A46 Newark Bypass

TR010065/APP/6.1

6.1 Environmental Statement
Chapter 14 Climate

APFP Regulation 5(2)(a)

Planning Act 2008

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

Volume 6

April 2024

Infrastructure Planning

Planning Act 2008

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

A46 Newark Bypass

Development Consent Order 202[x]

ENVIRONMENTAL STATEMENT

CHAPTER 14 CLIMATE

Regulation Number:	Regulation 5(2)(a)
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Contents

14 Climate

14.1 Introduction

14.1.1 This Chapter presents the information required by the Infrastructure Planning (Environmental Impact Assessment) Regulations 2017 (as amended) to be provided in the Environmental Statement (ES) to enable the identification and assessment of likely significant effects on climate.

14.1.2 The Scheme has the potential to cause both adverse and beneficial effects. The climate topic encompasses the following:

- The effects on climate associated with greenhouse gas (GHG) emissions
- The vulnerability of the Scheme to climate change

14.1.3 This assessment considers both construction and operational phase effects and has been prepared in accordance with the Design Manual for Roads and Bridges (DMRB) LA114 - Climate[1] as per National Highways requirement.

14.1.4 This Chapter has been undertaken in compliance with the Planning Inspectorate's Scoping Opinion **(TR010065/APP/6.10)** received for this Scheme. Appendix 4.3 (Scoping Opinion Schedule of Comments and Responses) of the ES Appendices **(TR010065/APP/6.3)** contains further information on how each of the matters raised in the Scoping Opinion have been addressed.

14.1.5 This Chapter presents the results of the identification and assessment of likely significant effects of the Scheme on climate. This Chapter outlines the methodology applied within the assessment and reports the effects on climate associated with GHG emissions. This Chapter also assesses the vulnerability of the Scheme to climate change.

14.1.6 Chapter 2 (The Scheme) of this ES contains a detailed description of the Scheme. The drawings referenced in this Chapter can be found in the ES Figures **(TR010065/APP/6.2)**, and the technical appendices referred to in this Chapter are presented in the ES Appendices **(TR010065/APP/6.3)**.

14.2 Competent expert evidence

14.2.1 The competent expert has a master's level degree in Environmental Science, is a Chartered Environmentalist and full member of the

[1] National Highways (2021) DMRB LA 114 version 0.0.1 (June 2021) – Climate, Revision 0 [online] available at: d1ec82f3-834b-4d5f-89c6-d7d7d299dce0 (standardsforhighways.co.uk) (last accessed January 2023).

Institute of Environmental Management and Assessment. The competent expert has 23 years' experience in the field of environmental impact assessment and climate change, including the preparation of ES chapters as part of Development Consent Order (DCO) applications for other road schemes.

14.3 Legislative and policy framework

14.3.1 The principal legislation and planning context for the assessment of the environmental effects of the Scheme on climate and the resilience of the Scheme to climate is presented below. The relevant legislation and policies listed below have been taken account of in the assessment.

International Legislation

14.3.2 Relevant international law has been considered in accordance with the Planning Act section 104(4), which states the Secretary of State is to determine the Development Consent Order (DCO) in accordance with the National Policy Statement for National Networks (NPSNN) unless the Secretary of State is satisfied that deciding the application in accordance with any relevant national policy statement would lead to the United Kingdom being in breach of any of its international obligations.

United Nations Framework Convention on Climate Change (UNFCCC)[2]

14.3.3 Signed in 1992, the UNFCCC is the foundational treaty that has provided a basis for international climate negotiations since it was established, including landmark agreements such as the Kyoto Protocol (1997) and the Paris Agreement (2015). The Convention has been ratified by 197 states who have committed to act on climate change and regularly report on their progress.

14.3.4 The key objective of the Convention was the "*stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system"* within a timeframe that allows people and planet to adapt and economies to develop sustainably.

Kyoto Protocol[3] (1997)

14.3.5 With 192 signatories currently, the Kyoto Protocol was adopted on 11 December 1997, and it entered into force on 16 February 2005 and ran till 2015, before being superseded by the Paris Agreement (2015). The objective of the Kyoto Protocol was to operationalise the

[2] United Nations Framework Convention on Climate Change Handbook (October 2006); Available at - [redacted]

[3] What is Kyoto Protocol (UNFCCC Website)? What is the Kyoto Protocol? | UNFCCC

UNFCCC by committing industrialised countries and economies in transition to limit and reduce greenhouse gas (GHG) emissions in accordance with agreed individual targets. The Convention itself only asks those countries to adopt policies and measures on mitigation and to report periodically.

Paris Agreement[4] (2015)

14.3.6 The Paris Agreement is a legally binding international treaty on climate change. It was adopted by 196 Parties at the UN Climate Change Conference (COP21) in Paris, France, on 12 December 2015. It entered into force on 4 November 2016.

14.3.7 Its overarching goal is to hold "the increase in the global average temperature to well below 2°C above pre-industrial levels" and pursue efforts "to limit the temperature increase to 1.5°C above pre-industrial levels." The Paris Agreement is a landmark in the multilateral climate change process because, for the first time, a binding agreement brings all nations together to combat climate change and adapt to its effects.

14.3.8 In December 2020, the United Kingdom of Great Britain and Northern Ireland (the UK) communicated its Nationally Determined Contribution (NDC) to the UNFCCC in line with Article 4 of the Paris Agreement. In its NDC, the UK commits to reducing economy-wide greenhouse gas emissions by at least 68% by 2030, compared to 1990 levels. This has been further strengthened and detailed since the COP26 in Glasgow.

National Legislation

Climate Change Act 2008, (as amended)

14.3.9 On 27 June 2019 the United Kingdom (UK) Government amended the Climate Change Act 2008 and it imposes a duty on the Secretary of State as to the level of the "net UK carbon account" (the amount of net UK emissions of targeted greenhouse gases for a period adjusted by the amount of carbon units credited or debited to the account) for the year 2050. The duty is to ensure that the net UK carbon account is lower than the "1990 baseline". This seeks to align with the Paris Agreement which provides an international framework to keep global warming well below 2°C, pursuing efforts to limit the temperature increase to 1.5°C. In October 2021 the UK Government released its net-zero strategy, further outlining how this reduction is to be achieved. The Climate Change Act creates a new approach to managing and responding to climate change in the UK, by:

a) Setting ambitious, legally binding emission reduction targets.

b) Giving powers to help meet those targets.

[4] UNFCCC- What is the Paris Agreement? The Paris Agreement | UNFCCC

c) Strengthening the institutional framework.

d) Enhancing the UK's ability to adapt to the impact of climate change.

e) Establishing clear and regular accountability to the UK Parliament and to the devolved legislatures[5].

14.3.10 The Climate Change Act also establishes a framework to deliver on the requirements of adapting to climate change. As set out in the Climate Change Act, the UK Government is required to assess the risks and opportunities from climate change for the UK and to adapt to them. The Act also established the Committee on Climate Change to advise Government on climate change risk and assess adaptation progress. The UK Government is also required to produce a UK Climate Change Risk Assessment (CCRA) every five years, which assesses current and future risks to the UK from climate change, including national summaries for the devolved administrations. Following publication of the CCRA, the Climate Change Act requires the UK Government to produce a National Adaptation Programme.

14.3.11 The UK has in place carbon budgets for 5-year periods up to 2037 see Table 14-1. The Secretary of State has a duty to ensure that the net UK carbon account for a budgetary period does not exceed the carbon budget. The UK is currently in the third carbon budgetary period (2018-2022), the budget for which is 2,544 $MtCO_2e$ net. t. The carbon budget for the 2023 to 2027 budgetary period is 1,950 $MtCO_2e$, and the budget for 2028 to 2032 is 1,725 $MtCO_2e$. The sixth carbon budget requires a 63% reduction in emissions from 2019 to 2035 (78% relative to 1990)[6] Whilst budgets are not set beyond this, there is a legal requirement for the UK to reach 0 $MtCO_2e$ by 2050.[7]

Table 14-1: UK carbon budgets

Carbon budgets	Carbon budget level ($MtCO_2e$)	Reduction below 1990 levels
Third Carbon Budget (2018-2022)	2,544	36% by 2020
Fourth Carbon Budget (2023-2027)	1,950	51% by 2025
Fifth Carbon Budget (2028-2032)	1,725	57% by 2030
Sixth Carbon Budget (2033-2037)	965	78% by 2035

Source: The Carbon Budget Order 2021

[5] DECC (2012) Climate Change Act 2008.

[6] UK Parliament (2021) *The Carbon Budget Order 2021* available at https://www.legislation.gov.uk/uksi/2021/750/contents/made.

[7] UK Parliament (2012), *Climate Change Act 2008* available at: Climate Change Act 2008 (legislation.gov.uk).

National policy

National Policy Statement for National Networks

14.3.12 The National Policy Statement for National Networks (NPSNN) sets out the policy which the Scheme should comply with. It is also the basis for informing a judgement on the impacts of the Scheme, for example whether it is consistent with the requirements of the NPSNN. Compliance of the Scheme with the NPSNN is detailed within the NPSNN Accordance Table **(TR010065/APP/7.2)**.

14.3.13 A draft NPSNN was published for consultation in March 2023. The consultation period ended in June 2023. The draft NPSNN may be subject to change following the consultation and once published in its designated form. Although this is currently in draft it may still be an important consideration for the Secretary of State for Transport when determining whether to consent the DCO for this Scheme. Accordingly, the Draft NPSNN Accordance Tables **(TR010065/APP/7.3)** summarise compliance of the Scheme with the draft NPSNN.

14.3.14 The policies of relevance to climate within the current NPSNN and detail on how they have been addressed in the assessment are provided below.

14.3.15 The NPSNN Paragraph 4.43 requires *'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'.*

14.3.16 Paragraph 5.17 of the NPSNN advises on an applicant's assessment of carbon emissions and states that *'it is very unlikely that the impact of a road project will, in isolation, affect the ability of Government to meet the targets of its carbon reduction target plan.'* However, the paragraph goes on to say that applicants should provide evidence of the carbon impact of the *'project'* and an assessment against the Government's carbon budgets.

14.3.17 Paragraph 5.18 of the NPSNN advises on decision making. It refers to the range of non-planning policies that, subject to the unlikely event of a road scheme in isolation affecting the Government's ability to meet its carbon reduction plan targets, will ensure any carbon increases from road developments do not compromise its overall carbon reduction commitments. It advises that any increase in carbon emissions is not a reason to refuse development consent, unless the increase in carbon emissions resulting from a proposed scheme are so significant that it would have a material impact on the ability of the Government to meet its carbon reduction targets.

14.3.18 Paragraph 5.19 of the NPSNN outlines the need for appropriate mitigation measures to be implemented in both design and construction. The effectiveness of such mitigation will be considered

by the Secretary of State for Transport in order to ensure that, in relation to design and construction, the carbon footprint is not unnecessarily high with the adequacy of the measures constituting a material factor in the decision-making process.

14.3.19 The climate change adaptation section in the NPSNN sets out how the NPSNN puts Government policy on climate change adaptation into practice, and in particular how applicants and the Secretary of State for Transport should take the effects of climate change into account when developing and consenting infrastructure.

14.3.20 Paragraph 4.38 of the NPSNN necessitates the need to deal with the potential impacts of climate change. It states that 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.

14.3.21 The Government has published a set of UK Climate Projections and has developed a statutory National Adaptation Programme. In addition, the Government's Adaptation Reporting Power will invite reporting authorities to build on their climate change risk assessments and report on progress implementing adaptation actions.

Department for Transport: Decarbonising Transport – setting the challenge (2020)[8]

14.3.22 The document presents transport modes and their current GHG emissions, the existing strategies and the policies already in place to deliver against current targets. It covers the projected trajectory of the forecast GHG emissions from transport to the fifth carbon budget (2028 to 2032) and beyond, based on the firm and funded commitments outlined. The document describes the challenge in meeting carbon budgets and net zero by 2050 and splits the challenge into six strategic priorities:

- Accelerating modal shift to public and active transport
- Decarbonisation of road vehicles
- Decarbonising how we get our goods
- Place-based solutions for emissions reduction
- UK as a hub for green transport technology and innovation
- Reducing carbon in a global economy

14.3.23 The document sets out the approach interested parties and communities around the UK need to take for urgent action to mitigate

[8] DfT (2020) Decarbonising Transport – setting the challenge https://assets.publishing.service.gov.uk/Government/uploads/system/uploads/attachment_data/file/932122/decarbonising-transport-setting-the-challenge.pdf

climate change, as well as delivering the substantial co-benefits of decarbonisation.

Department for Transport: Highways England (now National Highways): Licence – Secretary of State for Transport statutory directions and guidance to the strategic highways company (2015)[9]

14.3.24 Part 4, 4.2 commits National Highways (in section g) to minimise the environmental impacts of operating, maintaining and improving its network and seek to protect and enhance the quality of the surrounding environment; and (in section h) conform to the principles of sustainable development.

Ten Point Plan for a Green Industrial Revolution[10]

14.3.25 The ten-point plan, published in November 2020 sets out the approach the UK government will take to build back better, support green jobs, and accelerate the net-zero transition.

14.3.26 The cumulative effect of this plan will be to reduce UK emissions by 180 million tonnes of carbon dioxide equivalent (Mt CO2 e) between 2023 and 2032.

