M3 Junction 9 Improvement

Scheme Number: TR010055

6.1 Environmental Statement Chapter 14 Climate (Rev 1) Tracked

APFP Regulations 5(2)(a)

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6.1 ENVIRONMENTAL STATEMENT - CHAPTER 14: CLIMATE

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14 Climate

14.1 Introduction

14.1.1 This chapter presents the findings of the assessment of the construction and operation of the M3 Junction 9 Improvement Scheme (hereafter referred to as the Scheme) on climate change and the vulnerability of the Scheme to climate change. This chapter outlines legislative, policy framework and guidance, describes the assessment methodology, study area, baseline conditions, an overview of potential impacts, mitigation measures, likely residual effects, monitoring and a summary. This chapter has been prepared by a competent expert, further details are provided in **Appendix 1.1 (Competent Expert Evidence)** of the **ES (Document Reference 6.3)**.

14.1.2 This chapter should be read in conjunction with **Environmental Statement (ES)**, **Figure 14.1 (Climate Change: Road Network)** of the **ES (Document Reference 6.2)** and **Appendices 14.1** to **14.4** of the **ES (Document Reference 6.3)** which comprise:

- ES Appendix 14.1: Construction GHG Assessment Calculations
- ES Appendix 14.2: Operation GHG Assessment Calculations
- ES Appendix 14.3: GHG Benchmarking
- ES Appendix 14.4: Climate Projections Data

14.1.3 This chapter should be read in parallel to **Chapter 6 (Air Quality), Chapter 7 (Landscape and Visual), Chapter 8 (Biodiversity), Chapter 10 (Material Assets and Waste), Chapter 13 (Road Drainage and the Water Environment)** and **Chapter 15 (Cumulative Effects)** of the **ES (Document Reference 6.1)**.

14.2 Consultation

14.2.1 Consultation and engagement have informed the climate change assessment. Comments and responses to the Scoping Opinion received in November 2020 are provided in **Appendix 4.2 (Scoping Comments and Responses)** of the **ES (Document Reference 6.3)** and comments and responses received during statutory consultation between May and June 2021 are provided in **Appendix K** of the **Consultation Report (Document Reference 5.1)**. No further engagement or consultation has been undertaken to inform the climate change chapter.

14.3 Legislative, policy framework and guidance

14.3.1 This assessment has been undertaken considering current legislation, together with national, regional, and local plans and policies. A list is provided below, and further detail regarding National Policy can be found in the **National Policy**

Statement for National Networks (NPS NN) Accordance Table (Document Reference 7.2):

- Climate Change Act 2008 and Climate Change Act 2008 (2050 Target Amendment) Order 2019
- The Carbon Budget Order 2009, Carbon Budget Order 2011, Carbon Budget Order 2016 and Carbon Budget Order 2021
- National Policy Statement for National Networks (2014)
- The Road to Zero 2018
- Transport Decarbonisation Plan, 2021
- Net Zero Highways: our 2030 / 2040/ 2050 plan, National Highways
- Net Zero Strategy: Build Back Greener
- UK Government Ten Point Plan
- Clean Growth Strategy 2017
- Electric Vehicles and Infrastructure Paper (2020)
- The Second National Adaptation Programme 2018-2023
- Third UK Climate Change Risk Assessment 2021
- National Planning Policy Framework (2021)
- Planning Practice Guidance (online resource)
- Winchester District Local Plan Part 1 – Joint Core Strategy (2013)
- Winchester District Local Plan Part 2 – Development Management and Site Allocations (2017)
- South Downs Local Plan (2019)
- Hampshire Minerals and Waste Plan (2013)
- Winchester District Draft Local Plan 2018 -2038 (emerging)
- The Winchester City Council Climate Emergency Declaration and Climate Action Plan (2019)

14.3.2 In addition to the legislation and national and local planning policies listed above, this assessment has also been carried out in accordance with the following professional standards and guidance:

- DMRB, Sustainability and Environment Appraisal, LA 114 Climate (Highways England, 2021)
- National Highways Carbon Tool Guidance V2.4
- Emissions Factors Toolkit (EFT) Version 11.01 (Defra, 2021)
- Department for Transport, Transport Analysis Guidance (TAG) Unit A3 Environmental Impact Appraisal, Chapter 4 Greenhouse Gases (July 2021)
- Publicly Available Standard (PAS) 2080:2016 Carbon management in Infrastructure (British Standards Institute (BSI), 2016)
- World Business Council for Sustainable Development (WBCSD) and World Resources Institute (WRI) Greenhouse Gas Protocol guidance (WBCSD and WRI, 2004)
- UKCP18 Guidance: How to use the UKCP18 Land Projections (Fung et al., 2018a)
- National Highways Preparing for climate change on the strategic road network - third adaptation report under the Climate Change Act (National Highways, 2022)

14.4 Approach to assessment

14.4.1 The climate assessment covers the following two elements as required by the Infrastructure Planning (Environmental Impact Assessment) Regulations 2017 (the EIA Regulations) and the Design Manual for Roads and Bridges (DMRB) LA 114 Climate (Highways England, 2021):

- Impact of the Scheme on climate change (from greenhouse gas (GHG) emissions – 'carbon')
- Vulnerability of the Scheme to climate change (climate change risk assessment (CCRA))

14.4.2 The two parts of the assessment have different methodologies, baseline conditions, receptors, potential impacts, significance and mitigation measures. This chapter therefore sets out the GHG emissions assessment and climate vulnerability assessment separately. Accordingly, this chapter is structured as follows:

- **Part 1: Effects of the Scheme on Climate (GHG emissions assessment)** – considers the activities associated with the Scheme with the potential to emit GHG emissions and the mitigation measures implemented to reduce these emissions
- **Part 2: Vulnerability of the Scheme to Climate Change** – reviews the outcomes of a proportionate CCRA undertaken for the Scheme and the mitigation measures implemented to increase climate resilience

14.4.3 Cumulative climate effects, that is impacts on receptors in the surrounding environment as a result of the combined impact of the Scheme and climate change (in-combination impacts), have been considered within **Chapter 15 (Cumulative Effects)** of the **ES (Document Reference 6.1).**

14.5 Part 1: Effects of the Scheme on climate (GHG emissions assessment)

Scope of the assessment

14.5.1 The methodology used for assessing climate is the DMRB LA114 Climate (Highways England, 2021).

14.5.2 The scope of the GHG assessment aligns with the WBCSD and WRI Greenhouse Gas Protocol (WBCSD and WRI, 2004) and BSI PAS 2080 (BSI, 2016) methodology. The ES chapter categorises direct and indirect emissions. Direct emissions are emissions from sources that are controlled by the Scheme. Indirect GHG emissions are emissions that are a consequence of the activities of the Scheme but occur at sources owned or controlled by another entity. The GHG Protocol (WBCSD and WRI, 2004) categorises direct and indirect emissions into three broad scopes:

- Scope 1: all direct GHG emissions
- Scope 2: indirect GHG emissions from consumption of purchased electricity, heat, or steam
- Scope 3: other indirect emissions, such as the extraction and production of purchased materials and fuels, electricity-related activities not covered in Scope 2, outsourced activities, waste disposal, etc

14.5.3 Identifying the scopes of emissions is standard practice in GHG reporting and is useful to identify where a project or entity has control over emissions. This helps to avoid double counting. The scope of each source of emissions identified for the Scheme (i.e. Scope 1, 2 or 3) is set out in **Table 14.1**.

14.5.4 The assessment and reporting of GHG emissions associated with the Scheme considers the following stages:

- Construction (of the Scheme). PAS 2080 uses life cycle stages and defines this stage as the ‘before use stage’ with sub-categories A0-A5. Further information is provided on these sub-stages in **Table 14.1** below). Stage A0 ‘preliminary studies and consultation’ is scoped out of the assessment in accordance with Table 3.11.1 in the DMRB LA114 Climate (Highways England, 2021).
- Operation – PAS 2080 defines this stage as the ‘use stage’ with sub-categories B1- B9 (see **Table 14.1**). Stages B7 ‘Operational Water Use’ and B8 ‘other operational process’ are scoped out of the assessment in accordance with Table 3.11.1 in the DMRB LA114 Climate (Highways England, 2021).

14.5.5 Activities associated with the Schemes' construction and operation life cycle stages that have the potential to emit GHG emissions are outlined in **Table 14.1**.

Table 14.1: Sources and Lifecycle Stages of the Schemes' GHG Emissions, based on the DMRB LA 114 Climate (Highways England, 2021) and PAS 2080 Lifecycle Stages

Main Lifecycle Stage	Sub Lifecycle Stage	Emissions Scope	Activity Data – sources of GHG emissions data
Construction	A1-A3 Product stages – raw material supply, transport, and manufacture	Indirect Scope 3 emissions from primary raw material extractions, manufacturing, and transportation within the supply chain (i.e., to the suppliers) of all materials required for the permanent assets	Data on A1-A3 stages extracted from estimated material quantities and design model. This includes all major scheme elements including steel for structures, concrete elements, drainage items, road surfacing and pavements and other general construction materials such as imported soil.
	A4 Construction process stage - transport to works site	Direct Scope 1 emissions from vehicles transporting materials to site. Indirect Scope 3 emissions from employees commuting to site.	Transportation of materials to site, mode/distance (based on assumptions and typical location of materials)

Main Lifecycle Stage	Sub Lifecycle Stage	Emissions Scope	Activity Data – sources of GHG emissions data
	A5 Construction process stage – construction including Land use, land use change and forestry	Direct Scope 1 emissions from plant equipment, temporary welfare facilities, soil disturbance, ground works and landscaping. Indirect Scope 3 emissions from construction waste	Fuel/electricity consumption data based on estimated plant usage and associated fuel consumption data. Construction waste estimates from the Scheme's bill of quantities. Type and area of habitat subject to change, taken from **Chapter 8 (Biodiversity)** and Biodiversity Net Gain Assessment Report **(Appendix 8.2** of the **ES (, Document Reference 6.3))**.
Operation	B1 Use - installed products and materials	Direct Scope 1 emissions from carbon sequestration from proposed planting.	Type and area of habitat subject to change, taken from Chapter 8 Biodiversity and Biodiversity Net Gain Assessment **(Appendix 8.2** of the ES **(Document Reference 6.3))**.
	B2-B5 Maintenance, repair, replacement, and refurbishment	Direct and indirect Scope 1, 2 and 3 emissions from	Qualitative assessment of likely sources of GHG emissions.

Main Lifecycle Stage	Sub Lifecycle Stage	Emissions Scope	Activity Data – sources of GHG emissions data
		new materials and activities of organisations conducting routine maintenance, repair, replacement, and refurbishment of infrastructure.	
	B6 Operational energy use	Indirect Scope 2 emissions from energy consumption from subway lighting, CCTV, and traffic signalling infrastructure within the Scheme.	Electrical load data based on lighting and traffic signalling equipment specifications, and annual usage assumptions.
	B9 User utilisation of infrastructure	Direct Scope 1 exhaust emissions and indirect Scope 2 electric vehicle (EV) charging emissions from end-user vehicles movements.	Traffic modelling outputs including numbers of vehicles, vehicle type, speed, and distance travelled (link lengths) across the road network.
Opportunities for reduction	Applicable to all the above	Mitigation such as designing the Scheme using PAS 2080 (BSI, 2016).	Scheme's design model, **first iteration Environmental Management Pan (fiEMP) (Document Reference 7.3)**

14.5.6 GHG emissions associated with the decommissioning of the Scheme was scoped out of further assessment within the Scoping Opinion. This is because the long design life of the Scheme (more than 60 years) means there is not enough certainty about the likelihood, type or scale of activities that could emit GHG emissions at the time of decommissioning.

Study area and baseline approach

14.5.7 In accordance with section 3.8 of the DMRB LA 114 Climate (Highways England, 2021), the study area during construction comprises GHG emissions associated with project construction related activities/materials and their associated transport.

14.5.8 In accordance with section 3.9 of the DMRB LA 114 Climate (Highways England, 2021), for operational road user GHG emissions, the study area is consistent with the affected road network defined in a project's traffic model.

