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APPENDICES

7.1 - GHG Emissions Assessment

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7 Climate

7.1 Introduction

7.1.1 This chapter presents the Preliminary Environmental Information (PEI) in relation to the climate assessment.

7.1.2 In accordance with *Design Manual for Roads and Bridges (DMRB) LA 114 Climate (DMRB LA 114)* (Highways England, 2021)[1], the chapter presents the assessment under the following two headings:

- Impact of the project on climate (Greenhouse Gas (GHG) emissions assessment) – these sections of the report cover the potential additional and avoided GHG emissions associated with the construction and operation of the project, in comparison with current and future baseline GHG emissions. It will also identify mitigation measures to reduce the GHG emissions.
- Vulnerability of the project to climate change (Climate Change Risk (CCR) assessment) – these sections of the report cover how climate change is anticipated to manifest itself in the future and the vulnerability of the project to such climate change. It also evaluates the effectiveness and feasibility of adaptation (mitigation) measures to be integrated into the project to increase the resilience of the project to climate change risk.

7.1.3 Climate change also has the potential to influence impacts considered under other disciplines. There will be interrelationships related to the potential effects on climate and other disciplines and each discipline will consider the potential for climate impacts to influence the impacts identified by their topic. Therefore, please also refer to the following chapters:

- Chapter 5: Air Quality
- Chapter 6: Biodiversity
- Chapter 8: Cultural Heritage
- Chapter 9: Geology and Soils
- Chapter 10: Landscape and Visual Effects
- Chapter 11: Material Assets and Waste
- Chapter 13: Population and Human Health
- Chapter 14: Road Drainage and the Water Environment.

7.2 Legislative and Policy Framework

Legislation

7.2.1 The following key legislation is relevant to this assessment:

- The Kyoto Protocol
- The Paris Agreement
- The Climate Change Act
- Climate Change Act 2008 (2050 Target Amendment) Order 2019
- Climate Change Act 2008 (Credit Limit) Order 2021
- Town and Country Planning (Environmental Impact Assessment) Regulations 2017

[1] Highways England (2019a) DMRB LA 114 Climate, available from: https://standardsforhighways.co.uk/dmrb/search/d1ec82f3-834b-4d5f-89c6-d7d7d299dce0 [accessed 20 July 2021]

National policy statement for national networks

7.2.2 The primary policy basis for deciding whether or not to grant a Development Consent Order (DCO) is the *National Policy Statement for National Networks (NPSNN)* (Department for Transport, 2014) [2], which sets out policies to guide how DCO applications will be decided and how the effects of national networks infrastructure should be considered by the relevant decision maker. The policies for climate adaptation and carbon include statements that:

"..*Climate change mitigation is essential to minimise the most dangerous impacts of climate change, as previous global greenhouse gas emissions have already committed us to some degree of continued climate change for at least the next 30 years. Climate change is likely to mean that the UK will experience hotter, drier summers and warmer, wetter winters. There is an increased risk of flooding, drought, heatwaves, intense rainfall events and other extreme events such as storms and wildfires, as well as rising sea levels. Adaptation is therefore necessary to deal with the potential impacts of these changes that are already happening. New development should be planned to avoid increased vulnerability to the range of impacts arising from climate change. When new development is brought forward in areas which are vulnerable, care should be taken to ensure that risks can be managed through suitable adaptation measures, including through the provision of green infrastructure."* (NPSNN paragraphs 4.37 and 4.38)

7.2.3 The NPSNN also advises:

"Carbon impacts will be considered as part of the appraisal of scheme options (in the business case), 70 prior to the submission of an application for DCO. Where the development is subject to EIA, any Environmental Statement will need to describe an assessment of any likely significant climate factors in accordance with the requirements in the EIA Directive. It is very unlikely that the impact of a road project will, in isolation, affect the ability of Government to meet its carbon reduction plan targets. However, for road projects applicants should provide evidence of the carbon impact of the project and an assessment against the Government's carbon budgets." (NPSNN paragraph 5.17)

7.2.4 Table 7-1: Relevant NPSNN policies for the climate assessment methodology, identifies the *NPSNN* policies relevant to the climate assessment methodology.

Table 7-1: Relevant NPSNN policies for the climate assessment methodology

Relevant NPSNN paragraph reference	Requirement of the NPSNN (paraphrase)
Climate Change Adaption	
4.40	Applicants must consider the impacts of climate change when planning location, design, build and operation. Any accompanying environment statement should set out how the proposal will take account of the projected impacts of climate change.
4.41	Where transport infrastructure has safety-critical elements and the design life of the asset is 60 years or greater, the applicant should apply the UK

[2] Department for Transport (2014) National Policy Statement for National Networks, available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/387222/npsnn-print.pdf [accessed 6 September 2021]

Relevant NPSNN paragraph reference	Requirement of the NPSNN (paraphrase)
	Climate Projections 2009 (UKCP09) high emissions scenario (high impact, low likelihood) against the 2080 projections at the 50% probability level.
4.42	The applicant should take into account the potential impacts of climate change using the latest UK Climate Projections available at the time and ensure any environment statement that is prepared identifies appropriate mitigation or adaptation measures. This should cover the estimated lifetime of the new infrastructure.
4.43	The applicant should demonstrate that there are no critical features of the design of new national networks infrastructure which may be seriously affected by more radical changes to the climate beyond that projected in the latest set of UK climate projections.
4.44	Any adaptation measures should be based on the latest set of UK Climate Projections, the Government's national Climate Change Risk Assessment and consultation with statutory consultation bodies. Any adaptation measures must themselves also be assessed as part of any environmental impact assessment and included in the environment statement, which should set out how and where such measures are proposed to be secured.
Carbon Emissions	
5.17	Carbon impacts will be considered as part of the appraisal of scheme options (in the business case), prior to the submission of an application for DCO. Where the development is subject to EIA, any Environmental Statement will need to describe an assessment of any likely significant climate factors in accordance with the requirements in the EIA Directive. Applicants should provide evidence of the carbon impact of the project and an assessment against the Government's carbon budgets
5.19	Evidence of appropriate mitigation measures (incorporating engineering plans on configuration and layout and use of materials) in both design and construction should be presented.

National planning policy framework

7.2.5 The NPPF originally published in March 2012 and most recently updated in July 2021, sets out the government's planning policies for England and provides a framework within which locally prepared plans can be produced. The NPPF is "an important and relevant matter to be considered in decision making for NSIP".

Local planning policy

7.2.6 The following local planning policies are relevant to the assessment:

- Eden District Council *Local Plan 2014-2032* (Eden District Council, 2018)[3] Policy ENV 5

[3] Eden District Council (2018) Adopted Eden Local Plan, available from: https://www.eden.gov.uk/planning-and-building/planning-policy/adopted-eden-local-plan/ [accessedaccessed 23 July 2021]

- County Durham *Local Plan 2020-2035* (County Durham, 2020)[4] Objective 16: Adaptation to Climate Change, objective 17: Low Carbon, Policy 21: Delivering Sustainable Design and Policy 29: Sustainable Design.
- Richmondshire *Local Plan 2012-2028 Core Strategy* (Richmondshire District Council, 2014)[5] Core Policy 2: Responding to Climate Change
- Eden County Council Climate Emergency (Eden District Council, 2019)[6]
- *Eden Level 1 Strategic Flood Risk Assessment* (Eden District Council, 2020)[7]
- Durham County Council Climate Emergency (Durham County Council, 2019)[8]
- Durham County Council Climate Emergency Response Plan (2020-2022)[9]
- *Durham County Council level 1 Strategic Flood Risk Assessment* (Durham County Council, 2018)[10]
- Richmondshire District Council Climate Emergency (Richmondshire District Council, 2019)[11]
- *North West Yorkshire Level 1 Strategic Flood Risk Assessment* (Harrogate Borough Council, 2010)[12]
- Cumbria County Council Carbon Management Strategy (Cumbria County Council, 2020)[13]

Standards and guidance

7.2.7 In addition to compliance with the *NPSNN* and *NPPF*, this assessment has been compiled in accordance with professional standards and guidance. The standards and guidance which relate to the assessment are:

[4] County Durham (2020) County Durham Plan, available from: https://www.durham.gov.uk/media/34069/County-Durham-Plan-adopted-2020-/pdf/CountyDurhamPlanAdopted2020vDec2020.pdf?m=637424969331400000 [accessed 26 July 2021]
[5] Richmondshire District Council (2014) Local Plan 2021-2028, available from: https://www.richmondshire.gov.uk/planning-and-climate-change/current-planning-policy/local-plan-2012-2028/ [accessed 26 July 2021]
[6] Eden District Council (2019) Zero Carbon Eden, available from: https://www.eden.gov.uk/your-environment/zero-carbon-eden/about-zero-carbon-eden/ [accessed 23 July 2021]
[7] Eden District Council (2020) Eden Level 1 Strategic Flood Risk Assessment, available from: https://www.eden.gov.uk/media/5918/2018s0424_eden_district_council_sfra_final_report_v30.pdf [accessed 26 July 2021]
[8] Durham County Council (2019) Climate emergency, available from: https://www.durham.gov.uk/climatechange [accessed 26 July 2021]
[9] Durham County Council (2020) Climate Emergency Response Plan, available from: https://democracy.durham.gov.uk/documents/s119824/7%20Climate%20Change%20Action%20Plan%202020.pdf [accessed 23 July 2021]
[10] Durham County Council (2018) Strategic Flood Risk Assessment, available from: https://durhamcc-consult.objective.co.uk/kse/folder/52317 [accessed 26 July 2021]
[11] Richmondshire District Council (2019) Our climate emergency declaration, available from: https://www.richmondshire.gov.uk/planning-and-climate-change/climate-change/environment-and-climate-emergency-declaration/ [accessed 26 July 2021]
[12] Harrogate Borough Council (2010) North West Yorkshire Level 1 SFRA Update, available from: https://www.richmondshire.gov.uk/media/8255/north-west-yorkshire-level-1-sfra-update.pdf [accessed 26 July 2021]
[13] Cumbria County Council (2020) Carbon Management Strategy (Corporate Estate) 2020-2025, available from: https://cumbria.gov.uk/elibrary/Content/Internet/536/6181/44147113255.pdf [accessed 15 July 2021]

- The *Road Investment Strategy 2 (RIS2)* (Department for Transport, 2020)[14]
- *Climate Change: second national adaptation programme 2018-2023* (Department for Environment Food & Rural Affairs, 2018)[15]
- *UK Climate Change Risk Assessment* (UK Climate Risk, 2021)[16]
- The *Clean Growth Strategy* (UK Government, 2017)[17]
- *Road to Zero Strategy* (UK Government, 2018)[18]
- The *Transport Decarbonisation Plan* (Department for Transport, 2021)[19]
- *Net Zero Highways: our 2030/2040/2050 plan* (Highways England, 2021a)[20]

7.3 Assessment Methodology

7.3.1 The methodology used will follow the requirements of *DMRB LA 114* and are presented under the following assessment headings:

- Impact of the project on climate (GHG emissions assessment)
- Vulnerability of the project to climate change (CCR assessment).

