (incorporating engineering plans on configuration and layout, and use of materials) in both design and construction should be presented.*'	Mitigation measures have been implemented or are proposed (see Section 15.10 of this chapter) which would reduce GHG emissions associated with the proposed scheme, both in terms of its design and its construction. These measures are considered likely to substantially reduce the carbon footprint of the proposed scheme.

15.4.6 As set out in Chapter 1: Introduction, of the Environmental Statement [TR010060/APP/6.1], the assessment has considered the Overarching National Policy Statement for Energy (EN-1) and National Policy Statement for Gas Supply Infrastructure and Gas and Oil Pipelines (EN-4) (Department of Energy and Climate Change, 2011a; 2011b) in relation to the diversion of an existing high-pressure gas main (the 'gas main diversion') owned and operated by Cadent Gas Limited (Cadent). Draft versions of the updated EN-1 and EN-4 NPS have also been considered (BEIS, 2021b; 2021c).

15.4.7 A review of the relevant requirements of EN-1 and EN-4 (including the draft updated versions), relating to the EIA of gas main diversion works, identified that the requirements are not materially different to those set out in the NNNPS. As such, it is considered that by meeting the NNNPS requirements set out in Table 15.3, the requirements of EN-1 and EN-4 are also met.

National Planning Policy Framework

15.4.8 In addition to the NNNPS, the National Planning Policy Framework (NPPF) (Ministry of Housing, Communities & Local Government, 2021) is of relevance to this aspect chapter, as outlined in Table 15.4.

Table 15.4 NPPF requirements for climate

Document	Requirements in relation to climate	How this is addressed in the assessment
National Planning Policy Framework (NPPF)	Paragraph 154 of the NPPF states that '*New development should be planned for in ways that:* *a) avoid increased vulnerability to the range of impacts arising from climate change. When new development is brought forward in areas which are vulnerable, care should be taken to ensure that risks can be managed through suitable adaptation measures, including through the planning of green infrastructure; and* b) *can help to reduce greenhouse gas emissions, such as through its location, orientation and design.'*	Having identified possible changes in climate (Section 15.8 of this chapter), potential impacts associated with these changes (Section 15.9 of this chapter) and the measures embedded within the design of the proposed scheme to mitigate these impacts (Section 15.10 of this chapter), an assessment of the residual risk of each impact has been undertaken based on the assumed likelihood and consequence of each potential impact occurring (Section 15.11 of this chapter). As identified in Section 15.10 of this chapter, a number of mitigation measures have been or would be implemented in order to reduce GHG emissions associated with the proposed scheme.

Local policy

15.4.9 In addition to the national policy set out in the NNNPS, the proposed scheme has also had regard to relevant local plans and policy. A summary of the policy framework is provided in Appendix 1.1 of the Environmental Statement [TR010060/APP/6.3]. Key local policies relevant to this aspect are included in Table 15.5.

Table 15.5 Local policy requirements for climate

Local authority	Local policy document and requirements	How this is addressed in the assessment
Braintree District Council	Core Strategy (Braintree District Council, 2021) Policy CS8 requires that all development proposals take account of the potential impacts of climate change.	In accordance with paragraphs 3.26 to 3.45 of DMRB LA 114, possible future changes in climate over a 60-year appraisal period, and potential impacts on the proposed scheme associated with these climatic changes, have been considered. Measures to mitigate these potential impacts, which are embedded within the design of the proposed scheme, are identified within this aspect chapter and residual risks assessed (see Sections 15.8 to 15.11 of this chapter).
	Local Plan Review, saved policies (Braintree District Council, 2005) Policy RLP 77 requires that new developments demonstrate the optimum use of energy conservation and incorporate energy conservation and efficiency measures in order to contribute to the reduction in their total energy consumption.	Mitigation measures are embedded within the proposed scheme design and would be implemented going forwards in order to reduce GHG emissions during both the construction and operation of the proposed scheme (see Section 15.10 of this chapter). Energy efficient light emitting diode (LED) lighting would also be used during the operation of the proposed scheme, in order to reduce operational energy consumption (and associated GHG emissions).
	Braintree Publication Draft Local Plan Section 2 (Emerging) (Braintree District Council, 2017) Policy LPP 55 indicates planning permission will be granted where development proposals incorporate measures for environmental sustainability throughout the construction, occupation and demolition of the development, in relation to climate change and the use of materials with low overall energy requirements.	Mitigation measures are embedded within the proposed scheme design and would be implemented going forwards in order to reduce GHG emissions during both its construction and operation (see Section 15.10 of this chapter). As per paragraph 2.3 of DMRB LA 114, GHG emissions associated with decommissioning have not been considered within this aspect chapter due to the assumed length of the operational phase of the proposed scheme (i.e. >60 years).

Local authority	Local policy document and requirements	How this is addressed in the assessment
	Braintree Publication Draft Local Plan Section 2 (Emerging) (Braintree District Council, 2017) Policy LPP 74 indicates that planning permission will only be granted for proposals that demonstrate the principles of climate change mitigation and adaptation have been embedded into the development.	Having identified possible changes in climate (Section 15.8 of this chapter), potential impacts associated with these changes (Section 15.9 of this chapter) and the measures embedded within the design of the proposed scheme to mitigate these impacts (Section 15.10 of this chapter), an assessment of the residual risk of each impact has been undertaken based on the assumed likelihood and consequence of each potential impact occurring (Section 15.11 of this chapter).
Chelmsford City Council	Chelmsford Local Plan (Chelmsford City Council, 2020) Strategic Policy S2 indicates that the Council will encourage developments that reduce GHG emissions and encourage design and construction techniques which contribute to climate change mitigation and adaptation.	Mitigation measures are embedded within the proposed scheme design and would be implemented going forwards in order to improve its resilience to climate change and reduce GHG emissions during both its construction and operation (see Section 15.10 of this chapter).
Colchester Borough Council	Colchester Local Plan 2017–2033 Section Two – Local Plan for Colchester (Emerging) (Colchester Borough Council, 2017) Policy CC1 seeks to encourage design and construction techniques which contribute to climate change mitigation and adaptation by using landform, layout, building orientation, massing, tree planting and landscaping to reduce energy consumption and provide resilience to a changing climate.	Mitigation measures are embedded within the proposed scheme design and would be implemented going forwards in order to improve its resilience to climate change and reduce GHG emissions during both its construction and operation (see Section 15.10 of this chapter). The mitigation hierarchy set out in paragraph 3.22.1 of DMRB LA 114 has been followed when developing GHG mitigation measures, namely firstly seeking to avoid / prevent GHG emissions, then to reduce emissions and finally to remediate emissions (where practicable to do so).

Local authority	Local policy document and requirements	How this is addressed in the assessment
Maldon District Council	Maldon District Approved Local Development Plan 2014–2029 (Maldon District Council, 2017) Policy D2 seeks to reduce the impact of new development on the environment by incorporating principles such as maximising the use of building materials from sustainable sources and applying sustainable construction methods where appropriate, contributing towards making more efficient use or re-use of existing resources and reducing the lifecycle impact of materials used in construction and incorporating green infrastructure as a way of adapting and mitigating for climate change. Policy S1 indicates that when considering development proposals, the Council will enable and adapt to the effects of climate change by limiting greenhouse gas emissions through the efficient use of energy and use of renewable alternatives, coastal management, and mitigating against flooding.	Mitigation measures are embedded within the proposed scheme design and would be implemented going forwards in order to improve its resilience to climate change and reduce GHG emissions during both its construction and operation (see Section 15.10 of this chapter).

Plans and strategies

15.4.10 A number of plans and strategies have been published which are relevant to this aspect, as outlined in Table 15.6.

15.4.11 The Climate Change Committee is an independent statutory body, established under the Climate Change Act 2008, whose purpose is to advise the UK and devolved governments on GHG emissions targets and to report to Parliament on progress made in reducing GHG emissions and preparing for and adapting to the impacts of climate change. The Climate Change Committee's independent assessment of the UK's Net Zero Strategy (Climate Change Committee, 2021b) states that '*Our overall assessment is that it is an ambitious and comprehensive strategy that marks a significant step forward for UK climate policy, setting a globally leading benchmark to take to COP26. Further steps will need to follow quickly to implement the policies and proposals mapped out in the Net Zero Strategy if it is to be a success'*.

15.4.12 The Climate Change Committee also notes that '*A zero emission vehicle mandate will be the key delivery tool for electric vehicles, as recommended by the Committee*' and '*The Transport Decarbonisation Plan is a reasonably comprehensive strategy for transitioning to a system in which almost all journeys are zero-carbon*'.

Table 15.6 Climate related plans and strategies

Organisation	Plan or strategy
HM Government	Net Zero Strategy: Build Back Greener (HM Government, 2021) This strategy sets out the UK's approach to meeting UK carbon budgets, its 2030 Nationally Determined Contribution and net zero by 2050. As such, it includes: • decarbonisation pathways to net zero by 2050, including illustrative scenarios • policies and proposals to reduce GHG emissions for each sector • cross-cutting action to support the transition The High Court declared that this strategy was unlawful on 15 July 2022. This strategy was not quashed, however, and the UK Government will be updating it to address the Court's concerns in the near future.
Department for Transport	Decarbonising Transport: A Better, Greener Britain (DfT, 2021b) This document sets out the Government's commitments and the actions needed to decarbonise the entire transport system in the UK. The plan includes commitments for zero emission vehicles, delivering a zero emission freight and logistics sector, maximising the benefits of sustainable low carbon fuels, more choice and better efficiency in the future transport system, hydrogen's role in decarbonising the transport system and increased investment in cycling and walking. The plan recognises, however, that continued high investment in our roads is, and will remain, as necessary as ever, to ensure the functioning of the nation and to reduce congestion which in itself is a major source of GHG emissions.
National Highways	Net Zero Highways: Our 2030/2040/2050 Plan (National Highways, 2021b) This document sets out National Highway's programme for a net zero future. This centres on net zero GHG emissions for National Highways own operations by 2030 (corporate emissions); net zero for maintenance and construction of the National Highways network by 2040 (maintenance and construction emissions); and net zero carbon travel from users of the National Highways Network by 2050 (road user emissions).
National Highways	Preparing for Climate Change on the Strategic Road Network (National Highways, 2022) This adaption report identifies key climate change related risks relevant to the Strategic Road Network (SRN), assesses progress made towards adapting the SRN to these risks and sets out actions which will be undertaken by National Highways to respond to climate change related risks going forwards.

Organisation	Plan or strategy
Essex County Council	Net Zero: Making Essex Carbon Neutral (Essex County Council, 2021) This document sets out the plan to tackle climate change and the key steps needed for Essex to reach net zero by 2050. Specifically, for transport, the document sets out a series of recommendations that the Commission focuses on, including increasing active and sustainable travel provision within the county; reducing reliance on the car; and creating new cycling, walking and bus routes from and to key destinations for residents and visitors, while supporting the shift to alternative fuels.

15.5 Assessment methodology

Assessment scope

15.5.1 This assessment provides an assessment of both the impact of the proposed scheme on climate (i.e. GHG emissions) and the vulnerability of the proposed scheme to climate change.

Greenhouse gas emissions

15.5.2 As per paragraph 3.11 and 3.11.1 of DMRB LA 114, GHG emissions associated with the proposed scheme have been estimated and reported for the construction phase and operational phase (over a 60-year appraisal period). Therefore, the temporal scope of the assessment of GHG emissions covers the period from the commencement of construction works (i.e. 2024) to 60 years after the opening year of the proposed scheme (i.e. 2086).

Construction phase

15.5.3 An estimate has been made of GHG emissions which are likely to be generated during the construction phase as a result of the following activities, in alignment with the 'before use' life cycle stage and modules A1 to A5 identified in PAS 2080:2016 Carbon Management in Infrastructure (British Standards Institution, 2016):

- Embodied GHG emissions associated with the required raw materials (product stage (modules A1–A3))
- Transport of materials to the construction site (construction process stage (module A4))
- Transport of waste from the construction site and subsequent treatment (construction process stage (module A5))
- Transport of construction workers, onsite staff and visitors to and from the construction site (construction process stage (module A5))
- Operation of construction plant and onsite activities (construction process stage (module A5))
- Onsite consumption of fuel, electricity and water (construction process stage (module A5))

15.5.4 The GHG emissions mobilised by vegetation losses and soil disturbance during the construction phase have also been estimated, as required by Table 3.11.1 of DMRB LA 114.

Operational phase

15.5.5 An estimate has been made of GHG emissions which are likely to be generated during the operational phase as a result of the following activities, in alignment with the 'use' life cycle stage and modules B2 to B6 and B9 identified in PAS 2080:2016:

- Maintenance, repair, replacement and refurbishment of the proposed scheme assets over its operational life (modules B2–B5)
- Operational energy use by proposed scheme lighting (module B6)
- The use of the proposed scheme by end users and the effect the proposed scheme is predicted to have on traffic flows across the wider road network (module B9)

15.5.6 The GHG emissions mobilised by ongoing changes in land use and forestry due to the presence of the proposed scheme have also been estimated, as required by Table 3.11.1 of DMRB LA 114.

Decommissioning

15.5.7 As per paragraph 2.3 of DMRB LA 114, GHG emissions associated with decommissioning of the proposed scheme (i.e. modules C1 to C4 of the 'end of life' life cycle stage identified in PAS 2080:2016) are excluded from the assessment due to the length of the operational phase of the proposed scheme's assets (which is assumed to be greater than the 60-year appraisal period required by DMRB LA 114).

Vulnerability to changes in climate

15.5.8 As per paragraph 3.31 of DMRB LA 114, the assessment of the proposed scheme's vulnerability to climate change has taken the life span of the project to be 60 years (i.e. from 2027 to 2086, inclusive). Climate projections for the 2030s, 2060s and 2080s, for the high emissions (i.e. RCP8.5) scenario at the 50% probability level, have, therefore, been used to represent changes in climate over the short, medium and long term, respectively, as per paragraph 3.32 of DMRB LA 114.

15.5.9 As identified in Table 15.18 (in Section 15.8 of this chapter), projected changes in climate over the longer term suggest that there could be substantial increases in both summer temperatures and winter precipitation in the area of the proposed scheme. Furthermore, Table 15.19 indicates that maximum daily temperatures could increase substantially over the lifespan of the proposed scheme, while Table 15.20 indicates that climate events such as hot spells, heatwaves, dry spells and droughts could occur more frequently.

15.5.10 The assessment of the vulnerability of the proposed scheme to climate change has therefore focused on potential impacts associated with changes in temperature and precipitation only.