14.5.9 The study area is defined within **Section 14.6.**

14.5.10 In accordance with section 3.10 of the DMRB LA 114 Climate (Highways England, 2021), the baseline GHG emissions have been identified for current (do nothing) and future baselines (do-minimum (DM)), for the 2027 opening year and 2042 design year. Baseline data is outlined in **Section 14.7** and has been informed by the UK Carbon Budget Orders 2009, 2011, 2016 and 2021. Road user vehicle emissions for 2027 and 2042 DM scenarios have been calculated using traffic data from the Scheme's traffic model. This is explained further in **paragraphs 14.4.26 – 14.4.28**.

14.5.11 Data on emissions was also gathered at a local authority and south east England level for additional context purposes, however it should be noted that these emissions are not taken further within the assessment as they cannot be factored forward to the 2027 and 2042 assessment years. Further explanation on how carbon budgets have been accounted for in the assessment is explained further in **paragraph 14.5.40.** Local and south east England contextual data has been sourced from readily available desk-based information as follows:

- UK Greenhouse Gas Emissions, Final figures, Department for Business, energy and Industrial Strategy, National Statistics (Ricardo Energy and Environment for DBEIS, 2022).
- UK local authority and regional carbon dioxide emissions national statistics: 2005 to 2020 (Ricardo Energy and Environment for DBEIS, 2022)

Approach to design, mitigation and enhancement measures

14.5.12 The Scheme has been designed to avoid or reduce effects on emissions. Embedded mitigation is listed within **Chapter 4 (Environmental Assessment Methodology)** of the **ES (Document Reference 6.1).** Embedded and essential mitigation measures have been identified within this chapter. This mitigation is also included within the **fiEMP (Document Reference 7.3)**.

Assessment approach – calculation methodology

14.5.13 The following GHGs are defined in the United Nations Framework Convention on Climate Change (UNFCCC) Kyoto Protocol GHGs):

- Carbon dioxide (CO_2)
- Methane (CH_4)
- Nitrous oxide (N_2O)
- Sulphur hexafluoride (SF_6)
- Hydrofluorocarbons (HFCs)
- Perfluorocarbons (PFCs)
- Nitrogen trifluoride (NF_3)

14.5.14 Each GHG contributes differently to climate change, and some have a greater global warming potential (GWP) than others. To calculate each GHG's contribution equivalent, each tonne of GHG is divided by its GWP and reported using the same unit, tCO_2e. This stands for tonnes (t) of carbon dioxide (CO_2) equivalent (e).

14.5.15 It should be noted that the assessment refers to both GHG and carbon emissions interchangeably. Carbon is used as a shorthand for GHGs as defined by the Kyoto Protocol.

14.5.16 The GHG emissions assessment uses recognised calculation methodologies and tools.

14.5.17 All GHG calculations have been rounded to the nearest 10 within this chapter. The supporting appendices show the calculations in more detail (see **Appendix 14.1 (Construction GHG Assessment Calculations)** and **Appendix 14.2 (Operational GHG Assessment Calculations)**).

Stages A1, A2, A3 and A5

14.5.18 The National Highways Carbon Tool V2.4- (the Carbon Tool) has been used to assess the GHG emissions associated with the extraction, manufacturing, and transportation within the supply chain of permanent construction materials, plant equipment, temporary welfare facilities and construction waste (Stages A1, A2, A3 and A5). The Carbon Tool splits these into 10 categories as follows:

- Bulk materials
- Earthworks.
- Fencing, barriers and road restraint systems

- Drainage
- Road pavements
- Street furniture and electrical equipment
- Civil structures and retaining walls
- Fuel, energy and water
- Business and employee transport (construction only)
- Waste

14.5.19 Each of the above categories are further split into items, material and products for which there are GHG emission factors. These are used to calculate emissions from an activity or material using the calculation-based methodology as per the below equation:

Activity data x GHG emissions factor = GHG emissions value

14.5.20 Activity data has been extracted from the Scheme's design model and Bill of Quantities which was obtained from the Contractor to provide an estimate of the Scheme's material quantities. Information on estimated plant equipment use, for example equipment used to move soil, and welfare facilitates has been provided by the project team. Information on estimated waste quantities has been provided by the Scheme's waste consultant.

14.5.21 GHG emissions associated with land use change, soil disturbance and vegetation loss during construction (A5) have been calculated based on representative carbon stock factors for habitat types contained in guidance developed by Natural England (Natural England, 2012 and Natural England, 2021). Multiplication of these factors with where there will be a decrease in habitat areas within the Site Boundary provides an estimate of carbon stock loss due to construction. Habitat areas used within the assessment have been taken from the **Biodiversity Net Gain (BNG) Assessment** for the Scheme (**Appendix 8.2, Document Reference 6.3**).

14.5.22 The emissions from equipment used to move soil have been quantified as part of equipment use, see **paragraph 14.5.20.**

Stages A4

14.5.23 GHG emissions from the movement of materials and of construction workers to site (Stage A4) has been calculated using the Department for Environment, Food and Rural Affairs (Defra) Emissions Factors Toolkit (EFT) Version 11.01 (Defra, 2021).

14.5.24 The EFT requires various input data, including traffic flows (in AADT format), vehicle composition (i.e. the proportion of Heavy Duty Vehicles (HDVs), length of the road link, road type and average vehicle speed. This information has been

provided by the project team based on the Bill of Quantities and experience from similar schemes.

Stage B9

14.5.25 The assessment of operational end-user GHG emissions (Stage B9) uses the EFT as detailed above in Stage A4.

14.5.26 The 2027 Opening Year and 2042 Design Year have been assessed, as per the DMRB LA114 Climate (Highways England, 2021). The GHG emissions assessment calculates the difference between a DM scenario (traffic flows on the road network without the Scheme) and 'do something' (DS) scenario (traffic flows with the Scheme) to determine the impact of the Scheme, as shown below:

Do Something – Do Minimum = Scheme Emissions

14.5.27 The road network on which the operational end-users utilise, is defined by the Scheme's transport model which covers the entirety of the south-east region of England, as required by the DMRB LA 114 Climate (Highways England, 2021). **Figure 14.1 (Transport Model Study Area)** of the **ES** (**Document Reference 6.2)** shows the extent of the transport model. The transport model includes traffic flows generated by other cumulative developments in the surrounding area. The assessment of operational end-user GHG emissions is therefore inherently cumulative. Traffic data for the 2027 and 2042 DM and DS scenarios has been provided for these scenarios by the Scheme's transport consultants.

14.5.28 In addition to the EFT, the DfT have approved a sensitivity test based on the rate of improvements shown in Figure 2 of the DfTs Transport Decarbonisation Plan (TDP) (DfT, 2021), which can be applied to CO_2e emissions calculated within this ES. The sensitivity test has been undertaken and provided within the assessment table comparing the Schemes emissions to the UK Carbon Budgets (**Table 14.8**).

Stage B6

14.5.29 The emissions of operational energy usage i.e., from lighting, traffic signals, CCTV, and variable-message signs (VMS) have been calculated using the National Highways Carbon Tool with information, including electrical load data and assumed annual usage, from the design model for the Scheme.

Stages B1

14.5.30 Carbon sequestration resulting from proposed planting during operation (B1), has been undertaken by applying Natural England carbon stock factors by habitat type (Natural England, 2012 and 2021), as noted in **paragraph 14.5.21**. The assessment approach takes a conservative approach by excluding the operational phase carbon sequestration from the evaluation of significance (i.e. excluding GHG benefits arising from new habitat creation when assessing the significance of changes in GHG emissions).

Stages B2-B5

14.5.31 Repair, maintenance and replacement (B2-B5) have been assessed qualitatively, as agreed through the EIA scoping process and within the Scoping Opinion.

Assessment approach – sensitive receptors

14.5.32 GHG emissions have a global effect rather than directly affecting specific local receptors to which levels of sensitivity can be assigned. The global climate has therefore been treated as a single receptor.

Assessment approach - significance

14.5.33 Section 3.20 in the DMRB LA 114 Climate (Highways England, 2021) states that a significant effect occurs where the increase in carbon emissions resulting from the Scheme would have a "*material impact on the ability of Government to meet its carbon reduction targets*". This is based on paragraph 5.17 of the National Policy Statement for National Networks (2014) that states *"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"*.

14.5.34 In order to determine the impact of the Scheme on national carbon budgets the following has been undertaken:

- Comparison of the Scheme's emissions to the UK carbon budgets, as required in section 3.18 of the DRMB LA 114 climate (Highways England, 2021). Construction is expected to start in late 2024 and the Scheme is expected to be open to traffic in 2027. Therefore, the construction period for the Scheme falls wholly within the fourth carbon budget. Operation of the Scheme would commence in 2027 and is assessed against the fourth, fifth and sixth carbon budgets, up to 2037.

- How the Scheme has embedded design features to reduce GHG emissions and identified opportunities for further mitigation in the Scheme design and delivery. These are provided in **Section 14.9.**

14.5.35 The assessment of these together will indicate whether the Scheme will have a material impact on the ability of Government to meet its carbon reduction targets. At the time of writing, budgets have not yet been adopted for the period beyond 2038.

14.5.36 For illustrative purposes and to comply with section 3.21 of the DRMB LA 114 climate (Highways England, 2021), benchmarking the Scheme's emissions against similar highways projects has been undertaken.

14.5.37 The GHG assessment is inherently cumulative as it considers the combined impact of the different sources of GHGs resulting from the Scheme on the global climate. In addition, the assessment utilises the traffic model which includes the Scheme and other locally committed development, as well as contextualising the Scheme's GHG emissions against the UK carbon budgets. Further

information on cumulative effects is set out in **Chapter 15 (Cumulative Effects)** of the **ES (Document Reference 6.1).**

14.5.38 It is noted that the CCA 2008 does not impose a legal duty to set carbon budgets at a smaller scale than national i.e. regional, local or sectoral. The Government has not made public any forecasts of carbon emissions from all relevant cumulative sources at a scale less than the national level, over a time frame relevant to the assessment of a particular proposed road scheme, which reflects existing government policy to attain the 6th carbon budget and net zero 2050 and which does not include carbon emissions from the proposed road scheme. Therefore, there is no reasonable basis upon which an assessment can be made on the carbon emission impact of the Scheme at a local, regional or sectoral level. The impact assessment has therefore only been undertaken against national level carbon budgets. This approach is in accordance with DRMB LA 114 climate (Highways England, 2021).

Reasonable worse case parameters for assessment

14.5.39 An assessment has been conducted within the Limits of Deviation (LoD) outlined within **Chapter 2 (The Scheme and its Surroundings)** of the **ES (Document Reference 6.1)**. The vertical and lateral LoD for the Scheme have been reviewed with respect to the sensitive receptor identified within this ES chapter. The vertical and lateral LoD would not affect the conclusions of the assessment reported in this chapter.

Assessment assumptions and limitations

14.5.40 The following assumptions and limitations should be noted:

- The Defra EFT uses data from the National Atmospheric Emissions Inventory (NAEI) to account for likely changes to national vehicle fleet composition such as increasing uptake of electric vehicles (EVs). The Defra EFT provides a projection of fleet composition up to the year 2050. The EFT notes however, that the emission outputs for 2031-2050 may not fully align with those applied for the purpose of NAEI projections. It should also be noted that the CO_2 output of the EFT includes both direct emissions from vehicle tailpipes and indirect emissions associated with the charging of electric/plug-in-hybrid vehicles. This assumption relates to the calculation of lifecycle stage B9

- The projections in the Defra EFT Toolkit are based on assumptions which were current before the Covid-19 outbreak in the UK. In consequence these tools do not reflect short- or longer-term impacts on emissions in 2020 and beyond resulting from behavioural change during the national or local lockdowns. This assumption relates to the calculation of lifecycle stage B9

- The trajectory of emissions factors into the future is dependent on influences outside of the Applicant's control, for example Government policy and global technology and economic shifts. Furthermore, the National Grid is anticipated to continue to decarbonise over the next decade, which would

further reduce emissions from elements dependant on grid energy, including the lighting and traffic signalling systems. Therefore, there are inherent uncertainties that overestimate GHG emissions in the assessment made of future GHG emissions, which is a conservative approach. This assumption relates to the calculation of lifecycle stage B6

- The GHG assessment is based on preliminary design information that was available at the time of assessment and provided by the Scheme's design team. Where appropriate, the selection of reasonable worst-case assumptions have been made to provide sufficient flexibility for design decisions to change at detailed design without altering the findings of this assessment, for example by assessing a material mix that does not contain recycled materials. It is acknowledged that there are some elements of Scheme design which cannot be quantified until the detailed design stage, such as the exact materiel quantities required to construct the Scheme. Whilst not available for inclusions within assessment work reported in this ES, such inclusions would not result in new or different likely significant effects to those reported in **Section 14.10**. It is assumed that should any material change to the design be made; the EIA would need to be re-assessed. This assumption relates to the calculation of lifecycle stage A1-A5 and B6.