7.3.2 The *DMRB GG 103 Introduction and general requirements for sustainable development and design* (Highways England, 2019b)[21] also identifies the general requirements for sustainable development and design. The principles in the document must be applied to all stages of a design lifecycle, from inception through to end of first life. *GG 103* includes a series of Goals of Sustainable Development including to 'minimise greenhouse emissions' and to 'be resilient to future climate change'.

[14] Department for Transport (2020) Road Investment Strategy 2, available from: https://www.gov.uk/government/publications/road-investment-strategy-2-ris2-2020-to-2025 [accessed 23 July 2021]
[15] Department for Environment Food & Rural Affairs (2018) Climate change: second national adaptation programme (2018 to 2023), available from: https://www.gov.uk/government/publications/climate-change-second-national-adaptation-programme-2018-to-2023 [accessed 23 July 2021]
[16] UK Climate Risk (2021) Independent Assessment of UK Climate Risk (CCRA3), available from: https://www.ukclimaterisk.org/ [accessed 23 July 2021]
[17] UK Government (2017) The Clean Growth Strategy Leading the way to a low carbon future, available from: https://www.gov.uk/government/publications/clean-growth-strategy] [accessed 16 August 2021]
[18] UK Government (2018) Road to Zero Strategy, available from: https://www.gov.uk/government/publications/reducing-emissions-from-road-transport-road-to-zero-strategy [accessed 16 August 2021]
[19] Department for Transport (2021) Transport decarbonisation plan, available from: https://www.gov.uk/government/publications/transport-decarbonisation-plan [accessed 16 August 2021]
[20] Highways England (2021a) Net zero highways: our 2030/2040/2050 plan, available from: https://highwaysengland.co.uk/media/eispcjem/net-zero-highways-our-2030-2040-2050-plan.pdf [accessed 16 August 2021]
[21] Highways England (2019b) DMRB GG103 Introduction and general requirements for sustainable development and design, available from: https://www.standardsforhighways.co.uk/dmrb/search/89d10ef2-7833-44df-9140-df85cd6382b9 [accessed 20 July 2021]

Impact of the project on climate (GHG emissions assessment)

Quantification of emissions

7.3.3 The assessment of the nature and magnitude of GHG emissions has been undertaken pursuant to *DMRB LA 114* and the *Specification of infrastructure carbon management (PAS 2080)* (British Standard Institute, 2016)[22].

7.3.4 *PAS 2080* introduces a lifecycle assessment approach centred around a number of "*Work Stages of Infrastructure Delivery*". Those relevant to this assessment are:

- Construction and Commissioning[23]
- Operation (including maintenance and use of the asset)

7.3.5 For the purpose of quantifying GHG emissions, an assumed design life of 60 years has been used, which is consistent with the CCR assessment. In line with *DMRB LA 114*, 'end of life' impacts have been excluded from the assessment due to length of the assets' operational phase.

7.3.6 The assessment methodology for the PEI Report is based upon the information available at the time of assessment. In some cases, conservative assumptions have been made to provide a reasonable worst-case scenario for the particular item or factor to inform a precautionary assessment. Further information on assessment assumptions and limitations is provided in Section 7.4: Assessment Assumptions and Limitations and in Appendix 7.1: GHG Emissions Assessment, and Appendix 7.3: CCR Assessment.

7.3.7 It should be noted that the approach to climate assessment within the *DMRB LA 114 Climate* methodology is inherently cumulative through the inclusion of the project and other locally committed development within the traffic model on which the GHG emissions calculations is based, and through the consideration of the project against the UK carbon budgets, which consider and report on the carbon contributions across all sectors.

7.3.8 Table 7-2: Project lifecycle stages and potential sources of GHG emissions considered by the GHG emissions assessment presents the potential sources of GHG emissions during the Construction and Operation work stages of the project and whether they have been included in the GHG emissions assessment for the PEI Report.

Table 7-2: Project lifecycle stages and potential sources of GHG emissions considered by the GHG emissions assessment

Project Work Stage	Potential Sources of GHG Emissions	Source of Data Used in Assessment (where assessed)	Inclusion in the PEI Report
Construction	Embodied GHG emissions from materials	Material quantities from design teams	Yes

[22] With the exception of setting project level carbon reduction targets as instructed by DMRB LA 114 (paragraph 2.7). British Standard Institute (2016) PAS 2080:2016 Carbon Management in Infrastructure, available at: https://shop.bsigroup.com/ProductDetail?pid=000000000030323493&_ga=2.44876396.974118440.1626686164-579123538.1626686162 [accessed 23 July 2021]

[23] Decommissioning is not in scope of the climate assessment.

Project Work Stage	Potential Sources of GHG Emissions	Source of Data Used in Assessment (where assessed)	Inclusion in the PEI Report
	Emissions from the transportation of materials	Schedule of material delivery and assumed transportation distances	Yes
	Energy use	Fuel usage during construction processes	Yes - High level conservative assumptions provided by buildability contractor based on information from previous schemes[24]
	Business and employee travel	Number of staff and estimated commute frequency and distances	Yes - High level conservative assumptions provided by buildability contractor based on information from previous schemes[25]
	Waste and waste transport	Waste quantities and assumed distance to disposal facilities	Yes (partially) – Quantity of cut and fill waste available. No information provided on waste associated with site preparation/construction or demolition. This information will be sought for inclusion in the ES[26].
	Land use change	Type and area of land subject to change in usage taken from Chapter 6: Biodiversity	Yes
Operation	Vehicles using the highways infrastructure	Emissions from vehicles derived from the traffic model	Yes
	Energy use and material use for operation of the highway	Typical replacement periods for key materials	Yes – conservative assumptions based on previous schemes

[24] It is anticipated that at ES, more detailed information on the design will provide more detailed data for energy use during construction. This information will be used to refine the quantification of GHG emissions.
[25] It is anticipated that at ES, more detailed information on the design will provide more detailed data for business and employee travel during construction. This information will be used to refine the quantification of GHG emissions.
[26] It is anticipated that at ES, more detailed information on the design will provide more detailed data for waste and waste transport (e.g. cut and fill volumes, site preparation and demolition) during construction. This information will be used to refine the quantification of GHG emissions.

Project Work Stage	Potential Sources of GHG Emissions	Source of Data Used in Assessment (where assessed)	Inclusion in the PEI Report
	Ongoing land use emissions and sequestration	Not assessed at PEI Report. (Intended for assessment for the ES, information on the type and area of land subject to change in usage from ES Chapter 6: Biodiversity would be used for the assessment if assessed)	No – Information relating to ongoing land use, including natural environment mitigation measures will be assessed within the ES[27]

7.3.9 The purpose of the GHG emissions assessment is to calculate and report the emissions anticipated to be generated or avoided by the project for each of the project work stages. The purpose of this is to:

- Enable consideration of magnitude against the relevant UK Carbon Budget(s)
- Enable identification of emissions hot spots to inform identification and prioritisation of mitigation measures to minimise GHG emissions from the project

7.3.10 *DMRB LA 114* requires use of an industry recognised carbon calculation tool(s) in accordance with the Overseeing Organisation requirements. The Highways England *Carbon emissions calculation tool* (Highways England, 2019c)[28] has been used to calculate:

- All construction stage emissions, as identified in Table 7-2: Project lifecycle stages and potential sources of GHG emissions considered by the GHG emissions assessment,, with the exception of land use change (the method for which is described separately in paragraph 7.3.10)
- All operation stage emissions, as identified in Table 7-2: Project lifecycle stages and potential sources of GHG emissions considered by the GHG emissions assessment,, with the exception of emissions from vehicles using the highways infrastructure (the method for which is also described separately in paragraph 7.3.11).

7.3.11 Construction phase carbon emissions associated with land use change have been quantified by calculating the potential loss of carbon stock associated with the loss or degradation of existing vegetation, habitats and soils (e.g. peatland habitats) due to the project. The existing habitats have been assessed by suitably qualified ecologists following the Phase 1 Habitat survey methodology (Joint Nature Conservation Committee, 2010)[29], which has provided areas (in hectares) of habitats with the potential to be lost or damaged as a result of the construction of the project. The land use change quantification uses guidance developed by Natural England (Natural

[27] It is anticipated that at ES, more detailed information on biodiversity mitigation through design will provide information for land use emissions and sequestration during operation. The assessment at ES would utilise information on the type and area of land subject to change in use for the purpose of mitigating environmental impacts, taken from the Biodiversity chapter. This information will be used to refine the quantification of GHG emissions.
[28] Highways England (2019c) Carbon emissions calculation tool, available from: https://www.gov.uk/government/publications/carbon-tool [accessed 20 July 2021]
[29] Joint Nature Conservation Committee (2010) Handbook for Phase 1 Habitat Survey – a Technique for Environmental Audit. Joint Nature Conservation Committee, Peterborough.

England, 2021)[30], which provides carbon stock factors for soils and vegetation of different habitat types. Multiplication of these factors with the area of habitat type provides an estimate of carbon stock loss due to the construction phase of the project. Results in section 7.9: Assessment of Likely Significant Effects are presented in tonnes of carbon dioxide (tCO_2) as only carbon emissions are considered by the Natural England literature.

7.3.12 The assessment of operational phase emissions from vehicles using the highways infrastructure draws on existing traffic modelling information from earlier stages of the project, as explained in the *Local Traffic Report* (Highways England, 2021b)[31] which is available as part of the Statutory Consultation. This information is used to calculate emissions for the baseline, opening year (2031) and design (future) year (2046) under the following scenarios:

- 2018 Baseline scenario
- 2031 Do-Minimum (DM) scenario: the traffic scenario at the modelled opening year without the project
- 2031 Do-Something (DS) scenario: the modelled opening year with the project.

7.3.13 Emissions drawn from the traffic modelling are provided in carbon dioxide (CO_2) not carbon dioxide equivalents (CO_2e). To provide GHG emissions estimates as CO_2e, carbon emissions data has been converted to CO_2e by applying an additional 1% of the CO_2 emissions[32].

7.3.14 The traffic data used for the operational phase modelling is based on an opening year (2031) later than that which is used throughout this PEI Report (2029). This is due to changes in the construction programme as a result of acceleration of the project and applies to all modelled aspects of the assessment.

7.3.15 As a result of the modelled opening year, GHG emissions, as taken from the traffic modelling, could have been underestimated for the year 2029-30 (assuming consistent traffic volumes). This is as the modelling uses an opening year of 2031 and as emissions factors remain static/constant in the traffic model after 2030. The assumptions and limitations of the traffic model are further explained in Chapter 5: Air Quality. Overall, the difference in effects is considered unlikely to be significant or influence the conclusion of the GHG emissions assessment. The GHG emissions assessment will be refined at the ES stage, in light of revised traffic modelling.

7.3.16 The limitation on the modelled opening and design (future) years is recognised in the GHG assessment limitations set out in Appendix 7.1: GHG Emissions Assessment and the modelling will be revised at ES to reflect an opening year of 2029 to address this.