Summary

15.5.11 Table 15.7 summarises the scope of the assessment, which is as detailed in the ESR submitted for the proposed scheme (Highways England, 2020a). The scope presented in Table 15.7 is also in line with the Scoping Opinion received (Planning Inspectorate, 2021).

Table 15.7 Summary of climate scope

Matter	Sub-matter	Scoped in – construction	Scoped in – operation
GHG emissions	Product stage (embodied carbon in construction materials)	✓	✓[a]
	Transport of construction materials to site	✓	✓[a]
	Fuel consumption (onsite plant and machinery)	✓	✓[a]
	Fuel consumption (all staff vehicles)	✓	✓[a]
	Electricity, natural gas and water consumption	✓	✓
	Transportation, treatment and disposal of waste materials	✓	✓[a]
	Land use change and forestry	✓	✓
	Road users	N/A	✓
Vulnerability of scheme to climate change	Changes in seasonal precipitation and temperature	✓	✓
	Increased frequency of extreme precipitation and temperature events	✓	✓

[a] During maintenance activities (including repair, replacement and refurbishment).

N/A: Not applicable

General approach

15.5.12 Whilst the assessment of this aspect has been undertaken in accordance with DMRB LA 114, reference has also been made, where relevant and appropriate to do so, to the following:

- PAS 2080: Carbon Management in Infrastructure (BSI, 2016)
- Woodland Carbon Code Carbon Calculation Guidance (Woodland Carbon Code, 2021)
- National Highways Carbon Tool Guidance (National Highways, 2021a)
- Emissions Factors Toolkit v11.0 User Guide (Department for Environment, Food and Rural Affairs (Defra), 2021)

- Environmental Impact Assessment Guide to: Climate Change Resilience and Adaptation (Institute of Environmental Management and Assessment (IEMA), 2020)
- Assessing Greenhouse Gas Emissions and Evaluating their Significance (IEMA, 2022).

Greenhouse gas emissions

15.5.13 An assessment of the net change in GHG emissions associated with the proposed scheme against UK Government carbon budgets (in metric tonnes of carbon dioxide equivalent (tCO_2e)) has been undertaken in accordance with paragraph 3.18 of DMRB LA 114, and as required by the NNNPS. As the construction and operational phases of the proposed scheme extend over multiple carbon budget periods, GHG emissions have been reported against each relevant carbon budget, for the construction and operational phases respectively.

15.5.14 There is no set significance threshold for carbon. IEMA guidance (IEMA, 2022) indicates that the crux of significance is not whether a project emits GHG emissions, nor even the magnitude of GHG emissions alone, but whether the project contributes to reducing GHG emissions relative to a comparable baseline consistent with a trajectory towards net zero by 2050 (see section 6.2 of the IEMA guidance).

15.5.15 The IEMA guidance addresses significance principles and criteria in section 6.3 and Figure 5 and advises (amongst other things) that:

- a project that follows a ‘business-as-usual’ or ‘do minimum’ approach and is not compatible with the UK’s net zero trajectory, or accepted aligned practice or area-based transition targets, results in significant adverse effects;
- a project that is compatible with the budgeted science-based 1.5 degree Celsius trajectory (in terms of rate of emissions reduction) and which complies with up-to-date policy and ‘good practice’ reduction measures to achieve that has a minor adverse effect that is not significant - such a project may have residual emissions but it is doing enough to align with and contribute to the relevant transition scenario to keep the UK on track towards net zero by 2050 with at least a 78% reduction by 2035 and thereby potentially avoiding significant adverse effects; and
- a project that achieves emissions mitigation that goes substantially beyond the reduction trajectory, or substantially beyond existing and emerging policy compatible with that trajectory, and has minimal residual emissions, is considered to have negligible effect that is not significant and such a project is playing a part in achieving the rate of transition required by nationally set policy commitments.

15.5.16 The adoption of a net zero target does not mean that consent cannot be granted for development that will increase carbon emissions; rather, as set out in paragraph 5.18 of the NNNPS, it is necessary to continue to evaluate whether (amongst other things) the increase in carbon emissions resulting from a proposed development would have a material impact on the ability of Government to meet its carbon reduction targets.

15.5.17 The Government has adopted the carbon budgets in order to meet the goals of the Paris Agreement. Thus, a proposed development which is compatible with the 2050 target and interim carbon budgets is consistent with the approach to addressing the adverse effects of climate change. This aligns with the approach to significance set out in the IEMA guidance (IEMA, 2022). The approach set out in the NNNPS continues to be relevant in light of international obligations and domestic obligations related to reducing carbon emissions that have come into force since the NNNPS was designated.

15.5.18 It is also to be noted that the carbon budgets are economy-wide and not just targets in relation to transport.

15.5.19 In the light of the above, an assessment has then been made, based on professional judgement, as to whether increases in GHG emissions as a result of the proposed scheme could have a material impact on the ability of the UK Government to meet its carbon reduction targets (and would therefore potentially be significant).

15.5.20 In order to estimate GHG emissions associated with the construction and operational phases of the proposed scheme, a number of different GHG emissions estimation methods were used. These methods and associated data sources are summarised in Table 15.8 for the construction phase and Table 15.9 for the operational phase. Further details on the methods and data used are provided in Appendix 15.1 of the Environmental Statement [TR010060/APP/6.3].

Table 15.8 Summary of construction phase GHG emissions estimation methods

Emissions source	Emission estimation method	Data sources
Product stage (embodied carbon in construction materials)	National Highways Carbon Tool v.2.4 (National Highways, 2021a)	Types and quantities of materials and items from the Bill of Quantities (BoQ) for the proposed scheme (for both temporary and permanent works)
Transport of construction materials to site		Assumed transport distances from suppliers to site and within site and the assumed mode of transport for all materials and items within BoQ
Fuel consumption (onsite plant and machinery)		Estimated based on recorded fuel consumption for a similar project (the A14 Cambridge to Huntingdon scheme), adjusted to account for the relative difference in scale between the two projects
Fuel consumption (employee transport)		Estimated total distance travelled to and from, and within, the construction site by different transport modes based on expected numbers of employees over the construction period and assumptions regarding distances travelled and modes used
Onsite electricity, gas and water consumption		Estimated based on recorded onsite electricity and water consumption for a similar project (the A14 Cambridge to Huntingdon scheme), adjusted to account for the relative difference in scale between the two projects
Transportation, treatment and disposal of waste materials		Estimated type and quantities of waste materials contained within BoQ Types and quantities of materials and items within the BoQ and assumed wastage rates Assumed disposal methods and transportation distances
Land use change	Natural England average carbon stock estimates (Natural England, 2012)	Area and type of different land uses within the Order Limits Assumptions regarding the proportion of carbon stock held in vegetation and soil which would be lost as a result of disturbance or loss of soils and vegetation during construction

Table 15.9 Summary of operational phase GHG emissions estimation methodology

Emissions source	Emission estimation methodology	Data sources
Product stage (embodied carbon in maintenance materials and replacement items)	National Highways Carbon Tool v.2.4 (National Highways, 2021a)	Types and quantities of materials and items from the BoQ for the proposed scheme (for permanent works) and assumed replacement frequencies for materials and items in accordance with their expected design life
Transport of maintenance materials and replacement items to site		Assumed transport distances from suppliers to site and within site and the assumed mode of transport for all materials and items
Transportation, treatment and disposal of waste materials		Estimated type and quantities of waste materials likely to be used during maintenance and assumed wastage rates Assumed disposal methods and transportation distances
Fuel consumption during maintenance (onsite plant and machinery)	Estimated based on GHG emissions for the construction phase factored by the ratio of embodied carbon in the 'product stage' between the construction phase and operational phase	
Fuel consumption during maintenance (employee transport)		
Onsite electricity, gas and water consumption during maintenance		
Land use change	Weighted average change in equilibrium non-organic soil carbon density for changes between different land types in England from the UK Annual National Inventory Report (BEIS, 2021d)	Type and area of land uses within the area of permanent land-take
Changes in forestry	Woodland Carbon Code Carbon Calculation Spreadsheet v2.4 (Woodland Carbon Code, 2021)	Type, spacing and areas of trees retained, removed, and planted

Emissions source	Emission estimation methodology	Data sources
Electricity consumption	Electricity emission factors (BEIS, 2021e)	Anticipated annual electricity consumption based on the number, wattage and operating schedule of the proposed scheme lighting
Road users	Emissions Factors Toolkit v11.0 (Defra, 2021)	Modelled traffic data for the Do-Minimum and Do-Something scenarios in the opening year (i.e. 2027) and design year (i.e. 2042) of the proposed scheme. Emissions were then linearly interpolated between the opening year and design year, and assumed to remain constant thereafter, in order to estimate GHG emissions over the assumed 60-year life span of the proposed scheme. The assessment was based on the difference in GHG emissions between the Do-Minimum and Do-Something scenarios.

Vulnerability to changes in climate

15.5.21 For the assessment of the proposed scheme's vulnerability to changes in climate, the following tasks have been undertaken in line with paragraphs 3.26 to 3.35 of DMRB LA 114, and as required by the NNNPS:

- Analysis of published historical regional weather data to understand the current climate impacts on the study area
- The identification of historical climate-related events (e.g. floods, landslides) in the study area to provide an indication of past vulnerability
- Analysis of projected baseline climate conditions using UK Climate Projections 2018 (UKCP18) datasets (Met Office, 2020) in order to identify the type and magnitude of changes in climate to which the proposed scheme could potentially be exposed
- The identification of receptors, during both the construction (e.g. workforce, plant, machinery) and operational phases (e.g. scheme assets and end users), which are potentially vulnerable to changes in climate (e.g. increased rainfall and/or temperature extremes)
- The identification of climate change related impacts (e.g. flooding or landslides) on the receptors identified, which could potentially be significant
- The identification of design and mitigation measures which would be embedded within the design of the proposed scheme in order to improve its resilience to climate change, in liaison with the proposed scheme design team and relevant environmental aspect specialists

15.5.22 For construction phase impacts, a qualitative description of the potential risk of disruption during the construction phase has been reported (as per paragraph 3.40 of DMRB LA 114).

15.5.23 For operational phase impacts, a qualitative risk assessment of the residual likelihood and consequence of each impact has been undertaken with reference to the indicative framework set out in Table 3.39a (likelihood categories) and Table 3.39b (measure of consequence) of DMRB LA 114 (replicated in Table 15.10 and Table 15.11 below).

Table 15.10 Likelihood categories

Likelihood category	Description (probability and frequency of occurrence)
Very high	The event occurs multiple times during the lifetime of the proposed scheme (60 years) e.g. approximately annually, typically 60 events.
High	The event occurs several times during the lifetime of the proposed scheme (60 years) e.g. approximately once every five years, typically 12 events.
Medium	The event occurs limited times during the lifetime of the proposed scheme (60 years) e.g. approximately once every 15 years, typically four events.
Low	The event occurs during the lifetime of the proposed scheme (60 years) e.g. once in 60 years.
Very low	The event can occur once during the lifetime of the proposed scheme (60 years).

Table 15.11 Measure of consequence

Consequence of impact	Description
Very large adverse	Operation – national level (or greater) disruption to strategic route(s) lasting more than one week.
Large adverse	Operation – national level disruption to strategic route(s) lasting more than one day but less than one week or regional level disruption to strategic route(s) lasting more than one week.
Moderate adverse	Operation – regional level disruption to strategic route(s) lasting more than one day but less than one week.
Minor adverse	Operation – regional level disruption to strategic route(s) lasting less than one day.
Negligible	Operation – disruption to an isolated section of a strategic route lasting less than one day.

Assessing the significance of effects

Greenhouse gas emissions

15.5.24 Parliament has set the appropriate geographical scale for the assessment of the significance of GHG emissions from NSIPs at the national level. The Climate Change Act 2008 does not impose a legal duty to set carbon budgets at a smaller scale than those set out nationally. There are no legal duties that require particular geographical areas within the UK to achieve particular reductions in GHG emissions by particular dates. There are no legal duties to

identify and set any sectoral targets for GHG reductions related to transport, or any other sector. There is no requirement in the Climate Change Act 2008, or in Government policy, for GHG emissions for all road transport to become net zero. The NNNPS requires the significance of GHG emissions from NSIPs to be assessed by reference to whether the predicted emissions would have a material effect on the Government's ability to meet carbon budgets.

15.5.25 In line with DMRB LA 114, an assessment has been made, based on professional judgement, as to whether estimated increases in GHG emissions as a result of the proposed scheme could have a material impact on the ability of the UK Government to meet its carbon reduction targets (and would therefore potentially be significant).

Vulnerability to changes in climate

15.5.26 For the operational phase, the residual likelihood and consequence of each of the potential climate related impacts identified has been combined in order to assess significance as per Table 3.41 (significance matrix) of DMRB LA 114 (replicated in Table 15.12).

Table 15.12 Evaluation of significance

		Measure of likelihood				
		Very low	Low	Medium	High	Very high
Measure of consequence	Very large	NS	S	S	S	S
	Large	NS	NS	S	S	S
	Moderate	NS	NS	S	S	S
	Minor	NS	NS	NS	NS	NS
	Negligible	NS	NS	NS	NS	NS

Table notes: NS = Not significant, S = Significant

15.6 Assessment assumptions and limitations

Greenhouse gas emissions

15.6.1 The assessment of construction phase GHG emissions provided within this chapter is based on the BoQ for the proposed scheme, which was produced in October 2021. Whilst it is noted that a number of localised alterations have been made to the proposed scheme design since this point, these changes are considered unlikely to have a material influence on material quantities, and therefore likely project-related GHG emissions, compared to those presented in this chapter. This approach is in keeping with paragraph 3.14 of DMRB LA 114, which indicates that a '*proportionate approach shall be applied to capture the principal contributing factors associated with GHG emissions*'.

15.6.2 A contingency factor has been applied within Chapter 11: Material assets and waste, of the Environmental Statement [TR010060/APP/6.1], in an attempt to account for uncertainty in material quantities and to provide a more conservative assessment. This approach has not been taken within this chapter, however, in order to provide a clear and traceable link between the material quantities in the BoQ and those used within the National Highways Carbon Tool (National Highways, 2021a). The application of a contingency factor to material quantities (e.g. 15%) and subsequent impact on the estimated GHG emissions associated with the proposed scheme would not, however, alter the conclusions of this assessment.

15.6.3 The potential impact of minor changes to the vertical or horizontal alignment of the proposed scheme (within the defined limits of deviation) on GHG emissions has not been assessed as they are considered unlikely to result in a material change in material quantities. As such, they are considered unlikely to have a material impact on GHG emissions associated with the proposed scheme.