- The assessment of GHG emissions from land use change has been based on Natural England's carbon stock factors and their supporting assumptions and limitations (Natural England, 2012 and 2021). The carbon stock values for woodland assumes a 30-year old age profile. The loss of trees older than 30-years old as a result of the Scheme could mean the carbon stock loss has been underestimated. In addition, carbon stock factors reflect soil disturbance at varying depths varying from 15cm to 1m. As a result, the GHG emissions from land use change may be underestimated should disturbance occur at a greater depth. The values given to the baseline and the proposed habitat areas assume the habitats are mature, and that the proposed habitats reach maturity within the lifetime of the Scheme, including restoration of carbon stocks in soils, reach equilibrium (i.e. there is no further sequestration of carbon) and the habitat is in a healthy state. This could result in an overestimation of carbon stocks should habitats be in a degraded state.

14.6 GHG study area

14.6.1 The study area for the GHG emissions assessment relates to the location of potential sources of emissions that are considered within the assessment, however, as noted in **Section 14.4**, the receptor is the global atmosphere.

14.6.2 In accordance with section 3.8 of the DMRB LA 114 Climate (Highways England, 2021), the study area for the construction assessment includes construction-related activities that occur within the Scheme's Application Boundary and extends to include activities that occur beyond the Scheme's Application Boundary, such as the generation of electricity off site and transport of construction materials. It is not possible to define the exact location for some

sources of GHG emissions that would occur outside the Scheme's Application Boundary, such as material production.

14.6.3 For operational end-user GHG emissions and in accordance with the DMRB LA 114 Climate (Highways England, 2021), the study area is consistent with the Schemes traffic model, which covers the south-east region of England. Other operational emissions include activities within the Scheme's Application Boundary, such as from operational lighting.

14.7 GHG baseline conditions

14.7.1 This section establishes the existing GHG emissions at a national (UK), sector (transport) and regional (south-east England) level, as well as outlining the baseline GHG emissions of land within the Scheme's Application Boundary.

National GHG emissions

14.7.2 From a national perspective, in 2019, UK net GHG emissions were estimated to be 454,800,000 tonnes carbon dioxide equivalents (tCO_2e), a decrease of 2.9% compared to 2018 (Ricardo Energy & Environment for DBEIS, 2021a). The Climate Change Act (CCA) legally binds the UK to reduce its GHG emissions through carbon budgets. The total emissions for the UK over the last two carbon budgets are shown in **Table 14.2**. Both the 2008-2012 and 2013-2017 budgets were successfully met. National GHG emissions in 2019 have decreased by 43.8% since 1990 (Ricardo Energy and Environment for DBEIS, 2021a).

Table 14.2: 2008-2037 UK Carbon Budgets

UK Budget	Carbon Budget (tCO_2e)	Reduction below 1990 levels	UK Emissions
1st carbon budget (2008 to 2012)	3,018,000,000 tCO2e	25% (achieved)	2,982,000,000 tCO_2e
2nd carbon budget (2013 to 2017)	2,782,000,000 tCO2e	31% (achieved)	2,398,000,000 tCO_2e
3rd carbon budget (2018- 2022)	2,544,000,000 tCO_2e	37% by 2020	N/A
4th carbon budget (2023- 2027)	1,950,000,000 tCO_2e	51% by 2025	N/A

UK Budget	Carbon Budget (tCO_2e)	Reduction below 1990 levels	UK Emissions
5th carbon budget (2028- 2032)	1,725,000,000 tCO_2e	57% by 2030	N/A
6th carbon budget (2033-2037)	965,000,000 tCO_2e	78% by 2035	N/A

Sector GHG emissions

14.7.3 Statistics for the transport sector are composed of road transport, rail, shipping, and aviation. I sector continues to be the largest emitting sector in the UK. Transport emissions in 2019 were 5% lower than in 1990. The impact of the COVID-19 pandemic means emissions are estimated to have been around 23% lower in 2020 than in 1990. An estimated 98,800,000 tCO_2e, or 24% of net UK GHG emissions, are attributed to the transport sector (Ricardo Energy & Environment for DBEIS, 2022).

14.7.4 The vast majority of these emissions arise from road transport. The main sources of emissions are the use of petrol and diesel in road transport, in particular from passenger cars. As a result of improvements to fuel efficiency in petrol and diesel cars, as well as lower petrol consumption, a general decrease in emissions has been observed since the mid-2000s.

Regional and local GHG emissions

14.7.5 The Department for Business, Energy & Industrial Services (DBEIS) provides emission data for each local planning authority (Ricardo Energy and Environment for DBEIS, 2022), including south-east England and Winchester City Council. **Table 14.3** shows the total emissions and transport emissions from these two areas in 2020.

Table 14.3: South east England and Winchester City Council 2020 baseline GHG emissions (Ricardo Energy and Environment for DBEIS, 2022)

	Transport Sector Emissions (tCO_2)	Total Emissions (tCO_2)
South-east England	15,538,900	40,399,600
Winchester City Council	356,500	754,500

14.7.6 A climate emergency was declared by Winchester City Council in June 2019 and Winchester City Council is now committed to being carbon neutral by 2024, with a wider goal of carbon neutrality in the city by 2030. Carbon neutrality is defined by the UN Environmental Programme as "*achieving net zero carbon*

emissions by balancing a measured amount of carbon released with an equivalent amount sequestered or offset." The target takes into account both production and consumption emissions, with a focus on the biggest sources of carbon emissions – transport, property, and energy. Winchester City Council would work with partners across the city to deliver this goal.

Existing land within the Application Boundary baseline GHG emissions

14.7.7 There is no construction currently taking place within the Application Boundary. It is noted that the M3 Junction 9 to 14 Safety Barrier Improvement Scheme, which comprises of upgrade works to the central reservation barrier, will be completed prior to the construction of the Scheme. Therefore, the baseline position for construction phase (stage A1-5) GHG emissions is considered to be zero.

14.7.8 Existing GHG emissions within the Application Boundary relate to operation and maintenance (B2-B5) of the current road, including road users (B9), lighting (B6) and carbon sequestration from existing planting (B1).

Baseline evolution

14.7.9 The carbon budget for England for the period 2023-2026 is set within the CCA to reduce GHG emissions by an average of 51% lower than the 1990 baseline emissions, as set out in **Table 14.2**. The sixth carbon budget, for the period 2033-37 was passed into law by the Government in June 2021. This is the first budget to consider the UK's net zero target by 2050 with a trajectory that is consistent with the Paris Agreement, requiring a 78% reduction by 2035.

14.7.10 The transport sector is a key driver in the trend of projected UK emissions. A combination of policy initiatives and technical advancements are predicted to influence the decline of GHG emissions from the transport sector. The UK Government has made several strategic and policy commitments to curb the UK's transport GHG emissions and support the uptake of zero emission vehicles.

14.7.11 In 2018, the UK Government launched the Road to Zero strategy, which sets out it's ambition to reduce emissions from vehicles on UK roads and promote the uptake of zero emissions vehicles (DfT, 2018). Proposed support mechanisms to facilitate this transition include increasing the supply and sustainability of low carbon fuels in the UK through a legally-binding 15-year strategy, offering grants for plug-in vehicles and introduce a voluntary industry-supported commitment to reduce HGV greenhouse gas emissions by 15% by 2025, from 2015 levels.

14.7.12 In March 2020, the Electric Vehicles and Infrastructure paper was published, which outlined how the infrastructure for Electric Vehicles have been planned for and what incentives are available to encourage growth.

14.7.13 In November 2020, the UK Government announced that the sale of new petrol and diesel cars would be stopped in the UK by 2030 (DfT, 2020b). The two

phased processed would see the phase out date for the sale of new petrol and diesel cars and vans be brought forward to 2030, and all new cars and vans to be fully zero emissions at the tailpipe from 2035. Significant investment has been allocated to support the greater uptake of zero emission vehicles, including £1.8 billion to build more charge points, as well as £582 million in grants.

14.7.14 In July 2021, the DfT published the Transport Decarbonisation Plan (DfT, 2021), which sets additional commitments, actions and timings for decarbonising transport. Further investments would be made for cycling and walking by investing £2 billion over 5 years with the aim that half of all journeys in towns and cities would be cycled or walked by 2030. It would also deliver decarbonised public transport, with the commitment to deliver 4,000 new zero emission buses and the infrastructure needed to support them. It also builds on the commitment to phase out petrol and diesel vehicles, including a series of consultations to agree timescales.

2027 and 2042 baseline GHG emissions for land within the Application Boundary

14.7.15 The baseline GHG emissions from the existing road are associated with existing traffic and road users. GHG emissions from traffic flows in the DM scenario for the 2027 opening year and 2042 design year have been modelled in accordance with DMRB LA 114 Climate (Highways England, 2021). The modelling includes the total GHG emissions for all existing traffic using the strategic road network (covered by the traffic model) in the vicinity of the Scheme and its surrounding region (south east England).

14.7.16 The end-user carbon emissions for the DM scenario is as follows:

- 2027: ~~3,214,777~~ 4,157,875 tCO_2e
- 2042: ~~2,497,839~~ 3,549,335 tCO_2e
- Total over modelled 60-year operation (2027-2086): 222,088,200 ~~160,624,500~~ tCO_2e

14.7.17 The transport data used within this assessment takes account of other development (including predicted development) in the area of the Scheme and therefore inherently considers cumulative effects.

14.7.18 In addition to end-user emissions, there are GHG emissions associated with maintenance and repair of the existing junction.

14.8 GHG potential impacts

Construction (including site preparation)

14.8.1 The proposed construction duration for the Scheme would be approximately three years. GHG emissions during construction are expected to arise from:

- Raw material extractions and manufacturing
- Vehicles transporting materials to site
- Plant equipment, temporary welfare facilities, soil movement, ground works, landscaping, land use change and construction waste

Operation

14.8.2 The life of the Scheme is anticipated to be 60-years from 2027, with bridge structures designed to last over 100 years. Over this time, the operation of the Scheme has the potential to result in an increase in local GHG emissions generated from transport due to changes in vehicle distributions and speed limits. Emissions would also arise from operational energy use (for example, subway lighting). Sources of GHG emissions have been identified in **Table 14.1**. This would result in increased concentrations of GHGs in the atmosphere, contributing to climate change.

14.9 GHG design, mitigation, and enhancement measures

14.9.1 Mitigation measures incorporated into the design of the Scheme are reported as embedded mitigation in **Chapter 4 (Environmental Assessment Methodology)** of the **ES (Document Reference 6.1)**, those relevant are included below. This section also outlines essential mitigation, which is mitigation critical for the delivery of a project, the deliverability of which is flexible (as set out in **Chapter 4 Environmental Assessment Methodology)** of the **ES (Document Reference 6.1)**. Essential mitigation is outlined within the **fiEMP (Document Reference 7.3).** Prior to the implementation of mitigation, the Scheme has the potential to have GHG impacts during construction and operation.

Embedded mitigation

Construction (including site preparation)

14.9.2 Strategically, emissions are mitigated by applying the carbon reduction hierarchy as set out in section 3.22.1 of the DMRB LA 114 Climate (Highways England, 2021) as follows:

1. Avoid / prevent:
    a. maximise potential for re-using and/or refurbishing existing assets to reduce the extent of new construction required, and/or explore alternative lower carbon options to deliver the project objectives (i.e., shorter route options with smaller construction footprints)
    b. identify through projects and delivery programmes opportunities to influence user GHG emissions
2. Reduce:

a. apply low carbon and/or reduced resource consumption solutions (including technologies, materials, and products) to minimise resource consumption during the construction, operation, and at end of life

3. Remediate:

a. Identify, assess, and integrate measures to further reduce carbon through on or off-site offsetting or sequestration

14.9.3 Embedded mitigation during construction relates mainly to the design of the Scheme and the associated embodied carbon emissions. The Scheme has been designed using PAS 2080:2016 Carbon management in Infrastructure (British Standards Institute (BSI), 2016) to manage and reduce embodied carbon and has been iteratively updated to refine and improve the proposals in relation to a range of design requirements and criteria, including the consideration of sustainability, material use and construction efficiency.