[30] Natural England (2021) Carbon Storage and Sequestration by Habitat 2021 (NERR094), available from: http://publications.naturalengland.org.uk/publication/5419124441481216 [accessed 30 July 2021]

[31] Highways England (2021b) Local Traffic Report, available as part of the consultation material on http://www.highwaysengland.co.uk/A66-NTP

[32] Assumption of 1% conversion factor, assumes petrol and diesel fuels are used in vehicles using the highway infrastructure and is based upon analysis of the BEIS Conversion factors for Fuels, comparing the difference of CO_2 and CO_2e emissions factors on 'Fuels', which gives an approximate 1% difference in the factors. This uplift of 1% has then been used to convert CO_2 to CO_2e for emissions from vehicles using the highways infrastructure. BEIS (2021) Greenhouse gas reporting: conversion factors 2021, available from: https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2021 [accessed 26 August 2021]

7.3.17 The assessment uses the traffic modelling information to calculate the additional GHG emissions associated with the project (under the 'Do-Something' scenario) above the existing anticipated increase in traffic emissions without the project (the 'Do-Minimum' scenario). The assessment calculation subtracts the modelled 'Do-Minimum' emissions from the modelled 'Do-Something' emissions to provide estimated additional GHG emissions associated with the project from vehicles using the highways infrastructure.

7.3.18 In line with *DMRB LA 114*, the assessment presents the estimated net project-wide operational GHG emissions for the modelled design (future) year (2046) ('Do-something' scenario minus the 'Do-minimum' scenario).

7.3.19 For the assessment of significance, the assessment uses the estimated additional GHG emissions associated with the project from vehicles using the highways infrastructure combined with the total estimated emissions relating to maintenance and refurbishment for the project, to provide a total estimated GHG emissions for the project in the operational phase (for the assumed 60-year lifetime). This is then reported against the Sixth Carbon Budget (as this is the *Carbon Budget* set furthest into the future able to represent the operational phase) to consider significance, to provide a reasonable worst case assessment using information currently available on carbon budgets.

7.3.20 As set out in Chapter 2: The Project, the project involves a number of discrete sections of road along the route, forming eight schemes. As a result of ongoing work to understand the baseline environment and further development of the design of the Preferred Route and its terminal junctions, alternative alignments have been considered at this stage for a number of the schemes. Emissions arising from construction and operational emissions relating to maintenance and refurbishment[33] will therefore be quantified for each alternative alignment for the preliminary assessment of total project-wide construction phase GHG emissions. The results of the GHG emissions assessment will therefore be presented as a range (in section 7.9 Assessment of Likely Significant Effects), representing the minimum and maximum potential GHG emissions associated with the amalgamation of various combinations of scheme alternative alignments.

Evaluation of significance

7.3.21 In line with *DMRB LA 114* guidance, to evaluate the significance of project GHG emissions, project GHG emissions will be reported against the legislated for *UK Carbon Budgets* as set out in Carbon Budget Orders (Department for Business Energy and Industrial Strategy, 2021)[34] (shown in Table 7-3: UK Carbon Budgets) considered relevant to the stage of the project under consideration.

7.3.22 Total estimated GHG emissions from the construction stage of the project will be considered against the Fourth Carbon Budget (2023-2027) and Fifth Carbon Budget (2028-2032) respectively, as construction works are expected to take place between 2024 and 2029.

[33] Carbon dioxide emissions arising from road users for alternative alignments were not available for the GHG emissions assessment as emissions were not quantified as part of air quality assessments conducted on the alternative alignment options. However, qualitative judgements of potential carbon impacts arising from road users have been considered as part of the optioneering process for alternative alignments (please see the Route Development Report, available as part of Statutory Consultation).

[34] Department for Business Energy and Industrial Strategy (2021) UK Carbon Budgets, available from: https://www.gov.uk/guidance/carbon-budgets [accessed 23 July 2021]

7.3.23 Total estimated GHG emissions from the operational stage of the project will be considered against the Sixth Carbon Budget (2033-2037) as this is the *Carbon Budget* set furthest into the future able to represent the operational phase, to provide a reasonable worst case assessment using information currently available on carbon budgets.

Table 7-3: UK Carbon Budgets

Carbon Budget	Years	Carbon Budget (for 5-year period) ($MtCO^2e$)
Third	2018-2022	2,544
Fourth	2023-2027	1,950
Fifth	2028-2032	1,725
Sixth	2033-2037	965

7.3.24 In line with *DMRB LA 114,* at ES the GHG emissions performance of the project will be benchmarked against other recent road scheme projects within the Strategic Road Network.

Vulnerability of the project to climate change (CCR assessment)

7.3.25 In line with *DMRB LA 114*, the CCR assessment is a qualitative assessment to identify whether anticipated changing climate conditions and weather events are likely to have significant adverse effects on the project. It considers the potential impacts and risks of climate change on the project based on professional expertise and judgement.

Scope of the assessment

7.3.26 A detailed CCR assessment for the construction phase of the project has not been taken forward to consider the potential for likely significant effects from climate change. Extreme weather events are a feature of the current baseline and Highways England have standard construction processes in place to address extreme weather events. The UKCP18 climate projections for the construction phase (2020s) suggest that, whilst the climate will have changed by the construction period, there are unlikely to be significant changes in climatic conditions within this period. The short-term nature of the construction period (5 years) means there is a lower likelihood of an extreme climate event occurring within the construction period than operational phase of the project.

7.3.27 In this context, it is therefore considered there are not likely to be any significant effects associated with the vulnerability to climate change during the construction phase, such that a likely significant effect could occur. This conclusion is applicable to all alternative alignments presented within the PEI Report. Therefore, the detailed CCR assessment only covers the operational phase of the project.

7.3.28 The Environmental Management Plan (EMP) will set out specific measures for this project that the contractor will employ during the construction period in order to provide resilience to extreme weather, which builds on existing Highways England standard construction processes. An outline of the EMP is included at Appendix 4.1: Outline of Environmental Management Plan, and a draft will be submitted with the DCO. The ES and draft EMP will define the outcome that the mitigation will need to achieve (i.e. protection of construction site to prevent environmental impact in the event of extreme weather events) and examples of mitigation that could be employed. The mitigation will then be developed further by the contractor(s) to achieve those objectives. The types of measures that will be included are climate resilience

measures such as ensuring construction materials are covered when stored, and pro-active planning undertaken that accounts for the possibility of extreme weather events, including the use of extreme weather alert systems. A draft of the EMP will be submitted with the DCO, which will contain some of the proposed mitigation measures to guide the mitigation of climate change risk. However, there will be some mitigation measures, e.g. those relating to construction methods and site management methods, which will be provided by the contractor who is carrying out site-level management of risks.

7.3.29 On the assumption that the EMP and other associated risk management and site safety procedures are implemented effectively and are successful in mitigating risk, a detailed CCR assessment of the vulnerability of the project to climate change during the construction period has not been taken forward because there is unlikely to be significant changes in climatic conditions within this period, such that a likely significant effect could occur. The CCR assessment presented therefore relates to the operational phase of the project only.

7.3.30 The topic of 'Major Events (Major Accidents and Disasters)' has also been scoped out of the wider EIA assessment, with no further consideration of the vulnerability of the project to major accidents and disasters (man-made and natural) being included as part of the EIA. However, the wider EIA assessment methodology (as set out in the Scoping Report (*A66 Northern Trans-Pennine PCF Stage 3 Environmental Scoping Report* (Highways England, 2021b)[35]) states that *"Where further design mitigation is unable to remove the potential interaction between a major event and a particular topic, the relevant ES chapter would be required to identify the potential consequence for receptors covered by the topic and give a qualitative evaluation of the potential for the significance of the reported effect to be increased as a result of a major event."* The CCR assessment considers the potential for major events to result in climate change risk and the need for mitigation across all alternative alignments.

7.3.31 The CCR assessment is comprised of these main steps:

- the analysis of climate change projections and weather data to identify future climate conditions
- the identification and assessment of relevant climate hazards and disruptive weather conditions, based on climate trends, which could impact the project, and the identification of potential risks from these climate hazards to the infrastructure and operations of the project
- the assessment of the resilience of the project to each identified risk within the context of any embedded mitigation measures, considering the likelihood and consequence of impacts should they occur
- the evaluation of any significant risks and the need for any further adaptation (mitigation) measures

[35] Highways England (2021b) A66 Northern Trans-Pennine PCF Stage 3 Environmental Scoping Report, available at: https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/TR010062/TR010062-000025-TR010062%20-%20Scoping%20Report%20(Part%201%20of%2011%20-%20Main%20Report%20&%20Appendices).pdf [accessed 28 July 2021]

Climate change projections

7.3.32 *UK Climate Projections 2018 (UKCP18)* (Met Office, 2018)[36] have been used to provide quantitative estimates of future climatic conditions for the project. In accordance with *DMRB LA 114*, all *UKCP18* projections used in the assessment reflect the high emissions scenario, representative concentration pathway 8.5 (RCP8.5) against a baseline period of 1981-2010. The CCR assessment uses the UKCP18 probabilistic projections for climate change and the UKCP18 regional projections for climate change to identify the future baseline. For the UKCP18 probabilistic projections, the 50th percentile (median) projections are used to inform the assessment.

7.3.33 The assessment of climatic effects on the project is assessed over an assumed 60-year operational life cycle, in line with *DMRB LA 114*.

Identification of climate hazards and risks

7.3.34 The following climate hazards have been considered in the CCR assessment:

- High temperatures
- High precipitation
- Low precipitation
- High humidity
- Extreme winds.

7.3.35 A Flood Risk Assessment (FRA) for the project is being undertaken and will be reported in ES Chapter 15: Road Drainage and the Water Environment. The FRA will incorporate Environment Agency allowances for increases in rainfall intensity and peak river flow (Environment Agency, 2016)[37] in a future changed climate[38]. As the FRA was not available to inform the preliminary assessment, the CCR assessment is currently based upon professional judgement in relation to flood risk and water management. The design standards upon which the project has been designed take conservative assumptions on flood risks. Design and assessment will be further refined at ES following the receipt of FRA information.

Assessment of likelihood and consequence

7.3.36 As part of the CCR assessment, the potential likelihood of climate change risks occurring, and the potential consequence should they occur, are scored using professional judgement and using a qualitative five-point scale, as set out in *DMRB LA 114*. The qualitative five point scales for likelihood and consequence are presented in Table 7-4: Likelihood categories – A qualitative five-point scale for assessing likelihood of climate change impacts occurring (*DMRB LA 114*, 2021) and Table 7-5: Measure of consequence - A qualitative five-point scale for assessing the consequence of climate change impacts if they were to occur (*DMRB LA 114*, 2021) below.

Table 7-4: Likelihood categories – A qualitative five-point scale for assessing likelihood of climate change impacts occurring (*DMRB LA 114*, 2021)

[36] Met Office (2018) UK Climate Projections, available at: https://www.metoffice.gov.uk/research/approach/collaboration/ukcp/index [accessed 28 July 2021]
[37] Environment Agency (2016) Flood risk assessments: climate change allowances, available at: https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances [accessed 20 July 2021]
[38] It is noted that the Environment Agency updated their projections in July 2021. These have not been considered as part of the PEI Report (as the FRA has not yet been conducted). Information will be refined to reflect the updated projections in the ES.

Likelihood of Impact	Description (probability and frequency of occurrence)
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).