14.3.27 The plan also necessitates the need to collaborate with industry to devise further sectoral plans and meet the carbon budgets and target of net zero by 2050. The 10 points of focus are:

1. Advancing Offshore Wind
2. Driving the Growth of Low Carbon Hydrogen
3. Delivering New and Advanced Nuclear Power
4. Accelerating the Shift to Zero Emission Vehicles
5. Green Public Transport, Cycling and Walking
6. Jet Zero and Green Ships
7. Greener Buildings
8. Investing in Carbon Capture, Usage and Storage
9. Protecting Our Natural Environment
10. Green Finance and Innovation

[9] Department for Transport (DfT) (2015) Highways England: Licence – Secretary of State for Transport statutory directions and guidance to the strategic highways company Highways England: licence (publishing.service.gov.uk).

[10] UK Government's Ten Point Plan for a Green Industrial Revolution, November 2020; Available at: The Ten Point Plan for a Green Industrial Revolution (publishing.service.gov.uk)

Net Zero Strategy: Build Back Greener[11]

14.3.28 Published in October 2021 prior to the COP 26, this strategy sets out policies and proposals for decarbonising all sectors of the UK economy to meet its net zero target by 2050. The strategy was subsequently updated in April 2022 to correct for a misalignment between energy demands and the sector emissions pathways.

14.3.29 The document outlines a delivery pathway showing indicative emissions reductions across sectors to meet our targets up to the sixth carbon budget (2033-2037). This is based on current understanding of each sector's potential, and a whole system view of where abatement is most effective.

14.3.30 The document highlights the significant package of public funding designed to accelerate the UK's 'Green Industrial Revolution' as mentioned in 14.3.25.

25 Year Environment Plan

14.3.31 The Department for Environment, Food & Rural Affairs (Defra) 25 Year Environment Plan (2018)[12] is a policy paper setting out what Government will do to improve the environment, including restoring and safeguarding wildlife habitats. The first revision of the 25 year plan 'Environmental Improvement Plan' was published in February 2023.

14.3.32 The plan sets out aims to take all possible action to mitigate climate change, while adapting to reduce its impact, by:

- Continuing to cut GHG emissions including from land use, land use change, the agriculture and waste sectors and the use of fluorinated gases.
- Making sure that all policies, programmes and investment decisions take into account the possible extent of climate change this century.

Local Policy

14.3.33 Three East Midlands councils (Leicester City Council, Leicestershire County Council and Nottingham City Council) have signed the UK100 Net Zero Pledge, with a statement to 'bring our council emissions to net zero by 2030 and we will work with our residents and businesses

[11] Net-Zero Strategy: Build Back Greener, April 2022; Available at: assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1033990/net-zero-strategy-beis.pdf

[12] HM Government (2018) A Green Future: 25 Year Environment Plan - GOV.UK (www.gov.uk). (Last accessed November 2023).

to bring our wider communities' emissions in line with net zero as soon as possible (and by 2045 at the latest).[13]

Newark-on-Trent and Sherwood Local Development Framework Core Strategy Development Plan (amended 2019)[14]

14.3.34 The Development Plan outlines the approach to sustainable development. Strategic objective 11 outlines the need to produce a district that is sensitive to the environment where opportunities are taken to reduce our impact on the climate system, including the reduction of CO_2 emissions and encouraging the use of appropriate renewable energy solutions, and to adapt to the implications of climate change.

14.3.35 Core policy 9 states that the district council will expect new development proposals to demonstrate a high standard of sustainable design that both protects and enhances the natural environment and contributes to and sustains the rich local distinctiveness of the District. Therefore, all new development should provide for development that proves to be resilient in the long-term, taking into account the potential impacts of climate change and the varying needs of the community.

14.3.36 Core policy 10 reflects the advice on flood risk set out in the NPSNN.

14.3.37 In terms of potential impacts of climate change, the Newark and Sherwood District, with the Trent, Greet and Maun Rivers within the area, is particularly vulnerable to flooding and saw significant district-wide flooding in 2007, and at a number of locations, including Southwell and Lowdham, from extreme rainfall in 2013.

14.3.38 A climate emergency was declared by the Newark & Sherwood District Council on 16 July 2019. Newark & Sherwood District Council has produced the following documents in relation to Climate Change:

14.3.39 Newark & Sherwood District Council climate emergency strategy[15] which sets out the framework and roadmap for reducing carbon emissions across Newark & Sherwood District Council's own operations in providing these services.

14.3.40 Newark & Sherwood District Council community plan[16] which highlights that a key output from resident consultation exercises was

[13] Regional leaders commit to reaching Net Zero at least five years earlier than central government (2020) Press Release available at PRESS RELEASE - Regional leaders commit to reaching Net Zero at least five years earlier than central government_2.pdf (uk100.org)

[14] Newark and Sherwood District Council (2019) *Amended Core Strategy DPD* available at https://www.newark-sherwooddc.gov.uk/amendedcorestrategy/

[15] Newark and Sherwood District Council Climate Emergency Strategy (September,2020).Available at: Carbon Reduction Action Plan Design v0.1 (newark-sherwooddc.gov.uk)

[16] Newark and Sherwood District Council Community Plan 2020-2023 (September 2020). Available at: 13.10.20---Community-Plan-Appendix---Final.pdf (newark-sherwooddc.gov.uk)

enhancing and protecting the natural environment and details out the objectives, vision, funding, and performance.

National Highways

National Highways Net Zero (2021)

14.3.41 In addition to the UK Government, National Highways (the "Applicant") have outlined their net zero strategy to achieve net zero[17]:

- Corporate emissions – net zero by 2030
- Maintenance and construction emissions – net zero by 2040
- Road user emissions – net zero by 2050

14.3.42 To enable net zero by 2040 for construction and maintenance the following interim targets are proposed:

- A trajectory of 0-10% reduction by 2025
- 40-50% by 2030
- 70-80% by 2035
- Net zero by 2040 against a 2020 baseline

14.3.43 National Highways also target the use of only zero carbon plant on their sites by 2030. The Scheme will directly affect the maintenance and construction emissions of National Highways.

National Highways: Preparing for climate change on the strategic road network – third adaptation report under the Climate Change Act (2022)[18]

14.3.44 The third report, published under the Climate Change Act's (2008) Adaptation Reporting Power (ARP):

- Re-evaluates significant climate risks threatening the safe operation of England's strategic road network (SRN) using more up-to-date climate projections.
- Assesses progress against previously identified adaptation actions.
- Identifies areas for improvement and appropriate actions.

14.3.45 Building on advice from the Climate Change Committee's CCRA3 report, the report aims to address the increased risk brought to the UK's strategic road network with the overarching vision that in 2050 *'The SRN is resilient to climate change and incidents, such as flooding, poor weather conditions, blockages on connecting transport networks'*. The report carries out a risk assessment of likely highways impacts which include, but are not limited to:

[17] National Highways (2021) Net zero highways: our 2030/2040/2050 plan available at https://nationalhighways.co.uk/media/eispcjem/net-zero-highways-our-2030-2040-2050-plan.pdf

[18] National Highways (2022) *Preparing for climate change on the strategic road network - third adaptation report under the Climate Change Act* available at https://nationalhighways.co.uk/media/z1ndodqx/preparing-for-climate-change-on-the-strategic-road-network.pdf

- Overwhelming of drainage due to fluvial (river) and pluvial (surface) and groundwater flooding
- Ground saturation affecting stability of geotechnical assets
- Destabilisation of earthworks due to standing water
- Waterlogging of pavement surface

National Highways: Strategic Business Plan 2020-2025 (2020)[19]

14.3.46 The Strategic Business Plan 2020-2025 sets out National Highways' response to Government's second Road Investment Strategy (RIS2).[245] It presents the careful balancing between maintaining and operating the strategic road network (SRN) safely and providing new capacity where it is needed. It supports Government's ambition to achieve net zero UK carbon emissions by 2050. It notes that National Highways has a shared responsibility to tackle climate change and is dedicated to minimising the GHG emissions generated from the activities within National Highways' control including designing schemes and services to be carbon and energy efficient, reducing carbon footprint through initiatives such as introducing energy-saving measures for maintenance depots and using low-energy lighting and control systems for motorways.

Topic-specific guidance

British Standards Institution Publicly Available Specification 2080 – Carbon management in infrastructure in 2016[20]

14.3.47 This Publicly Available Specification (PAS) includes requirements for all value chain members to show the right leadership and to establish effective governance systems for reducing whole life carbon through the use of a carbon management process. The individual value chain requirements in the carbon management process are structured around the following components:

- Setting appropriate carbon reduction targets
- Determining baselines against which to assess carbon reduction performance
- Establishing metrics (eg Key Performance Indicators) for credible carbon emissions quantification and reporting
- Selecting carbon emissions quantification methodologies (to include defining boundaries and cut off rules)
- Reporting at appropriate stages in the infrastructure work stages to enable visibility of performance

14.3.48 Continual improvement of carbon management and performance.

[19] National Highways (2020) *Strategic Business Plan* available at https://nationalhighways.co.uk/strategic-business-plan/

[20] BSI (2016). *'PAS 2080 – Carbon Management in Infrastructure* available at:

Institute of Environmental Management & Assessment Guide: Assessing Greenhouse Gas Emissions and Evaluating their Significance 2nd Edition (2022)[21]

14.3.49 Whilst DMRB LA 114 remains the sole standard which the Scheme has been assessed against and reported in this ES, the Institute of Environmental Management and Assessment (IEMA) guidance has been used to assist, as it provides a complementary narrative to some elements of DMRB LA 114. IEMA states that this guidance is to assist GHG practitioners with addressing GHG emissions assessment, mitigation and reporting in statutory and non-statutory EIA. It is a revision of the 2017 IEMA guidance on Assessing Greenhouse Gas Emissions and Evaluating their Significance.

IEMA Environmental Impact Assessment Guide to: Climate Change Resilience & Adaptation[22]

14.3.50 This guide provides a framework for the effective consideration of climate change resilience and adaptation in the EIA process in line with the UK Town and Country Planning (EIA) Regulations (2017).[23]

14.3.51 This guidance notes that environmental statements should provide clarity on whether climate resilience has been appropriately considered in the design and development of a scheme.

14.3.52 Environmental statements produced in line with this advice will:

- Be proportionate in their approach and not include superfluous assessment that does not address likely material issues and always make reference to climate change.
- Provide a concise explanation of how a project's resilience to climate change was considered.
- Set out clearly how effects related to climate change have been assessed.
- Define significance of effects pragmatically, taking account of the knowledge base used in the impact assessment.

14.4 Consultation

14.4.1 This Chapter has been undertaken in compliance with the Planning Inspectorate's Scoping Opinion **(TR010065/APP/6.10)** received for this Scheme. Appendix 4.3 (Scoping Opinion Schedule of Comments and Responses) of the ES Appendices **(TR010065/APP/6.3)** contains further information on how each of the matters have been addressed.

[21] IEMA (2022) *Assessing Greenhouse Gas Emissions and Evaluating their Significance 2nd Edition* available at [redacted]

[22] IEMA (2020) Environmental Impact Assessment Guide to: Climate Change Resilience & Adaptation

[23] Town and Country Planning (Environmental Impact Assessment) Regulations 2017, No. 571. Available at: http://www.legislation.gov.uk/uksi/2017/571/ pdfs/uksi_20170571_en.pdf

14.4.2 In relation to flood risk and drainage design, the design and flood risk assessment has been produced in accordance with the climate change requirements of the Environment Agency and Nottinghamshire County Council as the Lead Local Flood Authority (LLFA). Appendix 13.2 (Flood Risk Assessment) of the ES Appendices **(TR010065/APP/6.3)** has used the latest climate change allowances. Meetings have continued as part of the Flood and Drainage Steering Group.

14.4.3 Consultation has continued through the key stakeholder engagement exercises throughout the development of the Scheme design and this ES.

14.5 Assessment methodology

Effects on climate

14.5.1 The scope of the assessment covers the lifecycle stages of the Scheme. The GHG assessment comprises two parts reflecting both the level of certainty of future activity and GHG emissions, and the extent that the predicted GHG emissions would be additional to the existing GHG inventory.

- The first part considers the construction of the Scheme itself.
- The second part considers the operation (including maintenance) and the 'use' of the Scheme.

Construction

14.5.2 The full assessment of the construction effects on climate includes an assessment of GHGs emitted during construction using credible and recognised calculation methodologies and tools. These include:

- The Mott MacDonald Moata Carbon Portal (a tool to produce carbon assessments using a library of emission factors) which is PAS 2080 certified to undertake the embodied carbon assessment.
- The Royal Institute of Chartered Surveyors (RICS)[24] guidance and assumptions on the transport of materials to site used where actual supplier information is not known.
- Environmental Product Declarations (EPDs)[25] detailing the emissions for certain design aspects where appropriate for bespoke items.

14.5.3 GHG emissions have been assessed using a calculation-based methodology as per the below equation:

Activity data x GHG emissions factor = GHG emissions value

[24] RICS (2017). *Whole life carbon assessment for the built environment, RICS professional statement*.

[25] An Environmental Product Declaration (EPD) 'quantifies environmental information on the lifecycle of a product to enable comparisons between products fulfilling the same function'.