15.6.4 The construction GHG emissions appraisal was constrained due to limited data availability for certain elements, which are typically unknown at this stage of a project. Specifically, there was incomplete or unknown information relating to onsite energy consumption and site utilities, the transport distances of raw materials, commuter distances, volumes and transport distances of waste. Likewise, the maintenance frequencies of materials and assets which would be required during the operational phase are uncertain. A number of assumptions, therefore, have been made within the assessment using professional judgement, relevant guidance and experience gained from other projects. These assumptions, which in many cases were worst case, are considered unlikely to have had a material influence on the resulting magnitude of estimated GHG emissions. A complete description of the methodology used, along with the associated limitations and assumptions, is provided in Appendix 15.1 of the Environmental Statement [TR010060/APP/6.3].

15.6.5 The road user GHG emissions estimates presented in this chapter are based on data derived from the A12 Project Control Framework (PCF) Stage 3 DCO traffic model (based on a 2019 base year). There are uncertainties inherent within all modelled road traffic data, including those on which the operational road user GHG emissions calculations presented within this chapter are based. The traffic model outputs used have, however, been appropriately validated, as discussed within the Combined Modelling and Appraisal Report [TR010060/APP/7.3], and are therefore considered suitably robust.

15.6.6 The methodology used to estimate road user GHG emissions presented in this chapter is considered the most appropriate, however, it is subject to uncertainty, not least regarding the assumed uptake of electric vehicles and improvements in vehicle efficiency (i.e. fuel consumption) over time. While the vehicle fleet projections and engine efficiency factors used within the Emissions Factors Toolkit v11.0 (Defra, 2021) were provided by National Highways and the Department for Transport in July 2021, it is likely that these will be updated in the near future (e.g. to account for policies within the recently published Transport Decarbonisation Plan (TDP) (DfT, 2021b)). The vehicle fleet projections and fuel consumption parameters used within this assessment are,

therefore, considered likely to be conservative, as they do not yet account for more recent government plans to decarbonise the UK vehicle fleet (in particular heavy goods vehicles (HGVs)). In an attempt to understand the potential impact of the TDP on the magnitude of operational road user GHG emissions considered in this assessment, two sensitivity tests have been undertaken based on the 'upper' and 'lower' bounds of the projected rate of improvement in road user GHG emissions shown in Figure 2 of the TDP, the results of which are presented in Table 15.24.

15.6.7 There are limitations inherent within Defra's Emission Factors Toolkit v11 (Defra, 2021), which is the tool used to estimate changes in road user GHG emissions within this assessment. For example, there is uncertainty in the projected composition of the national vehicle fleet in future years contained within the tool (particularly beyond 2030), which may therefore affect the road user GHG emissions estimates within the fifth and sixth carbon budget periods presented within this assessment. All modelling has its limitations, however, and as such includes a level of uncertainty, and it is considered that Defra's Emission Factors Toolkit v11 (Defra, 2021) is the most appropriate tool currently available for estimating road user GHG emissions in future years.

15.6.8 In the absence of modelled traffic data for any year beyond 2042, Do-Minimum and Do-Something road user GHG emissions are assumed to remain constant between 2042 and 2086, whereas in reality they are likely to decrease substantially over time due to increasing proportions of electric vehicles and improvements in vehicle efficiency over time.

15.6.9 The construction phase land use change emission calculations apply average carbon stock estimates published by Natural England (Natural England, 2012). It was assumed that 25% of the carbon stock in the surface soil and 100% of the carbon stock in vegetation would be released to the atmosphere when an area is 'disturbed' during construction, and that all land within the Order Limits would be 'disturbed'. This is considered to be a conservative assumption. It was further assumed that all of the carbon stock that was lost would be released in the form of CO_2 (as opposed to CH_4, for example).

15.6.10 For the calculation of operational land use change GHG emissions, emissions per hectare are assumed to be equivalent to the change in equilibrium soil carbon density with land use change outlined in the UK National Inventory Report (BEIS, 2021e). The operational land use change GHG emissions were calculated over the area of permanent land use change, with the relevant change in soil carbon density assumed to occur in full over the 60-year appraisal period. This is considered to be a conservative assumption.

15.6.11 The areas which could be affected by construction activities and operational land use change were apportioned into different land use types using the Ordnance Survey MasterMap dataset (Ordnance Survey, 2021). As described in Appendix 15.1 of the Environmental Statement [TR010060/APP/6.3], a number of assumptions were made when translating the land use categories within the Ordnance Survey MasterMap dataset into those used in the construction and operational land use change emission calculations. The outputs of these assumptions, which informed the land use change emission

calculations, are illustrated visually on Figure 15.2 and Figure 15.3 [TR010060/APP/6.2].

15.6.12 The estimation of GHG emissions associated with the consumption of raw materials does not include those associated with some essential mitigation measures which have been proposed as part of the Environmental Statement (i.e. after the BoQ was developed). Any such GHG emissions are, however, considered likely to be relatively minor and therefore unlikely to have a material influence on the total proposed scheme GHG emissions.

15.6.13 The GHG emissions associated with the proposed gas main diversion and other utility diversions have not been estimated within this assessment as the information required was not available (e.g. detailed estimates of material quantities). The GHG emissions associated with the diversion are, however, likely to be negligible in comparison to those associated with the proposed scheme itself. Furthermore, the standard mitigation measures and enhancements set out in Section 15.10 of this chapter would reduce GHG emissions associated with the proposed diversion.

15.6.14 In the absence of detailed information on existing and proposed tree planting (e.g. regarding the mix of different species and the age and spacing of trees, which would be developed at the detailed design stage), a number of assumptions were made to inform estimates of carbon sequestration (i.e. the amount of CO_2 captured and stored in woodland over time). Wherever possible, these assumptions were informed by the information available (e.g. ecological surveys), however, the data used in these calculations should be considered indicative. As consistent assumptions were applied in both the Do-Minimum and Do-Something scenarios, however, the outputs of these calculations are considered appropriate for estimating the potential net change in carbon sequestration as a result of the proposed scheme.

15.6.15 In the absence of detailed information regarding material quantities, it has not been possible to estimate operational maintenance GHG emissions in the absence of the proposed scheme (i.e. in the Do-Minimum scenario) using the National Highways Carbon Tool v.2.4 (National Highways, 2021a). Instead, potential Do-Minimum operational maintenance GHG emissions have been derived from estimated Do-Something operational maintenance GHG emissions using a ratio of 66%. This ratio was derived based on a simple, high-level comparison of the differences between the proposed scheme and the existing section of the A12 which it would replace (e.g. the number of lanes and junctions).

15.6.16 In order to estimate GHG emissions associated with the materials required to backfill Colemans Farm Quarry (see Section 2.5 of Chapter 2: The proposed scheme, of the Environmental Statement [TR010060/APP/6.1]) it has been assumed that 300,000m^3 of material would be sourced from borrow pit J within the Order Limits, which would be supplemented with 650,000m^3 of imported recycled and secondary mixture. These assumptions are considered likely to be worst-case.

Vulnerability to changes in climate

15.6.17 There is inherent uncertainty in the climate models which form the basis of the climate projections used to inform this assessment (i.e. the climate models used in the UK Climate Projections 2018 (UKCP18) datasets (Met Office, 2020)). However, the use of the UKCP18 High Emissions Receptor Concentration Pathway 8.5 (RCP8.5) projections dataset (Met Office, 2020) is likely to provide a more conservative estimate of future climate change, as it represents the highest modelled GHG emissions scenario.

15.6.18 The grid cell located most centrally to the proposed scheme, for each of the UKCP18 datasets considered (ranging from 2.2km to 25km), was selected to describe the climatic conditions in the study area considered within this assessment. Therefore, it is assumed that climatic conditions across the study area are adequately described by the selected grid cell. This is considered appropriate as climate conditions are not expected to vary substantially over short distances (the length of the proposed scheme is approximately 24km) and in many cases a large proportion of the proposed scheme falls within the grid cell used.

15.6.19 Given the number of different variables involved, there is substantial uncertainty regarding the likelihood and consequence of climate change related impacts on the performance of UK road transport infrastructure in response to a certain change in climate. A qualitative, risk-based approach has therefore been used, supported by professional judgement, where relevant.

15.6.20 Where relevant, aspect-specific measures to mitigate the vulnerability of the proposed scheme to climate change are detailed in the corresponding chapters. For example, mitigation with regards to increased flood risk as a result of climate change is addressed in Chapter 14: Road drainage and the water environment, of the Environmental Statement [TR010060/APP/6.1].

15.6.21 The proposed scheme's vulnerability to climate change has been assessed based on the assumption that all relevant design standards are suitable for both current and future climatic conditions.

15.6.22 The DMRB LA 114 states that climate assessments should use the H++ climate scenarios to test the sensitivity of vulnerable safety-critical features, to ensure that such features would not be affected by more radical changes to the climate beyond that projected in the latest set of UK Climate Projections. The H++ scenarios cover heat waves, cold snaps, low and high rainfall, droughts, floods and windstorms. However, of these climate related events, the greatest risks to safety critical features (e.g. structures) are considered likely to be those associated with flooding. The H++ scenarios were developed using a set of climate change projections which have since been superseded (i.e. UKCP09); however, the Met Office does not propose to update these scenarios using UKCP18 (Met Office, 2018a). Following the publication of updated guidance on climate change allowances, the H++ scenarios are no longer used to inform peak river flow allowances on highway schemes. As discussed in Chapter 14: Road drainage and the water environment, of the Environmental Statement [TR010060/APP/6.1], however, consideration has been given to potential changes to the risk of flooding should more radical changes in climate occur.

This analysis identified no locations where the maximum credible climate change allowance published at that time (i.e. a 65% climate change allowance for peak river flow) would result in a risk of flooding to the carriageway due to the freeboard (i.e. the difference between the design flood level and the soffit level of a bridge/culvert) at all watercourse crossings. Since this analysis was undertaken, however, the recommended maximum credible climate change allowance for peak river flow has been increased from 65% to 72%. As there is significant freeboard for each of the main rivers considered, and generally small, modelled changes in flood depth due to the additional allowances for climate change considered, the risk of flooding to the proposed scheme with even a 72% climate change allowance is considered low.

15.6.23 Whilst future changes in climate could impact the gas main diversion, the main climate related risks relating to this element of the proposed scheme are considered to be those associated with flood risk. As such, an assessment of the vulnerability of the gas main diversion to potential changes in flood risk has not been undertaken within this chapter, as this issue is addressed within Chapter 14: Road drainage and the water environment, of the Environmental Statement [TR010060/APP/6.1].

15.7 Study area

Greenhouse gas emissions

15.7.1 In line with DMRB LA 114, different study areas need to be defined for different types of emission source. As such, the following study areas are defined for the emission sources considered within this assessment:

- The GHG emissions resulting from construction – this is the study area necessary to consider all of the GHG emissions associated with construction materials and their associated transport to site from the supplier. It also includes GHG emissions associated with construction activities carried out within the Order Limits, the distances that workers travel to and from the construction site and the transport and processing of waste offsite for reuse, recycling, treatment, or disposal. As such, the study area is defined by the greatest extent of these activities, some of which, it is assumed, may occur at a national scale (i.e. within England).

- The GHG emissions resulting from operational road users – the study area comprises the road network included within the Traffic Reliability Area (TRA) of the traffic model developed for the proposed scheme (as shown in Figure 15.1 [TR010060/APP/6.2]). The TRA is defined in DMRB LA 105 Air Quality (Highways England, 2019) as the '*area covered by the traffic model, that the competent expert for traffic has identified as reliable for inclusion in an environmental assessment*'. Paragraph 3.9 of DMRB LA 114 states that the study area shall be consistent with the 'affected road network' defined in a project's traffic model (i.e. limited to those roads where changes in traffic are modelled to exceed the traffic scoping criteria defined in paragraph 2.1 of DMRB LA 105). However, the TRA, which covers a greater area than the affected road network, has been considered within this assessment in order to provide a more complete assessment of changes in road user GHG

emissions and to be consistent with the study area used to inform the corresponding economic appraisal of changes in GHG emissions.

- The GHG emissions resulting from operation and maintenance – the study area is based on a similar extent as the construction phase (e.g. to include replacement of assets which may be delivered from suppliers located across England). It also includes the GHG emissions from the energy consumed within the Order Limits required to operate the proposed scheme.

Vulnerability to changes in climate

15.7.2 The study area for the proposed scheme's vulnerability to climate comprises the construction footprint of the proposed scheme, including compounds and temporary land-take. This is shown as the Order Limits on Figure 1.1 [TR010060/APP/6.2].

15.8 Baseline conditions

Baseline sources

Greenhouse gas emissions

15.8.1 The following key sources of information have been used to define baseline and future baseline GHG emissions in the study area relevant to the proposed scheme:

- The CO_2 emissions at a UK and county level – UK Local Authority and Regional Carbon Dioxide Emissions National Statistics: 2005 to 2019 (BEIS, 2021f)
- Estimated Do-Minimum (i.e. without the proposed scheme) road user GHG emissions for the base year (2019) and over a 60-year appraisal period after the proposed scheme opening year (2027), in line with DMRB LA 114
- Estimated baseline and future baseline GHG emissions associated with operational maintenance activities for the extents of the existing A12 and surrounding road network, which would be replaced by the proposed scheme

Vulnerability to changes in climate

15.8.2 The following key sources of information have been used to define the baseline and future baseline climate in the study area relevant to the proposed scheme:

- Current climate data within the study area for the proposed scheme – HadUK-Grid regional observations dataset v1.0.1.0 for the 'climate normal' period of 1981–2010 (Met Office *et al*., 2019), for the 25km grid square centred on grid reference TL 87500 12500
- Climate extreme indices – State of the UK Climate 2017: Supplementary Report on Climate Extremes (Met Office, 2018b)

- Projected climate changes within the study area for the proposed scheme – UK Climate Projections 2018 (UKCP18) relative to the baseline period of 1981–2010 (Met Office, 2020), under the high emissions scenario (i.e. RCP8.5) and for a 50% probability of occurrence, for the 25km grid square centred on grid reference TL 87500 12500
- Projected climate data within the study area for the proposed scheme – UKCP18 relative to the baseline period of 1981–2010 (Met Office, 2020), under the high emissions scenario (i.e. RCP8.5), for the 12km grid square centred on grid reference TL 82000 10000 and the 2.2km grid square centred on gird reference TL 82500 12500
- Geological hazards – British Geological Survey (BGS) GeoIndex (BGS, 2021a) and GeoClimate Open (BGS, 2021b) datasets
- Independent Assessment of UK Climate Risk. Advice to Government for The UK's Third Climate Change Risk Assessment (CCRA3) (Climate Change Committee, 2021a)

Baseline information

Greenhouse gas emissions

15.8.3 Baseline GHG emissions have been assessed using the local authority and regional CO_2 emissions estimates dataset (BEIS, 2021f), which provides a spatial breakdown of estimated UK CO_2 emissions on an 'end-user' basis. Within this dataset, therefore, UK CO_2 emissions are distributed according to the point of energy consumption (e.g. electricity consumed in residential properties) or point of emission (if not energy related). The data helps identify the key contributors to total UK CO_2 emissions in an area. Whilst the data is only provided on this basis for CO_2 (and not other GHGs), CO_2 is the main GHG, accounting for approximately 80% of estimated UK GHG emissions in 2019.