Table 7-5: Measure of consequence - A qualitative five-point scale for assessing the consequence of climate change impacts if they were to occur (*DMRB LA 114*, 2021)

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

7.3.37 The potential likelihood and consequence of each climate change risk has been determined based upon the professional judgement of climate change experts in the EIA team, designers, structural engineers, drainage engineers and geotechnical experts from the wider design team delivering the project design.

7.3.38 The CCR assessment incorporates confirmed (embedded) design and mitigation measures at the time of assessment.

7.3.39 Climate change risks have been identified and assessed based on the 'worst-case' climate *UKCP18* RCP 8.5 projection for each climate change parameter and across the spatial extent of the project (referred to from hereon in as the 'project-wide assessment').

7.3.40 Where there are risks that apply only to specific schemes, or which differ from the project-wide CCR assessment, these are identified. Conversely, where project-wide risks are not applicable to a specific scheme these have also been identified.

7.3.41 For schemes where additional alternative alignments have been included at this stage, a commentary on where the climate change risks for alternative alignments may differ from the assessment of the climate change risk on a project-wide basis are described for each alternative alignment in section 7.9: Assessment of Likely Significant Effects and Appendix 7.3: CCR Assessment.

Evaluation of significance

7.3.42 To evaluate the significance of each risk, the likelihood and consequence of each risk, as outlined in Table 7-1: Relevant NPSNN policies for the climate assessment

methodology, is combined to provide a significance conclusion using the significance matrix, as set out in Table 7-5: Significance matrix.

Table 7-6: Significance matrix. Note: NS = Not significant; S = Significant (DMRB LA 114, 2021)

		Measure of Likelihood				
		Very low	Low	Medium	High	Very High
Measure of Consequence	Very large	NS	S	S	S	S
	Large	NS	NS	S	S	S
	Moderate	NS	NS	S	S	S
	Minor	NS	NS	NS	NS	NS
	Negligible	NS	NS	NS	NS	NS

7.3.43 In accordance with *DMRB LA 114*, where any climate change risk is concluded to be significant, additional mitigation measures (i.e. resilience measures to protect against the impacts of climate change) are identified, which seek to reduce the identified risk.

7.3.44 The likelihood and consequence of each significant risk is then reassessed based on the assumption that the additional proposed mitigation will be implemented successfully to reassess for significance.

7.3.45 Any residual significant effects (if any) will be presented in the conclusion of the assessment.

7.4 Assessment Assumptions and Limitations

Impact of the project on climate (GHG emissions assessment)

7.4.1 The assessment of GHG emissions is based on relevant design and construction information provided by design teams and buildability contractors, e.g. construction material quantities, transport and plant emissions, as set out in Chapter 2: The Project. Due to ongoing design development and the current stage of construction programming, limited detailed information on the construction phase and operational design of the project was available at the time of the preliminary assessment. The assessment presented in this PEI Report is based on the information available at the time of assessment.

7.4.2 In some cases, conservative assumptions have been made to provide a reasonable worst-case scenario for the particular item or factor to inform a precautionary assessment. Where there are gaps, professional judgement has been used to adopt appropriate benchmark data (in line with good practice as set out in *PAS 2080*).

7.4.3 Assumptions have been made using:

- Emerging design detail
- Engineering specialist knowledge
- Environmental specialist knowledge
- Climate change and carbon specialist knowledge
- Manufacturer specifications
- Proxy engineering data from previous comparable projects.

7.4.4 The assessment of road user emissions is based on considering traffic volumes for the affected road network (ARN). The ARN was determined based on the regional screening criteria set out in *DMRB LA 114*. Emissions were taken from the *DMRB LA*

105 screening tool, which are based on the EFT v10 emission factors (Department for Environment Food & Rural Affairs, 2021)[39].

7.4.5 As set out in paragraph 7.3.11 above, within the GHG emissions assessment an assumption of an Opening Year of 2029 is assumed, except for the road user emissions (operational emissions), which is based on traffic modelling data that assumes an Opening Year of 2031. This is due to changes in the construction programme as a result of acceleration of the project and applies to all modelled aspects of the assessment.

7.4.6 As a result of the modelled opening year, GHG emissions, as taken from the traffic modelling, could have been underestimated for the year 2029-30 (assuming consistent traffic volumes). This is as the modelling uses an opening year of 2031 and as emissions factors remain static/constant in the traffic model after 2030. The assumptions and limitations of the traffic model are further explained in Chapter 5 Air Quality. Overall, the difference in effects is considered unlikely to be significant or influence the conclusion of the GHG emissions assessment. The GHG emissions assessment will be refined at the ES stage, in light of revised traffic modelling.

7.4.7 Appendix 7.1: GHG Emissions Assessment sets out the detailed assumptions and limitations associated with the preliminary GHG emissions assessment.

7.4.8 Where information was limited or not available at the time of assessment, or where assumptions have been needed to facilitate the assessment, this has been acknowledged and will be refined or provided as part of the Environmental Statement where possible.

Vulnerability of the project to climate change (CCR assessment)

7.4.9 The climate projections used in this assessment are based on simulations of potential future climate scenarios, under a range of hypothetical emissions scenarios and assumptions, and should not be viewed as predictions or forecasts.

7.4.10 The assessment will be largely qualitative and is based on the professional judgement of climate experts, structural engineers, drainage engineers and geotechnical experts.

7.4.11 Although there is guidance provided on the assessment methodology (IEMA and *DMRB LA 114*), the guidance and available case studies on the assessment of individual climate risks and impacts on different aspects of the project are limited.

7.4.12 A list of preliminary assumptions and limitations associated with the CCR assessment is provided in Appendix 7.3: CCR Assessment.

7.5 Study Area

Impact of the project on climate (GHG emissions assessment)

Construction

7.5.1 The study area for construction GHG emissions aligns with the engineering boundary, which covers all direct GHG emissions arising from activities and land use change where the excavation and engineering works take place within the draft DCO boundary. It also includes indirect emissions embedded within the construction

[39] Department for Environment Food & Rural Affairs (2021) Emissions Factors Toolkit, available at: https://laqm.defra.gov.uk/review-and-assessment/tools/emissions-factors-toolkit.html [accessed 23 July 2021]

materials arising as a result of the energy used for their production as well as emissions arising from the transportation of materials and waste to and from the site.

7.5.2 The preliminary assessment is based on the project (and the alternative alignments) as it is described in Chapter 2: The Project, including embedded mitigation inherent in the design that is presented. It does not include consideration of any other mitigation measures (including those mentioned in topic chapters of this PEI Report) to address impacts from other EIA topics. This will be considered further during the development of the ES once those mitigation measures are confirmed and the areas quantified[40].

Operation

7.5.3 The study area for operational GHG emissions arising from maintenance and refurbishment activities aligns with the engineering boundary within the draft DCO boundary.

7.5.4 The study area for operational GHG emissions from vehicles using the highways infrastructure is consistent with the ARN defined within the project traffic model.

7.5.5 The ARN has been defined for the project as one or more of the following scoping criteria included in *DMRB LA 114*, have been met:

- A change of more than 10% in Annual Average Daily Traffic (AADT)
- A change of more than 10% to the number of heavy duty vehicles
- A change in daily average speed of more than 20km/h

7.5.6 For the PEI Report, the GHG emissions assessment has considered those areas where a change in traffic meeting the criteria identified above occurs in the immediate area along and around the project.

7.5.7 The preliminary assessment is based on the project (and the alternative alignments) as it is described in Chapter 2: The Project, including embedded mitigation inherent in the design that is presented. It does not include consideration of any other mitigation measures (including those mentioned in topic chapters of this PEI Report) to address impacts from other EIA topics. This will be considered further during the development of the ES once those mitigation measures are confirmed and the areas quantified.

Vulnerability of the project to climate change (CCR assessment)

Operation

7.5.8 The study area for the CCR assessment is the engineering boundary within the draft DCO boundary. It includes potential climate hazards during the operational phase of the project to infrastructure and assets that constitute the proposed project within the draft DCO boundary. The preliminary assessment does not consider the potential impacts or risks of or to any mitigation measures implemented to address impacts from other EIA topics, which will be considered during ES once information on measures is available.

7.6 Baseline Conditions

Impact of the project on climate (GHG emissions assessment)

[40] For example, in some cases, mitigation measures for biodiversity may also have a net benefit for GHG emissions, through the sequestration of carbon; this will be quantified during ES, where information on the mitigation measures is available.

7.6.1 The baseline conditions relate to current and future anticipated conditions, with regards to GHG emissions, without implementing the project. It is split into the current baseline, setting out current conditions and the future baseline, which sets out future conditions that can be reasonably expected to exist, based upon the 'Do-minimum' scenario.

7.6.2 The future baseline scenario assumes that no significant construction activity will take place associated with the A66, aside from typical maintenance, from the current time to the future assessment years.

Historic baseline

7.6.3 The primary source of historic emissions data is the UK *Greenhouse Gas (GHG) Inventory* (Government, 2020a)[41], which is updated annually every February and shows historic GHG emissions for the UK.

7.6.4 The UK's most recent dataset of the UK GHG Inventory is for 2019 and shows national statistics of GHG emissions for the UK. The total UK GHG emissions in 2019 was 454.8 million tonnes of carbon dioxide equivalent ($MtCO_2e$).

7.6.5 UK total emissions have shown general downward trend in recent years, with 2019 UK total GHG emissions down 2.8% from 468.1$MtCO_2e$ in 2018 (Government, 2021)[42]. In 2019, the largest emitting sector was transport, accounting for 122.1$MtCO_2e$ (26% of national emissions). Transport emissions fell by 1.8% between 2018 and 2019, despite an increase in road traffic. This is due to lower petrol consumption by passenger cars outweighing an increase in diesel consumption, and improvements in fuel efficiency of both petrol and diesel cars.

7.6.6 The baseline year for emissions associated with vehicles using the highways infrastructure is 2018, as modelled by the traffic model. GHG emissions associated with vehicles using the highways infrastructure are estimated at 198,668tCO_2e in 2018.

7.6.7 Due to the way in which the UK GHG Inventory reports emissions[43], construction emissions relating to transport and transport infrastructure cannot be disaggregated from overall national emissions.

Future baseline

7.6.8 Similar to the historic baseline emissions, due to the way in which the UK GHG Inventory reports emissions there is no current mechanism to provide a forward projection of construction emissions relating to transport and transport infrastructure as part of a future baseline.

7.6.9 For road user emissions (vehicles using the highways infrastructure), the estimated future baseline GHG emissions utilises the 'Do-minimum' scenario. This scenario presents the known emissions for the baseline year and predicted emissions for the opening year, the modelled design (future) year and over the assumed project lifetime

[41] Government (2020a) UK Greenhouse Gas Inventory, 1990 to 2019: Annual Report for submission under the Framework Convention on Climate Change, available at: https://naei.beis.gov.uk/reports/reports?section_id=3 [accessed 23 July 2021]
[42] Government (2021). Final UK greenhouse gas emissions national statistics: 1990 to 2019. Available at: https://www.gov.uk/government/statistics/final-uk-greenhouse-gas-emissions-national-statistics-1990-to-2019 [accessed 23 July 2021]
[43] GHG emissions associated with construction and maintenance of infrastructure are aggregated within broader 'Industry and Construction' sector emissions estimates in the UK GHG Inventory.