14.9.4 Embedded mitigation for the Scheme includes the following measures that avoid/prevent, reduce, and remediate GHG emissions:

- The depth of cuttings and embankments throughout the Scheme have been carefully considered to remove a number of retaining walls where practical, reducing the volume of material required to construct retaining walls and their associated embedded carbon emissions
- Use of warm mix asphalt (WMA) instead of hot mix asphalt on all road surfaces, reducing embodied carbon associated with the production of materials
- Existing pavements are to be retained wherever possible within the scheme to reduce the requirement for additional materials and construction
- The bridleway to the east to link Easton Lane with Long Walk would be made from unbound material with a lower carbon intensity than asphalt
- Material excavated during construction is to be processed for use in the works wherever possible to reduce the amount of material disposed of
- Construction compounds are located close to the area of works which would reduce the distance of vehicle trips

Operation

14.9.5 The Scheme has been designed to minimise the requirement for energy consuming operational equipment such as intelligent transport systems wherever possible. Energy efficient Light Emitting Diodes (LEDs) would be used throughout the Scheme.

14.9.6 The Scheme seeks to facilitate and encourage active travel and sustainable forms of transport. The Scheme is enhancing the National Cycle Network (NCN)

23 through the gyratory, providing a shared path (unsegregated, combined footpath, cycle track and footway) along the west of the Scheme and adding a new bridleway link to the east of the Scheme connecting Long Walk and Easton Lane. The provision of a high quality accessible pedestrian and cyclist routes will encourage and enable travel by low-carbon, sustainable modes

14.9.7 Selecting appropriate materials can also help to reduce the need for maintenance and replacement and GHGs associated with this. Weathering steel is proposed for the gyratory bridges which eliminates the need for a paint system and associated maintenance.

Essential mitigation

Construction (including site preparation)

14.9.8 The adoption of the principles of the waste management hierarchy would be implemented throughout, with the Principal Contractor committed to achieve a diversion from landfill rate of 95%. This would reduce GHG emissions associated with waste management.

14.9.9 The following essential mitigation has not been taken into account within the GHG assessment given that specifics of, for example the proportion of recycled material, is not known at this stage.

14.9.10 Where practicable, measures to reduce GHG emissions would be secured through the **fiEMP (Document Reference 7.3)**. The fiEMP includes several mitigation measures covering transport, materials, waste and air quality during construction, these include:

- Using materials with lower embedded GHG emissions and water consumption
- Using sustainably sourced materials
- Using recycled or secondary materials
- Efficient use of materials to reduce waste
- Management of plant and equipment use so that there is no unnecessary idling of engines and equipment is maintained to check they are operating optimally
- Welfare facilities would be enabled to integrate renewable energy technology to reduce reliance on diesel or petrol generators for electricity

14.9.11 National Highways has set its target for net zero maintenance and construction activities by 2040 with an interim target of 10% reduction compared to 2020 by 2025 in their ‘Net zero highways: our 2030 / 2040 / 2050 plan’ (National Highways, 2021). The Scheme would be required to align with the plan by implementing measures such as those listed in the bullet points above. The Principal Contractor would be required to address the interim targets within the

plan, such as selecting Tier 1 and 2 suppliers that have certified carbon management systems.

14.9.12 Environmental and climate change considerations would continue to be factored into decision-making at detailed design. There would be opportunity to optimise the design to reduce material quantities, and the potential to select the most appropriate material available at the time, and/or local materials with reduced environmental and carbon impacts. For example, recycled aggregate would reduce the amount of embodied carbon associated with the Scheme. This would be explored at the detailed design stage to assess options with lower embodied carbon and would be considered in context of wider impact work undertaken within this ES.

14.9.13 The Scheme design would also seek to make efficiencies in the civils infrastructure and traffic control system during the detailed design stage by using emerging technology.

14.9.14 As outlined in **Chapter 10 (Material Assets and Waste)** of the **ES (Document Reference 6.21),** a Site Waste Management Plan (SWMP) would be implemented to manage waste during construction. The SWMP would be developed during the contract preparation stage and based on the draft SWMP appended to the **fiEMP (Document Reference 7.3)**. The SWMP would aim to ensure that the waste produced during the construction phase are dealt with in accordance with the duty of care provisions in the Environmental Protection Act (1990).

14.9.15 National Highways are committed to continue to seek carbon reductions through, for example:

- The use of Euro 6 compliant vehicles which are more fuel efficient and/or EVs within National Highways fleet used during the construction of the Scheme
- The use of electric and hybrid plant and equipment
- Manage plant and equipment use so that there is no unnecessary idling of engines
- Use of materials with lower embedded GHG emissions and water consumption where possible

14.9.16 A commitment to delivering this is set out in the Record of Environmental Actions and Commitments within the **first iteration Environmental Management Plan (fiEMP) (Document Reference 7.3)** and will be developed during detailed design.

Operation

14.9.17 There is substantial tree planting proposed within the Scheme, as shown on **Figure 2.3 (Environmental Masterplan)** of the **ES (Document Reference 6.2)**. Overall, the scheme would result in an increase of wooded areas once the

mitigation has effectively established and is approaching its early maturity stage and functioning as a woodland. The proposals show retention of existing vegetation where possible and a range of enhancement planting is proposed. Further detail of planting proposals is provided within **Chapter 7 (Landscape and Visual)** of the **ES (Document Reference 6.2)**.

14.9.18 At the detailed design stage, the planting specifications and tree mix would be explored to assess options according to the potential to maximise the carbon sequestration benefits of landscape features.

14.10 GHG assessment of likely significant effects

14.10.1 This section presents the assessment of likely significant effects for construction and operation on climate The assessment of effects takes into account the impacts following the implementation of embedded measures to determine the significance of the residual effects.

14.10.2 As noted in **Section 14.4**, the global climate is treated as a single receptor. Given the global scale and severe consequences of climate change and limited recoverability, the receptor sensitivity is considered to be high.

Construction (including site preparation)

14.10.3 During construction, the main source of GHG emissions is anticipated to be associated with construction materials and embodied carbon, comprising approximately 68.9% of overall construction emissions.

14.10.4 Construction emissions as a result of plant equipment use on land within the Application Boundary would also release GHG emissions, through combustion of fuel, and comprise approximately 20.8% of anticipated construction emissions. The use of portacabins and construction site welfare facilities which require electricity would also contribute 1.8% of construction GHG emissions.

14.10.5 Land use is estimated to comprise approximately 5.2% of construction emissions. It is anticipated that approximately 384,800m^{3}of earth would be required to be excavated during the construction phase, the majority of which is anticipated to be re-used at land within the Application Boundary to facilitate the construction of the development itself or through land reprofiling. Peat has been identified in the vicinity of the proposed footbridge around the River Itchen. However, it has not been identified in significant amounts and the works are unlikely to disturb the existing peat deposits directly, indirect effects are also unlikely. No other organic soil has been identified within the study area.

14.10.6 In addition, a relatively small proportion of GHG emissions would be released from the transportation of materials and staff to and from the areas of work within the Application Boundary, as well as the disposal of waste.

14.10.7 **Table 14.4** contains a breakdown of the estimated GHG emissions from activities during construction, associated with the whole construction period from 2024-2027. A summary of the calculations for the GHG emissions

assessment is included within **Appendix 14.1 (Construction GHG Assessment Calculations)** of the **ES (Document Reference 6.3)**.

Table 14.4: Summary of GHG emissions during construction

Lifecycle stage	Construction activity	Estimated GHG emissions (tCO_2e)	% Construction GHG emissions
A1-A3	Permanent construction materials	25,540	68.9
A4 Transport to Works Site	Transport materials and staff to area of works.	840	2.3
A5 Construction Plant and Waste	Construction plant and equipment emissions	7,710	20.8
	Welfare facilities and site offices	680	1.8
	Construction Waste	370	1.0
	Land Use Change	1,930	5.2
Total		**37,070**	**100**

Operation

14.10.8 During operation, the main source of GHG emissions is from 'end-users' i.e., traffic. GHGs emitted from subway lighting, CCTV, VMS and maintenance would contribute a relatively small amount to the overall operational carbon emissions.

14.10.9 Operational phase emissions for the modelled opening and design years and total over the modelled 60-year operational period are shown in **Table 14.5**. A conservative estimate is included for B6 operational energy use for 2042 based on 2020 greenhouse gas reporting conversion factors (BEIS, 2020). A qualitative assessment of Lifecycle stages B2 Maintenance and B4 Repair is provided below.

Table 14.5: Operation emissions for modelled opening year (2027), design year (2042) and total over the assumed 60-year operational period (2027 – 2087)

Sub-stage of operational life cycle	2027 annualised (modelled opening year DS) GHG Emissions (tCO_{2e})	2042 annualised (modelled design year DS) GHG emissions (tCO_{2e})	Total (cumulative) over modelled 60-year operation (2027–2087)
B6 Operational Energy Use	92	92	5,520
B9 User Utilisation (end-users)	4,161,194 ~~3,217,470~~	3,554,026 ~~2,500,050~~	222,349,080 ~~160,764,190~~
Total excluding land use change benefits	**4,161,286 ~~3,217,562~~**	**3,554,118 ~~2,500,142~~**	**222,354,600 ~~160,769,820~~**
B1 Use (land use)	-1,370	-1,370	-82,200
Total including land use change benefits*	**4,159,916~~3,216,192~~**	**3,552,748~~2,498,772~~**	**222,272,400~~160,687,620~~**

*for illustrative purposes only. These figures have not been factored into the impact assessment.

14.10.10 In addition to the above sources, the Scheme would require routine maintenance and repair to provide a safe, useable highway (including the maintenance of the drainage strategy). The primary sources of emissions are likely to result from road resurfacing, including the embodied GHG's associated with asphalt, and the fuel used to transport the materials to site and resurface the road. This is not considered to be any greater than baseline emissions from maintenance and repair of the existing junction.

14.10.11 It is noted that the National Grid is currently decarbonising, which is anticipated to continue over the next decade. This is an outcome of the continued uptake of renewable energies and the decline of coal-fired power stations across the UK. The increasing share of low carbon, renewable energy sources with a corresponding decrease in the use of fossil fuels, is termed "decarbonisation". When applying the DBEIS Green Book (DBEIS, 2021) electricity emission

factors for 2042, operational energy emissions may reduce to approximately 5 tCO_2e/yr. The impact of the Scheme's emissions has however been based on the carbon factor provided in the HE Carbon Tool, as set out in the methodology section of this chapter, which does not account for the decarbonisation of the grid and therefore provides a conservative approach.

14.10.12 There is potential for carbon sequestration associated with the Scheme and the environmental proposals. As detailed in **Chapter 8 (Biodiversity)** of the **ES** (**Document Reference 6.1**) and shown on **Figure 2.3 (Environmental Masterplan)** of the **ES** (**Document Reference 6.2**), habitat proposed to be retained and enhanced include native woodland, scrub and grassland. These habitats would sequester carbon over the lifetime of the Scheme. The potential sequestration benefit has been estimated and presented in **Table 14.5**, however this has not been factored into the overall impact assessment of the total operational calculations in **Table 14.6**.

Comparing the 'Do-Minimum' and 'Do-Something' scenarios

14.10.13 The estimated annual GHG emissions for the 2027 and 2042 'Do Minimum' and 'Do Something' scenarios are presented below in **Table 14.6**, to determine the significance of impacts of the Scheme. A summary of the calculations for the GHG emissions assessment is included within **Appendix 14.2 (Operation GHG Assessment Calculations)** of the **ES** (**Document Reference 6.3**).