15.8.4 The proposed scheme is located entirely within the area administered by Essex County Council. Table 15.13 shows CO_2 emissions by source for the Essex County geographical area. The data is also presented for England and the East of England region to provide context.

15.8.5 Estimated CO_2 emissions within Essex in 2019 totalled 6,834 kilotonnes (kt), representing approximately 20.1% of total estimated CO_2 emissions within the East of England and 2.5% of total estimated CO_2 emissions within England.

15.8.6 Road transport CO_2 emissions are estimated to comprise a significant proportion of the total CO_2 emissions within Essex (47.8%), the East of England (38.4%) and England (36.4%). A-roads, including the A12, of which the proposed scheme would form part, are estimated to contribute approximately 19.3% of the total CO_2 emissions within Essex, 17.8% of the total CO_2 emissions within the East of England, and 14.6% of the total CO_2 emissions within England.

15.8.7 In total, road transport emissions within Essex are estimated to contribute 25.0% of total road transport CO_2 emissions within the East of England and 3.2% of total road transport CO_2 emissions in England. Of this contribution, approximately 50% is considered potentially attributable to road traffic emissions from the strategic road network (SRN) within Essex.

Table 15.13 England, East of England and Essex CO_2 emissions estimates by source (2019)

Emission source	Estimated 2019 CO_2 emissions					
	England		East of England		Essex	
	kt	% of total	kt	% of total	kt	% of total
Industry total	**58,186**	**21.1%**	**5,243**	**15.5%**	**786**	**11.5%**
Commercial total	**26,523**	**9.6%**	**2,726**	**8.0%**	**584**	**8.5%**
Public sector total	**10,271**	**3.7%**	**959**	**2.8%**	**187**	**2.7%**
Domestic total	**77,628**	**28.1%**	**8,679**	**25.6%**	**2,097**	**30.7%**
Road transport (A-roads)	40,274	14.6%	6,048	17.8%	1,317	19.3%
Road transport (motorways)	24,380	8.8%	2,541	7.5%	717	10.5%
Road transport (minor roads)	35,888	13.0%	4,452	13.1%	1,232	18.0%
Diesel railways	1,506	0.5%	136	0.4%	13	0.2%
Transport other	2,139	0.8%	338	1.0%	54	0.8%
Transport total	**104,187**	**37.7%**	**13,514**	**39.8%**	**3,333**	**48.8%**
Land use, land-use change, and forestry (LULUCF) net emissions	-705	-0.3%	2,813	8.3%	-153	-2.2%
Total	**276,090**	**-**	**33,933**	**-**	**6,834**	**-**

15.8.8 Estimated operational road user GHG emissions based on modelled road traffic conditions across the study area, defined in Section 15.7 of this chapter, for the modelled base year (2019) along with estimated GHG emissions associated with the operational maintenance in the base year are shown in Table 15.14.

Table 15.14 Estimated baseline GHG emissions

Source	Baseline GHG emissions (tCO_2e)
	2019
Road users	734,067
Operational maintenance	1,790

15.8.9 The estimated road user emissions shown in Table 15.14 equate to approximately 22.5% and 0.7% of 2019 national estimates of road transport GHG emissions within Essex and the UK, respectively.

15.8.10 It is noted that the magnitude of estimated base year road user GHG emissions shown in Table 15.14 is smaller than that reported within the Preliminary Environmental Information Report (PEIR) (Highways England, 2021b), which was for a 2016 base year. This is primarily because a smaller study area, derived based on a better understanding of the area over which changes in traffic are expected to occur as a result of the proposed scheme, has been considered within this assessment. Furthermore, road user emissions (per vehicle) are estimated to be lower in 2019 than in 2016 due to improvements to the national vehicle fleet (e.g. an increased proportion of electric vehicles and newer, more efficient vehicles).

15.8.11 The results in Table 15.14 indicate that GHG emissions associated with operational maintenance are likely to be negligible in comparison to road user GHG emissions.

Vulnerability to changes in climate

15.8.12 With regard to baseline climate impacts, DMRB LA 114 states that:

- '*The assessment of a project's vulnerability to climate change shall use published historical regional weather data to demonstrate the current climate impacts on a study area*' (paragraph 3.26)
- '*Recent weather patterns and extreme weather events should be identified, to provide an indication of how the project will account for climate change in the immediate future i.e. during construction*' (paragraph 3.26.1)
- '*Historical events as a result of weather patterns and extreme weather events i.e. landslides after heavy rainfall, shall be identified to provide an indication of past vulnerability*' (paragraph 3.27)

15.8.13 As such, the baseline climate data for the East of England is summarised in Table 15.15, based on the data for the most recent 'climate normal' period available from the Met Office (i.e. 1981–2010) (Met Office *et al.*, 2019). The data has been compared to the similar data for England as a whole, which indicates that:

- The climate in the East of England region is warmer compared to across England as a whole, throughout the year, with the most sizeable differences recorded during summertime.
- The climate in the East of England region is drier compared to across England as a whole, throughout the year, with the greatest difference in precipitation being in wintertime.

Table 15.15 Baseline climate data for England and the East of England region

Climate variable	Observed climate baseline (1981–2010)			
	Period	England	East of England	Difference
Daily maximum temperature (°C)	Annual	13.4	14.2	+0.8
	Winter	7.1	7.3	+0.2
	Spring	12.7	13.4	+0.7
	Summer	20.1	21.3	+1.2
	Autumn	13.9	14.6	+0.7
Daily minimum temperature (°C)	Annual	5.9	6.1	+0.2
	Winter	1.3	1.4	+0.1
	Spring	4.4	4.7	+0.3
	Summer	10.9	11.4	+0.5
	Autumn	6.8	7.1	+0.3
Daily mean temperature (°C)	Annual	9.6	10.2	+0.6
	Winter	4.2	4.3	+0.1
	Spring	8.5	9.0	+0.5
	Summer	15.5	16.3	+0.8
	Autumn	10.3	10.9	+0.6
Mean accumulated precipitation (mm)	Annual	855	622	-233
	Winter	230	146	-84
	Spring	181	137	-44
	Summer	194	160	-34
	Autumn	250	179	-71

15.8.14 An overview of historical and more-recent extreme weather conditions recorded in the East of England is presented in Table 15.16, based on the data contained within the State of the UK Climate 2017: Supplementary Report on Climate Extremes (Met Office, 2018b). The data indicates that:

- Maximum temperatures in the East of England region are higher than across England as a whole, and appear to be increasing.
- The duration of ‘warm spells’ is shorter in the East of England region than across England as a whole (potentially as a result of coastal influences on meteorology), but they appear to be increasing.

- The duration of ‘cold spells’ and number of ‘icing days’ are lower in the East of England region than across England as a whole, and appear to be decreasing.
- Rainfall from ‘extremely wet days’ is lower in the East of England region than across England as a whole, and appears to be decreasing.
- Maximum ‘five-day precipitation’ is lower in the East of England region than across England as a whole, and appears to be decreasing.
- The ‘longest dry spell’ is longer in the East of England region than across England as a whole, but appears to be decreasing.

Table 15.16 Summary of climate extremes for England and East of England region

Climate variable	Period	England	East of England	Difference
Highest maximum temperature [a]	1981–2010	28.3	29.9	+1.6
	2008–2017	28.5	30.3	+1.8
	Change [b]	+0.2	+0.4	-
Warm spell duration index (days) [c]	1981–2010	10.0	8.8	-1.2
	2008–2017	15.0	13.2	-1.8
	Change [b]	+5.0	+4.4	-
Cold spell duration index (days) [d]	1981–2010	2.8	2.8	0.0
	2008–2017	2.0	1.0	-1.0
	Change [b]	-0.8	-1.8	-
Number of icing days [e]	1981–2010	2.5	2.0	-0.5
	2008–2017	1.9	1.0	-0.9
	Change [b]	-0.6	-1.0	-
Rainfall from extremely wet days (mm) [f]	1981–2010	69.3	56.8	-12.5
	2008–2017	72.0	53.2	-18.8
	Change [b]	+2.7	-3.6	-
Maximum five-day precipitation (mm) [g]	1981–2010	67.3	53.1	-14.2
	2008–2017	65.7	51.8	-13.9
	Change [b]	-1.6	-1.3	-

Climate variable	Period	England	East of England	Difference
Longest dry spell (days) [h]	1981–2010	22.2	24.5	+2.3
	2008–2017	20.1	22.2	+2.1
	Change [b]	-2.1	-2.3	-

[a] Highest daily maximum temperature recorded during the month

[b] Difference in observed value between 2008–2017 and 1981–2010

[c] Count of days with at least six consecutive days when daily maximum temperature is above the 90th percentile centred on a five-day window for the base period of 1961–1990

[d] Count of days with at least six consecutive days when daily minimum temperature is below the 10th percentile centred on a five-day window for the base period of 1961–1990

[e] Number of days when the daily minimum temperature is below 0°C

[f] Total rainfall falling on days with daily rainfall total in excess of the 99th percentile of daily rainfall

[g] Highest value of rainfall accumulated over five days

[h] Largest number of consecutive days with <1mm rainfall

15.8.15 Based on the Flood Risk Assessment undertaken for the proposed scheme (see Appendix 14.5 of the Environmental Statement [TR010060/APP/6.3]), there are significant areas at risk of fluvial flooding near the proposed scheme in a 1% Annual Exceedance Probability (AEP) event. One area of the existing A12 carriageway, just outside Kelvedon, is predicted to flood in this event. Further details are provided in Section 14.8 of Chapter 14: Road drainage and the water environment, of the Environmental statement [TR010060/APP/6.1].

15.8.16 A search of the Highways Agency Drainage Data Management System (HADDMS) (Highways England, 2021c) and internet sources, including local media outlets, also indicates flooding events have occurred on the A12 near the proposed scheme, which appear to have affected road users. Historical flooding to the A12 is generally believed to be surface water flooding, with several areas predicted to be at risk of flooding according to the Environment Agency Risk of Flooding from Surface Water mapping (Environment Agency, 2021a).

15.8.17 Risks from groundwater, water infrastructure and sewer flooding are also reported in Chapter 14: Road drainage and the water environment [TR010060/APP/6.1]; however, these relate to the wider area in which the proposed scheme is located, rather than the A12 itself, and therefore do not indicate existing vulnerability.

15.8.18 Based on GeoIndex (BGS, 2021a), no historical landslide events are recorded near to the proposed scheme, and therefore no such past vulnerability has been identified at this stage.

15.8.19 No records were available at the time of writing regarding past incidences of subsidence within the footprint of the proposed scheme.

Future baseline

Greenhouse gas emissions

15.8.20 The estimated Do-Minimum operational road user GHG emissions and GHG emissions associated with the operational maintenance in the opening year (2027), design year (2042) and over a 60-year appraisal period after scheme opening (2027–2086, inclusive) are shown in Table 15.17.

Table 15.17 Estimated future Do-Minimum GHG emissions

Source	Future baseline GHG emissions (tCO_2e)		
	Opening year (2027)	Design year (2042)	Appraisal period (2027–2086)
Road users	719,366	536,630	33,659,663
Operational maintenance	1,790	1,790	107,429

15.8.21 The estimates of road user emissions shown in Table 15.17 indicate that road user GHG emissions would decrease by approximately 25% between the modelled opening year (2027) and modelled design year (2042). This is despite the total number of vehicle kilometres travelled within the study area being modelled to increase by approximately 13% over this period. An overall decrease in road user GHG emissions occurs because of a substantial projected increase in the proportion of electric vehicles in the national vehicle fleet (which result in much lower GHG emissions than conventionally fuelled vehicles), coupled with improvements in vehicle efficiency. This illustrates the overriding influence that national policy (e.g. future bans on the sale of conventionally fuelled cars and vans) is expected to have on road user GHG emissions in future years.

15.8.22 It is noted that the magnitudes of these estimates are smaller than those reported within the PEIR, which is primarily because a smaller study area has been considered within this assessment. Furthermore, greater improvements in vehicle fuel efficiency and increases in the proportions of electric vehicles are assumed to occur within the Emissions Factors Toolkit v11.0 (Defra, 2021) used for this assessment (than in the superseded version of the TAG Data Book (DfT, 2020) which informed the emission estimation methodology used within the PEIR).

15.8.23 The results in Table 15.17 indicates that GHG emissions associated with operational maintenance are likely to be negligible in comparison to road user GHG emissions.

Vulnerability to changes in climate

15.8.24 Current and projected future changes in climate, in terms of temperature and precipitation, are presented in Table 15.18. This data utilises the 25km spatial resolution UKCP18 probabilistic dataset for the grid cell centred at grid reference TL 87500 12500. The current climate conditions (i.e. observed baseline) refer to the most recent historic climate dataset of 1981–2010. The

future climate conditions (i.e. climate projections) refer to projections made under the high emissions scenario (i.e. RCP8.5) with a 50% probability of occurrence for the 2030s (2020–2049), 2060s (2050–2079) and 2080s (2070–2099) respectively. These 30-year periods cover the lifespan of the proposed scheme (which is taken to be 60 years in accordance with paragraph 3.31 DMRB LA 114).