(60 years)[44]. This is summarised in Table 7-7: Estimated future baseline operational GHG emissions for the 'Do-minimum' scenario.

Table 7-7: Estimated future baseline operational GHG emissions for the 'Do-minimum' scenario

Project Work Stage	Definition	Emissions (tCO_2e)			
		Baseline (2018)[45]	Modelled Opening Year (2031)	Modelled Future Year (2046)	Total (over the 60 year assumed project lifetime)[46]
Operation	Vehicles using the highways infrastructure on the ARN	198,668	191,236	211,279	12,997,413

Vulnerability of the project to climate change (CCR assessment)

Existing baseline

7.6.10 The Met Office generates climatologies for different areas of the UK (known as climate districts) which include historical, regional climate information. The A66 crosses between the North East England and North West England regional climate zones (Met Office, 2016)[47]. As a result, historical observed weather varies across the route due to the changing topography and atmospheric conditions. Table 7-8: Synopsis of historical climate observations for the North West and North East England regional climate zones describes the historical observed weather for the two regional climate zones associated with the project.

7.6.11 Highways England also have records of historical flooding events on the existing A66 route, which will be presented and considered as part of the Environmental Statement.

[44] The traffic data used for the operational phase modelling is based on an opening year (2031) later than that which is used throughout this PEI Report (2029). This is due to changes in the construction programme as a result of acceleration of the project and applies to all modelled aspects of the assessment. The limitation has been recognised in the assumptions and limitations set out in Appendix 7.1. As a result of the modelled opening year, GHG emissions, as taken from the traffic modelling, could have been underestimated for the year 2029-30 (assuming consistent traffic volumes). This is as the modelling uses an opening year of 2031 and as emissions factors remain static/constant in the traffic model after 2030. The assumptions and limitations of the traffic model are further explained in Chapter 5 Air Quality. Overall, the difference in effects is considered unlikely to be significant or influence the conclusion of the GHG emissions assessment. The GHG emissions assessment will be refined at the ES stage, in light of revised traffic modelling.

[45] Data for road user emissions used for the preliminary assessments has been provided by the traffic modelling teams and utilises a different baseline date (2018) to that which is presented in the historic GHG emissions section (2019). It is anticipated that road user emissions data will be refined using a 2019 baseline for the ES to address this limitation. The limitation has been recognised in the assumptions and limitations set out in Appendix 7.1.

[46] Traffic growth held at 2055 levels for years following 2045 based on advice from traffic modelling team.

[47] The Met Office generates climatologies based on standard areas (UK climate districts) of the UK. The project spans across the North West and North East districts as shown on the UK climate districts map. Met Office (2016) UK regional climates, available online: https://www.metoffice.gov.uk/research/climate/maps-and-data/regional-climates/index [accessed 28 July 2021]

Table 7-8: Synopsis of historical climate observations for the North West and North East England regional climate zones

Climate Parameter	North West Region – Historical Weather Observations	North East Region – Historical Weather Observations
Temperature	Temperature depends heavily on altitude. Over low lying areas, mean annual temperatures vary between 9°C and 10.5°C.	The North East region of the UK is surrounded by the coldest waters and contains extensive areas of upland (higher altitude), meaning that temperatures are generally cool throughout the year (relative to elsewhere in the UK). Mean annual temperatures vary between 8.5°C and 10°C.
Precipitation	Annual precipitation varies significantly in the region between 3200mm per year in the Lake District and 800mm per year in the Eden. The driest season is in spring, whilst the wettest season is in autumn and winter when the Atlantic depressions are at their most vigorous.	Annual precipitation in the region varies between 1500mm in the Pennines and 600mm towards the East Coast. Seasonal patterns are similar to those for the North West region.
Wind	The region is among the most exposed parts of the UK as it is close to the Atlantic and contains large upland areas. The region experiences five to ten gales per year. Gales are defined as days that the wind reaches a mean speed greater than 34 knots over ten consecutive minutes.	Over the highest Pennines there are about 15 gales per year while along the coast gales occur on five to ten days and low-lying places inland experience less than five gales per year
Sunshine	Sunshine duration is controlled by the length of day and cloudiness. It decreases with increasing altitude, latitude and distance from the coast. Average annual sunshine ranges from 1200hrs to 1500hrs per year.	Average annual sunshine ranges from 1500hrs per year near the coast to 1250hrs further inland.
Ground frost	Ground frost occurs on average between 75 and 150 days per year Ground frost refers to a temperature below 0°C measured on a grass surface	Ground frost occurs on average between 80 and 135 days per year, depending on altitude.
Snowfall	The occurrence of snow is closely linked to temperature. The region experiences, on average, between 20 and 50 days of snowfall per year depending on altitude, with an additional five days of snowfall for every 100m of elevation gain. Depths of undrifted snow can occasionally reach up to 60cm.	The region experiences between 20 and 50 days of snowfall per year depending on altitude. Snow depths are similar to those described for the North West region.

Climate Parameter	North West Region – Historical Weather Observations	North East Region – Historical Weather Observations
	When depths of over 15cm occur in association with strong winds, serious drifting can occur and can cause widespread travel disruption where this occurs on transport routes.	

Future Baseline

7.6.12 The *UKCP18* projections provide the future baseline of how global climate change is likely to affect the study area, relative to the existing (historic) baseline conditions from 1981-2010.

7.6.13 All future climate projections for the UK indicate an increased likelihood of warmer, wetter winters and hotter, drier summers, in addition to an increase in the frequency of extreme weather. Near surface wind speeds over the UK are also projected to increase for the second half of the 21st century[48].

7.6.14 Two sources of information are used to describe the future climate within which the project will operate and to determine the likely climate hazards and their significance within the CCR assessment:

- *UKCP18* probabilistic projections of climate change - the median (50th percentile) change in average climate conditions for the RCP8.5 scenario (shown in Table 7-8: Synopsis of historical climate observations for the North West and North East England regional climate zones).
- *UKCP18* regional projections of climate change[36] - changes in extreme weather events for the RCP8.5 scenario (shown in Table 7-9: UKCP18 climate change projections for average climate variables for the four 25km grid squares intersected by the project. Projections reflect the RCP 8.5 high emissions scenario for the period of operation (2080s) [36,

UKCP18 probabilistic projections

7.6.15 Both summer and winter temperatures are projected to increase due to climate change. The largest increases in temperature are projected to be in the mean daily maximum summer temperatures, which are projected to increase by between 4.5°C and 4.7°C in the 2080s across the extent of the project, relative to the 1981-2010 baseline, for the high (RCP 8.5) emissions scenario.

7.6.16 Mean precipitation rates in the area surrounding the project are anticipated to change significantly throughout the next century. Winter precipitation rates are projected to increase by between 8% and 16% for the 2080s. Summer precipitation rate is projected to decrease by between 22% and 27% for the 2080s, relative to the 1981-2010 baseline, for the high (RCP 8.5) emissions scenario.

UKCP18 regional projections

7.6.17 The mean number of hot days per year, taken to be when the maximum temperature exceeds 25°C, is anticipated to increase by between 15 and 33 days compared to the existing (historic) baseline, up to a maximum of 85 days (seen on the grid squares covering the M6 Junction 40 Penrith to Kemplay Bank, and Penrith to Temple Sowerby schemes), as shown in Image 7 1: UKCP18 probabilistic data is provided in

[48] There is some uncertainty about climatic changes with regards to wind over the 21st century. Further information on these uncertainties and the approach taken within this chapter are set out in Appendix 7.3.

25km grid squares. This map shows the grid squares that are intersected by the A66 route. The mean number of cold days per year, when the mean daily temperature falls below 0°C is anticipated to decrease by between 39 and 60 days when compared to the baseline.

7.6.18 In the case of extreme precipitation, the mean number of days with heavy rainfall (defined by the Met Office as precipitation greater than 25mm/day) in a given year is expected to increase by between 0.1 and 2.3 days, up to a maximum of 6.3 days (seen on the grid squares 2 and 3 in Image 7-1, covering the Appleby to Brough scheme). Similarly, the mean number of dry spells in a given year, defined as periods of at least ten consecutive days with no precipitation, is anticipated to increase by between 0.4 and 0.7 days, to a maximum of 3.5 days per year (for the grid square 4, covering the Stephen Bank to Carkin Moor scheme).

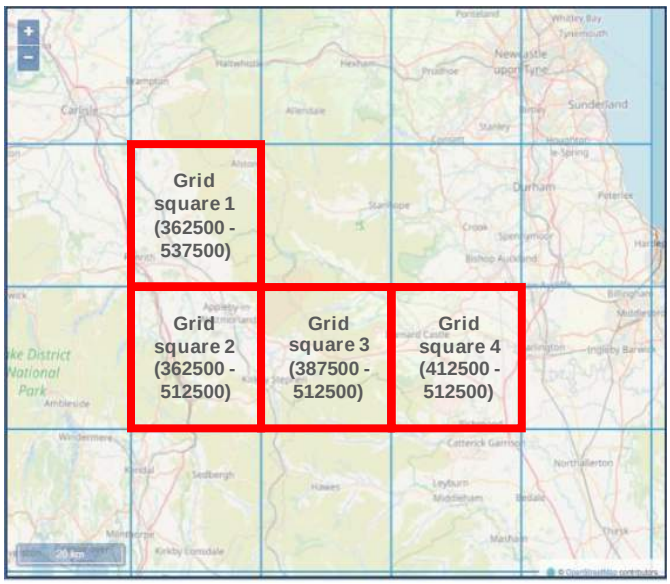

Image 7-1: UKCP18 probabilistic data is provided in 25km grid squares. This map shows the grid squares that are intersected by the A66 route.