14.5.4 Activity data has been sourced from three primary sources when undertaking an assessment after the baseline has been set:

- 3D design model which has first-hand data on the amounts of materials and other data pertaining to each of the assets.
- Bill of Quantities data used to produce bills of materials that are available at certain points in the design process. This has been used to make sure all activities have been captured in the same way for carbon as in cost.
- Supply chain data has been used to help define the specifications of certain materials and to define the travel and plant assumptions for the works.

14.5.5 The Scheme used the most complete, up-to-date and referenceable activity data.

14.5.6 Emission factor data has been selected based on its overall applicability to the Scheme. The following criteria have been applied:

- Age: the most recently published data was preferred
- Geography: data which applies to the location of actual suppliers and/or activities was preferred
- Technology: data which represent the actual product/activity in question was preferred
- Methodology: data which follow a published methodology or product category rules was preferred
- Competency: data which were produced from proficient entities was preferred

14.5.7 The construction carbon assessment has been presented against the following life cycle stages (modules) consistent with the principles set out in PAS 2080. The scope of assessment includes PAS 2080 lifecycle stages A1-A3, A4, A5 as presented in Table 14-2.

Table 14-2: Construction lifecycle stage activities

Life cycle stage	Activities incorporated
Product stage (modules A1-A3)	The extraction, processing and manufacturing of all materials required for the permanent assets. This includes all energy and carbon emissions from manufacturing plants, primary and secondary manufacturing stages as well as any transport emission between these stages.
Construction process stage – transport to site (module A4)	The transportation of all materials required for the permanent assets and construction equipment to site from the point of production (or point of storage in the case of plant and machinery).

Life cycle stage	Activities incorporated
Construction process stage – construction and installation (module A5)	Construction site works activities including: • temporary work, ground works and landscaping • materials storage and any energy or otherwise needed to maintain necessary environmental conditions • transport of materials and equipment on site • installation of materials and products into the infrastructure asset • emissions associated with site water demand • waste management activities (transport, processing, final disposal) associated with waste arising from the construction site • production, transportation, and waste management of materials/products lost during works

Source: Mott MacDonald

Operational

14.5.8 For the assessment of operational effects on climate, the following were included:

- A routine maintenance assessment: covering planned maintenance and repair.
- An assessment of the GHG emissions associated with the electricity requirements for the operation of the Scheme. This used data determined through design and publicly available emission factors for grid electricity taken from the Road Lighting and Energy Savings paper.[26] Future grid decarbonisation trajectories have been used.
- A road user assessment: A scenario-based approach is adopted for the assessment, with the quantification of different scenarios to provide a range of potential additional GHG emissions associated with the Scheme operation. These scenarios include:
- A ‘Do-Minimum’ (DM) scenario whereby the Scheme is not implemented.
- A ‘Do-Something’ (DS) scenario whereby the Scheme goes ahead and the GHG emissions reductions from embedded mitigation measures are considered.
- The carbon emissions have been calculated from the traffic model over a 60-year appraisal period presenting the net GHG emissions: the difference in GHG emissions between the DM and DS scenarios which will provide the traffic GHG impact figures for appraisal within the ES, using emission factor toolkit version 11 in line with LA 114. Further detail is provided in Appendix D of the Transport Assessment **(TR010065/APP/7.4)**.
- The land use assessment is based on the data inputted into the Biodiversity Net Gain Calculations using the emission factors for

[26] Road Lighting and Energy Savings; Lighting Research and Technology; September 2009

carbon flux from the Carbon Storage and Sequestration by Habitat Natural England paper.[27]

14.5.9 The operational carbon assessment has been presented against the following life cycle stages (modules). The scope of assessment includes lifecycle stages B1, B2, B4, B6 and B9 as presented in Table 14-3.

Table 14-3: Operational lifecycle stage activities[28]

Life cycle stage	Activities incorporated
Use stage – Use (module B1)	New stores of carbon eg carbon sequestration from Scheme planting.
Use stage – Maintenance (module B2)	The production, transportation (to and from the site) and end of life processing of all materials required for preventative maintenance. The electricity, fuel and water for regular preventative maintenance.
Use stage – Operational Energy Use (module B6)	The electricity used to run any Scheme lighting, highways communications.
Use stage – User utilisation of infrastructure (module B9)	Direct exhaust emissions from vehicles. Assessment to be undertaken in line with Transport Analysis Guidance (TAG) and requirements.

Significance of effect

14.5.10 The assessment of significance follows the DMRB LA 114 Climate as this is currently the most relevant methodology for highways schemes on the SRN.

14.5.11 DMRB LA 114 states that *'projects 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'.*

14.5.12 The assessment includes a comparison of estimated GHG emissions arising from the Scheme with UK carbon budgets and the associated reduction targets in line with DMRB LA 114. The results of this comparison have been presented following the format of Table 3.18 in DMRB LA 114.

14.5.13 To support DMRB LA 114, and following the IEMA guidance, the carbon footprint of the Scheme has been contextualised with relevant budgets and mitigated against.

Resilience of the Scheme to climate change

14.5.14 A qualitative methodology for assessing the resilience of the Scheme assets and construction processes to climate change has been produced in line with DMRB LA 114.

[27] Carbon storage and sequestration by habitat: a review of the evidence (second edition) Carbon Storage and Sequestration by Habitat 2021 - NERR094 (naturalengland.org.uk)

[28] Whole life carbon assessment for the built environment :RICS(2017) Available at: Whole Life Carbon Assessment for the Built Environment (rics.org)

14.5.15 The assessment identified hazards induced by climate change for the Scheme design receptors because of the projected climate changes detailed in Section 14.8. For the construction stage assessment a qualitative description of the risk is reported considering the elements below. A more detailed approach for operation is undertaken using the consequence and likelihood of impacts as described below.

14.5.16 The likelihood of these impacts occurring (see Table 14-4) and consequence of impact (Table 14-5) is defined to determine the significance. Professional experience and judgement through collaboration between climate change specialists and the design team was used to determine these factors.

Table 14-4: Criteria for determining likelihood of impacts occurring[28]

Likelihood category	Description (probability and frequency of occurrence)
Very high	The event occurs multiple times during the lifetime of the Scheme (60 years) eg approximately annually, typically 60 events.
High	The event occurs several times during the lifetime of the Scheme (60 years) eg approximately once every 5 years, typically 12 events.
Medium	The event occurs limited times during the lifetime of the Scheme (60 years) eg approximately once every 15 years, typically four events.
Low	The event occurs during the lifetime of the Scheme (60 years) eg once in 60 years.
Very low	The event can occur once during the lifetime of the Scheme (60 years).

Table 14-5: Criteria for determining measure of consequence

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

Source: Table 3.39b DMRB LA 114.

Significance of effect

14.5.17 The criteria for determining the significance of effect for the resilience of the Scheme is shown in Table 14-6. The likelihood and consequence of the impact is combined to determine the sensitivity of the receptor. The sensitivity is then combined with the magnitude of effect to the allow determination of whether the effect is significant or not significant.

Table 14-6: Significance matrix

		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	NS	S	S
	Minor	NS	NS	NS	NS	NS
	Negligible	NS	NS	NS	NS	NS

Table Key: NS – Not Significant; S – Significant
Source: DMRB LA 114

14.6 Assessment assumptions and limitations

14.6.1 The assessment has been based on the Scheme description and construction strategy presented in Chapter 2 (The Scheme) of this ES and has taken into account the lateral limits of deviation illustrated on the Works Plans **(TR010065/APP/2.3)** and vertical limits of deviation secured under Article 10 of the draft DCO **(TR010065/APP/3.1)** in order to establish a realistic worst case assessment scenario.

Effects on climate

14.6.2 The Scheme information that fed into the construction assessment was undertaken based on the Bill of Quantities (BoQ). The following assumptions were used where details on certain aspects within the BoQ was insufficient at this stage.

14.6.3 For the following design aspects the baseline data was used in the absence of data in the BoQ:

- Preliminaries
- Drainage
- Disposal of excavated material in line with baseline
- Utilities

14.6.4 For site clearance, the demolition of structures was estimated by the design team based on professional judgement as the detailed information on the number, size and material constituents was not available.

14.6.5 Across the construction assessment, an uplift value of 1.8% was used. This was based on the most likely uncertainty value for the construction works as a proportion of the total construction works cost, which excludes the contractor fee and inflation.

14.6.6 An uplift was added for the Landscape and Utilities sections as an approximation based on other National Highways schemes. This was carried out due to limited detailed information at the time of writing.

14.6.7 The full construction assessment is based on currently known design information and assumptions of plant and material as described within Chapter 2, (The Scheme) of this ES. Assumptions were necessary to ensure the aspects can be assessed. Minor assumptions were made while selecting the emission factors within the Mott MacDonald Moata Carbon Portal, to include selection of the closest match on dimensions. Where relevant the worst case scenario was selected.

14.6.8 The operational road user assessment is based upon outputs from the traffic model. Further details of the traffic model assumptions and limitations are detailed within the Transport Assessment **(TR010065/APP/7.4)**.

14.6.9 The extent of the projected uptake of lower carbon fuels, electric vehicles (EVs) and improved vehicle technology since the UK Government announced the move to end the sale of new petrol and diesel cars by 2030 is not currently fully captured in the modelling scenarios of future road traffic emissions.

14.6.10 Within the future road traffic modelling scenarios, increasing proportions of EVs are considered up until 2030, from which point the 2030 level of EV usage is assumed. Therefore, from 2030 onwards vehicle emissions are likely overestimated as EV uptake is expected to increase beyond this time.

14.6.11 Since the completion of the assessment a further announcement in September 2023 by the UK Government has moved the date of the end of the sale of new petrol and diesel cars to 2035. Whilst this amendment would impact the future emissions of the road users of the scheme it will not impact the assessment, which is considered the worst case scenario with the level of EVs included in the assessment not accounting for this ban of petrol and diesel vehicles.

14.6.12 In addition, future decarbonisation of the grid would have an impact upon the GHG emissions associated with the operation of the Scheme. Only tailpipe emissions are considered within the future road traffic modelling scenarios, so emissions data relating to electricity production and decarbonisation of the grid are not considered.

14.6.13 The operational GHG emissions reported in this assessment are, therefore, a worst-case scenario and are likely to be mitigated by existing plans and initiatives to decarbonise the grid and electrify road transport.

14.6.14 The maintenance assessment is based on professional judgement of the main aspects of a road that will need replacing and the maintenance regime. This has been determined from previous schemes and considers the extents of this Scheme.

14.6.15 The assessment of land use change is based upon the level of information available at the time of the proposed landscape design and habitat removal. Data on habitat creation and habitat removal was drawn from the biodiversity net-gain calculations Appendix 8.14

(Biodiversity Net Gain Report) of the ES Appendices **(TR010065/APP/6.3)**. The assessment considers the changes to sequestration over the operational period due to removed and created habitats only.

Resilience of the Scheme to climate change

14.6.16 Information on the climate baseline and future projections are based on freely available information from third parties, including the historical meteorological variables recorded by the Met Office and the UK Climate Projections (UKCP18) developed by the Met Office.

14.6.17 Climate projections are not predictions or forecasts but simulations of potential scenarios of future climate, under a range of hypothetical GHG emissions scenarios and assumptions. Therefore, the results from running the climate models cannot be treated as exact or factual, but projection options. They represent internally consistent representations of how the climate may evolve in response to a range of potential forcing scenarios, and their reliability varies between climate variables. Scenarios exclude outlying surprise or disaster scenarios, and any scenario necessarily includes subjective elements and is open to various interpretations. Generally, regional projections are more certain than global, and temperature projections are more certain than those for precipitation. Furthermore, the degree of uncertainty associated with all climate change projections increases for projections further into the future.

14.6.18 Accordingly, any further research, analysis or decision-making should take account of the nature of the data sources and climate projections, and should consider the range of literature, additional observational data, evidence, and research available, and any recent developments in these.

14.7 Study area

Effects on climate

14.7.1 For the assessment, the study area captures the emission of GHGs[29] resulting from the Scheme in its construction and operation phases. The study area is not limited to the geographic extent of the Scheme itself, as many emissions will result from upstream, downstream, and off-site activities such as materials production. DMRB LA 114 requires that the assessment and reporting shall identify the scale and nature of GHG emissions across the whole Scheme life cycle, taking into account design and mitigation measures already incorporated into the Scheme.

[29] Greenhouse gases, or GHGs, are compound gases that trap heat or longwave radiation in the atmosphere. The principal GHGs, also known as heat trapping gases, are carbon dioxide, methane, nitrous oxide, and the fluorinated gases (hydrofluorocarbons, perfluorocarbons, and hexafluoride sulfur).

14.7.2 The effects on climate relate to the potential impacts of the Scheme on the climate through an increase in GHG emissions. It captures all six GHGs[29] defined by the Kyoto Protocol[30] but for the purpose of this ES they have been considered analogous and have been referred to as 'GHG emissions', reported in terms of carbon dioxide equivalent (CO_2e).