Table 14.6: GHG end user emissions during operation

Operation Year	End-user Emissions (tCO_2e) – life cycle stage B9					
	DM Scenario	DS Scenario	Difference	Total (cumulative) over modelled 60-year operation (2027–2087) DM	Total (cumulative) over modelled 60-year operation (2027–2087) DS	Difference
2027	4,157,875 ~~3,214,780~~	4,161,194 ~~3,217,470~~	+ 3,319 ~~2,690~~	222,088,200 ~~160,624,500~~	222,349,080 ~~160,764,300~~	+ 260,880 ~~139,800~~
2042	3,549,335 ~~2,497,840~~	3,554,026 ~~2,500,050~~	+ 4,691 ~~2,210~~			

14.10.14 In the opening and design years, the Scheme would lead to an increase in operational end user emissions, of ~~2,690~~3,319tCO_2e/yr and ~~2,210~~4,691tCO_2e/yr respectively. This is an increase from the DM of approximately 0.08% for the opening year and 0.~~09~~1% for the design year.

Comparison to the UK Carbon Budgets

14.10.15 GHG emissions from the Scheme have been contextualised in relation to the UK Carbon Budgets, as shown in **Table 14.7**. **Table 14.7** shows the proportion of the relevant carbon budgets that the Scheme would contribute to, multiplied over the 5-year budget period.

Table 14.7: Scheme's predicted GHG emissions against relevant UK carbon budgets

Project Stage	Estimated total (cumulative) GHG emissions over carbon budgets (tCO2e) (DS Scenario)	Net (cumulative) GHG emissions over carbon budgets (tCO2e) (DS- DM Scenarios)	Net (cumulative) scheme GHG emissions per relevant carbon budget (tCO2e)			
			Third (2018 - 2022)	Fourth (2023 - 2027)	Fifth (2028 - 2032)	Sixth (2033-2037)
Construction (over period of 2024-2027)	37,070	37,070	N/A	37,070	N/A	N/A
Operation (modelled from 2027 through to 2037)	45,774,146 ~~35,393,180~~	37,521 ~~30,600~~	N/A	3,411 ~~2,790~~	17,055 ~~13,950~~	173,~~950~~055
Total	**45,811,216 ~~35,430,250~~**	**74,591 ~~67,670~~**	**N/A**	**40,481 ~~39,860~~**	**17,055 ~~13,950~~**	**17,055~~13,950~~**
% of Carbon Budget	**N/A**	**N/A**	**N/A**	**0.002%**	**0.001%**	**0.00~~12~~%**
Sensitivity Test for Operational Transport Emissions						
TDP (upper boundary)	N/A	N/A	N/A	~~2,650~~3,258	~~11,910~~16,428	~~8,460~~13,942
TDP (lower boundary)	N/A	N/A	N/A	~~2,270~~2,799	~~8,250~~11,305	~~4,460~~7,256

14.10.16 The Scheme is expected to contribute approximately 0.002% of the UK's 4th carbon budget and 0.001% of the 5th carbon budget and 0.002% of the 6th carbon budget. This is considered a small increase in the magnitude of emissions from the Scheme, and it is deemed unlikely that this Scheme, in isolation, would materially affect the UK's ability to meet its carbon budgets. Therefore, is not anticipated to give rise to a significant effect on climate, in line with the position set out within Section 5.18 of the NPS NN and the DMRB LA 114 Climate (Highways England, 2021).

14.10.17 The sensitivity test against the DfT Transport Decarbonisation Plan shows a lower volume of GHG emissions associated with transport than that assessed using the EFT. This demonstrates that the emissions assessed are likely to be an overestimation.

14.10.18 As set out in **Section 14.5**, the emissions assessed above are inherently cumulative as the traffic model used within this assessment includes the Scheme and other locally committed development.

14.10.19 Land-use benefits during the operational phase have been excluded from the evaluation of significance to provide a conservative assessment.

Comparison with other schemes

14.10.20 For illustrative purposes and to comply with section 3.21 of the DMRB LA 114 Climate (Highways England, 2021), the Scheme emissions have been benchmarked against similar schemes. The comparison is provided in **Appendix 14.3 (GHG Benchmarking)** of the **ES (Document Reference 6.3).** Construction related emissions are comparable with other projects on a per kilometre basis. The Schemes operational end-user emissions need to consider study area which differ for each project. Given the Scheme's transport model covers the region of south east England, DS end user emissions are considerably higher than that of the other schemes which use much smaller study areas.

14.11 GHG monitoring

14.11.1 As no significant effects have been identified for the GHG emissions assessment, no monitoring of significant effects is required. However, as required by the DMRB LA 114 Climate (Highways England, 2021), quarterly GHG emission returns during construction and operation shall be reported in accordance with National Highway's requirements. This is outlined within the **fiEMP** (**Document Reference 7.3)**.

14.11.2 Proposed landscaping measures would be monitored post-construction to deliver the desired level of mitigation. This would include the appropriate establishment and management of new landscape planting and features in accordance with relevant best practice and standards. **Appendix 7.6 (Outline Landscape and Ecological Management Plan (OLEMP))** of the **ES**

(Document Reference 6.3) identifies remediation strategies if areas aren't functioning as supposed to.

14.12 Part 2: Vulnerability of the Scheme to Climate Change

14.12.1 This section presents an assessment of the vulnerability of the Scheme to climate change during operation, also referred to as the Climate Change Risk Assessment (CCRA). The assessment is based on the DMRB LA 114 Climate (Highways England, 2021).

Scope of the assessment

14.12.2 The scope of the CCRA covers the operational phase of the Scheme, assuming a 60 year design life.

14.12.3 The impacts of climate change on the construction phase are scoped out of the CCRA due to the short timescales of the construction phase (construction is proposed to take place from 2024 until 2027). As agreed in the Scoping Opinion, it is anticipated that changes in climate would not significantly affect the construction workforce, location of construction compounds or type of machinery given the temporary short-term nature of the construction phase.

Study area and baseline approach

14.12.4 In accordance with section 3.25 of the DMRB LA 114 Climate (Highways England, 2021), the study area is based on the Scheme's Application Boundary. The study area is defined within **Section 14.13.**

14.12.5 Baseline data is outlined in **Section 14.14** has been informed through gathering readily available desk-based information. The following data sources were reviewed to establish the baseline and evolving baseline conditions:

- Met Office historic climate data (Met Office, N.Db) – to identify the historic trends of relevant climatic factors for the geographic area of the Scheme
- UK Climate Projections (UKCP18) (Met Office, N.Da) – to identify the climate projections for the geographic area and appropriate temporal scope of the Scheme
- a literature review of relevant publications which are referenced where relevant within **Part 2** of this chapter, for variables for which UKCP18 does not provide information (for example, wind direction)

14.12.6 In addition, a review was undertaken of the following ES chapters, which directly feed into the CCRA:

- **Chapter 7 (Landscape and Visual)** of the **ES (Document Reference 6.1)**
- **Chapter 8 (Biodiversity)** of the **ES (Document Reference 6.1)**
- **Chapter 9 (Geology and Soils)** of the **ES (Document Reference 6.1)**

- **Chapter 12 (Population and Human Health)** of the **ES (Document Reference 6.1)**
- **Chapter 13 (Road Drainage and the Water Environment)** of the **ES (Document Reference 6.1)**

UKCP18

14.12.7 The UKCP18 (Met Office, N.Da) comprise projections that combine climate model data, observations, and advanced statistical methods to simulate a wide range of climate outcomes for a range of emission scenarios.

14.12.8 UKCP18 probabilistic projections is available for the time period 1981 to 2099 at 25km resolution. The climate variables considered to pose the greatest risk to the Scheme are highly localised in nature, for example flash flooding, heavy rainfall and extreme hot and cold events. However, due to the distance covered by the Scheme, the 25km probabilistic projections are considered to be representative of the entire area potentially affected by the Scheme.

14.12.9 UKCP18 uses Representative Concentration Pathway (RCP) to develop projections and consider factors such as economic activity, population growth and land use change, which would result in a different range of climate projections. RCP 8.5 represents the highest emissions scenario. RCP8.5 is the most conservative, highest-impact scenario. The scenario reflects an average increase in global mean surface temperature compared to the pre-industrial period of 4.3˚C by 2081-2100. RCP 8.5 projections at the 50th percentile have been considered in this assessment, in line with the DMRB LA 114 Climate (Highways England, 2021). This is a conservative approach due to the uncertainties that exist around climate projections. This is also considered the most appropriate scenario for assessing the vulnerability of the Scheme to climate change based on policy and legislation for the UK to achieve net zero carbon by 2050, which is in line with limiting global temperature increases to 1.5˚C, and professional judgement.

14.12.10 In line with DMRB LA 114 Climate (Highways England, 2021) requirements, the life span of the Scheme is assessed as being 60 years. The Opening Year of the Scheme is 2027, therefore this CCRA assesses up to 2087. Lifecycle stages have then been assessed in the short, medium, and long term (i.e., 2030s, 2050s and 2080s).

14.12.11 To assess the climate hazards to the Scheme, the following data has been extracted from the UKCP18 climate projections:

- Annual Mean Temperature
- Maximum Average Summer Temperature
- Minimum Average Winter Temperature
- Average Annual Precipitation (% change)

- Average Summer Precipitation (% change)
- Average Winter Precipitation (% change)

14.12.12 The projections (see **Appendix 14.4 (Climate Projections Data)** of the **ES (Document References 6.3)**) show the potential change in temperature or precipitation above or below the observed temperature/precipitation for 1981-2000.

14.12.13 H++ (extreme) climate scenarios are considered within the **Flood Risk Assessment (FRA) (Document Reference 7.4)**, which allows for a more conservative climate change allowance of 120% than if H++ climate scenarios were not considered. **Section 14.15.4.** and the **FRA (Document Reference 7.4)** provides further information on how the Scheme has been designed with 120% climate change allowance.

Sensitive Receptors

14.12.14 The Scheme receptors within the study area which are vulnerable to climate change have been identified based on the below, as per section 3.34 of the DMRB LA 114 Climate (Highways England, 2021):

- The assets and their operation, maintenance and refurbishment
- End users, including the public and commercial operators

14.12.15 All aspects of the Scheme for the above bullet points have been assessed. The receptors are set out in further detail in **Section 14.13**.

Approach to design, mitigation, and enhancement measures

14.12.16 The Scheme has been designed to avoid or reduce vulnerability to climate change. Embedded mitigation is listed within **Chapter 4 (Environmental Assessment Methodology)** of the **ES (Document Reference 6.1).** Embedded and essential mitigation measures have been identified within this chapter. This mitigation is also included within the **fiEMP (Document Reference 7.3).**

Assessment approach - overview

14.12.17 The DMRB LA 114 Climate (Highways England, 2021) identifies the following three steps that would be undertaken to assess the vulnerability of the Scheme to climate change:

1) Identify climate hazards and benefits
2) Assess likelihood and consequences of hazards
3) Evaluation of significance

Assessment approach – identifying climate hazards

14.12.18 Climate hazards have been identified through establishing the future baseline using UKCP18 data as described above.

Assessment approach - likelihood categories

14.12.19 The assessment after identifying climate hazards and benefits then assigns likelihood categories. These are defined within **Table 14.8** and set out in Table 3.39a in the DMRB LA 114 Climate (Highways England, 2021).

Table 14.8: Likelihood categories (Highways England, 2021)

Likelihood Category	Description (probability and frequency)
Very High	The event occurs multiple times during the lifetime of the project (60 years) e.g., approximately annually, typically 60 events.
High	The event occurs several times during the lifetime of the project (60 years) e.g., approximately once every five years, typically 12 events.
Medium	The event occurs limited times during the lifetime of the project (60 years) e.g., approximately once every 15 years, typically 4 events.
Low	The event occurs during the lifetime of the project (60 years) e.g., once in 60 years.
Very Low	The event *can* occur once during the lifetime of the project (60 years).

Assessment approach –consequence of hazards

14.12.20 The criteria used to determine the consequence of a hazard is set out in **Table 14.9,** as per Table 3.39b in the DMRB LA 114 Climate (Highways England, 2021).

Table 14.9: Measure of consequence (Highways England, 2021)

Consequence of Impact	Description
Very Large Adverse	Operation - national level (or greater) disruption to strategic route(s) lasting more than 1 week.