Table 7-9: UKCP18 climate change projections for average climate variables for the four 25km grid squares intersected by the project. Projections reflect the RCP 8.5 high emissions scenario for the period of operation (2080s) [36,49]

Parameter		Grid Square 1		Grid Square 2		Grid Square 3		Grid Square 4	
		Baseline (1981-2010)	2080s (2070-2099)	Baseline (1981-2010)	2080s (2070-2099)	Baseline (1981-2010)	2080s (2070-2099)	Baseline (1981-2010)	2080s (2070-2099)
Temperature (°C)	Mean winter daily temperature	2.4	5.4	2.9	6.0	2.1	5.2	3.2	6.2
	Mean summer daily temperature	12.8	16.9	13.3	17.5	12.6	16.7	13.8	18.1
	Mean daily winter minimum temperature	-0.5	2.4	0.1	3.0	-0.5	2.5	0.1	2.9
	Mean daily summer maximum temperature	16.8	21.4	17.4	21.9	16.3	20.9	18.5	23.2
Precipitation rate (mm/day)	Winter mean precipitation rate	4.0	4.3	5.2	5.7	4.5	4.8	2.5	2.9
	Summer mean precipitation rate	2.9	2.3	3.0	2.2	2.8	2.2	2.1	1.5

[49] UKCP18 probabilistic projection data is provided in 25km grid squares. The project intersects four of these grid squares:
Grid square 1 projections cover the M6 Junction 40 to Kemplay Bank scheme; Penrith to Temple Sowerby scheme; and, the western part of the Temple Sowerby to Appleby scheme
Grid square 2 projections cover the eastern part of the Temple Sowerby to Appleby scheme and the Appleby to Brough scheme
Grid square 3 projections cover the Bowes Bypass scheme
Grid square 4 projections cover the Cross Lanes to Rokeby, Stephen Bank to Carkin Moor and A1(M) Junction 53 Scotch Corner schemes

Table 7-10: UKCP18 climate change projections[36] for extreme weather events for the local area (12km grid square) surrounding each scheme within the project[50]

Parameter		Sch. 1 and 2		Sch. 3		Sch. 4		Sch. 5 and 6		Sch. 7		Sch. 8	
		Baseline (1981-2010)	2060s (2050-2079)	Baseline (1981-2010)	2060s (2050-2079)	Baseline (1981-2010)	2060s (2050-2079)	Baseline (1981-2010)	2060s (2050-2079)	Baseline (1981-2010)	2060s (2050-2079)	Baseline (1981-2010)	2060s (2050-2079)
Temperature	Number of frost days (daily minimum temperature equal or lower than 0°C)	66.5	21.7	66.1	18.5	60.9	11.4	82.0	32.4	70.9	26.3	56.6	17.4
	Heatwaves (2 days with maximum temperature higher than 29°C and minimum temperature higher than 15°C)	3.4	5.6	2.7	4.5	2.7	4.1	2.0	3.7	4.5	7.2	5.9	9.5
	Number of hot days (daily maximum temperature higher than 25°C)	66.5	84.6	26.9	43.5	25.1	39.6	22.2	40.5	38.8	65.4	46.3	79.6
Precipitation	Dry spells (10 days or more with no precipitation)	2.8	3.3	2.5	2.9	2.7	3.1	2.0	2.5	2.9	3.5	2.8	3.5
	Heavy rain (number of days per year when precipitation is greater than 25mm per day (Met Office definition of 'heavy rain')	5.6	5.9	2.2	4.0	4.0	6.3	3.5	4.2	1.8	2.2	1.4	1.5

[50] All projections reflect the RCP8.5 high emissions scenario for the 2060s (this reflects the period for 2060-2079 as the Met Office do not currently provide data beyond 2079 for these parameters). 'Sch. 1' refers to M6 Junction 40 to Kemplay Bank. 'Sch. 2' refers to Penrith to Temple Sowerby. 'Sch. 3' refers to Temple Sowerby to Appleby. 'Sch. 4' refers to Appleby to Brough. 'Sch. 5' refers to Bowes Bypass. 'Sch. 6' refers to Cross Lanes to Rokeby. 'Sch. 7' refers to Stephen Bank to Carkin Moor. 'Sch. 8' refers to A1(M) Junction 53 Scotch Corner.

7.7 Potential Impacts

Impact of the project on climate (GHG emissions assessment)

Construction

7.7.1 As set out in Chapter 2: The Project section 2.7, construction works are expected to commence in 2024, with all schemes targeted for a 2029 completion or sooner depending on traffic management interface challenges.

7.7.2 The potential sources of GHG emissions during the construction work phase of the project are listed in Table 7-11: Potential sources of GHG emissions during construction.

Table 7-11: Potential sources of GHG emissions during construction

Sub-stage of Life Cycle	Potential Sources of GHG Emissions
Product stage; including raw material supply, transport and manufacture	Embodied GHG emissions associated with the required raw materials. Vehicle emissions for transportation prior to factory gate. Industrial and energy emissions in the manufacture of materials.
Construction process stage: including transport to and from works site as well as construction and installation processes	Vehicle emissions for transportation of materials to site. Energy use in construction processes.
Land use change	GHG emissions mobilised from vegetation or soil loss/degradation during construction phase.

Operation

7.7.3 The design lifetime of the project is assumed to be 60 years for the purpose of quantifying emissions for this assessment, in line with the assumption used for the CCR assessment. The assumed opening year is 2031 and design year is 2045 (15 years after opening).

7.7.4 The potential sources of GHG emissions and sequestration during the operation phase are listed in Table 7-12: Potential sources of GHG emissions during operation.

Table 7-12: Potential sources of GHG emissions during operation

Sub-stage of Life Cycle	Potential Sources of GHG Emissions
Use of the infrastructure by the end-user (road users)	Emissions from vehicles using highway infrastructure
Operation and maintenance (including repair, replacement and refurbishment)	Energy consumption for infrastructure operation and activities of organisations conducting routine maintenance including extraction, manufacture, transportation and installation energy use.
Land use and forestry	Ongoing land use GHG emissions and sequestration each year during the lifetime of the infrastructure.

Vulnerability of the project to climate change (CCR assessment)

7.7.5 During the operational phase of the project, there is potential for the changing climate and more frequent severe weather events to impact on the project in the medium to longer-term.

7.7.6 A summary of the potential impacts on the project from weather events that may affect the study area is presented in Table 7-13: Summary of weather events and the potential impacts on the project.

7.7.7 Details of the risk assessment, including the potential impacts assessed for the project can be found in Appendix 7.3: CCR Assessment.

Table 7-13: Summary of weather events and the potential impacts on the project

Primary Weather Event	Potential Impacts
Heavy rain and flooding	Raised river levels, flooded drains, collapsed culverts Road closures Danger to road users from reduced grip on the road surface Contaminated water Fallen trees Water scour causing structural damage Weakening or wash out of structural soils Changes in ground water level and soil moisture impacting earthwork stability
High winds and gales	Damage to structures from wind borne debris and power cuts Additional or uneven loading of structures Fallen trees and damage to landscaping Disruption and potential danger to crossing users Road closures Danger to road users from wind borne debris
Increased temperatures and prolonged periods of hot weather	Health impacts from breathing problems and sunstroke Grass and forest fires Stress on structures and technology Challenges from maintenance regimes Danger to road users (e.g. from vehicle breakdown associated with hot weather)
Increased frequency of extreme weather events	Increased requirement for maintenance and repair Increased costs (e.g. associated with increased frequency of maintenance and repair)
Lightning	Structural damage Danger to road users (e.g. from fallen trees blocking the road) Power surge and tripping electricity breakers. Fires Health impacts from direct strikes
Snow and ice	Road closures Danger to road users from reduced grip on the road surface Damage to roads Health impacts from slipping on ice and chest illnesses
Fog	Danger to road users due to reduced visibility

7.8 Design, Mitigation and Enhancement Measures

Impact of the project on climate (GHG emissions assessment)

7.8.1 *DMRB LA 114* requires that *"Projects shall seek to minimise GHG emissions in all cases to contribute to the UK's target for net reduction in carbon emissions".*

7.8.2 Minimising GHG emissions through design is also a core principle of the UK Government's Infrastructure Carbon Review (H.M. Treasury, 2013)[51] and *PAS 2080*.

7.8.3 The *NPSNN* requires that the project design should provide *"evidence of appropriate mitigation measures (incorporating engineering plans on configuration, layout, and use of materials) in both design and construction. The Secretary of State will consider the effectiveness of such mitigation measures in order to ensure that, in relation to design and construction, the carbon footprint is not unnecessarily high. The Secretary of State's view of the adequacy of the mitigation measures relating to design and construction will be a material factor in the decision-making process"*.

7.8.4 As the project progresses through design, GHG mitigation and enhancement measures will be considered and incorporated where beneficial. This preliminary assessment presents information on GHG mitigation available at the time of assessment, including in relation to different options being considered. A list of mitigation and enhancement measures that have been considered by the project design can be found in Appendix 7.2: Climate Mitigation.

7.8.5 Appendix 7.2: Climate Mitigation also presents a list of GHG mitigation opportunities that will be considered by the project as it progresses through design, to further minimise GHG emissions.

7.8.6 GHG mitigation and enhancement measures will be assessed further within the GHG emissions assessment in the ES. This will include consideration of how measures set out within the recently published Net Zero Highways: 2030/2040/2050 plan (Highways England, 2021) [52] and the Department for Transport's Transport Decarbonisation Plan[53] can contribute to and inform the mitigation of GHG emissions from the project.

Vulnerability of the project to climate change (CCR assessment)

7.8.7 Many general mitigation and adaptation measures to address CCR risks have been considered within the project to date and embedded into the current design. Many of these measures relate to impacts associated with other topic chapters and so have been identified within the relevant topic chapters of the PEI Report. For example, water management and addressing drainage issues relating to flooding are considered in Chapter 14: Road Drainage and the Water Environment, as well as through the scheme design process, led by the design teams.

[51] H.M. Treasury (2013) Infrastructure Carbon Review, available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/260710/infrastructure_carbon_review_251113.pdf [accessed 19 July 21]
[52] Highways England (2021) Net zero highways: our 2030/2040/2050 plan, available from: https://highwaysengland.co.uk/media/eispcjem/net-zero-highways-our-2030-2040-2050-plan.pdf [Accessed 16 August 2021]
[53] Department for Transport (2021) Transport decarbonisation plan, available from: https://www.gov.uk/government/publications/transport-decarbonisation-plan [Accessed 16 August 2021]

7.8.8 The CCR assessment identifies and takes into account existing resilience measures (embedded mitigation) for each climate variable where these are either already in place or identified as being included within the design development by the design teams.

7.8.9 The project will be designed to be resilient to impacts arising from weather events and climatic conditions in accordance with current planning, design and engineering practice, standards and codes. The climate assessment assumes that design and engineering practice standards and codes incorporate conservative assumptions of future climatic conditions, as guided by UKCP18, and that these are being used in the design process, particularly for safety critical assets[54].

7.8.10 Most weather and climate-related resilience effects during operation are expected to be mitigated through measures embedded in the design of the project as a result of meeting current planning, design and engineering practice and codes. It is expected that these practices and codes will provide effective resilience throughout the operational phase of the project (for the study period of a 60year project lifetime).

7.8.11 The embedded mitigation measures considered by the CCR assessment are set out in Appendix 7.2: Climate Mitigation.

7.8.12 To provide mitigation for increases in peak rainfall events and peak flows in watercourses as a result of climate change, and which might result in higher risk of flooding, a flood risk assessment (FRA) for the project is being delivered as part of Chapter 14: Road Drainage and the Water Environment, which will be presented in the ES (see paragraph 7.3.34).

7.8.13 The FRA will take into account Environment Agency allowances[37] for increases in rainfall intensity and peak river flow in a future changed climate and considers the increased future risk from both pluvial and fluvial flooding.

7.8.14 The assessment of the likely significant effects identifies three significant risks. It has then considered how implementing additional proposed future mitigation could reduce the likelihood and consequence of the significant risks identified, such that they are not significant.

7.8.15 Further assessment of the resilience of the project to future climate impacts will be conducted in the ES.

7.9 Assessment of the Likely Significant Effects

Impact of the project on climate (GHG emissions assessment)

7.9.1 *DMRB LA 114* guides that the assessment of projects on climate shall only report significant effects where increases in GHG emissions will have a material impact on the ability of Government to meet its carbon reduction targets.