Construction

14.7.3 For construction, the study area comprises GHG emissions associated with Scheme construction related activities/materials and their associated transport including:

- Raw material supply
- Manufacture
- Transport to and from site
- Construction/installation process (for construction related processes the study area will consider emissions associated with the construction site area)

Operation

14.7.4 The operational road user assessment has considered carbon emissions associated with users of the road within a study area that is consistent with the affected road network (ARN), which is defined by the traffic modelling output for the Scheme. The ARN is the area of the road network that experiences the greatest changes in traffic flows, and therefore the areas to be considered in the assessment as per the following criteria:

- 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

14.7.5 The operational maintenance study area includes:

- Maintenance activities
- Repair of existing assets
- Replacement of existing assets

14.7.6 The operational land use change assessment covers the extent of habitat removal and habitat creation or enhancement from the Scheme. This focuses on the changes to sequestration through the operational phase. The study area for the existing habitat includes 250 metres from the Order Limits as noted in Chapter 8 (Biodiversity) of this ES and described in Appendix 8.1 (Extended Phase 1 Technical Report) of the ES Appendices **(TR010065/APP/6.3)**.

[30] United Nations Climate Change (2021). *'What is the Kyoto Protocol?* available at: [redacted]

Resilience of Scheme to climate change

14.7.7 For the assessment in line with DMRB LA 114, the study area is based on the Order Limits including any construction compounds and temporary land take. The Order Limits are set out in Figure 2.1 (Scheme Location Plan) of the ES Figures **(TR010065/APP/6.2)**.

14.8 Baseline conditions

Effects on climate

14.8.1 The baseline for the effects on climate as detailed in DMRB LA 114 requires Scheme specific information, including baseline construction emission estimates, and operational emissions from road users in the DM scenario.

14.8.2 Operational baseline emissions equate to emissions in the Opening Year (2028) and Design Year (2043) assuming the Scheme was not constructed – the DM scenario. The results shown in Table 14-7 are taken from the operational assessment carried out following the methodology described in Section 14.5.

Table 14-7: Do-Minimum emissions

Category	Opening Year (2028) emissions (tCO_2e)	Design Year (2043) emissions (tCO_2e)
Road User	174,546	199,952

Construction

14.8.3 A construction carbon assessment of the Scheme design developed for the preferred route announcement, at the option selection stage, acts as the construction baseline. The estimated construction baseline emissions of the Scheme are 254,536 tCO_2e split between material, plant and transport as shown in Table 14-8.

Table 14-8: Split of carbon emissions by scope type (including 23% uplift)

PAS2080 Lifecycle stage	Carbon emissions tCO_2e (inc. uplift)	Percentage of total
Material (A1-3)	152,051	60%
Transport (A4)	62,079	24%
Plant (A5)	40,406	16%
Total	**254,536**	

Resilience of the Scheme to climate change

Current climate

14.8.4 Mean annual temperatures over the Midlands region vary from around 8°C to just over 10°C. The highest values occur in the lower Severn Valley, whilst the lowest occur at the higher altitudes such as the Peak District. This places the Midlands in the middle of the UK mean

temperate range of 7-11°C.[31] According to the Met Office, due to the Midland's distance from the regulating effects of the sea, the annual range is more pronounced than in most parts of the UK. Sharp winter frosts are common and there are occasional very hot summer days, particularly in the south and east of the region. These temperature extremes of both winter and summer are a key characteristic of the Midlands climate. As a result of this, the average number of days with air frost in the Midlands varies from about 40 a year in the lower Severn Valley to over 60 a year in the Peak District and sheltered areas of the Welsh Marches. Ground frost occurs on average on about 100 to 125 days per year, with a similar distribution to air frost.

14.8.5 The wettest areas in the Midlands, with an average of over 800 millimetres per year, are along the Welsh border, in the Cotswolds and, especially, in the Peak District; the highest altitudes exceed 1,000 millimetres. In contrast, the more sheltered areas of the South and East Midlands are the driest with less than 600 millimetres per year in parts of Northamptonshire, the lower Trent Valley and the Avon Valley. This is 80% lower than the highest precipitation area in the UK, but still 300-500 millimetres greater than the driest parts. Periods of prolonged rainfall can lead to widespread flooding, especially in winter and early spring when soils are usually near saturation.

Future projections

Effects on climate

14.8.6 The projections from the Department for Business, Energy & Industrial Strategy (referred to as the BEIS projections) show a decline in total GHG emissions by 2040 (GHG emissions are projected to fall by 24% from 2019 levels). In 2018, 97% of transport's final energy consumption was from oil-based fossil fuels but by 2040 this is projected to fall to 89% due to an increase in electric vehicles and increasing use of biofuels.[32] In 2021, the UK Government pledged to end the sale of new petrol and diesel vehicles by 2030 and that all new cars and vans are required to be fully zero emission at the tailpipe by 2035. Furthermore, the UK Government consulted to phase out all new, non-zero emission road vehicles and heavy goods vehicles by 2040 at the latest. Because of these changes, the BEIS projections are likely to be updated to meet these new policy goals. The BEIS projections show that the Third Carbon Budget is very likely to be achieved with headroom of approximately 26 $MtCO_2e$. However,

[31] UK Met Office (2018) *Midlands: climate* available at https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/weather/learn-about/uk-past-events/regional-climates/midlands_-climate---met-office.pdf

[32] Department for Business, Energy & Industrial Strategy (2022). Updated energy and emissions projections 2021 – 2040 available at: Updated energy and emissions projections 2021 to 2040 (publishing.service.gov.uk)

the projections show shortfalls for the Fourth Carbon Budget and Fifth Carbon Budget of 188 $MtCO_2e$ and 253 $MtCO_2e$ respectively.

14.8.7 The Committee on Climate Change (CCC) have stated that GHG emissions will need to fall more rapidly than these targets.[33]The CCC is an independent, statutory body established under the Climate Change Act 2008 to advise the UK and devolved governments on emissions targets and to report to Parliament on progress made in reducing greenhouse gas emissions and preparing for and adapting to the impacts of climate change.

14.8.8 The UK Government is required to conduct a UK Climate Change Risk Assessment (CCRA) every five years as set out in the UK Climate Change Act 2008. In January 2022 the UK government published the third five-year assessment of the risks of climate change on the UK. This was based on the Independent Assessment of UK Climate Risk,[34] the statutory advice provided by the Climate Change Committee (CCC), commissioned by the UK government and devolved administrations.

14.8.9 The CCC have also determined a balanced net-zero pathway for construction and manufacturing that includes a reduction of 43% by 2030, 75% by 2035, and 90% by 2040 to achieve a 97% reduction by 2050.[27] The pathway considers a proportion of the reduction will come from improved resource efficiency in production and material substitution. Therefore, significant effort is required to ensure that all contributing emissions are reduced as far as possible through the design, construction, and operational elements of all schemes.

Resilience of the Scheme to climate change

14.8.10 The Met Office provides information on observed and future climate change relative to the baseline period of 1961 to 1990, based on the latest scientific understanding United Kingdom Climate Projections 2018 (UKCP18). The Scheme sits within the Midlands region. Observed trends in the UK climate are as follows:[35]

- The UK's climate is changing. Recent decades have been warmer, wetter and sunnier than the 20th century.
- 2020 was third warmest, fifth wettest and eighth sunniest on record for the UK. No other year has fallen in the top 10 for all three variables for the UK.
- Heatwave (2022): England and Wales experienced the hottest summer on record with parts of England exceeding 40°C and a record of 40.3°C in the Lincolnshire area.

[33] Climate Change Committee (2020). *The Sixth Carbon Budget – The UKs path to Net-Zero.* available at: https://www.theccc.org.uk/publication/sixth-carbon-budget/

[34] Independent Assessment of UK Climate Risk (CCRA3) UK Climate Risk

[35] Met Office (2018) United Kingdom Climate Projections, available at https://ukclimateprojections-ui.metoffice.gov.uk/ui/home

- The UK has warmed at a broadly consistent but slightly higher rate than the observed change in global mean temperature.

Future climate projections

14.8.11 The future climate baseline for the Scheme has been derived from the Met Office UKCP18 tool, which provides projections for future climate change across the UK against a range of future climate scenarios. In line with the IEMA Guide to Climate Resilience and Adaptation (2020),[36] a 'precautionary approach' was taken by using the Representative Concentration Pathway (RCP) 8.5 (equivalent to a high greenhouse gas emission scenario) from a baseline of 1981-2000. The 50th percentile has been selected representing an 'as likely as not' probability of change.[37] The 10th and 90th percentiles are also presented as these represent a wider range of probabilities. Probabilistic projections have been used to obtain temperature and precipitation projection data using a 25-kilometre^2 grid cell in the UKCP18 projections (grid cell coordinates: 4875000 3625000) which covers the Scheme location. The data presented includes annual values as well as values for summer (June, July, August) and winter months (December, January, February).

14.8.12 DMRB LA 114[38] recommends the use of H++ scenarios used in UKCP09 which typically include projections in the 10th to 90th percentile range. However, as recommended by the IEMA Guide to Climate Resilience and Adaptation (2020)[39], use of UKCP18 is preferred as this supersedes UKCP09, offering the best available information on UK climate projections while also providing projections in the 10th to 90th percentile range.

14.8.13 Given the 120 year maximum design life of some aspects of the Scheme (see section on Demolition within Chapter 2 (The Scheme) of this ES) and using the approach described above, the following climate change time periods have been chosen for this assessment:

- UKCP18 probabilistic projections, 1981-2000 baseline, RCP8.5, 10th, 50th and 90th percentile, 2040-2059 (2050s) and 2080-2099 (2090s)
- UKCP18 probabilistic extreme projections, RCP8.5, 10th, 50th and 90th percentile, 1 in 20, 1 in 50 and 1 in 100-year return periods, 2055 and 2095

[36] IEMA (2020) IEMA EIA Guide to: Climate Change Resilience and Adaptation (2020). Available from: IEMA - IEMA EIA Guide to: Climate Change Resilience and Adaptation (2020). [Accessed: October 2022].

[37] The 50th percentile is the median line in a probability bell curve of assembled climate model projection data, and as such represents the point at which it is as likely that climate outcomes will lie one side of this median line as the other side, hence the term 'as likely as not'.

[38] Standards for Highways (2021). *Design Manual for Roads and Bridges – Sustainability and Environment LA 114 (Climate)* [online] available at: https://www.standardsforhighways.co.uk/dmrb/search/d1ec82f3-834b-4d5f-89c6-d7d7d299dce0 (last accessed January 2023).

[39] IEMA (2020) *IEMA EIA Guide to: Climate Change Resilience and Adaptation (2020)* [online]. Available at: IEMA - IEMA EIA Guide to: Climate Change Resilience and Adaptation (2020). (last accessed: February 2023).

Air temperature

14.8.14 Air temperature projections are presented in Table 14-9 and Table 14-10, which suggest that temperatures will increase throughout the year. In the 2050s at the 50th percentile (Table 14-9), maximum temperatures in the summer are projected to increase by 2.5°C and minimum temperatures in the winter projected to increase by 1.6°C. In comparison, in the 2090s at the 50th percentile (Table 14-10), maximum temperatures in the summer are projected to increase by 5.7°C and minimum temperatures in the winter projected to increase by 3.5°C. This will result in warming winters and hotter summers. Extreme maximum temperatures (Table 14-11) are also projected to increase with extreme temperatures of up to 41.1°C (1 in 100-year event) in 2095 at the 50th percentile. This is likely to increase the severity of summer heatwave events in the future.

Table 14-9: Temperature projections for the Scheme location (UKCP18 Probabilistic Projections, 1981-2000 baseline, RCP8.5, 2040-2059)

			Climate Projections		
Climate Variable		**1981-2000 Baseline**	**10th Percentile**	**50th Percentile**	**90th Percentile**
Mean Air Temperature	Annual	9.7 °C	+0.9 °C	+1.8 °C	+2.7 °C
	Summer	15.7 °C	+1 °C	+2.2°C	+3.5 °C
	Winter	4.1 °C	+0.5 °C	+1.6 °C	+2.7 °C
Maximum Air Temperature	Annual	13.7 °C	+0.8 °C	+1.9 °C	+2.9 °C
	Summer	20.8 °C	+0.8 °C	+2.5 °C	+4.2 °C
	Winter	7.1°C	+0.5 °C	+1.5 °C	+2.6 °C
Minimum Air Temperature	Annual	5.7 °C	+0.8 °C	+1.7 °C	+2.6 °C
	Summer	10.7°C	+1.0 °C	+2.0 °C	+3.1 °C
	Winter	1.1°C	+0.4 °C	+1.6 °C	+3.0 °C

Table 14-10: Temperature projections for the Scheme location (UKCP18 Probabilistic Projections, 1981-2000 baseline, RCP8.5, 2080-2099)

			Climate Projections		
Climate Variable		**1981-2000 Baseline**	**10th Percentile**	**50th Percentile**	**90th Percentile**
Mean Air Temperature	Annual	10.0 °C	+2.4 °C	+4.1 °C	+5.8 °C
	Summer	15.7 °C	+2.7 °C	+5.2 °C	+7.7 °C
	Winter	4.1 °C	+1.4 °C	+3.4 °C	+5.6 °C
Mean Maximum Air Temperature	Annual	14 °C	+2.5 °C	+4.3 °C	+6.2 °C
	Summer	20.8 °C	+2.6 °C	+5.7 °C	+9.1 °C
	Winter	7.1°C	+1.4 °C	+3.3 °C	+5.3 °C
Mean Minimum Air Temperature	Annual	5.9 °C	+2.2°C	+3.9°C	+5.8 °C
	Summer	10.7°C	+2.6 °C	+4.7 °C	+6.9°C
	Winter	1.1°C	+1.2 °C	+3.5 °C	+6.2 °C