Table 15.18 Projected changes in climate at the location of the proposed scheme

Climate metric	Observed baseline 1981–2010	Projected change (UKCP18 RCP8.5 (50% probability))		
		2030s (2020–2049)	2060s (2050–2079)	2080s (2070–2099)
Annual mean accumulated precipitation	564.0mm	+0.2%	-2.1%	-1.1%
Winter mean accumulated precipitation	134.8mm	+6.8%	+13.9%	+21.0%
Summer mean accumulated precipitation	140.7mm	-12.6%	-26.8%	-35.4%
Annual mean temperature	10.5°C	+1.1°C	+2.5°C	+3.7°C
Mean winter minimum temperature	1.7°C	+0.9°C	+2.2°C	+3.2°C
Mean summer maximum temperature	21.7°C	+1.5°C	+3.5°C	+5.3°C

15.8.25 Under the climate scenario considered, annual mean accumulated precipitation at the location of the proposed scheme is projected to slightly decrease over time, and by the 2080s is projected to have decreased by 1.1% compared to the observed baseline. However, projected changes in seasonal precipitation by the 2080s, i.e. +21.0% during wintertime and -35.4% during summertime, indicate substantially wetter winters and substantially drier summers could occur.

15.8.26 All of the temperature related metrics considered indicate that there could be a steady increase in temperatures, with the largest increase occurring during summertime. Specifically, the annual mean, mean winter minimum and mean summer maximum temperatures are projected to increase by 3.7°C, 3.2°C and 5.3°C, respectively, by the 2080s compared to the observed baseline values.

15.8.27 Other climate variables selected to represent more extreme conditions (i.e. the 10th and 90th percentiles of projected values) are presented in Table 15.19. These variables were derived utilising the regional (12km) and, where relevant, local (2.2km) spatial resolution UKCP18 high emissions scenario (i.e. RCP8.5) datasets for the grid squares centred at grid reference TL 82000 10000 and TL 82500 12500, respectively.

15.8.28 Daily projections for the period 2061–2080 were used to assess potential changes in more extreme daily temperature, precipitation and wind events. The 90th percentile of projected values has been used to represent the value above which any event happening within a day (e.g. a precipitation event) is likely to occur less frequently. For instance, for the period 2061–2080, maximum daily precipitation events greater than 6.7mm are likely to occur relatively infrequently. Similarly, the 10th percentile has been used to represent the value below which any event happening within a day is likely to occur less frequently. The corresponding metrics for the observed baseline period 1981–2010 (which is the baseline for the 12km and 2.2km projection datasets) are also presented for comparison.

Table 15.19 Projected changes in climate extremes at the location of the proposed scheme

Meteorological parameter	Observed baseline 1981–2010		Projected (RCP8.5) 2061–2080		Projected change	
	10th %ile	90th %ile	10th %ile	90th %ile	10th %ile	90th %ile
Daily precipitation (mm/day)	-	5.3 to 7.0	-	5.1 to 6.7	-	-0.3 to -0.2
Minimum daily temperature (°C)	-0.9 to 1.2	12.3 to 14.5	2.4 to 4.2	15.9 to 18.2	+3.0 to +3.3	+3.6 to +3.7
Maximum daily temperature (°C)	3.6 to 6.1	20.2 to 23.1	7.4 to 9.3	25.9 to 30.3	+3.2 to +3.8	+5.7 to +7.2
Daily temperature (°C)	1.6 to 3.8	16.0 to 18.6	4.9 to 6.7	20.6 to 23.8	+2.9 to +3.3	+4.6 to +5.2
Maximum daily wind gusts (m/s)	8.2 to 8.6	18.3 to 19.4	8.1 to 8.6	17.5 to 19.1	-0.1 to 0.0	-0.8 to -0.3

Note: Ranges are provided for each variable to account for differences in the outputs of the 12 ensembles (i.e. model runs) included within the UKCP18.

15.8.29 Under the climate scenario considered, the 90th percentile of daily precipitation values is projected to decrease slightly from 7.0mm/day during 1981–2010 to 6.7mm/day during 2061–2080 (upper limits used), indicating that more extreme precipitation events could occur slightly less frequently. However, it should be noted that when even less likely events are considered, i.e. in excess of the 90th percentile, precipitation intensity appears to increase between the two periods, suggesting that, while more extreme precipitation events could occur less frequently, very extreme precipitation events could be of higher intensity when they do occur. For instance, the 99th percentile of daily precipitation values is projected to increase by approximately 12% from 20.3mm/day to 22.7mm/day (upper limits used).

15.8.30 The 10th percentile of minimum daily temperatures is projected to increase from -0.9°C to 2.4°C (lower limits used), indicating that days with more extreme low temperatures could occur less frequently. The 90th percentile of maximum daily temperatures is projected to increase from 23.1°C to 30.3°C (upper limits used), indicating that days with more extreme high temperatures will potentially occur more frequently.

15.8.31 The intensity of the 90th percentile of maximum wind gusts is projected to decrease slightly from 19.4m/s to 19.1m/s, indicating that higher wind speeds will potentially occur less frequently.

15.8.32 Utilising the same dataset as for Table 15.19, a number of climate extreme indices for the study area were also calculated (see Table 15.20), which underpin the warmer and drier conditions identified above. For example, the number of annual air frost days (upper limit) during 2061–2080 will potentially be substantially lower than during 1981–2010, i.e. from up to 20 events to up to one event. Hot spells and heatwaves will potentially increase from up to seven events and up to five events per year during 1981–2010, to up to 57 events and up to 47 events per year, respectively, during 2061–2080. In addition, drought events and dry spells will potentially increase from up to two events to up to 11 events and from up to 17 events to up to 37 events, respectively. The annual number of days with wind gust events exceeding 45mph will potentially reduce slightly from up to 28 days to up to 25 days.

Table 15.20 Projected changes in climate extreme indices at the location of the proposed scheme

Climate extreme indices	Observed baseline 1981–2010	Projected (RCP8.5) 2061–2080	Change
Annual number of days when mean temperature >25°C	0 to 1	3 to 23	+3 to +22
Annual air frost days	5 to 20	0 to 1	-5 to -19
Annual hot spells (days)	0 to 7	15 to 57	+15 to +50
Annual heatwaves (days)	0 to 5	10 to 47	+10 to +42
Annual heavy rain days	1 to 2	1 to 3	0 to +1
Annual drought events	1 to 2	1 to 11	0 to +9
Annual dry spells	6 to 17	15 to 37	+9 to +20
Annual number of days when maximum wind gust >45mph	17 to 28	13 to 25	-4 to -3

Note: Ranges are provided for each variable to account for differences in the outputs of the 12 ensembles (i.e. model runs) included within the UKCP18.

15.8.33 Future changes in climate could exacerbate or reduce the effects of the proposed scheme on the environment (i.e. to result in 'in combination' effects). This issue has been considered within each of the relevant aspect chapters using aspect specific significance criteria, rather than within this chapter, as recommended within the Institute of Environmental Management and Assessment's (2020) Environmental Impact Assessment Guide to: Climate Change Resilience & Adaptation.

15.8.34 The UK Government is required to conduct a UK Climate Change Risk Assessment (CCRA) every five years as set out in the UK Climate Change Act (2008). In advance of the third CCRA, due to be published in 2022, the UK Government requested the Climate Change Committee to prepare an independent assessment setting out the risks and opportunities to the UK from climate change up to 2100, including the Committee's advice on priorities for adaptation for the coming five-year period.

15.8.35 The Independent Assessment of UK Climate Risk (Climate Change Committee, 2021a) provides the Committee's statutory advice to Government on priorities for the forthcoming national adaptation plans and wider action. It is informed by new evidence gathered for the accompanying Climate Change Risk Assessment (CCRA3) Technical Report (Climate Change Committee, 2021c). The CCRA3 Technical Report highlights that the gap between the level of risk faced and the level of adaptation underway has widened, where adaptation action has failed to keep pace with the worsening reality of climate risk.

15.8.36 In relation to infrastructure specifically, Chapter 4 of the CCRA3 Technical Report identifies the following key risk areas of relevance to the proposed scheme:

- Risks to infrastructure networks (including transport) from cascading failures
- Risks to infrastructure services from river and surface water flooding
- Risks to bridges from flooding and erosion
- Risks to transport networks from slope and embankment failure
- Risks to surface infrastructure from subsidence
- Risks to transport from high and low temperatures, high winds and lightning

15.8.37 The key messages of the CCRA3 Technical Report relevant to the proposed scheme include the following:

- Flooding remains a key risk to infrastructure with the latest climate projections indicating an increased likelihood of heavy precipitation.
- A changing climate continues to be a problem for the transport sector. Significant risks are still posed to roads, where problems are more likely to occur on local roads and smaller schemes and there is an underlying need to assess the impact of single points of failure more broadly (e.g. bridges, earthworks and subsidence).

- The systems nature of infrastructure means that any unmitigated risk could have a propagating impact across the network or lead to cascading failures across multiple networks.

Value and sensitivity of receptors

15.8.38 In line with DMRB LA 114, the following receptors have been identified:

- With regard to GHG emissions:
  - UK carbon budgets (as a proxy for the global climate)
- With regard to the proposed scheme's vulnerability to climate change, key receptors (further details of which are provided in Appendix 15.2 of the Environmental Statement [TR010060/APP/6.3]) are summarised as:
  - receptors associated with the construction process (including the construction workforce, plant and machinery)
  - the assets and their operation, maintenance and refurbishment (e.g. road pavement surfaces, structures, earthworks and drainage, technology assets, soft estate)
  - end-users (e.g. members of the public or commercial operators using the proposed scheme)

15.8.39 In the absence of specific guidance in DMRB LA 114 on the valuation of receptors with regard to climate impacts, all receptors are considered to be of high value given the global importance of climate change and the potential for climate related impacts to adversely affect the health and safety of employees and road users.

15.9 Potential impacts

Greenhouse gas emissions

15.9.1 Increases in GHG emissions could impact climate by contributing to the cumulative impact GHG emissions have on climate change. It is not possible, however, to attribute the resulting impact of a certain quantity of GHG emissions to effects on a specific receptor. Instead, the most appropriate geographic level for an assessment of the impact of a certain quantity of GHG emissions is at a national level (i.e. by comparison to UK carbon budgets), as that is the level at which Parliament has jurisdiction and has specified in NNNPS paragraph 5.18 the assessment shall be undertaken. It is very unlikely, however, that the impact of a road project will, in isolation, affect the ability of Government to meet its carbon reduction plan targets.

Construction

15.9.2 The GHG emissions during the construction phase of the proposed scheme would be associated with:

- Embodied carbon (i.e. GHGs generated during the manufacture of the raw materials required to build the proposed scheme)

- Energy consumption (e.g. through petrol or diesel combustion and use of electricity) and water consumption as a result of:
  - the transportation of raw materials to the construction site
  - the transportation and treatment of waste
  - the transportation of construction workers, onsite staff and visitors to, from and within the construction site
  - construction activities and the operation of onsite construction plant, machinery and equipment
- The disturbance or removal of carbon stored within vegetation and soil within the Order Limits
- Changes in the GHG emissions/sequestration balance within the Order Limits associated with changes in land use, for example through changes in the spatial extents and management of carbon sinks such as woodland

Operation

15.9.3 The GHG emissions during the operational phase of the proposed scheme would be associated with:

- Maintenance and operation of the road infrastructure – through consumption of energy (e.g. through petrol or diesel combustion and use of electricity) and materials to support activities such as the repair and replacement of lighting and structures (including fencing) and highway resurfacing
- Consumption of energy (e.g. through petrol and diesel combustion and use of electricity) by motorised vehicles using the road infrastructure – the proposed scheme could alter traffic volumes, composition and speeds on the local road network, both positively and negatively, which could act to alter the overall magnitude of road user GHG emissions
- Ongoing changes in the GHG emissions/sequestration balance within the Order Limits associated with changes in land use, for example through changes in the spatial extents and management of carbon sinks such as woodland

Vulnerability to changes in climate

Construction

15.9.4 As identified in Table 15.15, the East of England region experienced an increase in temperatures between 1981 and 2010. Furthermore, the projected changes in climate variables over the relatively short term (2020–2049) shown in Table 15.18 suggest that further increases in temperature could occur (especially during summer) and that precipitation could increase during winter. As a result, during the construction process, receptors may be vulnerable to a range of short-term climate risks, including:

- Increased precipitation during winter months resulting in flooding of the construction site, compounds, haul roads and excavations; this could result in damage to equipment and materials stored onsite, machinery and plant being damaged or trapped, site roads becoming impassable, contamination of water bodies through runoff, adverse impacts on health, safety and welfare of construction workforce, delays to the construction programme and increased costs
- Flooding of the local road network and site access roads from increased precipitation during winter months resulting in a disruption to the supply of materials and goods required to support construction activities and associated delays to the construction programme
- Increased precipitation during winter months resulting in higher pore water pressure in embankments and earthworks or increased erosion, leading to instability and risk of failure and increased maintenance requirements
- Very high summer temperatures and an increased number of hot spells leading to increased risk of heat stress or sunstroke for outdoor construction workers and the risk of mechanical failure of equipment due to overheating
- Fewer very cold days with freezing conditions due to increased temperatures resulting in reduced health, safety and welfare risks to construction workers associated with icy conditions or very cold temperatures and more favourable conditions for some construction activities, processes and equipment, benefiting the construction programme
- Higher temperatures and lower rainfall during summer leading to increased desiccation of soils and potential reductions in slope stability and increased risk of earthworks failure during or immediately after rain from summer storm events falling on desiccated soils
- Higher temperatures during summer months leading to accelerated hardening of bitumen and inappropriate conditions to lay pavements (e.g. very hot weather) resulting in delays to the construction programme

15.9.5 Further details on potential climate change hazards and opportunities, potential climate change related impacts and affected assets and receptors are presented in Appendix 15.2 of the Environmental Statement [TR010060/APP/6.3].

Operation

15.9.6 As identified in Table 15.18, projected changes in climate over the longer term suggest that there could be substantial increases in temperature, especially during summer, and precipitation during winter in the area of the proposed scheme. Furthermore, Table 15.19 indicates that maximum daily temperatures could increase substantially over the lifespan of the proposed scheme, while Table 15.20 indicates that climate events such as hot spells, heatwaves, dry spells and droughts could occur more frequently.

15.9.7 As a result, the proposed scheme could be impacted upon by a changing climate and more frequent severe weather events in the medium to longer term. Potential impacts include disruption and delays to road users, together with material and asset deterioration and damage giving rise to health and safety risks to road users and increased maintenance requirements.