7.9.2 The *NPSNN* also states that "*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".*

7.9.3 This preliminary assessment presents a high-level breakdown of the emissions calculated for the project and a comparison against UK Government carbon budgets to determine the significance of emissions.

[54] For example CG 501 Design of highway drainage systems: Section 4 makes reference to climate change; and DMRB CD 622 Managing Geotechnical Risk specifies that degradation of material parameters with respect to climate change is accounted for during design, and that the Geotechnical Design Report accounts for future climate change scenarios for drainage and flooding.

7.9.4 The quantification presented in this section is a high level indication of GHG emissions based upon information available at the time of the preliminary assessment. The assessment will be refined for the ES as the project design develops and updated design data, and traffic and air quality modelling data become available.

7.9.5 Therefore, the GHG emissions reported in this section of the PEI Report are intended for use to indicate the potential magnitude of GHG emissions from the project. It should be noted that the Construction Method Statement[55], which provides more indicative detail about how construction might be expected to be implemented, was prepared after this preliminary assessment was completed. It will continue to be developed and will inform the ES.

7.9.6 The assumptions and limitations associated with the preliminary assessment are listed in Appendix 7.1: GHG Emissions Assessment.

Construction

7.9.7 A summary of construction emissions from various sources of GHG emissions associated with the construction phase of the project is provided in Appendix 7.1: GHG Emissions Assessment.

7.9.8 Due to the assessment methodology including consideration of alternative alignments for some schemes the preliminary assessment of total project-wide construction phase GHG emissions is presented as a range.

7.9.9 It is anticipated that a single preferred alignment will be selected as part of the next phase of project development. Therefore, the ES Climate assessment will present a single quantification of GHG emissions associated with the project.

7.9.10 Total project-wide emissions associated with construction are estimated to be 905,588tCO_2e –1,400,052tCO_2e (depending on the alignment being considered).

7.9.11 The largest source of emissions during the construction phase of the project is expected to arise from construction materials, including sourcing, processing and manufacture.

Operation

7.9.12 Due to the assessment methodology including consideration of alternative alignments for some schemes, the preliminary assessment of total project-wide operational phase GHG emissions is presented as a range.

7.9.13 Total project-wide GHG emissions over the 60year assumed project lifetime associated with maintenance and refurbishment of the project are estimated to be 62,209tCO_2e–66,649tCO_2e (depending on the alignment being considered).

7.9.14 Project-wide user emissions associated with vehicles using the highways infrastructure, for the ARN and as defined by the traffic model and *DMRB LA 114* screening criteria, are presented in Table 7-14: Project-wide emissions associated with vehicles using the highways infrastructure[56].

[55] Construction Method Statement, available as part of the consultation materials at: http://www.highwaysengland.co.uk/A66-NTP

[56] The assessment of user emissions is based on considering traffic volumes for the ARN. Consideration of the long-term future emissions will require assumptions to be made on likely changes to the future efficiency and carbon intensity of road vehicles, informed by modelled projections. The ARN was determined based on the regional screening criteria set out in *DMRB LA*

7.9.15 The total project-wide road user emissions over the 60 year assumed project lifetime under the 'Do something' scenario are estimated to be 16,046,781tCO_2e. This would represent an additional (net increase of) 2,919,394tCO_2e (22%) in road user emissions against the 'Do-minimum' scenario (13,127,387tCO_2e).

7.9.16 For the design (future) year (2046), the total project-wide emissions under the 'Do something' scenario are estimated to be 260,283tCO_2e. This would represent an additional (net increase of) 46,891tCO_2e (22%) against the 'Do-minimum' scenario (213,392tCO_2e).

114. Emissions were taken from *DMRB LA 105* screening tool, which are based on the EFT v10 emission factors. For the forecast year emission factors for 2030 have been held constant. This assumption would result in a conservative estimate of emissions as the transition to low emission vehicles is anticipated to further progress beyond 2030. It is anticipated that this will be refined during ES through the use of WebTAG values, to refine traffic modelling to better reflect the transition to low emission vehicles beyond 2030. EFT v10: Department for Environment, Food and Rural Affairs (Defra), 2021. Emissions Factor Toolkit, available from: https://laqm.defra.gov.uk/review-and-assessment/tools/emissions-factors-toolkit.html [accessed 11 August 21]

Table 7-14: Project-wide emissions associated with vehicles using the highways infrastructure

	Estimated total emissions - over the 60 year assumed project lifetime (tCO_2e)			Estimated total emissions - modelled design (future) year (2046) (tCO_2e) (tCO_2e)		
	Estimated total emissions (tCO_2e) ('Do something' scenario)	Estimated total emissions (tCO_2e) ('Do-minimum scenario)	Additional (net) CO_2 project GHG emissions (tCO_2e) ('Do something' scenario minus the 'Do-minimum' scenario)	Estimated total emissions (tCO_2e) ('Do-something' scenario)	Estimated total emissions (tCO_2e) ('Do-minimum scenario)	Additional (net) CO_2 project GHG emissions (tCO_2e) ('Do something' scenario minus the 'Do-minimum' scenario)
Vehicles using the highways infrastructure	16,046,781	13,127,387	2,919,394	260,283	213,392	46,891

7.9.17 For the modelled design (future) year (2046) project-wide operational GHG emissions are anticipated to result in an additional (net increase of) 47,928–48,002tCO_2e in 2046 ('Do something' scenario minus the 'Do-minimum' scenario).

7.9.18 The total net project-wide operational GHG emissions ('Do-something' scenario minus the 'Do-minimum' scenario) plus the estimated maintenance and refurbishment emissions are estimated to result in an additional (net increase of) 2,981,603–2,986,043tCO_2e over the 60year assumed project lifetime associated with the project.

Evaluation of significance

7.9.19 The construction phase of the project is planned to start in 2024 with all schemes targeted for completion in 2029 and giving an opening year of 2029 for the operational phase[57]. Total construction phase GHG emissions have been assessed against the UK's Fourth (2023-2027) and Fifth Carbon Budgets (2028-2032) respectively.

7.9.20 The total estimated construction phase GHG emissions would represent 0.05%-0.07% of the Fourth Carbon Budget and 0.05%-0.08% of the Fifth Carbon Budget, respectively.

7.9.21 Total operational phase emissions have been assessed against the Sixth Carbon Budget, to provide a reasonable worst case assessment using information currently available on carbon budgets (as the Carbon Budget set furthest into the operational phase). The estimated operational phase GHG emissions would represent 0.3% of the Sixth Carbon Budget.

7.9.22 Table 7-15: Comparison of emissions against UK Carbon Budgets shows the GHG emissions of each project stage against to relevant *UK Carbon Budgets* against.

Table 7-15: Comparison of emissions against UK Carbon Budgets

Project stage	Estimated total GHG emissions over carbon budget (tCO_2e) ('Do-something' Scenario)[58]	Net CO_2 project GHG emissions (tCO_2e) (Do something -Do-minimum)[59]-Do minimum)[60]	Relevant carbon budget[61]		
			4th	5th	6th
Construction	905,588 – 1,400,052		0.05% - 0.07%	0.05% - 0.08%	
Operation	16,046,781	2,981,603 – 2,986,043			0.3%
Total	**16,952,369 – 17,446,833**	**2,981,603 – 2,986,043**	**0.05% - 0.07%**	**0.05% - 0.08%**	**0.3%**

[57] Noting the acknowledged limitation of traffic modelling data having an opening year of 2031, as outlined in paragraph 7.3.12.
[58] Figures presented are the total GHG emissions for construction of the project and the operation of the project over the assumed 60-year lifetime.
[59] Figures presented are the total net GHG emissions the operation of the project over the assumed 60-year lifetime.
[60] Figures presented are the total net GHG emissions the operation of the project over the assumed 60-year lifetime.
[61] Figures presented compare the total GHG emissions for construction of the project and the operation of the project over the assumed 60-year lifetime, against the relevant carbon budget(s).

7.9.23 The total construction phase emissions are estimated to be 905,588–1,400,052tCO2e. This would represent 0.05%-0.07% of the Fourth Carbon Budget or 0.05%-0.08% of the Fifth Carbon Budget, respectively.

7.9.24 The total net operational emissions are estimated to be 2,981,603–2,986,043tCO2e over the assumed 60-year lifetime of the project. This would represent 0.3% of the Sixth Carbon Budget.

7.9.25 The analysis following DMRB LA114 shows that emissions from the project to be low when compared in isolation against the Carbon Budget. As set out by *DMRB LA 114* and in line with the *NPSNN*, the assessment concludes that the project's estimated GHG emissions, in isolation will not have a significant effect on climate or a material impact on the ability of the Government to meet its carbon reduction plan targets and Carbon Budgets.

Vulnerability of the project to climate change (CCR assessment)

Project-wide assessment

7.9.26 Risks associated with climate change for the operational phase of the project have been identified and assessed for their likelihood and consequence to evaluate the significance, utilising information on the future baseline (drawn from the *UKCP18* probabilistic projections of climate change and the *UKCP18* regional projections of climate change).

7.9.27 Risks have been assessed on a project-wide basis, highlighting which schemes they are relevant to.

7.9.28 Appendix 7.3: CCR Assessment sets out further details on the risks identified, the schemes they are relevant to, the likelihood and consequence assigned to each risk and embedded mitigation considered within the assessment, which informed the assessment.

Analysis of CCR risks

7.9.29 The preliminary assessment has found that most climate change risks during the operational phase of the project are 'not significant' due to effective embedded mitigation measures in the existing project design or through monitoring and maintenance regimes assumed to be in place throughout operation.

7.9.30 With regards to flood risk, there are specific schemes and locations where the risk of flooding is high. These schemes and locations are:

- Temple Sowerby to Appleby – Trout Beck, which the Temple Sowerby to Appleby scheme crosses, has a wide floodplain area that is prone to flooding. The project will cross the floodplain. Alternative route alignments are being considered for this scheme within the PEI Report. The route chosen will need to be designed to mitigate against the risk of operational disruption from flooding.
- Appleby to Brough – The scheme, near Warcop, also crosses a floodplain. Compensatory floodwater storage areas will be established to mitigate flood risk and, depending on which route alignment is selected, the route will either be elevated on an embankment, or additional drainage capacity will be added to mitigate the risk.
- Bowes Bypass – A section of the eastbound carriageway within the Bowes Bypass scheme is in an area that has experienced historic flooding events (anecdotally from the design teams). The new route will remove the existing ditch that protects the current A66 from flooding. Land for flood compensation has been included within the draft DCO boundary for compensatory flood water storage. The design

team will add compensatory storage to the design if the flood risk assessment, which will incorporate climate change scenarios, suggests it is required.

7.9.31 The proposed design mitigation measures to be introduced to address flood risk are considered to address the risks that may arise at these locations and so the assessment has concluded that the residual risk from flooding in these locations is 'not significant'.