Consequence of Impact	Description
Large Adverse	Operation - national level disruption to strategic route(s) lasting more than 1 day but less than 1 week or regional level disruption to strategic route(s) lasting more than 1 week.
Moderate Adverse	Operation - regional level disruption to strategic route(s) lasting more than 1 day but less than 1 week.
Minor Adverse	Operation - regional level disruption to strategic route(s) lasting less than 1 day
Negligible	Operation - disruption to an isolated section of a strategic route lasting less than 1 day.

Assessment approach – evaluation of significance

14.12.21 In accordance with Table 3.41 in the DMRB LA 114 Climate (Highways England, 2021), the likelihood and consequence of each impact has been combined in the form of a matrix to assess the significance of each impact, as outlined in **Table 14.10**.

Table 14.10: Significance matrix (Highways England, 2021)

		Measure of likelihood				
Measure of Consequence		**Very Low**	**Low**	**Medium**	**High**	**Very High**
	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

NS = Not significant; S = Significant

14.12.22 In considering the elements of climate, professional judgement (using a proportionate approach), has been used to provide a qualitative description of the nature of the impacts.

14.12.23 As agreed through the EIA scoping process and within the Scoping Opinion, cumulative effects in relation to vulnerability to climate change have been scoped out. However, the assessment considers the wider strategic transport routes in the local area and is therefore inherently cumulative.

Reasonable worse case parameters for assessment

14.12.24 An assessment has been conducted within the Limits of Deviation (LoD) outlined within **Chapter 4 (Environmental Assessment Methodology)** of the **ES (Document Reference 6.1)**. The vertical and lateral LoD for the Scheme have been reviewed with respect to sensitive receptors identified within this ES chapter. The vertical and lateral LoD would not affect the conclusions of the assessment reported in this chapter.

Assessment assumptions and limitations

14.12.25 The following assessment assumptions and limitations should be noted:

- The UKCP18 are not predictions or forecasts but simulations of potential scenarios of future climate under a range of hypothetical emissions scenarios and assumptions, and therefore cannot be treated as exact or factual, but projection options. They represent internally consistent representations of how the climate may evolve in response to a range of potential forcing scenarios and their reliability varies between climate variables. Scenarios exclude outlying "surprise" or "disaster" scenarios in the literature and any scenario necessarily includes subjective elements and is open to various interpretations
- Generally global projections are more certain than regional, and temperature projections more certain than those for precipitation. The degree of uncertainty associated with all climate change projections increases for projections further into the future
- This ES chapter reports the climate change risk assessment which has used the latest information sources available at the time of writing. New climate information is published regularly as more in-depth analysis of climate changes is completed, which may supersede the information used to inform this assessment.
- The assessment is largely qualitative, with the exception of assessments relevant to drainage assets and flood risk, which have been informed by the Environment Agency climate change allowances for increases in peak river flow and rainfall intensity
- There is often uncertainty in the relationship between changes in climate hazards and the respective response in terms of Scheme performance. This uncertainty has been assessed qualitatively
- The assessment assumes that mitigation will be effectively implemented

14.12.26 The assessment aligns with the DMRB LA 114 Climate (Highways England, 2021) and with above matters taken into account, it is considered that a robust assessment has been undertaken

14.13 Climate change study area

14.13.1 The study area includes all areas of permanent land take within the Scheme's Application Boundary as per section 3.25 of the DMRB LA 114 Climate (Highways England, 2021). Receptors within the study area are identified in **Table 14.11**.

Table 14.11: Climate vulnerability receptors and aspects

Receptor	Aspect
Structures (including bridges and subways)	Foundations Bearings Joints Structure drainage
Pavements / Road Surfaces	Foundations Materials Embankments
Drainage	Surface water drainage systems Cross-culverts Road-edge drainage Attenuation Outfalls Drainage ditches
Signage	Stability
End users	Walkers, cyclists, and horse-riders Drivers
Landscape and Ecology	Planting

14.14 Climate change baseline conditions

14.14.1 This section outlines the current and future climatic baseline conditions for land within the Application Boundary and the surrounding area. Wider UK and regional observation data have also been taken into account to establish the baseline.

UK observations

14.14.2 For the UK as a whole, observed changes in climate over the last decade compared with the last seven decades include:

- The most recent decade (2009-2018) has been on average 0.3 °C warmer than the 1981-2010 average and 0.9 °C warmer than 1961-1990. All of the top ten warmest years have occurred since 2002 (Lowe *et al*., 2019)
- In the past few decades there has been an increase in annual average rainfall over the UK. However, natural variations are also seen in the longer observational record (Lowe *et al*., 2019)
- The period since 2000 accounts for two-thirds of hot-day records, and close to half of wet-day records, in monthly, seasonal and annual observations since 1910 (Kenton, 2014)
- Winters in the UK, for the most recent decade (2009-2018), have been on average 5% wetter than 1981-2010 and 12% wetter than 1961-1990. Summers in the UK have also been wetter, by 11% and 13% respectively (Met Office, 2019)
- The frequency of severe autumn and winter wind storms increased between 1950 and 2003 (Alexander *et al*., 2005), although there are no compelling trends in storminess as determined by maximum gust speeds from the UK wind network over the last four decades (Kendon *et al*., 2019)
- Widespread and substantial snow events have occurred in 2018, 2013, 2010 and 2009, but their number and severity have generally declined since the 1960s (Met Office, N.Dc)

Regional observations

14.14.3 Historic climate averages during the period 1981-2010 for the closest climate station to land within the Application Boundary (Martyr Worthy, Hampshire), obtained from the Met Office website (Met Office, N.Db), indicates the following:

- Average annual maximum temperature was 14.6°C
- Warmest month on average was July (mean maximum temperatures of 22.7°C)
- Coldest month on average was January (mean minimum temperature of 1.3°C)
- Average total annual rainfall was 746.5mm
- Wettest month on average was November (average monthly rainfall of 88.6mm)
- Driest month on average was April (average monthly rainfall of 50.1mm)

Local Climate Observations

14.14.4 The Scheme location adjacent to Winchester, lies partially within Flood Zone 3 which is associated with the River Itchen and its tributaries, as well as areas of Flood Zone 2 and 1. Chapter 13 (Road Drainage and the Water Environment) of the ES (Document Reference 6.1) notes that it is anticipated that climate change would cause these flood zone extents to increase in the future.

14.14.5 The Environment Agency's Historic Flood Map identifies maximum extent of recorded flood outlines from the rivers, sea and groundwater springs. A review of the map identifies no recorded historic flood events within the Scheme Application Boundary, although there are areas of historic flooding recorded with the surrounding area (Kings Worthy area immediately north-east of the A34) with most common source being groundwater, however this did not encroach on the road network.

14.14.6 Winchester City Council SFRA (Halcrow, 2007) identifies that there are historic flood records dating from 1997 to 2006 within the Winchester City Council local authority area; the source is identified to be a combination of groundwater, fluvial flooding and foul/combined systems. The nearest recorded flood report to the Scheme is approximately 750m south-west on Wales Street; flooding is reported to have occurred from sewer flooding (date not specified).

14.14.7 In terms of temperature, the Met Office issued an amber warning for high temperatures in July and August 2022 for Winchester and most of the UK, with local temperatures reaching up to 35°C. Hampshire reported their driest July in 2022 since 1836 (Met Office, 2022) and experienced a drought in 2004-2006. Local historical weather station data is available online from the Met Office which provides monthly data from long running historic sites.

Baseline evolution

14.14.8 Appendix 14.4 (Climate Projections Data) of the ES (Document Reference 6.3) shows the UKCP18 projections for the two 25 km UK grid squares that surround the Scheme for average summer, winter and annual precipitation, maximum average summer temperature, minimum average winter temperature and annual mean temperature. A summary of the projections is provided below in Table 14.12. The projections show the potential change in temperature or precipitation above or below the observed temperature/precipitation for 1981-2000.

Table 14.12: Summary of 50th percentile climate projections for 25km grid square using baseline 1981-2000 scenario RCP 8.5 (Grid Squares 437500.0 East, 137500.0 North and 462500.0 East 137500.0 North)

Year	Climate Variable at 50th Percentile					
	Mean Annual air temperature anomaly at 1.5m (Â°C)	Annual Precipitation rate anomaly (%)	Maximum Summer air temperature anomaly at 1.5m (Â°C)	Average Summer Precipitation rate anomaly (%)	Minimum Winter air temperature anomaly at 1.5m (Â°C)	Average Winter Precipitation rate anomaly (%)
2020	0.78	1.39	0.93	-5.76	0.67	12.35
2027	0.91	0.76	1.65	-9.27	0.70	3.70
2042	1.48	1.25	2.05	-18.21	1.35	13.34
2066	2.73	-0.83	3.96	-32.50	2.38	16.02
2087	4.09	1.73	6.21	-38.29	3.41	26.13

14.14.9 The projections show a continuous increase in annual average temperature over the next 60 years, with 2087 estimated to be over 4°C warmer than the 1981-2000 baseline.

14.14.10 This temperature increase is projected to be most severe during the summer months, with projections showing maximum temperatures in the summer of over 6°C in 2087 compared to the 1981-2000 baseline.

14.14.11 Temperatures are also anticipated to increase during the winter months, with the minimum air temperature estimated to be over 3°C warmer in 2087 compared to the 1981-2000 baseline.

14.14.12 However, natural variations in climate may occur, therefore the region is still expected to experience some relatively cold winters and cool summers.

14.14.13 Annual precipitation is shown to vary year on year, with some years being dryer or wetter than previous years. The trends are clearer for the seasonal data. During the summer months there is a clear negative trend, showing that the region may experience substantially less rainfall during the summer compared to the 1981-2000 baseline. In 2087, it is projected that there would be approximately 38.29% less rainfall in June, July and August compared to the 1981-2000 baseline.

14.14.14 During the winter months, the region may experience substantially more rainfall compared to the baseline. In 2087, it is projected that the region may receive

just over 26% more rainfall in December, January and February compared to the 1981-2000 baseline.

14.14.15 In the UK, the heaviest snowfalls tend to occur when the air temperature is between zero and 2°C (Met Office, N.Dc). There is less certainty in the magnitude of change to snow occurrence and amount, although climate models do show a downward trend in both falling and lying snow over time.

Extreme Weather Events

Heatwaves

14.14.16 A heatwave is an extended period of hot weather relative to the expected conditions of the area at that time of year, which may be accompanied by high humidity. For the UK, the Met Office defines a heatwave as "*when a location records a period of at least three consecutive days with daily maximum temperatures meeting or exceeding the heatwave temperature threshold*" (Met Office, N.Dd). The threshold varies by county and have been calculated using the 1981-2010 climatology of daily maximum temperature at the mid-point of the meteorological summer (15 July), which for the land within the Application Boundary is 27 ºC. As outlined in **Table 14.12**, temperatures are projected to increase by 4°C by 2087, which would near the threshold for this region.

14.14.17 Research has found that the likelihood of heatwave events in the UK is about 10 times higher with climate change than without climate change (Vautard R. *et al*., 2019). As discussed above, the maximum summer air temperature and annual average air temperature is expected to increase over the next 60 years, which could result in more intense and more frequent heatwaves.

14.14.18 The likelihood of heatwave events is considered to be Medium.

Extreme Cold Snaps

14.14.19 It is projected that winters may become increasingly milder, with minimum temperatures set to rise to over 3°C by 2087. Natural variations may mean that some cold and/or dry winters may still occur.

14.14.20 The likelihood of extreme cold snap events is considered to be Low.

Low Rainfall and Drought

14.14.21 Droughts are natural events which occur when a period of low rainfall creates a shortage of water. The UKCP18 projections show a trend toward drier summers on average, although the uncertainties of these are wide ranging. Research on the influence of climate change on drought in the UK is limited and given the several different factors that influence droughts (meteorological, hydrological, and societal), it is challenging to identify whether drought events would become more common and prolonged in the future.

14.14.22 The likelihood of low rainfall and drought is considered to be Low.

Heavier Rainfall

14.14.23 Heavy rainfall that may lead to flooding is hard to predict in the long term. A study has shown that an extended period of extreme winter rainfall in the UK is about seven times more likely due to human-induced climate change (Christidisa and Stott, 2015), although the largest changes in heavy rainfall since 1961 have occurred in Scotland and northern England.

14.14.24 The climate projections for land within the Application Boundary show there would be an increase in average winter precipitation. There is also a pattern of larger increases in winter precipitation over southern and central England toward 2100.