15.9.8 The key potential operational impacts on assets (including their operation, maintenance and refurbishment) are outlined below, with further details provided in Appendix 15.2 of the Environmental Statement [TR010060/APP/6.3]:

- Increased precipitation during winter months and more extreme rainfall events could cause:
  - road surface flooding, should drainage capacity be exceeded, which could result in danger or delay and disruption to road users, damage to road pavements and increased management or maintenance requirements and costs
  - fluvial flooding of roads and road infrastructure, such as bridges and underpasses, resulting in potential danger or delay and disruption to road users on a strategic route; damage to or accelerated degradation of proposed scheme structures and assets; and increased management or maintenance requirements and costs
  - culvert scouring leading to potential culvert failure or increased maintenance requirements and costs
  - bridge scouring leading to the potential failure of bridge foundations or increased maintenance requirements and costs
  - erosion at toe of embankments could result in the potential failure of embankments or increased maintenance requirements and costs
  - water ingress to cables and electrical equipment (e.g. signage and lighting) could lead to the potential damage to equipment, which could result in danger or delay and disruption to road users and increased maintenance requirements and costs
  - changes in groundwater levels which could affect earth pressures for retaining walls, resulting in damage to retaining walls and subsequent ground movement and associated increased maintenance requirements and costs
  - rise in groundwater level could lead to the flooding of underbridges (particularly in winter months), which could result in danger or delay and disruption to road users, together with damage to or accelerated degradation of proposed scheme structures and assets; this in turn could lead to increased maintenance requirements and costs
  - variations in groundwater levels, which could cause softening of embankment fill through capillary action and accelerated weathering effects, weakening embankments

- higher pore water pressure in embankments and earthworks, which could lead to instability and risk of failure resulting in delay and disruption to road users along this strategic route and increased maintenance requirements and costs
- flooding of roads, hard shoulders, verges and access routes, which could lead to challenges, delays, and disruption for the maintenance regime
- increased debris and sediment runoff, which could result in capacity reduction of the sustainable drainage systems (SuDS)
- increased debris washing into drainage infrastructure (e.g. gullies and culverts), which could lead to blockages of the drainage system, resulting in danger or delay and disruption to road users and increased maintenance requirements and costs
- increased number of heavy rain days, which could result in higher stripping rates of pavements leading to texture depth reduction, which could endanger road users and increase maintenance requirements and costs
- potholing, rutting and cracking from moisture entering and remaining in pavements (particularly in combination with frost formation) which could result in damage to road users' vehicles and increased maintenance requirements and costs

- Lower rainfall during the summer months and more frequent drought events and dry spells could cause:
  - soil shrinkage or subsidence, which could result in adverse impacts on foundations, including for bridges and other structures, which may lead to increased maintenance requirements or failure
  - reduced inflow into SuDS, which could result in planting/seeding failure and a reduction in the functional capacity of the SuDS
  - increases in the desiccation of soils, which could lead to slope stability reduction and earthworks failure during or immediately after summer storm events falling on desiccated soils
- Increase in the maximum summer temperatures, and the number and duration of hot days, hot spells and heatwaves could cause:
  - heating and thermal expansion beyond the design capability of structures and assets leading to the damage or failure of structures and assets
  - permanent deformation of asphalt (part of the paving mixture, i.e. flexible surfacing), particularly during prolonged hot weather conditions
  - surface rutting leading to water ponding in ruts and the reduced skid resistance due to fatting (accumulation of bituminous mix on the surface of the pavement)
  - acceleration of bitumen binder hardening, which could lead to pavements cracking and fretting with age and traffic loads

- longer growing season, which could lead to stability impacts on structures and deformation of pavements due to overgrown tree roots and also additional maintenance needs for the soft estate and SuDS, due to overgrown vegetation
- impacts on the performance of electrical equipment leading to reduced efficiency and lifespan of LED luminaires, for example

15.10 Design, mitigation and enhancement measures

Embedded (design) mitigation

15.10.1 The environment team has worked in close collaboration with the infrastructure design team to avoid or reduce environmental impacts through the proposed scheme design. This is referred to as embedded (or design) mitigation. Chapter 3: Assessment of alternatives, of the Environmental Statement [TR010060/APP/6.1], details the design alternatives that have been considered, including the environmental factors which have influenced the decision making.

Greenhouse gas emissions

15.10.2 Embedded mitigation relevant to this matter includes:

- Measures which have been taken which have reduced the magnitude of GHG emissions associated with construction phase activities, including:
  - greater use of proposed infrastructure at junction 19 (Boreham interchange) to reduce the footprint of the proposed scheme. As part of the Beaulieu Park development this junction will be improved by the developer by early 2023; through early engagement with this developer the design of the proposed scheme has been modified to avoid further works.
  - descoping verge and central reservation works between junction 19 and junction 20a (Hatfield Peverel South interchange), as the carriageway is already three lanes in this area
  - avoiding the need for the demolition of existing properties in Hatfield Peverel at junction 21 (Witham South interchange)
  - modifying the vertical alignment of the proposed scheme at junction 22 (Colemans interchange) to reduce earthworks and fill material requirements
  - removal of a ‘new’ junction 23 (Kelvedon South interchange) from the scope of the proposed scheme, with the existing A12 between junctions 22 and 23 being retained as a local access road
  - relocating the new junction 24 (Kelvedon North interchange) to Inworth Road which improves the earthworks cut and fill balance at this location, as the location relative to alignment levels has been optimised to reduce the earthworks required

- for the Prested Hall access, using part of the existing A12 northbound carriageway to provide the new access road, and reducing the number of new structures over the proposed A12 mainline from two to one
- where bridge spans allow, consideration in the design of pre-stressed concrete beams rather than steel beams (which have higher embodied carbon, whilst having similar properties)
- at the River Ter Bridge, the existing bridge width is to be retained, as opposed to physically widening the bridge
- pavement has been designed to utilise existing pavement as much as possible, based on the pavement assessments, to eliminate as far as possible full reconstruction of existing pavement
- reduction in the number of overbridges required through optimisation of the highways design
- review and optimisation of design for ancillary works to existing culverts to reduce flood compensation area requirements
- use of low noise pavement, which allowed the removal of noise barriers in certain locations eliminating the need for substantial additional civil works to accommodate such structures
- the use of borrow pits to source bulk earthworks materials instead of importing material (refer to Section 2.6 of Chapter 2: The proposed scheme, of the Environmental Statement [TR010060/APP/6.1]), which would reduce GHG emissions associated with the transport of materials

- Measures which have been taken in order to support active travel, thereby encouraging modal shift from private car and reducing operational phase road user GHG emissions, including:
  - maximising the use of existing infrastructure at junction 25 (Marks Tey interchange) to facilitate improvements for walkers, cyclists, and horse riders (WCH)
  - separate WCH links across four proposed major junctions, enabling users to bypass slip road junctions, including the national cycle route affected by the proposed scheme
  - provision of public rights of way (PRoW) bridge connections at a number of locations, either as separate WCH facilities or in conjunction with overbridges or side roads (refer to Section 2.5 of Chapter 2: The proposed scheme, of the Environmental Statement [TR010060/APP/6.1])
  - provision of paths to link groups of PRoW to proposed bridge facilities
  - provision of new toucan crossing facilities (crossings that allow both walkers and cyclists to cross)
  - improvements to existing shared pedestrian/cycling facilities
  - improved WCH connections across sections of the existing A12 to be bypassed, and reintroduction of bus stopping facilities

- Measures which have been taken in order to reduce carbon losses from existing carbon stores (such as soil and vegetation) and improve carbon sequestration, including:
  - modifications to the proposed scheme design in order to reduce land-take and the disturbance of existing carbon stores such as vegetation and woodland
  - planting of new areas of woodland and vegetation within the Order Limits

Vulnerability to changes in climate

Embedded mitigation relevant to this matter includes:

- Measures which have been or would be taken to mitigate climate related impacts on road surfaces and pavements including:
  - The proposed highway drainage system is designed to DMRB CG 501 Design of Highway Drainage Systems (Highways England, 2020b) which includes allowances for climate change in line with those set out in the national Environment Agency Climate Change Guidance (Environment Agency, 2021b).
  - Edge of pavement drains will be as detailed in pavement drainage design guidance DMRB CD 524 Edge of Pavement Details (Highways England, 2021d) to mitigate the risk of standing water and flooding of the carriageway areas. This includes incorporating the current climate change allowance requirements set out in DMRB CG 501 (Highways England, 2020b).
  - The road pavement is designed to DMRB CD 226 Design for New Pavement Construction (Highways England, 2021e), the foundation designed to DMRB CD 225 Design for New Pavement Foundations (Highways England, 2020c) and materials would be laid to the Manual of Contract Documents for Highways Works (MCHW) standards (Highways England, 2021f).
  - Worst case ground water conditions, based on the results of site-specific ground water monitoring, will be used to inform the proposed scheme design. The most appropriate drainage type will be selected and designed to meet the requirements of DMRB CG 501 to allow for ground water interception.
  - The road surface would be laid as per DMRB CD 236 Surface Course Materials for Construction (Highways England, 2021h) to ensure adequate Polished Stone Value (PSV) is adopted to reduce the risk of skidding caused by increased rainfall, especially for high-risk areas.
  - As per DMRB LD 117 Landscape Design (Highways England, 2020d), large trees would be planted at least 9m from the edge of carriageway, medium trees at least 7m from the edge of carriageway and shrubs at least 4.5m from edge of carriageway.

- Measures which have been or would be taken to mitigate climate related impacts on structures (including embankments, earthworks, bridges) including:
  - The application of suitable scour protection measures to new and extended existing crossings over watercourses in accordance with DMRB CD 356 Design of Highway Structures for Hydraulic Action (Highways England, 2020e).
  - New structure designs account for 1 in 100 year flood events and an allowance for climate change. Deck soffit levels are designed so that this level plus a minimum allowance of 600mm freeboard is achieved in accordance with DMRB CD 356 so that in extreme flood events, debris build up, impact forces and uplift forces do not detrimentally affect the structure and its elements.
  - Proposed drainage systems for underpasses are to be designed to DMRB CG 501 which includes allowances for climate change in line with those set out in the Environment Agency Climate Change Guidance (Environment Agency, 2021b).
  - Retaining structures, earthworks and embankment slopes will be designed for the worst-case groundwater conditions considering climate change.
  - Positive drainage measures (i.e. measures which encourage water to drain away from an area rather than pooling) would be installed behind all retaining walls, abutments and underpasses with accessible maintenance rodding points. Weepholes would also be provided as an additional drainage measure.
  - Structure abutments and foundations are designed using the worst-case parameters from drained and undrained ground conditions.
  - Drainage systems would be installed to prevent water build-up at toes of slopes and erosion protection measures installed where risk of erosion of the slope surface could lead to shallow slip failures.
  - Raking drains would be installed if groundwater is required to be lowered to increase slope stability.
  - Positive drainage would be installed over all bridge decks in the form of combined kerb drainage units or flush drainage units to prevent build-up of water over the deck.
  - Sub-surface deck drainage systems would be installed on top of deck waterproofing systems at low points adjacent to deck joints to collect and dispose of seeping water through the surfacing material.
  - Embankments will be designed from slope-stability analysis using site specific soil parameters and compacted and constructed in line with best practice including alignment with DMRB standards.

- The structures will be designed in accordance with the current version of Eurocode standard EN 1991-1-5 (British Standards Institution, 2010) and its associated National Annex (British Standards Institution, 2007).
- The bridges and underpasses are designed as fully integral structures where practicable, meaning there are no bridge bearings or deck movement joints, which may be impacted (i.e. expand) as a result of increases in temperature.
- Temperature effects in the structure will be taken into account through the soil and structure interaction in accordance with Eurocode 7: Geotechnical Design (British Standards Institution, 2004) and DMRB standards.

- Measures which have been or would be taken to mitigate climate related impacts on drainage systems including:
  - Additional storage capacity through sediment forebays at attenuation ponds that would allow sediment to settle out from surface water runoff caused by periods of increased precipitation or more intense rainfall events. Gullies and catchpits forming part of the surface water drainage systems would also provide further additional silt-trapping capacity at the attenuation ponds.
  - The drainage design will include accessible sediment traps (catchpits) that would be regularly cleared. Catchpits would have sumps where silt can be trapped and more easily removed than manholes.
  - Attenuation ponds will be designed to include a pool of water at the base of the pond (to create a wetland) that would retain the operational functionality of the attenuation ponds (i.e. so that vegetation is not lost during hot and dry periods and the treatment capacity of SuDS reduced).
- Measures which have been or would be taken to mitigate climate related impacts on road technology and street furniture (e.g. signs, signals and lighting) including:
  - Cabinet and equipment housings are designed to mitigate and reduce water ingress during periods of increased precipitation and more intense rainfall events.
  - The proposed scheme design will include the specification of suitable Ingress Protection ratings for both feeder pillars and luminaires to protect from water ingress during periods of increased precipitation and more intense rainfall events.
  - Cables would be specified correctly including a medium density polyethylene (MDPE) sheath where there is a risk of being located in water, particularly during periods of increased precipitation and more intense rainfall events.
  - Electrical equipment would be protected against main electrical supply surge and lightning current by surge protection devices.

- For feeder pillar locations the design will ensure there is sufficient free space to dissipate heat and passive cooling as required, particularly during periods of increased temperatures and periods of excessive temperatures, such as heat waves and hot spells.
- Luminaires selected for the proposed scheme design are tested to withstand heat in extreme weather climates such as the United Arab Emirates.
- The design includes the use of LED units with breather glands to remove heat to maintain a 'constant ambient temperature', keeping the heat-sink free of debris which is essential in keeping the LED within the required temperature range, particularly during periods of increased temperatures and periods of excessive temperatures, such as heat waves and hot spells.

- Measures which have been or would be taken to mitigate climate related impacts on landscaping, including:
  - The proposed landscape design would futureproof the proposed scheme in terms of climate change as well as in terms of pests and diseases by adhering to best practice. This would include diversifying planting species as much as practicable, including using drought tolerant species, whilst still having regard to the local character, and generally planting only native species.
  - In terms of increased future flood risk, the proposed landscape design would futureproof the proposed scheme by including species tolerant of flooding, such as willow and alder, on floodplains and next to watercourses.

Standard mitigation

15.10.3 Standard mitigation would occur as a matter of course due to legislative requirements or standard sector practices.

15.10.4 Standard mitigation is included in the REAC, within the first iteration of the EMP [TR010060/APP/6.5] which forms part of the DCO submission (refer to Chapter 5: Environmental assessment methodology, of the Environmental Statement [TR010060/APP/6.1]).

15.10.5 It should also be noted that the National Highways Net Zero Highways Plan indicates all of National Highways Tier 1 & Tier 2 suppliers will be required to have certified carbon management systems by 2025.