7.9.32 Three climate change risks have been assessed as significant:

- **Increased surface run-off resulting in scouring of embankments and cuttings, leading to earthworks failure** - The risk of scouring of embankments and cuttings from surface run-off was identified as a potential significant risk by the geotechnical team. This will be mitigated further during detailed design by identifying areas of high risk and implementing run-off defences such as masonry gullies. Future monitoring of embankments and cuttings during storm events will also help to identify any area for which additional run-off defences are required.
- **Extended periods of hot dry weather leading to a risk of spontaneous grassland fires in the vicinity of the route, affecting safety on the road** - Wildfires typically occur at the urban-rural interface (Philosophical Transactions of the Royal Society B: Biological Sciences, 2016)[62]. The national climate change risk assessment (Department for Environment, Food & Rural Affairs, 2021)[63] identified an increased frequency of wildfires as a key risk from climate change. The risk should be closely monitored throughout the operation of the road and an increased frequency of wildfires in the vicinity of the road should prompt an active collaboration between Highways England, landowners and land managers to install proactive, preventative measures to reduce the likelihood of wildfires occurring**.**
- **Flooding of the road surface (within the Kemplay Bank Underpass)** - The M6 Junction 40 to Kemplay Bank scheme consists mainly of an underpass, taking the main carriageway of the project underneath Kemplay Bank. If this underpass was to flood it has the potential to cause short-term regional disruption through closure of the road (A66). The geometry of the road within the underpass has the potential to create low spots or sags in the road surface where water could pond during storm events.

7.9.33 Table 7-16: Significant risks identified within the CCR assessment outlines these three risks identified as significant in the preliminary assessment. It also shows: the embedded mitigation considered in the assessment; the likelihood and consequence of each risk; and the schemes for which the risk is applicable.

[62] Philosophical Transactions of the Royal Society B: Biological Sciences (2016) Wildfire policy and management in England: an evolving response from Fire and Rescue Services, forestry and cross-sector groups, available at: https://royalsocietypublishing.org/doi/10.1098/rstb.2015.0341 [accessed 28 July 2021]

[63] Department for Environment, Food & Rural Affairs (2012) UK Climate Change Risk Assessment: Government Report, available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/69487/pb13698-climate-risk-assessment.pdf [accessed 28 July 2021]

Table 7-16: Significant risks identified within the CCR assessment

Potential Climate Change Risk to the Project	Existing or Embedded Mitigation Measure	Likelihood	Consequence	Schemes for Which Risk is Significant
Increased surface run-off resulting in scouring of embankments and cuttings, leading to earthworks failure	Attenuation ponds are designed for a 1/100 year event +20% allowance for climate change. A sensitivity test will also be performed for a +40% climate change allowance. Climate change allowance in critical drainage areas is increased to +40%.	Medium	Large adverse	All schemes
Extended periods of hot dry weathers leading to a risk of spontaneous grassland fires in the vicinity of the route, affecting safety on the road	Highways England 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	Moderate adverse	• Penrith to Temple Sowerby (Center Parcs) • Temple Sowerby to Appleby • Appleby to Brough (Warcop) • Bowes Bypass • Cross Lanes to Rokeby • Stephen Bank to Carkin Moor
Flooding of the road surface within the Kemplay Bank Underpass	In line with drainage design standards, run-off drainage systems will be designed to take into account a 40% increase in peak rainfall intensity by the 2080s. The underpass will be designed to the requirements of *CG 501* (Highways England, 2020b[64] and *CD 521* (Highways England, 2020c)[65] to provide a design	Medium	Moderate adverse	M6 Junction 40 to Kemplay Bank

[64] Highways England (2020b) CG 501 Design of highway drainage systems, available at: https://www.standardsforhighways.co.uk/prod/attachments/ada3a978-b687-4115-9fcf-3648623aaff2 [accessed 28 July 2021]
[65] Highways England (2020c) CG 521 Hydraulic design of road edge surface water channels and outlets, available at: https://www.standardsforhighways.co.uk/prod/attachments/16489700-3598-4122-b14e-151a395e65e1 [accessed 28 July 2021]

Potential Climate Change Risk to the Project	Existing or Embedded Mitigation Measure	Likelihood	Consequence	Schemes for Which Risk is Significant
	to ensure no flooding for a 1:100 year rainfall event.			

7.9.34 The assessment has considered how proposed and future mitigation could reduce the likelihood and consequence of the significant risks identified.

7.9.35 Table 7-17: Proposed future mitigation to mitigate the impact of significant risks to the Project presents the proposed and future mitigation against each of the significant risks.

Table 7-17: Proposed future mitigation to mitigate the impact of significant risks to the Project

Potential Climate Change Risk to the Project	Schemes for Which Risk is Significant	Proposed Future Mitigation
Increased surface run-off resulting in scouring of embankments and cuttings, leading to earthworks failure	All schemes	Areas of high risk will be identified and run-off defences (e.g. masonry gullies) will be built into detailed design by the design teams. Embankments and cuttings will need to be monitored by Highways England to identify any areas where additional run-off defences are required.
Extended periods of hot dry weathers leading to a risk of spontaneous grassland fires in the vicinity of the route, affecting safety on the road	• Penrith to Temple Sowerby (Center Parcs) • Temple Sowerby to Appleby • Appleby to Brough (Warcop) • Bowes Bypass • Cross Lanes to Rokeby • Stephen Bank to Carkin Moor	The occurrence of wildfires in the vicinity of the route will be closely monitored. If the frequency of wildfire events starts to increase, it is proposed that Highways England should engage landowners/land managers to discuss adaptive management techniques to reduce wildfire risk.
Flooding of the road surface within the Kemplay Bank Underpass	M6 Junction 40 to Kemplay Bank	The design will incorporate an exceedance test in the underpass area during detailed flood modelling. Extra storage will be installed to hold exceedance flows if required based on the flood modelling. Detailed modelling results will be incorporated into detailed design and will take into account the run-off from the cuttings in the underpass. Additional drainage mechanisms will be incorporated into the design for steep sections of the road surface where there is a danger of high velocity flow bypassing drainage outlets during storm events.

7.9.36 Table 7-18: Reassessment of significant climate change resilience risks during operation assuming the successful implementation of the proposed future mitigation outlined in Table 7-11 reassesses each of the significant risks, considering the proposed and future mitigation, based upon the assumption that the proposed future mitigation would be incorporated during further design and would be fully implemented successfully.

Table 7-18: Reassessment of significant climate change resilience risks during operation assuming the successful implementation of the proposed future mitigation outlined in Table 7-11

Potential Climate Change Risk to the Project	Likelihood of Occurrence Following Implementation of Proposed Future Mitigation	Consequence Following Implementation of Proposed Future Mitigation	Re-assessment of Significance Following Implementation of Proposed Mitigation
Increased surface run-off resulting in scouring of embankments and cuttings, leading to earthworks failure	Low	Large adverse	Not significant
Extended periods of hot dry weathers leading to a risk of spontaneous grassland fires in the vicinity of the route, affecting safety on the road	Low	Moderate Adverse	Not significant
Flooding of the road surface within the Kemplay Bank Underpass	Low	Moderate Adverse	Not significant

7.9.37 Following the inclusion of the additional mitigation measures, the likelihood and consequence of all climate change risks on the project are considered to be sufficiently reduced to be assessed as not significant.

7.9.38 Therefore, the preliminary assessment concludes no residual significant climate change risks for the project, assuming the identified mitigation is incorporated into the design and operation of the project.

Scheme alternative alignments assessment

7.9.39 Consideration of alternative alignments within individual schemes is presented in a commentary in Appendix 7.3: CCR Assessment to describe where the climate risks of the different alignments may differ to the project-wide assessment, e.g. identifying alignments where risks associated with flooding could be higher. Further information on the alternative alignments can be found in Chapter 2: The Project.

7.9.40 The commentary represents a high-level professional judgement on each alternative alignment. A full CCR assessment will be undertaken once the preferred route and detailed design is known, and will be presented in the ES. Further detail on alternative alignments is set out in Chapter 2: The Project.

7.9.41 For most alternative alignments, the climate risks and significance were considered to be similar to the project-wide assessment (as set out in Appendix 7.3: CCR

Assessment and summarised in this chapter), with the following exceptions and items to note:

- For all schemes' alternative alignments where significant earthworks are a feature of the design, the route wide risks to earthworks structures are particularly important.
- For all scheme alignments where underpasses are a feature of the design or adjacent access roads, the route wide risks of flooding of underpasses are particularly important.
- For the Blue and Red alternatives for the Temple Sowerby to Appleby scheme, the large multi-span bridge structures located within the floodplain are considered to be at risk of scouring due to increased wet weather or floodwaters. Structural design should take account of potential scouring and implement mitigation to address the risk if the alternative is selected.
- The Orange alternative for the Temple Sowerby to Appleby scheme is considered to have a reduced risk of wildfires impacting this alternative due to the more urban setting.
- For the Black alternative for the Appleby to Brough scheme (central section), embankments located within the floodplain are considered to be at risk of erosion and reduced structural stability due to increased wet weather or floodwaters, and changes in pore water pressure. Structural design should take account of potential erosion and pore water pressure impacts and implement mitigation to address the risk if the alternative is selected.
- The Blue alternative for the Appleby to Brough scheme (central section) is considered to be at an elevated risk of impacts of flooding as the road runs at grade (level with the surrounding environment) through a floodplain. Particular attention would need to be given to the results of the flood risk assessment in this area. Additional mitigation is likely to be needed to address the risk if the alternative is selected.
- The Red (Rokeby) junction alternative in the Cross Lanes to Rokeby scheme is considered to be at a reduced risk of flooding against the project-wide assessment as the road surface geometry design maintains overland flow to prevent the potential for ponding within the underpass.

7.10 Monitoring

Impact of the project on climate (GHG emissions assessment)

7.10.1 As no preliminary significant effects have been identified for the GHG emissions assessment, no monitoring of significant effects is expected to be required.

7.10.2 In line with the monitoring requirements set out in *DMRB LA 114*, and to be secured through the EMP, quarterly GHG emission returns during construction and operation shall be reported in accordance with Highways England's requirements. Data provided for the GHG returns shall be evaluated to inform any ongoing monitoring of GHG emissions and feed back into future assessment of projects during design development and planning approval.

7.10.3 The EMP will include a requirement that the mitigation outlined in section 0: Design, Mitigation and Enhancement Measures and Appendix 7.2: Climate Mitigation is monitored to ensure its effective application throughout construction.

7.10.4 As part of the ES, monitoring or adaptive mitigation needed will be further defined, as required.

Vulnerability of the project to climate change (CCR assessment)

7.10.5 Although a detailed CCR assessment has not been taken forward for construction, it is important that the adequacy of resilience measures set out in the EMP are monitored throughout the construction period.

7.10.6 In accordance with the monitoring requirements set out in *DMRB LA 114,* operational asset data will be managed, maintained and monitored to ensure the project is operating as intended with regards to climate resilience. Monitoring and maintenance regimes should be frequently reviewed to respond to actual or predicted climatic changes.

7.10.7 Where a design issue is identified, an assessment will be made to determine whether corrective action is appropriate.

7.10.8 Where corrective action is deemed appropriate, adaptive management measures will be used to improve the resilience of the asset. The additional resilience measures should be monitored after implementation to ensure they have successfully mitigated the risk.

7.10.9 As part of the ES, monitoring or adaptive mitigation needed will be further defined, as required.