14.14.25 While projections indicate a trend that summers would become dryer toward the end of the century, there is also evidence that summer rainfall events may become more intense when they do occur.

14.14.26 The likelihood of extreme rainfall events are considered to be Low.

Storms and Highspeed Winds

14.14.27 On average throughout the year, near-surface wind speeds are projected to decrease. However, during the winter season, where more significant impacts of winds are experienced (Met Office, 2019c), near-surface winds speeds are projected to rise towards the second half of the 21st Century.

14.14.28 However, these projections are modest compared to natural variability from month to month and season to season. Projections of future wind and storm occurrence and intensity are uncertain and confidence in projections is low. Research has shown that there are no compelling trends in maximum gust speeds over the last four decades (Kendon et al., 2019) and therefore there is no evidence that link climate change and storms. Storms are therefore only considered in terms of highspeed wind events.

14.14.29 The likelihood of highspeed wind events is considered to be Low.

Summary of Projected Climatic Changes

14.14.30 In summary, it is anticipated that the Scheme would experience the following climatic changes:

- An increase in average temperature
- An increase in maximum temperature, particularly in the summer
- An increase in winter rainfall
- A reduction in summer rainfall
- Extreme rainfall event

- Increased wind speed in the winter

14.14.31 **Appendix 15.1 (Long List of Cumulative Developments)** of the **ES (Document Reference 6.3)** provides a full list of schemes which have been identified as being likely to be in operation prior to the construction of the Scheme. Where relevant, these schemes therefore form part of the future baseline scenario and have been taken into account in the assessment of likely significant effects from the Scheme (operation) presented in this Chapter.

14.15 Climate change potential impacts

14.15.1 The projected climatic changes outlined in **Section 14.14** may have a direct impact on the Scheme or result in secondary impacts which may impact the performance or integrity of the Scheme. As a result of the projected climatic changes, there is an increased risk of:

- Overloading to drainage system which may result in damage, or flooding as a result of extreme rainfall events
- Stress on structures and surfaces resulting in damage and deterioration from extreme temperatures fluctuations such as heatwaves and extreme rainfall events
- Pollution run-off as a result of extreme rainfall events
- Damage to structures and potential health and safety impacts from windborne debris from high wind events
- Inaccessibility of the Scheme due to extreme and severe weather events
- Health and safety risks to road users and non-motorised users from extreme weather events such as heatwaves
- Increased requirement for maintenance and repair as a result of increased damage, wear, and tear from extreme weather events
- Impacts on ecology, landscaping and planting as a result of long-term changes to climatic norms as well as extremes such as droughts

14.16 Climate change design, mitigation, and enhancement measures

14.16.1 Mitigation measures incorporated into the design of the Scheme are reported as embedded mitigation in **Chapter 4 (Environmental Assessment Methodology)** of the **ES (Document Reference 6.1)**, those relevant to road drainage and the water environment are included below. This section also outlines essential mitigation required. Essential mitigation is outlined within the **fiEMP (Document Reference 7.3)**. Prior to the implementation of mitigation, the Scheme has the potential to have climate change impacts during operation.

Embedded mitigation

14.16.2 **Table 14.13** in the assessment section takes into account the mitigation set out in the below paragraphs.

Structural design

14.16.3 The Scheme has been designed in accordance with several UK and British Standards (BS), including the foundations, structures and pavements/road surfaces for example the BS EN 1991-1-5:2003 in relation to thermal action and BS EN 1991-1-4:2005 in relation to wind loading and the associated UK National Annex and PD 6688-1-4:2015. The Scheme has also been designed in accordance with National Highways Specification for Highway Works (SHW) (National Highways, 2021).

Flood risk and drainage design

14.16.4 To build in climate change resilience, the components of the Scheme have been designed to address the potential for increased rainfall and more extreme rainfall events. The following elements of the drainage design have incorporated flood alleviation measures:

- Stated in **Chapter 13 (Road Drainage and the Water Environment)** of the **ES (Document Reference 6.1)**, the operational drainage system has been designed to modern highway standards and the drainage strategy is set out in **Appendix 13.1 (Drainage Strategy Report)** of the **ES (Document Reference 6.3)**

- The attenuation storage within the system is designed to have a capacity to accommodate a 1 in 100-year flow event, with a climate change allowance of 40%

- Integration of Sustainable Drainage Solutions (SuDS) are proposed to be integrated within the highway drainage networks to enable surface water runoff from the carriageway and active travel routes to be treated prior to discharge to all waterbodies. SuDS features include basins, swales and filter drains

- DMRB CD356 – Design of Highway Structures for Hydraulic Action requires bridge soffit height to be set to a minimum of 600mm above the design 1 in 200 annual probability plus climate change allowance. The Scheme has been designed to +120% climate change allowance

Landscape and planting strategy

14.16.5 The substantial green infrastructure provision within the Environmental Masterplan (**Figure 2.3 (Environmental Masterplan)** of the **ES (Document Reference 6.2)**) would create multi-functional habitat corridors across the Scheme and would link to the wider landscape.

Essential mitigation

Operation

14.16.6 As outlined in **Chapter 8 (Biodiversity)** of the **ES (Document Reference 6.1)**, the design includes areas of new ecologically valuable habitat that are appropriate for the local areas within the land within the Application Boundary, as shown on **Figure 2.3 (Environmental Masterplan)** of the **ES (Document Reference 6.2)**. A diverse selection of species is proposed, including suitable seed mixes of chalk grassland species, native broadleaved woodland, and a mosaic of native scrub. The incorporation of a variety of species as well as the selection of low maintenance habitats provides greater climate resilience as there would be less needed to water the planting during periods of low rainfall or drought.

14.16.7 The Schemes planting specifications would be provided at detailed design stage. The soft landscape planting strategy for the Scheme (in accordance with the **first iteration Environmental Management Plan (fiEMP) (Document Reference 7.5)** should follow a contextual approach with regards to native species selection and pattern and be appropriate to its locality. Species with enhanced attributes to drought tolerance and waterlogging would be considered and incorporated where practicable to increase resilience to climate change. Further considerations in relation to landscape planting and wildfire risk would be undertaken at detailed design.

14.16.8 The **Appendix 7.6 (Outline Landscape and Ecological Management Plan)** of the **ES (Document Reference 6.3)** has been prepared which includes the appropriate establishment and management of new landscape planting and features in accordance with relevant best practice and standards. This includes avoiding the use herbicides and mowing regimes. Should it be considered appropriate for the proposed grassland to be managed with livestock, a suitable grazing regime should be in place that avoids over and under grazing and is flexible in response to seasonal variations. Suitable management of the proposed landscaping would help to ensure the long-term success of the planting.

14.16.9 The proposed planting and management includes several measures that are recommended in Natural England's Climate Change Adaption Manual (NE751) (Natural England, 2021), such as selecting a greater mix of native trees and shrubs. The manual defines grassland and woodland to have low sensitivity to climate change.

Enhancement measures

14.16.10 Enhancement is defined by DMRB LA 104 as *"a measure that is over and above what is required to mitigate the adverse effects of a project*".

14.16.11 No enhancements in relation to climate change are anticipated.

14.17 Climate change assessment of likely significant effects

14.17.1 This section presents the assessment of likely significant effects during operation on various Scheme design aspects and end-users of the Scheme. The assessment of effects takes into account the potential impacts to each receptor following the implementation of embedded and essential mitigation measures to determine the significance of the residual effects.

Operation

14.17.2 The potential impacts on the Scheme identified in **Section 14.14** above have been assessed as part of the CCRA to identify whether those impacts lead to likely significant effects. The outcomes are provided in **Table 14.13**.

Table 14.13: Assessment of likely significant effects of climate change on the Scheme

Receptor	Climatic change	Potential impact	Embedded and essential mitigation	Likeli-hood	Conse-quence	Signifi-cance
Structures including bridges (foundations, bearings, joints, structural drainage)	Increase in mean temperature. Increase in summer temperature extremes, including heatwaves and extended periods of hot dry weather leading to risk of wildfire.	High temperatures may induce greater stress and increased risk of deterioration, which may increase need for maintenance and repairs. Increased risk of wildfires due to extreme temperatures and dry conditions may also cause damage to the Scheme.	Thermal actions on structures have been designed in accordance with BS EN 1991-1-5:2003 and the associated UK National Annex. The structures would be designed for increased durability by designing reinforced concrete elements for the effects of early thermal cracking and incorporated well detailed weathering steel elements. National Highways standard emergency procedures for wildfires on or around the strategic road network.	Medium	Minor Adverse	Not significant
	Increase in winter rainfall. Reduction in summer rainfall. More extreme rainfall events.	Changes in ground water level may result in larger ground movement/ heave, which in turn may result in additional stress on structure, causing failure of components. This may increase need for maintenance and	The drainage design for structures has accommodated potential changes in precipitation. Attenuation storage within the system has been designed to accommodate 1:100 year return plus 40% climate change allowance. Bridge soffit heights are in accordance with DMRB (CD356),	Low	Moderate Adverse	Not significant

Receptor	Climatic change	Potential impact	Embedded and essential mitigation	Likeli-hood	Conse-quence	Signifi-cance
		repairs or inaccessibility to the Scheme.	set to a minimum of 600mm above the design 1 in 200 annual probability +120% climate change allowance. Soil conditions and ground water levels would be considered during the detailed design of the foundations which would be constructed in accordance with UK standards. It is considered that design guidance already allows for fluctuations in groundwater levels.			
	Increase in winter rainfall. More extreme rainfall events.	Increased risk of flooding and blockages, affecting large areas and causing disruption. This may increase need for maintenance and repairs or inaccessibility to the Scheme.	Structures drain into the network drainage. Drainage design allows for climate change levels of rainfall. Over-the-edge drainage, linear drains, gullies or filter drains are proposed to capture and direct drainage into the network and attenuation storage in the systems have been designed to accommodate 1:100 with 40% climate change allowance.	Low	Minor Adverse	Not significant
	Increase in wind speed in winter.	Potential minor loading on smaller	The Scheme is inland and low-lying, and it is therefore	Low	Minor Adverse	Not Significant

Receptor	Climatic change	Potential impact	Embedded and essential mitigation	Likeli-hood	Conse-quence	Signifi-cance
		structures, such as gantries. Anticipated that impact on bridges should be limited as wind is rarely a dominant load.	anticipated it is relatively resilient to changes in wind. Wind loading would be included in accordance with BS EN 1991-1-4:2005, the associated UK national annex and PD 6688-1-4:2015.			
Pavements / Road Surfaces (foundations, materials, embankments)	Increase in mean temperature. Increase in summer temperature extremes, including heatwaves and extended periods of hot dry weather leading to risk of wildfire.	Greater risk of surface failure or deterioration. Concrete pavements can curl/warp as a result of internal stresses caused by thermal gradients. This may increase need for maintenance and repairs or inaccessibility to the Scheme. Increased risk of wildfire may also cause damage to the road or inaccessibility to the Scheme.	Pavements have been designed in accordance with DMRB standards, which considers thermal contraction/ expansion to avoid unacceptably large stresses. Standards on pavement specification to mitigate against these impacts have been adopted. National Highways standard emergency procedures for wildfires on or around the strategic road network. Further considerations in relation to landscape planting and wildfire risk may be developed and refined at detailed design.	Medium	Minor Adverse	Not significant
	Increase in winter rainfall.	Changes in groundwater level	The Scheme has been designed in accordance with SHW	Low	Moderate Adverse	Not significant

Receptor	Climatic change	Potential impact	Embedded and essential mitigation	Likeli-hood	Conse-quence	Signifi-cance
	Reduction in summer rainfall. More extreme rainfall events.	and soil moisture may result in premature pavement failure, substantial deformation, and heaving and subsiding. This may increase need for maintenance and repairs or inaccessibility to the Scheme.	(National Highways, 2021). The SHW defines the technical approval and certification procedures to be used to ensure that risks associated with geotechnical activities are appropriately managed. Earthworks are comprised of granular materials for the embankments and are not susceptible to swelling/shrinkage.			
	Increase in winter rainfall. More extreme rainfall events.	Risk of flooding	Attenuation storage within the system is designed to accommodate 1:100 plus 40% climate change allowance. Earthworks are comprised of granular materials for the embankments, which allow for free drainage. Various SuDS features are proposed across the scheme, including basins, swales and filter drains.	Low	Minor Adverse	Not significant
Drainage (surface water drainage	Increase in winter rainfall.	Greater risk of damage to drainage network, overloading	Attenuation storage within the system designed to	Low	Moderate Adverse	Not significant