Greenhouse gas emissions

15.10.6 Standard mitigation for this matter includes:

- Measures which would reduce the magnitude of GHG emissions associated with construction phase activities, including:
  - Preparation and implementation of a Logistics Management Plan (or similar) to manage the transport to/from and onsite of employees and materials required for the construction of the proposed scheme. The

Logistics Management Plan (or similar) would set out measures where practicable, to reduce distances travelled, optimise journeys and use low emission modes of transport (such as public transport) or vehicles (e.g. electric vehicles) to reduce GHG emissions associated with transport. The Logistics Management Plan would set out measures with the aim of achieving 20% car share and 20% travel by public transport (with the use of mini-buses from local rail stations to the construction sites) for employee transport.

- Seeking to source materials from local suppliers, where practical and cost-effective to do so, in order to reduce the travel distance of materials and associated GHG emissions.

- Measures to reduce the magnitude of GHG emissions associated with the use of materials and waste disposal (for further details refer to Section 11.10 of Chapter 11: Material assets and waste, of the Environmental Statement [TR010060/APP/6.1]), including:

  - Implementing design for resource efficiency principles in a systematic manner to suit the scale of the proposed scheme, to identify, prioritise and select appropriate opportunities to improve project resource efficiency and design out waste.
  - Developing and implementing a Sustainable Procurement Plan (SPP). The SPP would set out a clear framework to increase the procurement and use of sustainably and responsibly sourced construction materials and products with proven sustainability credentials that reduce adverse impacts on people and the environment during the construction of the proposed scheme.
  - Implementing a Site Waste Management Plan (SWMP), in a manner to suit the requirements of the proposed scheme, to plan, implement, monitor and review waste minimisation and management throughout the construction of the proposed scheme.
  - Identifying the potential for using/re-using site-arising materials and resources, such as:
    - from borrow pits within the Order Limits
    - existing carriageway materials
    - rainwater for dust management purposes
  - With regards to the transport and disposal of waste the Principal Contractor would ensure that waste is stored, treated, re-used, recycled, recovered or disposed of as close as practicable to the point of origin during the construction of the proposed scheme, with consideration of the proximity principle, self-sufficiency principles and value for money principle, provided there are no unacceptable adverse impacts on people, the environment or local amenities. Locally permitted transfer, re-use, recycling, other recovery and disposal sites would be used during construction, where sufficient capacity is available.

Vulnerability to changes in climate

15.10.7 Standard mitigation for this matter includes:

- Measures which reduce the vulnerability of construction phase activities to climate related impacts, including:
  - Implementation of good construction practice (e.g. in accordance with relevant guidance such as the CIRIA Environmental Good Practice on Site Guide (CIRIA, 2015) and other relevant guidance) including determining appropriate locations for site offices and facilities and storage areas for materials
  - Suitable management of site drainage, as would be specified within the second iteration of the EMP
  - Incorporation of the requirement to use weather forecasting and to develop plans for extreme weather events (e.g. very high intensity rainfall events or heat waves) within the second iteration of the EMP
- Measures which reduce the vulnerability of the proposed scheme to potential future changes in climate, including:
  - The Principal Contractor will, in the choice of permitted materials for sub-bases and bases during detailed design, and in accordance with DMRB CD 226, have regard to the nature of those materials and of the sub-grade or any capping and the need to protect them from deterioration due to the ingress of water, the adverse effects of weather and the use of constructional plant.
  - The Principal Contractor will programme the laying and compaction of the sub-base and the subsequent pavement courses, where practicable, and take other steps, if necessary, to afford protection to the base, sub-base and subgrade to changes in climatic conditions, such as increases in heavy rainfall periods.
  - Implementation of an appropriate asset management strategy by the scheme operator to proactively identify and, where necessary, rectify potential climate related impacts (e.g. additional visual inspections of the proposed scheme's assets after extreme weather events).

Additional mitigation

15.10.8 No additional mitigation measures are identified following the implementation of embedded and standard mitigation.

Enhancement

Greenhouse gas emissions

15.10.9 Opportunities for enhancement which have been identified that are relevant to this matter, but which have not been taken into account within this assessment (as they are not necessary to mitigate impacts nor are able to be confirmed at this stage), include:

- Measures which would be taken to further avoid or reduce GHG emissions during the construction stage, where practicable and cost-effective, including:
  - using electric (or alternative lower-carbon fuel) construction equipment instead of conventional diesel-powered construction plant
  - using vehicles fitted with telematics and start/stop technology
  - using onsite renewable energy generation and storage to reduce diesel generator use and power taken from the grid
  - using low resource and low energy solutions for the site compound, offices and welfare facilities
  - ensuring availability of grid connections for compounds (maximising access to lower carbon-intensity energy from grid electricity)
- Measures which would be taken to further avoid or reduce GHG emissions associated with the consumption of raw materials, where practicable and cost effective, including:
  - The design specification, which will be developed as part of the detailed design, would aim to reduce or avoid, where practicable, the use of carbon intensive materials (e.g. concrete and cement). Where this is not practicable, material volumes or processes would be substituted with lower intensity replacements where practicable and if achievable within the bounds of the design standards for safety and quality. In order to help guide this process, a voluntary 30% carbon reduction target has been set for the embodied carbon associated with the proposed scheme, progress against which would be determined and assessed with reference to PAS:2080. It should be noted that this 30% reduction will be measured against a ‘baseline’ which will be determined at the detailed design stage (e.g. based on more detailed design information), which could therefore differ from the estimates of embodied carbon presented within this chapter.
- Measures to further reduce the magnitude of GHG emissions associated with the use of materials and waste disposal, including:
  - Undertaking a pre-demolition assessment of all highway structures and assets and third-party buildings to be removed or demolished as part of the proposed scheme. This assessment would be used to determine the quantities of demolition assets, elements, components, products and materials; and to make recommendations for their re-use (on and off-site), recycling, other recovery or final disposal. This assessment would also support the production of the SWMP and SPP by identifying the types and quantities of each waste to be produced during demolition and any opportunities to use these site-won materials to offset the use of primary materials (refer to Section 11.10 of Chapter 11: Material assets and waste, of the Environmental Statement [TR010060/APP/6.1]).

Vulnerability to changes in climate

15.10.10 Opportunities for enhancement which have been identified that are relevant to this matter include:

- Measures would be taken, where reasonably practical, to further mitigate climate related impacts on road surfaces and pavements including:
  - consideration of special materials such as polymer modified bitumen, which is less sensitive to temperature than plain temperature, for areas subject to rutting
  - consideration of the use of special material selection, such as EME2 binder course (high strength, long life asphalt base and binder course), to mitigate against cracking and fretting of the carriageway, thereby reducing maintenance requirements
- Measures would be taken, where reasonably practical, to further mitigate climate related impacts on structures (e.g. embankments, earthworks, bridges) including:
  - consideration of the installation of a drainage blanket layer to embankments to aid drainage of formations and improve slope stability following heavy rainfall
  - consideration of the use of granular materials in earthwork embankments that are less susceptible to weathering
  - if capillary action is considered an issue, additional drainage or sub-surface drainage would be considered where groundwater levels are close to the base of embankments
  - consideration of water filled tension cracks that could have an impact on retaining wall or slope stability in the detailed design to improve slope stability

15.11 Assessment of likely significant effects

15.11.1 This section presents the assessment of likely significant effects on and of climate during both construction and operation of the proposed scheme. The assessment of effects takes into account the potential impacts to each receptor following the implementation of embedded and standard mitigation measures (but not including potential enhancements) to determine the significance of the residual effects.

Greenhouse gas emissions

Construction

15.11.2 Estimated construction phase GHG emissions are summarised in Table 15.21, with a more detailed breakdown provided in Appendix 15.1 of the Environmental Statement [TR010060/APP/6.3]. The GHG emissions from the construction phase are estimated to total 428,626tCO_2e.

Table 15.21 Construction phase GHG emissions

Main stage of project life cycle	Sub-stage of life cycle*		GHG emissions (tCO_2e)	% of total construction GHG emissions
Construction phase	Product stage; including raw material supply, transport and manufacture (A1–A3)		238,050	55.5 %
	Construction process stage; including:	Transport of materials to works site (A4)	59,071	13.8 %
		Transport and treatment of waste (A5)	19,938	4.7 %
		Employee transport (A5)	5,784	1.3 %
		Construction/installation processes (A5)	65,281	15.2 %
	Land use change (net change in carbon stocks in soil and vegetation)		39,823	9.3 %
	Forestry (net change in carbon sequestration)		678	0.2 %
	Construction stage total		**428,626**	**-**

* Sub-stages of the construction life cycle and modules shown in this table align with PAS 2080 boundary stages

15.11.3 The largest proportion of construction phase GHG emissions (55.5%) is estimated to be associated with the production of materials. The construction process stage, which includes the transport of materials to site, the transport and treatment waste, employee transport, and construction and installation processes, is estimated to contribute 35.0%. The GHG emissions associated with changes in land use and forestry during the construction phase are estimated to contribute 9.5%.

Operation

15.11.4 Estimated operational phase GHG emissions over a 60-year appraisal period after the scheme opening (i.e. between 2027 and 2086, inclusive) are presented in Table 15.22, with a more detailed breakdown provided in Appendix 15.1 of the Environmental Statement [TR010060/APP/6.3].

Table 15.22 Estimated operation GHG emissions

Main stage of the project life cycle	Sub-stage of life cycle*	Estimated GHG emissions (tCO_2e) over appraisal period (2027–2086)		
		Do-Minimum	Do-Something	Change
Operation ('use-stage')	Use of the infrastructure by the end-user (road user GHG emissions) (B9)	33,659,663	35,195,222	1,535,559
	Maintenance and refurbishment (B2–B5)	105,402	158,103	52,701
	Operational energy use (B6)	Not known	94	94
	Land use change (net change in carbon stocks in soil and vegetation)	N/A	24,312	24,312
	Forestry (net change in carbon sequestration)	-11,394	-51,208	-39,814
	Operation ('use-stage') total	**33,753,671**	**35,326,522**	**1,572,851**

* Sub-stages of the operation ('use-stage') life cycle and modules shown in this table align with PAS 2080 boundary stages

15.11.5 The results in Table 15.22 indicate that operational phase GHG emissions are dominated by road user GHG emissions. It should be noted, however, that changes in forestry as a result of the proposed scheme are estimated to result in a small increase in carbon sequestration (i.e. a net benefit) during its operation.

Comparison with carbon budgets

15.11.6 Estimates of total Do-Something GHG emissions and the net change in GHG emissions (i.e. Do-Something minus Do-Minimum GHG emissions) within relevant UK carbon budget periods are shown in Table 15.23.

15.11.7 All construction phase GHG emissions are assumed to occur in the fourth carbon budget period (i.e. between 2023 and 2027), along with GHG emissions generated during the first year of operation (2027). Only operational GHG emissions would occur in the fifth and sixth carbon budget periods.

Table 15.23 Estimated GHG emissions compared to UK carbon budgets

Project stage	Estimated total GHG emissions over carbon budget periods (tCO_2e) (Do-Something scenario)	Net change in GHG emissions with proposed scheme over carbon budget periods (tCO_2e)	Net change in GHG emissions with proposed scheme within relevant carbon budget period (tCO_2e) (and as % of relevant carbon budget)		
			4th carbon budget (2023–2027)	5th carbon budget (2028–2032)	6th carbon budget (2033–2037)
Construction	427,801	428,626 [a]	428,626 [a] (0.022%)	-	-
Operation	7,577,097	318,195	30,209 (0.002%)	147,364 (0.009%)	140,622 (0.015%)
Total	8,004,897	746,820	458,835 (0.024%)	147,364 (0.009%)	140,622 (0.015%)

[a] Including construction phase GHG emissions and changes in carbon sequestration due to woodland being removed during construction phase (prior to replanting).

15.11.8 The results in Table 15.23 indicate that estimated changes in GHG emissions as a result of the proposed scheme are negligible in comparison to relevant UK carbon budgets. On this basis, GHG emissions associated with the proposed scheme are considered unlikely to have a material impact on the ability of the UK Government to meet its carbon reduction targets and are therefore considered to be **'not significant'**, in line with DMRB LA 114 and the NNNPS.

15.11.9 It should also be noted that this assessment is considered likely to be worst case as the estimated operational road user GHG emissions presented in this report (derived using Defra's Emission Factors Toolkit v11 (Defra, 2021)) do not fully account for the most recent projections for the uptake of electric cars and vans described in the latest version of DfT's TAG data book (DfT, 2021c). Nor do they take account of the projected reductions in GHG emissions depicted in Figure 2 of the Transport Decarbonisation Plan (TDP) (DfT, 2021b, page 45). The impacts of the TDP are expected to lead to a substantive decrease in GHG emissions from all forms of road transport between now and 2050. As the TDP has only recently been published, vehicle composition projections and emission factors have not yet been updated to reflect the emerging policy position described by the TDP. The DfT have advised National Highways that a sensitivity test based on the impact of the policy measures set out in TDP can now, however, be undertaken for schemes. The DfT have approved a sensitivity test based on the rate of improvement shown in Figure 2 of the TDP which can be applied to road user GHG emissions calculated for the proposed scheme assessment.

15.11.10 Table 15.24 presents total operation phase GHG emissions in the Do-Something scenario and the change in operation stage GHG emissions compared to the Do-Minimum scenario, split by carbon budgets, for the TDP sensitivity test (upper and lower bounds). Construction phase GHG emissions are not presented, as these remain the same as presented in Table 15.23.

15.11.11 The results in Table 15.24 indicate that the implementation of the TDP will result in substantially lower operational phase GHG emissions and changes in operational phase GHG emissions than presented in Table 15.23 within both the fifth and sixth carbon budget periods and in future years.

Table 15.24 TDP Sensitivity Test GHG emissions compared to UK carbon budgets

Project stage	Estimated total GHG emissions over carbon budget periods (tCO_2e) (Do-Something scenario)	Net change in GHG emissions with proposed scheme over carbon budget periods (tCO_2e)	Net change in GHG emissions with proposed scheme within relevant carbon budget period (tCO_2e) (and as % of relevant carbon budget)		
			4th carbon budget (2023–2027)	5th carbon budget (2028–2032)	6th carbon budget (2033–2037)
Operation (TDP upper bound)	6,136,822	249,850	30,209 (0.002%)	132,031 (0.008%)	87,610 (0.009%)
Operation (TDP lower bound)	4,660,386	193,239	30,209 (0.002%)	107,674 (0.006%)	55,356 (0.006%)

15.11.12 In addition to the TDP, National Highways has recently published its own 2030/2040/2050 Net Zero Highways Plan (National Highways, 2021b). This plan includes commitments to ensure that National Highways' corporate GHG emissions will become net zero by 2030, its maintenance and construction activities will become net zero by 2040 and road user GHG emissions on the strategic road network will become net zero by 2050. Again, the impacts of these commitments have not been factored into this assessment.