Table 14-11: Extreme temperature projections for the Scheme location (UKCP Probabilistic Extreme Projections, RCP8.5, 10th, 50th and 90th percentile, 1 in 20, 1 in 50 and 1 in 100 year return period[40], 2055 and 2095)

Climate Variable		Climate Projections			
		Return Period	10th Percentile	50th Percentile	90th Percentile
Maximum Extreme Air Temperature (2055)	Summer	1 in 20 year	32.8 °C	35.3 °C	38.3 °C
		1 in 50 year	33.5 °C	36.2 °C	39.3 °C
		1 in 100 year	33.9 °C	36.7 °C	40.1 °C
	Winter	1 in 20 year	16.8 °C	17.7 °C	18.7 °C
		1 in 50 year	17.3 °C	18.4 °C	19.7 °C
		1 in 100 year	17.6 °C	18.9 °C	20.5 °C
Maximum Extreme Air Temperature (2095)	Summer	1 in 20 year	33.5 °C	38.6 °C	44.5 °C
		1 in 50 year	34.1 °C	39.6 °C	45.8 °C
		1 in 100 year	34.5 °C	40.2 °C	46.6 °C
	Winter	1 in 20 year	18 °C	19.5 °C	21.4 °C
		1 in 50 year	18.5 °C	20.3 °C	22.5 °C
		1 in 100 year	18.9 °C	20.8 °C	23.4 °C

Precipitation and rainfall intensity

14.8.15 Precipitation projections are presented in Table 14-12 and Table 14-13, which suggest that precipitation patterns will change in the location of the Scheme throughout the year. In the 2090s at the 50th percentile, precipitation in the summer is projected to decrease by 36.2% but projected to increase in the winter by 12.2%. This will result in drier summers and wetter winters. Drier summers may lead to an increased frequency and severity of drought events and wetter winters may increase risk of surface water flooding and ponding.

14.8.16 During the summer months, despite there being an overall projected decrease in precipitation, intense rainfall events may be more severe in the form of summer storms with up to a 1-day total precipitation[41] of 73.3 millimeters (1 in 100-year event) and 5-day total precipitation[42] of 114.9 millimeters (1 in 100-year event) in 2095 at the 50th percentile. During the winter months, the increase in winter precipitation may intensify rainfall events with up to a 1-day total precipitation of 40.2 millimeters (1 in 100-year event) and 5-day total precipitation of 73.6 millimeters (1 in 100-year event) in 2095 at the 50th percentile.

[40] Return period refers to the period over which it is likely that a particular magnitude of an event would be exceeded in any given year. A 1 in 20 year event is the probability that an event will occur once every 20 years.

[41] 1-day total precipitation is the largest precipitation total that falls within a single 24-hour day.

[42] 5-day total precipitation is the total precipitation that falls over a consecutive 5-day period.

Table 14-12: Precipitation projections for the Scheme location (UKCP18 Probabilistic Projections, 1981-2000 baseline, RCP8.5, 2040-2059 and 2080-2099)

Climate Variable		Climate Projections			
		1981-2000 Baseline	10th Percentile	50th Percentile	90th Percentile
Precipitation change (2050s)	Annual	592.9 mm	-11.9%	-2.1%	+7.7%
	Summer	5.1 mm	-36.7%	-13.6%	+8.3%
	Winter	4.6 mm	-4.8%	+7.2%	+20.8%
Precipitation change (2090s)	Annual	592.9 mm	-15.6%	-2.6%	+11.3%
	Summer	5.1 mm	-61%	-35.4%	-5.6%
	Winter	4.6 mm	-1.1%	+18.7%	+43.1%

Table 14-13: Extreme precipitation projections for the Scheme location (UKCP Probabilistic Extreme Projections, RCP8.5, 10th, 50th and 90th percentile, 1 in 20, 1 in 50 and 1 in 100-year return period, 2055 and 2095)

Climate Variable		Climate Projections			
		Return Period	10th Percentile	50th Percentile	90th Percentile
1-day total precipitation (2055)	Summer	1 in 20 year	34.5 mm	41.9 mm	51.3 mm
		1 in 50 year	40.2 mm	51.5 mm	67.1 mm
		1 in 100 year	44 mm	59.3 mm	82 mm
	Winter	1 in 20 year	26.4 mm	30.4 mm	35.3 mm
		1 in 50 year	29.4 mm	35.1 mm	42.5 mm
		1 in 100 year	31.4 mm	38.7 mm	48.7 mm
1-day total precipitation (2095)	Summer	1 in 20 year	31.2 mm	43.8 mm	58.7 mm
		1 in 50 year	36.6 mm	53.8 mm	77.2 mm
		1 in 100 year	40.6 mm	62.1 mm	94.4 mm
	Winter	1 in 20 year	28.3 mm	34.9 mm	42.9 mm
		1 in 50 year	31.6 mm	40.2 mm	51.3 mm
		1 in 100 year	33.7 mm	44.2 mm	58.4 mm
5-day total precipitation (2055)	Summer	1 in 20 year	69.1 mm	79.7 mm	92.2 mm
		1 in 50 year	74.1 mm	86.7 mm	102.6 mm
		1 in 100 year	77 mm	91.4 mm	110.1 mm
	Winter	1 in 20 year	55.7 mm	61.4 mm	69.8 mm
		1 in 50 year	59.5 mm	67.4 mm	79.5 mm
		1 in 100 year	61.9 mm	72 mm	87.6 mm
5-day total precipitation (2095)	Summer	1 in 20 year	60 mm	81.2 mm	105.9 mm
		1 in 50 year	65.2 mm	89 mm	118 mm
		1 in 100 year	68.2 mm	93.6 mm	127 mm
	Winter	1 in 20 year	57.7 mm	68.2 mm	82.6 mm
		1 in 50 year	61.3 mm	74.6 mm	93.9 mm
		1 in 100 year	63.7 mm	79 mm	103.3 mm

14.8.17 The Environment Agency updated its Flood risk assessments: Climate change allowances guidance in May 2022[43] giving recommendations on climate change allowances to incorporate within the design of new developments to manage flood risk and improve resilience.

14.8.18 Climate change allowances for the Scheme area, the Lower Trent and Erewash Management Catchment, are provided in Table 14-14 below.

Table 14-14: Lower Trent and Erewash Management Catchment peak river flow allowances[44]

Time Period	Central	Higher	Upper
2020s	13%	18%	29%
2050s	17%	23%	38%
2080s	29%	39%	62%

14.9 Potential impacts

Effects on climate

14.9.1 The following potential impacts from the Scheme have been identified for the construction and operational stages.

14.9.2 Increases in GHG emissions could impact climate by contributing to the cumulative impact GHG emissions have on climate change. It is not possible, however, to attribute the resulting impact of a certain quantity of GHG emissions to effects on a specific receptor. Instead, the most appropriate geographic level for an assessment of the impact of a certain quantity of GHG emissions is at a national level (i.e. by comparison to UK carbon budgets), as that is the level at which Parliament has jurisdiction and has been specified in the NPSNN paragraph 5.17.

Construction

14.9.3 The main impact on climate during construction would be the release of GHGs which contribute towards altering the UK's climate beyond what would be expected from natural variation.

14.9.4 This impact could be caused by GHG released by:

- Diesel and HVO plant and machinery
- Construction process stage; including transport to/from works site and construction/installation processes
- Materials production
- Land use change because of the habitat loss to accommodate Scheme

[43] Environment Agency (2022) – Flood risk assessments: climate change allowances: Available at: Flood risk assessments: climate change allowances - GOV.UK (www.gov.uk)

[44] Based on information generated by the UK Centre for Ecology and Hydrology using UK Climate projections. Available at Climate change allowances for peak river flow in England (data.gov.uk)

- Changes to traffic flows causing increased congestion during construction

Operation

14.9.5 The main impact on climate during operation would be the release of GHGs which contribute towards altering the UK's climate beyond what would be expected from natural variation.

14.9.6 This impact could be caused by GHG released by:

- Changes in vehicle distributions and speed limits
- Maintenance activities
- Energy usage for Scheme operation
- Reduced carbon sequestration from land-use change

Resilience of the Scheme to climate change

Construction

14.9.7 The climate of the study area has already changed from its natural state, as a result of climate change, and is projected to change significantly over the lifetime of the Scheme. Whilst the Scheme's construction (planned to commence 2025) is not expected to be so far in the future enough to be affected by climate change, present-day extreme weather events may affect construction. This assessment has considered the climate projections provided in Section 14.8.

14.9.8 Furthermore, if construction coincides with extreme weather event(s) such as drought or storms there may potentially be further construction impacts.

14.9.9 Extreme weather events and the potential impacts associated with each to the Scheme during construction are presented in Table 14-15 below.

Table 14-15 : Extreme weather events and anticipated impacts during construction

Climate Event	Impact
Increased winter precipitation	Damage to construction site and equipment through loss of stability in ground surface due to ground being waterlogged. Risk of damage or resultant pollution from surface water flooding from the areas of construction along the River Trent and Old Trent Dyke.
Changes in the future precipitation regime (varying from drought conditions to heavy rainfall)	Increasing the risk to earthworks stability. Risk of damage or resultant pollution from surface water flooding from the areas of construction along the River Trent and Old Trent Dyke.
Increase yearly average temperature	Safer driving conditions in winter if fewer frost and ice days.
Increased summer temperature	Damage to plant and machinery in adversely hot temperatures. Risk to workforce in extreme heat.
Extreme weather events	Damage to plant and machinery in adversely hot temperatures, flooding and high winds. Risk to workforce in extreme heat/flooding.

Operation

14.9.10 This assessment has considered the climate projections in Section 14.8 over the lifetime of the Scheme and identified the following risks in Table 14-16 below.

Table 14-16: Climate event and anticipated impacts during operation

Climate event	Impact
Increased winter precipitation	Increasing sub-surface moisture and inducing premature pavement failure. Increasing standing water, the build-up of particulates on road surfaces, and flood risk. Increase safety risk for active travel users e.g cyclists. Increase in occurrence of potholes (by weakening the soil beneath the carriageway) increasing maintenance requirements and associated traffic disruption.
Changes in the future precipitation regime (varying from summer drought conditions to winter increased seasonal rainfall)	Pavements and earthworks heave. Increasing the risk to earthworks stability and landslips. Increased risk of 'summer ice' where rain occurs after prolonged dry spells producing a slippery surface on the road from the mix of oil, dirt and heavy rain.
Increase yearly average temperature	Reduced freeze thaw erosion which could damage underground assets, in turn reducing maintenance requirements and associated traffic disruption. Safer driving conditions in winter if fewer frost and ice days.
Increased summer temperature	Greater risk of joint, bearing or surface failure due to expansion. Accelerating the weathering of road markings. Increased temperatures which may be greater than the rated equipment tolerance and lead to electrical and mechanical equipment failure. Increased likelihood of disease of roadside vegetation, and changing precipitation patterns including greater frequency of drought, leading to vegetation dieback. Soil dessication and erosion may cause soil instability, increasing maintenance requirements, replanting/reseeding and associated traffic disruption. Soil dessication and erosion lading to sedimentation within the schemes drainage infrastructure that reduces its capacity and so increases the risk of flooding, which causes traffic disruption. Additional maintenance work to prevent flooding may also cause traffic disruption.
Extreme weather events	Impact to signs from high winds. Safety concerns associated with extreme weather which may result in reduced likelihood of maintenance. Safety concerns relating to high sided vehicles. Impacts on electrical equipment include more regular lightning strikes and extreme hot temperatures causing thermal over loading of circuits. Repair and maintenance cause traffic disruption.
Longer vegetation growing season	Leading to increased need for maintenance of vegetation (due to warmer winters and wetter summers).

Environmental receptors

14.9.11 Potential operational impacts on environmental receptors that are related to, or could be intensified by, climate change are assessed as

in-combination effects. These are summarised in this Chapter and have been developed in parallel with the assessments for the other environmental topics. Examples of potential impacts on environmental receptors include:

- Warmer winters reducing the requirement for road salting with benefits for water quality in nearby surface water bodies.
- Drier summers, with occasional heavy convectional rainfall, resulting in water quality in nearby surface water bodies becoming more vulnerable to impacts from first flush events. This is when long periods of dry weather enable contaminants to build up on road surfaces which then mobilise in surface water runoff following a heavy rainfall event and enter aquatic systems via surface water runoff and drainage infrastructure in large quantities. Pollutants in this runoff can be harmful to aquatic life.
- Hotter and drier summers lowering river water levels. In the future water quality impacts related to the Scheme's surface water drainage discharges could increase as the capability of these watercourses to dilute discharges reduces.
- Operational impacts on air quality from Scheme traffic emissions. In the future, impacts caused by the Scheme's vehicle emissions could be intensified as hotter summers brought on by climate change will increase the formation of ground-level ozone.