Receptor	Climatic change	Potential impact	Embedded and essential mitigation	Likeli-hood	Conse-quence	Signifi-cance
systems, cross-culverts, road-edge drainage, attenuation, outfalls, drainage ditches)	Reduction in summer rainfall. More extreme rainfall events.	of drainage network and flooding. In turn impacts performance of network e.g., increased risk of congestion and accidents, increased rates of deterioration of assets and increased risk of pollution to watercourses and groundwater.	accommodate 1:100 plus 40% climate change allowance Various SuDS features are proposed across the scheme, including basins, swales, and filter drains.			
	Reduction in summer rainfall.	Lower levels of drain dilution which would be more concentrated with pollutants due to receiving water courses carrying less water.	Various SuDS features are proposed across the scheme, including basins, swales and filter drains.	Low	Moderate Adverse	Not significant
Signage (stability)	Increase in wind speed in winter.	Potential for damage to signage.	The Scheme is inland, low-lying and therefore relatively resilient to change in wind. Risks from wind loading and flying debris are therefore anticipated to be limited.	Low	Minor Adverse	Not significant

Receptor	Climatic change	Potential impact	Embedded and essential mitigation	Likeli-hood	Conse-quence	Signifi-cance
End users (walkers, cyclists and horse-riders (WCH), drivers)	Increase in average temperature. Increase in summer temperature extremes, including heatwaves and extended periods of hot dry weather leading to risk of wildfire.	Increased risk of vehicles breaking down/ overheating or vehicle fires. Risk to road users unable to exit the network if stuck in a queue at a time of extreme temperature. Increased risk from wildfires has the potential to cause smoke on the road, reducing user visibility Risk to health of WCH during heatwaves as well increased risk from wildfires.	The **Transport Assessment Report** (**Document 7.13**) concludes that the Scheme delivers transport benefits, including reducing journey times, reducing traffic and reducing congestion in the town centre. The Scheme would therefore be able to reduce queue times and reduce risk to road users stuck on the highway. Areas of woodland adjacent to the bridleway, footway and cycle route would provide shading. National Highways standard emergency procedures for wildfires on or around the strategic road network. Further considerations in relation to landscape planting and wildfire risk may be developed and refined at detailed design.	Medium	Minor Adverse	Not significant
	Increase in winter rainfall. More extreme rainfall events.	Increased risk of more incidents caused by ice including skidding vehicles, traction-	Attenuation storage within the system designed to accommodate 1:100 plus 40% climate change allowance, which would help to keep the Scheme	Low	Moderate Adverse	Not significant

Receptor	Climatic change	Potential impact	Embedded and essential mitigation	Likeli-hood	Conse-quence	Signifi-cance
		related incidents and losing control on standing water.	clear of standing water to reduce incidents.			
	Increase in winter rainfall. More extreme rainfall events.	Increased risk of flooding may need to open up diversion routes increased risk of local authority routes gridlock. Increased risk of flooding may also cause areas of the footway and cycle route to be inaccessible.	Attenuation storage within the system designed to accommodate 1:100 plus 40% climate change allowance. Various SuDS features are proposed across the scheme, including basins, swales and filter drains.	Low	Moderate Adverse	Not significant
	Increase in wind speed in winter	Increased risk of needing to close structures to high sided vehicles more frequently. Increased risk of flying debris causing health and safety risk to all road users.	The Scheme is inland, low-lying, and therefore relatively resilient to change in wind. Risks from wind loading and flying debris are therefore anticipated to be limited.	Low	Minor Adverse	Not significant

Receptor	Climatic change	Potential impact	Embedded and essential mitigation	Likeli-hood	Conse-quence	Signifi-cance
Landscape and Ecology (planting)	Increase in average temperature. Increase in summer temperature extremes, including heatwaves and extended periods of hot dry weather leading to risk of wildfire.	Impact on productivity, function and structure of ecosystem services by, for example, causing an increase in erosion as soils and substrates dry out, as well increased risk from wildfires.	The variety of the planting proposals, including areas of native woodland, scrub, and grassland, would help to embed climate resilience through provision of biodiverse habitats for a range of species. The soft landscape planting strategy for the Scheme would follow a contextual approach where practicable with regards to native species selection and pattern and be appropriate to its locality. Species with enhanced attributes to drought tolerance and waterlogging would be considered. National Highways standard emergency procedures for wildfires on or around the strategic road network. The road will also act as a firebreak, providing a gap in combustible material that will act as a barrier to slow or prevent the progress of a wildfire.	Medium	Negligible	Not significant

Receptor	Climatic change	Potential impact	Embedded and essential mitigation	Likeli-hood	Conse-quence	Signifi-cance
			Further considerations in relation to landscape planting and wildfire risk can be developed and refined at detailed design.			
	Increase in winter rainfall. Reduction in summer rainfall and droughts. More extreme rainfall events.	Increased risk of flooding has the potential to damage planting and habitats on land within the Application Boundary. Impact on productivity, function, and structure of ecosystem services by change in summer rainfall and droughts.	Various SuDS features are proposed across the scheme, including basins, swales, and filter drains. SuDS would also provide biodiverse habitats to support a range of species. As noted above, species selection and pattern and would be appropriate to its locality. Species with enhanced attributes to drought tolerance would be considered.	Low	Moderate Adverse	Not significant

14.17.3 Following the assessment of likelihood and consequence for all climate risk, and with the implementation of embedded and essential mitigation there will be no significant effects.

14.17.4 The below mentioned local and regional alternate routes provide some flexibility should a climate hazard cause traffic disruption that may drive a need for re-routing.

14.17.5 Alternate road routes around the Scheme are primarily provided by the A31, B304, A33, A272 and A3090. In a regional context it is considered that:

- Traffic traveling to the south of the scheme towards Eastleigh can use the A31, Bar End Road or Bull Drove to join the M3 at Junction 10 or the B3335 to join at Junction 11. The B3335 could also be used as an alternative to reach Eastleigh, along with the A3090 and B3043
- Traffic travelling to the north of the scheme toward Basingstoke can use the A33 to join the M3 at Junction 8 or continue on the A30 to Basingstoke

14.17.6 In addition, Winchester rail station offers main line routes to London Waterloo, Portsmouth Harbour, Bournemouth and Poole. This provides a further alternative means of travel should the Scheme not be usable.

14.17.7 The assessment in **Table 14.13**, taken together with the mitigation set out in **Section 14.16** and the alternative routes noted above come together to build resilience to climate change across the local and regional transport network.

14.17.8 It is likely that the broad number of journey options available, coupled with the level of mitigation embedded in the design of the Scheme and the rail network (as demonstrated through, for example, the regional weather resilience and climate adaptation plans for the rail network) would provide a sufficient level of systemic resilience to mitigate a likely significant effect when considered against the criteria for significance set out in **Tables 14.8, 14.9 and 14.10** which align with the methodology in the DMRB LA 114 Climate (Highways England, 2021).

14.18 Climate change monitoring

14.18.1 The assessment of effects from the Scheme has not identified effects which are considered to be significant. No monitoring is therefore required in relation to the vulnerability of the Scheme to climate change. However, structures of the Scheme would be inspected in accordance with DRMB CS 450 Inspection of Highway Structures. There would be a General Inspection every two years and a Principal Inspection every six years (in place of the General Inspection that two-year period) which would involve full access to all parts of the bridge. This would monitor the condition of the structure and identify any potential need for maintenance, which might arise as a result of deterioration from climatic changes.

14.18.2 In addition, the drainage strategy for the Scheme (see **Appendix 13.1 (Drainage Design Report)** of the **ES (Document Reference 6.3))** would require ongoing maintenance, and a Maintenance Schedule (Section 8 of the above document) has been proposed to demonstrate that performance can be maintained at sufficient levels over the lifetime of the network.

14.19 Summary

14.19.1 This chapter has assessed the likely significant effects of the Scheme on climate change, and the likely significant effects of climate change on the Scheme, with due regard to DMRB LA 114 Climate (Highways England, 2021).

GHG Assessment

14.19.2 The GHG emissions assessment has summarised how the Scheme is likely to impact climate change based on its potential to emit GHG emissions. GHG emissions were calculated during the construction and operation of the Scheme, based on the PAS 2080 (BSI, 2016) lifecycle stages and scopes.

Construction

14.19.3 During construction, the main source of GHG emissions is anticipated to be associated with construction materials embodied carbon, comprising approximately 68.9% of overall construction emissions. Construction emissions as a result of plant equipment use within the work area would also release GHG emissions, through combustion of fuel, and comprise approximately 20.8% of anticipated construction emissions. Land use is estimated to comprise approximately 5.2% of construction emissions. 1.8% of construction emissions arise as a result of the power required for the welfare facilities. The remaining 2.3% and 1.0% are anticipated to arise from transport of materials and construction waste respectively. In total, it is anticipated that an estimated 37,070 tCO_2e would be emitted during construction.

14.19.4 The Scheme has been designed using PAS 2080 (BSI, 2016) to manage and reduce embodied carbon and has been iteratively updated to refine and improve the proposals in relation to a range of design requirements and criteria, including the consideration of sustainability, material use and construction efficiency.

14.19.5 The **fiEMP (Document Reference 7.3)** includes several mitigation measures covering transport, materials, waste and air quality which would help to reduce GHG emissions during construction. A Site Waste Management Plan (SWMP) would be implemented to manage waste during construction, which would help to reduce GHG emissions associated with waste management, a draft SWMP is appended to the **fiEMP (Document Reference 7.3).**

Operation

14.19.6 During operation, the main source of GHG emissions is from ‘end-users’ i.e. traffic. GHGs emitted from operational energy use (i.e. subway lighting, CCTV, VMS and traffic signalling) would contribute a relatively small amount to the overall operational carbon emissions. Based on the transport model for the Scheme, in 2027, end-user and operational energy is anticipated to emit 4,161,2863,217,562 tCO_{2e} annually and by 2042 this is anticipated to reduce to 3,554,1182,500,142 tCO_{2e} annually. When compared to the baseline, net emissions from traffic and operational energy use are anticipated to result in 3,3192,782 tCO_{2e} annually and by 2042, 4,6912,302 tCO_2e annually.

14.19.7 The incorporation of active travel routes would encourage more sustainable, low carbon modes of transport, reducing GHG emissions associated with private vehicles. The Scheme also includes tree and woodland planting which would provide minor carbon sequestration benefits once the maturity stage has been reached.

14.19.8 Technological changes, including the increased uptake of Electric Vehicles, the banning of the sale of petrol and diesel cars by 2030, and the decarbonisation of the National Grid, is anticipated to continue to reduce the GHG emissions associated with the Scheme over time.

14.19.9 In comparison to the UK carbon budget, the Scheme is anticipated to comprise 0.002% of the 4th carbon budget and 0.001% of the 5th carbon budget and 0.002% of the 6th carbon budget. It is considered that the increase in emissions as a result of the Scheme would not have a material impact on the ability of UK Government to meet its carbon budgets, therefore in accordance with the DMRB, there would be no significant effect.

Climate Change

Operation

14.19.10 UKCP18 climate projections were used to establish evolving baseline climate conditions up to 2099. It is expected that the Scheme may experience warmer, drier summers and milder, wetter winters, along with an increase in frequency and intensity of extreme weather events such as droughts or heatwaves. This has the potential to adversely affect receptors within the Scheme, including structures, pavements, drainage, lighting and signage and end users, including WCH.

14.19.11 To build in climate resilience, the drainage system incorporates flood alleviation measures, including the attenuation storage with a capacity to accommodate a 1 in 100-year flow event with a climate change allowance of 40%, the integration of Sustainable Drainage Solutions such as basins swales.

14.19.12 New landscaping and planting would create multifunctional habitat corridors within the Scheme and include the creation of new native woodland grassland and scrub. Consideration would be given to drought tolerance and waterlogging species at the detailed design stage.

14.19.13 With this mitigation in place, the impact of climate change on the Scheme is considered Not Significant.