15.11.13 National Highways recognise it has a key role in the development and maintenance of the SRN that will facilitate the journey to net zero GHG emissions. As part of this, the National Highways Net Zero Highways Plan sets out commitments to develop a blueprint for electric vehicle charging and energy storage by 2023, and to report to government on global HGV technology trials and set out proposals for trials in the UK in 2022.

Potential cumulative effects

15.11.14 The traffic model used for the proposed scheme has been developed in line with DfT requirements and is inherently cumulative. This is because, in brief, traffic models used to support scheme assessment contain data about the following:

- The proposed scheme and adjoining SRN and local road network
- Other transport schemes promoted by National Highways or local authorities in the near vicinity of the proposed scheme with high certainty that they are to be progressed, i.e. progressed beyond preferred route announcement stage. Details of the specific transport schemes included within the A12 PCF Stage 3 DCO traffic model used to inform this assessment can be found in Section 4.2 of Appendix C of the Combined Modelling and Appraisal Report [TR010060/APP/7.3]
- Foreseeable developments promoted by third parties that are likely (based on discussions with relevant local planning authorities) to be developed in a similar timeline to the proposed National Highways' scheme; knowing where the proposed third-party development is to be sited, the extents and types of development, and the timescales of when it is to be completed are requirements to ensure that the third-party developments can be reasonably described in the traffic model. Details of the specific developments included within the A12 PCF Stage 3 DCO traffic model used to inform this assessment can be found in Section 5.6 of Appendix C of the Combined Modelling and Appraisal Report [TR010060/APP/7.3].
- National government regional growth rates which include a representation of likely growth rates excluding known planning developments already included in the traffic model; this is represented by DfT's National Trip End Model (NTEM)/Trip End Model Presentation Program (TEMPRO) growth factors for car usage, and growth in freight is derived from DfT's National Transport Model

15.11.15 Changes in operational road user GHG emissions as a result of the proposed scheme have been evaluated within this assessment by comparing changes in road user GHG emissions on the SRN and local road network between the 'without scheme scenario' and the 'with scheme scenario'. This takes into account the assessment of the proposed scheme and all other developments likely to have an influence on the proposed scheme and on the area the proposed scheme is likely to influence.

15.11.16 In essence, as both with and without scheme scenarios already include all likely developments and traffic growth factors, the assessment presented above is inherently cumulative as regards operational GHG emissions.

15.11.17 Climate impacts (that is those as a consequence of global heating) are observable at a national and global scale. Assessment of significance is based on whether the increase in global GHG emissions represent a significant contribution to global atmospheric GHG concentrations in the context of national carbon budgets.

15.11.18 The approach to the assessment of cumulative effects arising from GHG emissions is incorporated into the methodology for appraising emissions from construction and operation as set out in DMRB LA 114. The assessment of cumulative GHG emissions cannot be carried out in a process analogous to other environmental topics because there is no causal link between the location of GHG emissions and the impacts arising from the cumulative aggregation of GHGs in the atmosphere. This limitation has also been recognised in the recent update to guidance on the assessment of GHG emissions produced by IEMA. Because of this limitation - and because it is necessary to consider GHGs in the context of a scientifically based trajectory compliant with the planetary limits for GHG emissions - the best available comparison benchmark are the carbon budgets adopted by the UK that provide a series of five-yearly budgets within which the UK must stay in order to remain on track to achieve Net Zero by 2050.

15.11.19 The net GHG impacts of the proposed scheme have been assessed and reported within the context of national carbon budgets. The approach to climate assessment within the methodology set out in DMRB LA 114 is inherently cumulative through the inclusion of the proposed scheme and other locally committed transport schemes and developments within the traffic model on which the GHG emissions calculations are based (see paragraph 15.11.14 of this chapter), and through the consideration of the GHG emissions associated with the proposed scheme against the UK carbon budgets. The assessment of construction stage emissions is based on design data and estimates of construction activity. The assessment of operational emissions is based on the validated traffic model for the proposed scheme (as directed by DMRB LA 114). These are then presented in the context of the national carbon budgets for the periods where budgets have been set. The total emissions are presented in the context of the relevant carbon budget period in which they are expected to fall. No separate cumulative assessment has therefore been undertaken on GHG emissions.

Benchmarking

15.11.20 Paragraph 3.21 of DMRB LA 114 requires that the performance of a project should be benchmarked by comparing estimated GHG emissions with those associated with other highway projects. As such, Table 15.25 compares estimated construction phase GHG emissions associated with the proposed scheme against other highway projects.

15.11.21 In order to enable a more direct comparison, and as per paragraph 3.21.1 of DMRB LA 114, estimated construction phase GHG emissions for each project have also been normalised by dividing total construction phase GHG emissions by the length of the scheme. It should be noted, however, that factors other than length will influence the magnitude of construction phase GHG emissions associated with any particular project (e.g. the number of lanes, junctions and structures).

15.11.22 The GHG emissions associated with changes in land use and forestry have been excluded from Table 15.25 in order to provide a like for like comparison as GHG emissions have not been estimated for this emission source for the majority of the other projects considered.

15.11.23 A similar comparison has not been undertaken for operational phase GHG emissions as operational phase GHG emissions are dominated by road user GHG emissions, changes in which will be specific to each scheme based on a number of factors (not just scheme length), including not least the schemes' geographical location and existing levels of traffic flows and congestion. Furthermore, as v11 of Defra's Emission Factors Toolkit (Defra, 2021) had only just been released at the time of this assessment, no published information was available for other projects which had also used this method to enable a like for like comparison.

15.11.24 The data presented in Table 15.25 indicates that the proposed scheme is estimated to result in normalised construction phase GHG emissions towards the lower end of the range of the projects considered.

Table 15.25 Comparison of proposed scheme's construction GHG emissions with other road projects (tCO_2e)

Sub-stage of project life cycle	Element	Project and project length					
		Proposed scheme	M54 to M6 Link Road [a]	A14 Cambridge to Huntingdon improvement scheme [b]	A57 Link Roads [c]	A417 Missing Link [d]	A428 Black Cat to Caxton Gibbet improvements [e]
		24km	2.5km	37km	3.1km	5.5km	19km
Product stage; including raw material supply, transport and manufacture (A1–A3)	All	238,050	49,620	740,062	22,796	40,698	163,230
Construction process stage (A4–A5):	Employee commuting	5,784	2,420	210,278	371	2,668	4,430
	Transport of fuel	1,444	Not given	518	20		Not given
	Transport of materials	59,071	15,940	22,391	8,490		Included in product stage
	HGVs onsite	Included in above	Not given	2,792	Not given		Not given
	Onsite consumption of fuel, energy & water	63,838	4,250	5,110	7,273	20,818	45,210
	Waste treatment and transport	19,938	7,780	281	19		1,360

Sub-stage of project life cycle	Element	Project and project length					
		Proposed scheme	M54 to M6 Link Road [a]	A14 Cambridge to Huntingdon improvement scheme [b]	A57 Link Roads [c]	A417 Missing Link [d]	A428 Black Cat to Caxton Gibbet improvements [e]
		24km	2.5km	37km	3.1km	5.5km	19km
Construction phase total (excluding GHG emissions associated with changes in land use and forestry)		388,124	80,010	981,432	38,970	64,184	214,230
Construction phase total (tCO_2e per km)		16,172	32,004	26,525	12,571	11,670	11,275

Data sources

[a] https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/TR010054/TR010054-000158-TR010054%20M54%206.1%20Environmental%20Statement%20Chapter%2014.pdf

[b] TR010018-000797-A14 6.3 ES Appendix 13.02.pdf (planninginspectorate.gov.uk)

[c] https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/TR010034/TR010034-000161-6.3%20Environmental%20Statement%20Chapter%2014%20Climate.pdf

[d] https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/TR010056/TR010056-000221-6.2%20Environmental%20Statement%20-%20Chapter%2014%20-%20Climate.pdf

[e] https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/TR010044/TR010044-000248-TR010044_A428_Black_Cat_to_Caxton_Gibbet_Improvements_6-1_Environmental_Statement_Chapter_14.pdf

Vulnerability to changes in climate

Construction

15.11.25 Potential climate change related hazards and opportunities, potential climate change related impacts, impacted assets and receptors and measures proposed to mitigate such impacts during the construction phase are presented in Table 2.1 of Appendix 15.2 of the Environmental Statement [TR010060/APP/6.3].

15.11.26 As shown in Table 2.1 of Appendix 15.2 [TR010060/APP/6.3], the risks of substantial disruption to construction phase activities (following mitigation) are likely to be negligible and are therefore considered to be **'not significant'**.

Operation

15.11.27 Potential climate change related hazards and opportunities, potential climate change related impacts, impacted assets and receptors, and measures proposed to mitigate such impacts during the operational phase are presented in Table 2.2 of Appendix 15.2 [TR010060/APP/6.3].

15.11.28 The likelihood of each potential impact occurring during the operational phase, with embedded and standard mitigation in place, has been assessed along with the consequence of that impact if it occurred. This assessment, along with the resulting significance of each impact, is presented in Table 2.2 of Appendix 15.2 [TR010060/APP/6.3] using the approach and methodology outlined in Section 15.5 of this chapter.

15.11.29 Based on the assessment undertaken it is considered that with the embedded and standard measures in place, the potential climate-related hazards and impacts identified during the operational phase are anticipated to be **'not significant'**.

Potential cumulative effects

15.11.30 Whilst a range of climate change impacts may occur within the Order Limits, affecting the proposed scheme, the physical effects of climate events may also occur beyond the project boundary and affect other nearby strategic transport infrastructure, potentially resulting in a cumulative impact, which may have a significant effect. An additional assessment is therefore made here to consider whether other strategic transport infrastructure beyond the boundary of the proposed scheme, may when also subject to climate impacts, result in significant effects.

15.11.31 Given the proposed scheme's importance to regional transport, cumulative climate vulnerability effects are considered at both local and regional scales. The main transport networks at these scales include:

- at a local level, an alternate road route around the proposed scheme is provided by the A120 and A131 (via Braintree), which would provide local resilience in the event of climate vulnerability impacts in the area
- at a regional level, traffic travelling from the south of the proposed scheme (e.g. from London) towards Ipswich (or vice versa) can interchangeably use the M11 and A14 for long distance journeys

15.11.32 The proposed scheme would improve transport resilience by providing additional capacity on the A12. A number of assets being replaced or improved on the proposed scheme would also be designed so they are more resilient to climate change compared to the existing infrastructure assets. Further details on the climate change mitigation that is embedded into the proposed scheme design can be found in Table 2.2 of Appendix 15.2 of the Environmental Statement [TR010060/APP/6.3]. For example, with regards to flood risk and anticipated climate change, the proposed scheme has been designed to appropriate standards (see Chapter 14: Road drainage and the water environment, of the Environmental Statement [TR010060/APP/6.1]).

15.11.33 Were significant climate vulnerability events to occur and affect one or more strategic routes, it is likely that the alternative journey options available, coupled with the level of mitigation embedded in the design of the proposed scheme would provide a sufficient level of systemic resilience to avoid a significant effect when considered against the consequence and likelihood criteria described in Table 15.10 and Table 15.11 and criteria for significance in Table 15.12.

15.12 Monitoring

Construction

Greenhouse gas emissions

15.12.1 Quarterly GHG emissions reporting, using the National Highways Carbon Tool (National Highways, 2021a), during the construction phase would be undertaken by the Principal Contractor in line with DMRB LA 114. This facilitates reviewing the performance of the proposed scheme against the carbon estimates developed at the detailed design stage utilising data available in the construction phase, thereby allowing identification of further GHG emissions reduction opportunities. This measure is included in the REAC, within the first iteration of the EMP [TR010060/APP/6.5].

Operation

Greenhouse gas emissions

15.12.2 Quarterly GHG emissions reporting of operational maintenance related GHG emissions, using the National Highways Carbon Tool (National Highways, 2021a), or subsequent updates, during the operational phase would be undertaken by National Highways contractors in line with DMRB LA 114. The reports would be informed by actual materials, and fuel and energy consumption data and would facilitate reviewing the performance of the proposed scheme against the carbon estimates in the Environmental Statement, allowing the identification of further GHG emissions reduction opportunities. This requirement would be included in the third iteration of the EMP.

Vulnerability to changes in climate

15.12.3 Operational maintenance plans would include the visual inspection of the proposed scheme's assets to ensure that appropriate maintenance is undertaken in addition to the pre-defined maintenance intervals. The inspections would primarily occur in:

- Wintertime: when the mean accumulated precipitation is highest and projected to increase, and would include one-off inspections after certain precipitation events, e.g. intense storm events
- Summertime: when the mean maximum temperature is highest and projected to increase, and would include one-off inspections after heat waves and hot spells and periods of drought

15.12.4 This requirement would be included in the third iteration of the EMP.

15.13 Summary

Greenhouse gas emissions

15.13.1 Whilst mitigation measures have been and would be implemented going forwards to reduce GHG emissions, the proposed scheme is estimated to result in an increase in GHG emissions during both its construction and operation. The impact of the proposed scheme on climate (i.e. GHG emissions) is, however, considered to be **not significant** as it is considered unlikely to have a material impact on the ability of UK Government to meet its carbon reduction targets.

15.13.2 The GHG emissions associated with the gas main diversion, which have not been considered within this assessment, are likely to be negligible in comparison to those associated with the proposed scheme itself.

15.13.3 As such, no significant residual effects are expected to occur, and the proposed scheme is considered to comply with the relevant requirements of the NNNPS and energy NPS.

Vulnerability to changes in climate

15.13.4 Assets and infrastructure designed as part of the proposed scheme are likely to be affected by climate change. A number of potential risks have been identified and assessed which would be mitigated by applying robust design standards as part of the embedded design measures or implementing relevant mitigation measures and incorporating such measures into relevant asset management processes.

15.13.5 The assessment indicates that, with embedded and standard mitigation measures in place, it is unlikely the potential climate-related hazards identified would result in significant impacts during the construction or operational phases of the proposed scheme.

15.13.6 Therefore, **no significant residual effects** are deemed likely during construction and operation due to vulnerability to changes in climate and the proposed scheme is considered to comply with the relevant requirements of the NNNPS.

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