14.10 Design, mitigation, and enhancement measures

Effects on climate

Design measures

14.10.1 The development of the Scheme design has been an iterative process. The design adheres to the principles of the design and mitigation hierarchy outlined in DMRB LA 114. The first principle being to avoid potential adverse effects where possible, before seeking to minimise or mitigate any unavoidable impacts. This has formed a well-developed mitigation strategy. Embedded mitigation incorporated into the Scheme design development is outlined in Chapter 2 (The Scheme) of this ES. Embedded mitigation measures incorporated in the Scheme design include resource efficiency through retrofitting existing structures and use of borrow pits to provide structural fill. These features are shown on Figure 2.3 (Environmental Masterplan) of the ES Figures **(TR010065/APP/6.2)**.

14.10.2 The effective assessment and management of impacts on climate offers the opportunity to reduce the impact of schemes on climate by minimising the magnitude of GHG emissions as far as possible. The Scheme has worked with the 80:20 rule in mind where targeted interventions into the largest 20% of causes can impact a large proportion (80%) of the Scheme.

14.10.3 The carbon management process followed for the design is in line with the Applicant's process aligning with PAS 2080. This ensures the consideration of carbon reduction through all phases of the Scheme. It outlines the process to be followed to reduce carbon, the methodology for the carbon assessment, and has been updated with progress made through the design. The following high-level approach to mitigation (as defined within PAS 2080) has been applied and developed, with a particular focus on the hotspots identified through the carbon assessment:

- Build nothing: evaluate the basic need for an asset and explore alternative approaches to achieve outcomes set by the asset owner/manager.
- Build less: evaluate the potential for reusing and/or refurbishing existing assets to reduce the extent of new construction required.
- Build clever: consider the use of low carbon solutions (including technologies, materials, and products) to minimise resource consumption during the construction, operation, and user utilisation stages of the asset.
- Build efficiently: use techniques that reduce resource consumption during the construction and operational phases.

14.10.4 To aid design development, value engineering and management workshops have taken place. Considering the principles detailed above, a Design for Resource Efficiency Workshop was held by the Applicant in April 2022, identifying opportunities to improve resource efficiency and reduce carbon. This led to the identification of reduction opportunities. The opportunities identified were ranked based on their level of impact and ease of implementation and implemented where possible. Further to this, in January 2023 a Carbon Reduction Workshop was held by the Applicant with the key members from the design team in attendance. Key ideas implemented through the design to drive carbon reduction include:

- Updates to earthwork balance to reduce cut and fill
- Reuse of existing infrastructure including existing carriageway where possible
- Use of warm mix asphalt
- Design for inclusion of prefabricated and precast where possible

14.10.5 An iterative design process has been undertaken to maximise reuse and refurbishment throughout the Scheme's life as well as to identify opportunities to manage ecological assets (retention, creation, and enhancement) to provide carbon sinks. These ideas are to be further investigated and explored during detailed design to reduce emissions further. Key ideas for inclusion are:

- Detailed exploration of the reuse of existing office area as the site compound and the refurbishment to be in line with future uses for the site

- Confirmation of the level of inclusion of Hydrogenated Vegetable Oil and Electric Plant
- Maximise use of recycled aggregate including collaboration with other schemes in the area
- Ensure best practice construction processes followed for greatest durability
- Provision or procurement of renewable energy for the compound

14.10.6 Opportunities for carbon reduction identified and progressed have been recorded and updated within the Carbon Opportunities Log which is to be shared with the Principal Contractor as the project progresses through design and into construction.

14.10.7 Further work will be completed through the detailed design to retain and create woodland and other habitats where feasible to capture a greater amount of carbon sequestration.

Mitigation measures – construction

14.10.8 Mitigation measures of relevance during construction are included within the First Iteration Environmental Management Plan (EMP) **(TR010065/APP/6.5)** which will be developed into a Second Iteration EMP for implementation during construction of the Scheme. Details on the First and Second Iteration EMPs, including how mitigation is secured within the draft DCO **(TR010065/APP/3.1)**, is provided within Section 4.4 of Chapter 4 (Environmental Assessment Methodology) of the ES.

14.10.9 Requirements have been set with subcontractors and suppliers to engage with provision of the following:

- Low/zero carbon solutions
- Competency/training requirements
- Reporting expectations
- Collaboration requirements

14.10.10 A construction Carbon Management Plan would be completed by the contractor in conjunction with the Second Iteration EMP and would include the following topics:

- Procurement
- Materials and resource management on site
- Change process for low/zero carbon solutions
- Low/zero carbon plant and management
- Construction techniques and competency
- Training matrix

Mitigation measures – operation

14.10.11 The Scheme has been designed to ensure the lifetime operation is as efficient as possible ensuring whole-life low carbon supporting the Applicant's ambitions.

14.10.12 Opportunities identified during the design and construction of the Scheme for operation will be captured within the Carbon Opportunities Log which will be updated by the Principal Contractor and handed over to the maintenance provider to pursue as part of the Third Iteration EMP. The Third Iteration EMP will be developed from the Second Iteration EMP at construction completion and set out those commitments and measures to mitigate the impacts of the Scheme during operation, which are included in the First Iteration EMP **(TR010065/APP/6.5)**.

Enhancement measures

14.10.13 No enhancement measures have been identified for effects on climate considering the Scheme is due to result in net emissions. Mitigation as detailed above has been implemented to reduce emissions in line with the relevant targets.

Resilience of the Scheme to climate change

Design measures

14.10.14 The development of the Scheme design has been an iterative process. The design adheres to the principles of the design and mitigation hierarchy outlined in DMRB LA 114. The first principle being to avoid potential adverse effects where possible, before seeking to minimise or mitigate any unavoidable impacts. This has formed a well-developed essential mitigation strategy. Embedded mitigation incorporated into the Scheme design development is outlined in Chapter 2 (The Scheme) of this ES and Figure 2.3 (Environmental Masterplan) of the ES Figures **(TR010065/APP/6.2)**.

14.10.15 The design has considered the climatic changes where appropriate to ensure the Scheme is resilient to future changes in climate and extreme weather events. The design guidance ensures the consideration of temperature ranges and precipitation levels.

Structural and highways design

14.10.16 The Scheme's design is in line with the latest design code which, following consultation with the design team, is believed to be sufficient in providing resilience from the impacts of climate change. These include:

- Wind loads determined in accordance with BS EN 1991-1-1-4 - Eurocode 1. Actions on Structures and corresponding UK National Annex.[45]

[45] BSI (2004) *BS EN 1991-1-4 Eurocode 1. Actions on Structures. Wind Actions* [online] available at: [redacted] (last accessed February 2023).

- Thermal actions determined in accordance with BS EN 1991-1-5 Eurocode 1. Actions on Structures and the corresponding UK National Annex.[46]
- Power cables for highways lighting and electronic signage would be buried, which ensures protection from above-ground climate events.
- The design considers the use of pavement materials that provide greater durability including resilience to changes in precipitation and temperature. These details are to be confirmed during detailed design.

Flood risk and drainage design

14.10.17 The Scheme's design is in line with DMRB CG 501 – Design of highway drainage systems[47] which stipulates that the design should include an assessment of and mitigation against the potential impacts of climate change. This also includes the use of the latest climate change allowances in accordance with relevant national policy. Alterations to the road network will provide adequate drainage to accommodate potential changes in surface runoff, including allowance for climate change in accordance with the DMRB CG 501 – Design of highway drainage systems[43] standards and through consultation with the Environment Agency and the LLFA (Nottinghamshire County Council).

14.10.18 As such, the following measures are included in the flood risk and drainage design of the Scheme which provides resilience from the impacts of climate change:

- A 40% climate change allowance has been used for a sensitivity check of the design.
- Proposed drainage has been modelled and passed using 1% Annual Exceedance Probability (AEP) fluvial event with a 39% climate change allowance.
- Retention basins have been designed to hold the 1 in 30 year (plus 25% climate change (CC)) pluvial storm events volumes within the floodplain. The deviation from the standard to hold the 1 in 100 year (plus 25% CC) has been preliminarily approved by Nottinghamshire County Council and the Environment Agency subject to a volume impact assessment proving no adverse impact on landowners and stakeholders.
- Proposed highway drainage is designed in accordance with the DMRB CG 501 which includes a 30% increase to design rainfall intensities to account for climate change, and to avoid ponding or areas of standing water during intense rainfall events.
- Incorporation of appropriate Sustainable Drainage Systems (SuDS) into the highway drainage system where appropriate to mitigate risk of

[46] BSI (2004) *BS EN 1991-1-5 Eurocode 1. Actions on Structures. Thermal Actions* [online] available at: [redacted] (last accessed February 2023).

[47] National Highways (2022) *CG 501 – Design of highway drainage systems* [online] available at: CG 501 - Design of highway drainage systems - DMRB (standardsforhighways.co.uk) (last accessed February 2023).

surface water flooding, through the use of raised swales and provision of a blue-green corridor consisting of forebays, swales, ponds and retention basins.

- All electrical, instrumentation, control and automation equipment and generators for pumping stations and electrical substations will be placed on raised platforms above the most applicable flood levels of as minimum.

Mitigation measures – construction

14.10.19 The following mitigation measures have been incorporated into the Scheme construction to reduce the overall impact:

- Contingency plans for situations where flooding leads to restricted site access or key staff being unable to get to work, leading to construction delays.
- Contingency plans for situations where storms, high winds or flooding lead to loss of mains power supply or communications, and the identification of safety critical and construction programme consequences.
- Workforce health and safety plans and welfare management systems to be put in place by the contractor, including details to be outlined within works plans and task briefs as appropriate. These would consider both low temperatures, snow and ice which may lead to injury to construction staff due to slips and falls, and also high temperatures, which may lead to risks of heatstroke, especially for construction staff working in exposed locations at a distance from welfare facilities.
- Regular monitoring of ground levels and conditions during construction.
- Planning of the site layouts for temporary works will include siting of fuel and chemical storage outside of potentially floodable areas where possible.
- The pavement construction is planned to be undertaken in a more effective way than considered in earlier stages of the design development to improve pavement durability. The construction method will be through paving in echelon. By running asphalt plant side by side the entire surface will be laid in one to remove the longitudinal joints between lanes. Minimising joins reduces points of ingress for water and as such increases durability.
- Species for mitigation planting will be considered based on their climate resilience, including drought tolerance.

Mitigation measures – operation

14.10.20 The design measures create a road surface and infrastructure which is resilient to the potential impacts identified above.

14.10.21 A summary on specific operational mitigation which will be required is noted within Table 14-22. The procedures and plans required to be put in place are detailed below:

- To alleviate potential issues with disruption to the network emergency response plans and contingency plans alongside standard operation procedures would be put in place. These are to include identification of suitable network redundancies and diversion routes.
- To minimise risk from flooding, summer ice or snow and ice build-up regular maintenance of drainage systems would be required along with incorporation of increased maintenance capacity to allow for potential extended maintenance intervals.
- To reduce risk of summer ice and damage to pavement or other assets, regular sweeping and cleaning to remove debris would be required.
- To minimise impacts of climate change on assets regular maintenance of assets to detect deterioration, such as bridge scour and damage, would be undertaken. Where necessary this would include the use of deterioration models to identify appropriate maintenance regimes.
- Regular inspection and maintenance of the soft estate to minimise risk of disruption due to vegetation falling on the network would occur.
- Regularly review and update of the road operator's (the Applicant and local highway authority) winter maintenance plans would be required to reduce the risk of snow and ice build-up. This would include regular monitoring and maintenance of pavement condition.

Enhancement measures

14.10.22 No enhancement measures have been identified for climate. Enhancement measures for resilience of the Scheme to climate change will be considered further as part of the detailed design development.

14.11 Assessment of likely significant effects

14.11.1 The assessment of likely significant effects considers effects on climate and the resilience of the Scheme to climate, during construction and operation. These effects are determined following the incorporation of the essential mitigation measures outlined in section 14.10 of this Chapter and embedded mitigation measures at section 2.5 of Chapter 2 (The Scheme) of this ES.

Effects on climate

14.11.2 For both construction and operational effects on climate, it is unlikely that the Scheme will result in GHG emissions that would be defined as significant considering the GHG emissions from the Scheme are unlikely to have a material impact on the Government achieving its carbon targets. That said, in line with the UK Government's Carbon Reduction Plan, the Scheme has sought to reduce GHG emissions as far as practicable to contribute to the UK's net reduction in GHG emissions and maximise the potential for reducing GHG emissions. Assessing the level of GHG emissions associated with the Scheme

has been key in assisting and focusing the reduction effort. A carbon assessment has been carried out using the methodology identified in Section 14.5 and presented in the following sections.

Construction

14.11.3 Embodied carbon associated with the use of materials is a reasonable contributor to the carbon footprint of the Scheme, where typical road construction materials like steel, concrete and bitumen have high embodied carbon content depending on their specifications.

14.11.4 Construction activities including plant use, which requires fuels and oils such as diesel, treatment, disposal and associated transportation of waste material from the site also contribute to the GHG construction footprint. Transportation of materials to the site would also contribute to the construction GHG footprint.

14.11.5 Table 14-17 below shows the breakdown of construction emissions by life cycle stages of the Scheme. It is seen that stages A1-A3 (product stage) contributes to the highest emissions. This includes the raw material supply, transport and manufacturing. These values include the 1.8% uplift.

Table 14-17: Scheme life cycle stage emissions

Life cycle stage	Associated emissions (tCO_2e)
Product stage (modules A1-A3)	95,176
Construction process stage -transport to site (module A4)	30,001
Construction process stage -construction and installation (module A5)	18,710
Total	143,887

14.11.6 Table 14-18 below shows the series breakdown of emissions. This is inclusive of the material, transportation and plant per series. Earthworks is the largest emissions category amounting to 51,404 tCO_2e and structures is second totaling to 42,084 tCO_2e.

Table 14-18: Construction carbon assessment (inc. uplift)

No	Item	Emissions (tCO_2e)
1	Preliminaries	28,899
2	Site Clearance	125
3	Fencing	90
4	VRS	1,379
5	Drainage	2,244
6	Earthworks	51,404
7	Pavements	7,689
8	Kerbs and Footways	898
9	Traffic Signs	245
10	Road Lighting	237

No	Item	Emissions (tCO_2e)
11	Electrical Work for Signs and Lighting	-
12	Motorway Communications	5
13	Structures	42,084
14	Accommodation Works	-
15	Landscaping and Ecology	656
16	Utilities*	7,930
Total		143,887

14.11.7 The assessment of construction emissions shows a 44% reduction in Scheme emissions compared to the baseline assessment shown in Table 14-18.

Operational

14.11.8 Operational emissions calculated for the entire assessment period include the vehicle use emissions, plus the annual GHG emissions associated with maintenance, operational energy use and land use change emissions. These are shown in Table 14-19 below.

Table 14-19: Operational emission sources

Source of emissions	60-year assessment period (tCO_2e)
Road user emissions	523,019
Renewals and maintenance	15,416
Operational energy	2,963
Land use change emissions	-2,085
Total	539,312

14.11.9 A comparison of operational road user GHG emissions between the DM and DS scenarios for the Scheme Opening Year (2028) and the Design Year (2043) are presented in Table 14-20. The increase in emissions is due to the increase in vehicle kilometres travelled as a result of the Scheme.

Table 14-20: Comparison of road user emissions – 'DM' vs 'DS' scenarios

Reporting category	Opening Year (2028) emissions (tCO_2e)	Design Year (2043) emissions (tCO_2e)
Do-Minimum	174,546	199,952
Do-Something	182,541	208,780
Difference (DS-DM)	7,995	8,828

Assessment against carbon budgets

14.11.10 In line with the requirement of the NPSNN (paragraph 5.17), an assessment of the Scheme's GHG emissions impact against the UK Government's five-year carbon budgets has been undertaken. The NPSNN (paragraph 5.17) states that it is very unlikely that the impacts of a road *'project'* would, in isolation, affect the ability of the Government to meet its carbon reduction plans.

14.11.11 Emissions from construction fall within the nearer term third and fourth carbon budgets as shown in Table 14-1. Emissions from the operation of the Scheme fall into the fourth, fifth, sixth and subsequent future budgets, once set, through to 2050. Table 14-21 presents the net tCO_2e associated with the operation of the Scheme during each of these legally binding carbon budget periods.

Table 14-21: Summary of Scheme emissions against carbon budgets

Scheme stage	**Estimated total GHG emissions over relevant carbon budgets (tCO_2e) (DS Scenario)**	**Net GHG emissions over relevant carbon budgets (tCO_2e) (DS - DM)**	**Net GHG scheme GHG emissions per relevant carbon budget (tCO_2e)**		
			4th (2023 to 2027)	5th (2028 to 2032)	6th (2033-2037)
Construction	143,887	143,887	107,915	35,972	0
Operation	12,333,180	539,312	-	40,601	41,991
Total	12,477,067	683,200	107,915	76,573	41,991

14.11.12 For the purposes of identifying to what extent the Scheme may impact the Government's ability to meet its carbon budgets, a comparison has been made between the UK carbon budget assessment findings and those identified within the calculation of lifecycle emissions. The assessment has identified that the emissions arising as a result of the Scheme represent less than 0.007% of the total emissions in any 5-year UK legally binding carbon budget during which they would arise. Accordingly, the assessment has concluded that the GHG emissions impact of the Scheme would not be significant.

Potential cumulative effects

14.11.13 The approach to the assessment of cumulative effects arising from GHG emissions is incorporated into the methodology for appraising emissions from construction and operation as set out in DMRB LA 114. The assessment of cumulative GHG emissions cannot be carried out in a process analogous to other environmental topics because there is no causal link between the location of GHG emissions and the impacts arising from the cumulative aggregation of GHGs in the atmosphere. This limitation has also been recognised in the recent

update to guidance on the assessment of GHG emissions produced by IEMA. Because of this limitation - and because it is necessary to consider GHGs in the context of a scientifically based trajectory compliant with the planetary limits for GHG emissions - the best available comparison benchmarks are the carbon budgets adopted by the UK that provide a series of five-yearly budgets within which the UK must stay in order to remain on track to achieve Net Zero by 2050.

14.11.14 The traffic model used for the proposed scheme has been developed in line with the Department for Transport requirements and is inherently cumulative. This is because, in brief, traffic models used to support scheme assessment contain data about other transport schemes promoted by National Highways and the proposed scheme and the adjoining SRN and local road network. For full details on the traffic model used to inform the assessment refer to the Transport Assessment **(TR010065/APP/7.4)**. The operational road user assessment compares the DM vs the DS. Both scenarios take into account likely development and growth factors, the assessment presented above is inherently cumulative as regards operational GHG emissions.

14.11.15 The total emissions are presented in the context of the relevant carbon budget period in which they are expected to fall. No separate cumulative assessment has therefore been undertaken on GHG emissions.

Resilience of the Scheme to climate change

Construction

14.11.16 Section 14.9 and 14.10 identified a number of potential impacts of the Scheme to climate change during construction. The assessment has identified, considering the mitigation that is in place, that climate resilience impacts and effects on the Scheme during the construction phase are not expected to be significant, due to the duration and nature of the construction activities associated with the Scheme.

14.11.17 The frequency and severity of impacts from climate change are projected to increase over long-term timeframes (2080s), however, the construction period is in the near future and shorter in duration.

Operational

14.11.18 The assessment of operational impacts and effects has considered the likelihood of climate events and hazards occurring, and the consequence of the potential impacts on disruption on the road network, taking into account the identified embedded and essential mitigation measures to be implemented through operation.

14.11.19 The findings of the assessment are presented within Table 14-22. These have concluded that no significant effects would occur to the Scheme in respect of climate change.

Potential cumulative effects

14.11.20 No cumulative effects are anticipated on the basis that the resilience of the scheme to climate change considers impacts of climate change on the scheme only and doesn't consider impacts of climate change on neighbouring developments.

In-combination effects

14.11.21 In-combination climate change impacts are the extent to which climate change exacerbates or ameliorates the effect of an existing impact of the project. The potential in-combination climate change impacts are presented within Table 14-23, which has concluded that no significant in-combination climate change effects would occur to the Scheme.

Table 14-22: Summary of effects

Receptor	Climate event	Impact (climate event and hazard together)	Mitigation built into Scheme design	Proposed management practices	Measure of likelihood	Measure of consequence	Effect significance
End-users (members of public, commercial operators etc)	Severe weather events	Health and safety risks to road users	N/A	Identification of suitable network redundancies and diversion routes. Emergency response and contingency plans in place. Standard operating procedures in place for use in the event of necessary road closure and/or traffic diversion. Regular maintenance of drainage systems and incorporation of increased maintenance capacity to allow for potential extended maintenance intervals.	Low	Moderate adverse	Not significant
	Severe weather events	Disrupted and/or inaccessible network	N/A	Identification of suitable network redundancies and diversion routes. Emergency response and contingency plans in place. Standard operating procedures in place for use in the event of necessary road closure and/or traffic diversion. Regular maintenance of drainage systems and incorporation of increased maintenance capacity to allow for potential extended maintenance intervals.	Low	Moderate adverse	Not significant
	Increased	Damage to roads,	Incorporation of SuDS	Emergency response and	Medium	Minor adverse	Not significant

Receptor	Climate event	Impact (climate event and hazard together)	Mitigation built into Scheme design	Proposed management practices	Measure of likelihood	Measure of consequence	Effect significance
	frequency of heavy precipitation events	bridges, cuttings and drainage systems due to flooding.	where appropriate. Road drainage design includes future climate change allowances in line with DMRB CG 501 standards to improve its resilience. Use of attenuation features to detain runoff from all events expected to occur. Scheme design includes flood storage areas which take appropriate account of climate change.	contingency plans in place. Regular sweeping and cleaning to remove debris. Regular maintenance of assets to detect deterioration, such as bridge scour, and damage in line with relevant DMRB standards, including CS 450, at the time of construction.			
	Increased frequency of dry spells and heavy precipitation events	'Summer Ice', which occurs after a prolonged period of no rain when dirt and oil residue builds up on the road. When the first rain event occurs, this material becomes very slippery and dangerous (similar to ice on the road).	N/A	Regular sweeping and cleaning to remove debris. Regular maintenance of drainage systems to allow for effective drainage of the residues.	Low	Moderate adverse	Not significant
The assets and their operation,	Increased summer temperature	Material and asset deterioration due to high	Use of construction materials with suitable properties (such as	Regular maintenance of assets to detect deterioration and damage. Deterioration	Medium	Minor adverse	Not significant

Receptor	Climate event	Impact (climate event and hazard together)	Mitigation built into Scheme design	Proposed management practices	Measure of likelihood	Measure of consequence	Effect significance
maintenance and refurbishment (ie pavements, structures, earthworks & drainage, technology assets etc)		temperatures.	tolerance to temperature ranges).	models used identify appropriate maintenance regimes.			
	Severe weather events	Increased slope instability leading to subsidence and landslides.	Flood storage area, alterations to the locations of embankments, or localised reprofiling of land taken, consideration of climate change, notably changing precipitation regime.	Emergency response and contingency plans in place.	Medium	Minor adverse	Not significant
	Severe weather events	Damage and disruption to gantries, power supply and other linked infrastructure.	Provision of surge protection on electrical equipment.	Emergency response and contingency plans in place. Identification of suitable network redundancies and diversion routes.	Medium	Minor adverse	Not significant
	Increasing average temperatures and increasing frequency of hot days and heatwaves	Overheating of electrical equipment, such as information and communication systems.	Installation of equipment capable of withstanding high temperatures.	Emergency response and contingency plans in place.	Medium	Minor adverse	Not significant
	Gradual climate change. Severe weather	Traffic related rutting and migration of materials from pavement.	Use of construction materials with suitable properties (such as tolerance to temperature ranges).	Regular maintenance of assets to detect deterioration and damage. Deterioration models used identify appropriate maintenance	Low	Moderate adverse	Not significant

Receptor	Climate event	Impact (climate event and hazard together)	Mitigation built into Scheme design	Proposed management practices	Measure of likelihood	Measure of consequence	Effect significance
	events			regimes.			
	Increasing average temperatures and increasing frequency of hot days and heatwaves	Thermal expansion and movement of bridge joints and paved surfaces.	Use of construction materials with suitable properties (such as increased tolerance to fluctuating temperature ranges).	Regular maintenance of assets to detect deterioration and damage.	Low	Moderate adverse	Not significant
	Increased frequency of dry spells and heavy precipitation events	Increased pollution from road runoff. Increased sediment transport.	Control surface water runoff at its source through the use of sustainable highways drainage techniques to manage road runoff.	Regular maintenance of assets to detect deterioration and damage.	Low	Moderate adverse	Not significant
	Gradual climate change Severe weather events	Longer vegetation growing seasons leading to reduced soil moisture and/or increased tree leaf coverage combined with an increased magnitude and frequency of storm events may result in tree fall and increased maintenance and management requirements.	N/A	Regular maintenance of assets to detect deterioration and damage. Regular sweeping and cleaning to remove debris. Regular inspection and maintenance of the soft estate. Emergency response and contingency plans in place.	Medium	Negligible	Not significant

Receptor	Climate event	Impact (climate event and hazard together)	Mitigation built into Scheme design	Proposed management practices	Measure of likelihood	Measure of consequence	Effect significance
	Severe weather events	Reduced safety and visibility as a result of spray from standing water.	N/A	Regular maintenance and cleaning of drainage systems. Emergency response and contingency plans in place.	Low	Minor adverse	Not significant
	Gradual climate change	Reduced safety risks due to snow and ice.	N/A	Ensure effective, essential winter maintenance. Emergency response and contingency plans in place. Standard operating procedures in place for use in the event of necessary road closure and/or traffic diversion.	Very low	Minor beneficial	Not significant
	Snow and ice. Increased frequency of heavy precipitation events. Increasing average temperatures and increasing frequency of hot days and heatwaves.	Reduced pavement friction coefficient.	Use of construction materials with superior properties (such as increased tolerance to fluctuating temperatures). Use of appropriate materials on pavement sections to maintain adequate friction coefficient.	Regular sweeping and cleaning to remove debris. Regular maintenance of assets to detect deterioration and damage. Deterioration models used to identify appropriate maintenance regimes.	Low	Minor adverse	Not significant
	Gradual climate change	Reduced pavement deterioration from less exposure to	N/A	Regularly reviewed and updated winter maintenance plans. Regular monitoring and maintenance of pavement	Low	Negligible	Not significant

Receptor	Climate event	Impact (climate event and hazard together)	Mitigation built into Scheme design	Proposed management practices	Measure of likelihood	Measure of consequence	Effect significance
		freezing, snow and ice Reduced need for snow clearing.		condition.			

Table 14-23: Summary of in-combination climate change impacts

Environmental discipline	Climate variable	Potential in-combination climate change impact	Embedded mitigation	Effect significance
Geology and soils	Precipitation	Increase in winter precipitation and frequency of extreme rainfall events may lead to impacts on ground conditions	The Scheme's design is in line with DMRB CG 501 – Design of highway drainage systems. This also includes the use of the latest climate change allowances in accordance with relevant national policy. Alterations to the road network will provide adequate drainage to accommodate potential changes in surface runoff, including allowance for climate change in accordance with the DMRB CG 501.	Not significant due to the consideration of climate change allowances within the drainage design.
Biodiversity	Precipitation	Increase in winter precipitation and frequency of extreme rainfall events may increase runoff and therefore the risk of contaminants entering watercourses.	The flood risk and drainage design is in accordance with DMRB CG 501. SuDs have also been incorporated within the drainage design.	Not significant due to the specification of climate change allowances and SUDs within the drainage design.
	Temperature	Increase in	Climate resilient species will be	Not significant due to

Environmental discipline	Climate variable	Potential in-combination climate change impact	Embedded mitigation	Effect significance
		temperatures throughout the year, particularly in the summer, and severity of extreme heat events may lead to a change in species composition or introduction of invasive species.	procured as part of the species mix to be planted for the Scheme.	specification of planting to be resilient under warmer temperatures.
Landscape and visual effects	Temperature Precipitation	Increase in temperatures throughout the year, particularly in the summer, and severity of extreme heat events as well as drought events may lead to failure of vegetation and planting	Climate resilient species will be procured as part of the species mix to be planted for the Scheme. The Second Iteration Environmental Management Plan will include a Landscape Environmental Management Plan detailing the monitoring requirements for the first five years of planting in order to minimise planting failure.	Not significant due to specification of planting to be resilient under warmer temperatures.
Road drainage and the water environment	Precipitation	Increase in winter precipitation and extreme precipitation events may lead to the overwhelming of drainage systems, resulting in surface water flooding on the Scheme.	The flood risk and drainage design is in accordance with DMRB CG 501. SuDs have also been incorporated within the drainage design. Regular maintenance of assets to detect deterioration and damage. Deterioration models used identify appropriate maintenance regimes.	Not significant due to the specification of climate change allowances and SUDs within the drainage design.

14.12 Monitoring

14.12.1 Monitoring would be undertaken despite it being anticipated that there will be no likely significant effects on climate.

14.12.2 Monthly GHG emission returns required during the construction phase and quarterly emission returns required during operation phase would be provided by the Principal Contractor in accordance with the National Highways' requirements[48]. This is detailed in Commitment C4 of Table 3-2 Register of Environmental Actions and Commitments (REAC) within the First Iteration EMP **(TR010065/APP/6.5).**

14.12.3 Actual data provided for the GHG returns would be evaluated using National Highways carbon tool to inform any ongoing monitoring of GHG emissions and also feed back into future assessment of schemes during design development and through the DCO process.

14.12.4 The First Iteration EMP **(TR010065/APP/6.5)** sets out monitoring to be undertaken during the construction stage to ensure that the mitigation measures embedded in the Scheme design are implemented. During the construction phase of works, and in accordance with Requirement 3 of the draft DCO **(TR010065/APP/3.1)** a Second Iteration EMP will secure the monitoring requirements and procedures to reduce or eliminate impacts on the environment.

14.12.5 In line with DMRB LA 114 the operation of the Scheme is required to manage, maintain and monitor asset data to ensure the Scheme is operating as intended. Adaptive management would be employed during the operational period where it is necessary to adapt the asset management in response to climate impacts. Where appropriate, additional interventions would be determined and implemented. During detailed design a detailed monitoring plan would be determined in line with the requirements for the Scheme and the planned operational procedures noted in Section 14.10 which will feed into the Second Iteration EMP.

14.13 Conclusions

14.13.1 No significant effects on climate are anticipated. The construction and operation of the Scheme would result in an overall increase of 725,643 tCO_2e in GHG emissions. However, the contributions of the Scheme to the UK's carbon budget for the relevant carbon budget periods are not significant, less than 0.007%, and therefore it can be concluded that the GHG emissions impact of the Scheme would not

[48] National Highways' Carbon emissions calculation tool

have any material impact on the UK Government meeting its legally binding carbon reduction targets.

14.13.2 Mitigation measures have been identified through engagement workshops, which would be implemented by the Principal Contractor to reduce the impacts and effects that construction of the Scheme is likely to have on climate change and GHG emissions.

14.13.3 A number of potential impacts of climate change on the Scheme during construction and operation were identified. Impacts due to climate change will increase in the long-term, however, the construction period is in the near future and shorter in duration. In addition, mitigation has been identified during the construction phase to reduce the potential impacts therefore there are not considered to be any significant impacts to the construction phase as a result of climate change.

14.13.4 The assessment of operational impacts on the resilience of the Scheme to climate change has considered the likelihood of climate events and hazards occurring, and the consequence of the potential impacts on disruption on the road network. Embedded mitigation measures have been included to reduce the risk and consequence of impacts. In addition, through construction and operation further monitoring and determination of operational procedures would occur to further reduce the impacts. With implementation of the mitigation measures it has been concluded that no significant effects would occur to the Scheme in respect of climate change. Further enhancement will be sought through detailed design.

14.14 References

[1] National Highways (2021) DMRB LA 114 version 0.0.1 (June 2021) – Climate, Revision 0 [online] Available at: d1ec82f3-834b-4d5f-89c6-d7d7d299dce0 (standardsforhighways.co.uk) (standardsforhighways.co.uk) (Last accessed November 2023).

[2] United Nations Framework Convention on Climate Change Handbook (October 2006); Available at - Handbook.pdf (unfccc.int). (Last accessed November 2023).

[3] What is Kyoto Protocol (UNFCCC Website)? What is the Kyoto Protocol? | UNFCCC. (Last accessed November 2023).

[4] UNFCCC- What is the Paris Agreement? The Paris Agreement | UNFCCC. (Last accessed November 2023).

[5] DECC (2012) Climate Change Act 2008.

[6] UK Parliament (2021) *The Carbon Budget Order 2021* Available at https://www.legislation.gov.uk/uksi/2021/750/contents/made. (Last accessed November 2023).

[7] UK Parliament (2012), *Climate Change Act 2008* Available at: Climate Change Act 2008 (legislation.gov.uk). (Last accessed November 2023).

[8] DfT (2020) Decarbonising Transport – setting the challenge https://assets.publishing.service.gov.uk/Government/uploads/system/uploads/attachment_data/file/932122/decarbonising-transport-setting-the-challenge.pdf. (Last accessed November 2023).

[9] Department for Transport (DfT) (2015) Highways England: Licence – Secretary of State for Transport statutory directions and guidance to the strategic highways company Highways England: licence (publishing.service.gov.uk). (Last accessed November 2023).

[10] UK Government's Ten Point Plan for a Green Industrial Revolution, November 2020; Available at: The Ten Point Plan for a Green Industrial Revolution (publishing.service.gov.uk). (Last accessed November 2023).

[11] Net-Zero Strategy: Build Back Greener, April 2022; Available at: assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1033990/net-zero-strategy-beis.pdf. (Last accessed November 2023).

[12] HM Government (2018) A Green Future: Our 25 Year Plan to Improve the Environment [online] Available at: 25 Year Environment Plan - GOV.UK (www.gov.uk). (Last accessed November 2023).

[13] Regional leaders commit to reaching Net Zero at least five years earlier than central government (2020) Press Release. Available at PRESS RELEASE - Regional leaders commit to reaching Net Zero at least five years earlier than central government_2.pdf (uk100.org) (Last accessed November 2023).

[14] Newark and Sherwood District Council (2019) *Amended Core Strategy DPD.* Available at https://www.newark-sherwooddc.gov.uk/amendedcorestrategy/. (Last accessed November 2023).

[15] Newark and Sherwood District Council Climate Emergency Strategy (September,2020). Available at: Carbon Reduction Action Plan Design v0.1 (newark-sherwooddc.gov.uk). (Last accessed November 2023).

[16] Newark and Sherwood District Council Community Plan 2020-2023 (September 2020). Available at: 13.10.20---Community-Plan-Appendix---Final.pdf (newark-sherwooddc.gov.uk). (Last accessed November 2023).

[17] National Highways (2021) Net zero highways: our 2030/2040/2050 plan. Available at https://nationalhighways.co.uk/media/eispcjem/net-zero-highways-our-2030-2040-2050-plan.pdf. (Last accessed November 2023).

[18] National Highways (2022) *Preparing for climate change on the strategic road network - third adaptation report under the Climate Change Act* Available at https://nationalhighways.co.uk/media/z1ndodqx/preparing-for-climate-change-on-the-strategic-road-network.pdf. (Last accessed November 2023).

[19] National Highways (2020) *Strategic Business Plan.* Available at https://nationalhighways.co.uk/strategic-business-plan/. (Last accessed November 2023).

[20] BSI (2016). *'PAS 2080 – Carbon Management in Infrastructure.* Available at: [redacted] (Last accessed November 2023).

[21] IEMA (2022) *Assessing Greenhouse Gas Emissions and Evaluating their Significance 2nd Edition* Available at [redacted] Last accessed November 2023).

[22] IEMA (2020) Environmental Impact Assessment Guide to: Climate Change Resilience & Adaptation

[23] Town and Country Planning (Environmental Impact Assessment) Regulations 2017, No. 571. Available at: The Town and Country Planning (Environmental Impact Assessment) Regulations 2017 (legislation.gov.uk). (Last accessed November 2023).

[24] RICS (2017). *Whole life carbon assessment for the built environment, RICS professional statement*.

[25] [Clarification note]

[26] Road Lighting and Energy Savings; Lighting Research and Technology; September 2009 [redacted]. (Last accessed November 2023).

[27] Carbon storage and sequestration by habitat: a review of the evidence (second edition) Carbon Storage and Sequestration by Habitat 2021 - NERR094 (naturalengland.org.uk). (Last accessed November 2023).

[28] Whole life carbon assessment for the built environment: RICS(2017) Available at: Whole Life Carbon Assessment for the Built Environment (rics.org). (Last accessed November 2023).

[29] [Clarification note]

[30] United Nations Climate Change (2021). *'What is the Kyoto Protocol?* available at: [redacted]. (Last accessed November 2023).

[31] UK Met Office (2018) *Midlands: climate* Available at https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/weather/learn-about/uk-past-events/regional-climates/midlands_-climate---met-office.pdf. (Last accessed November 2023).

[32] Department for Business, Energy & Industrial Strategy (2022). Updated energy and emissions projections 2021 – 2040. Available at: Updated energy and emissions projections 2021 to 2040 (publishing.service.gov.uk). (Last accessed November 2023).

[33] Climate Change Committee (2020). *The Sixth Carbon Budget – The UKs path to Net-Zero.* Available at: https://www.theccc.org.uk/publication/sixth-carbon-budget/. (Last accessed November 2023).

[34] Independent Assessment of UK Climate Risk (CCRA3) UK Climate Risk (Last accessed November 2023).

[35] Met Office (2018) United Kingdom Climate Projections, Available at https://ukclimateprojections-ui.metoffice.gov.uk/ui/home. (Last accessed November 2023).

[36] IEMA (2020) IEMA EIA Guide to: Climate Change Resilience and Adaptation (2020). Available from: IEMA - IEMA EIA Guide to: Climate Change Resilience and Adaptation (2020). (Last accessed November 2023).

[37] [Clarification note]

[38] Standards for Highways (2021). *Design Manual for Roads and Bridges – Sustainability and Environment LA 114 (Climate)* [online] Available at: https://www.standardsforhighways.co.uk/dmrb/search/d1ec82f3-834b-4d5f-89c6-d7d7d299dce0 (last accessed November 2023).

[39] IEMA (2020) *IEMA EIA Guide to: Climate Change Resilience and Adaptation (2020)* [online]. Available at: IEMA - IEMA EIA Guide to: Climate Change Resilience and Adaptation (2020). (Last accessed November 2023).

[40] [Clarification note]

[41] [Clarification note]

[42] [Clarification note]

[43] Environment Agency (2022) – Flood risk assessments: climate change allowances: Available at: Flood risk assessments: climate change allowances - GOV.UK (www.gov.uk). (Last accessed November 2023).

[44] Based on information generated by the UK Centre for Ecology and Hydrology using UK Climate projections. Available at Climate change allowances for peak river flow in England (data.gov.uk). (Last accessed November 2023).

[45] BSI (2004) *BS EN 1991-1-4 Eurocode 1. Actions on Structures. Wind Actions* [online] Available at: BS EN 1991-1-5 - Eurocode 1. Actions on structures. General actions. Thermal actions (bsigroup.com) (Last accessed November 2023).

[46] BSI (2004) *BS EN 1991-1-5 Eurocode 1. Actions on Structures. Thermal Actions* [online] Available at: BS EN 1991-1-4 - Eurocode 1. Actions on structures. General actions. Wind actions (bsigroup.com) (Last accessed November 2023).

[47] National Highways (2022) *CG 501 – Design of highway drainage systems* [online] Available at: CG 501 - Design of highway drainage systems - DMRB (standardsforhighways.co.uk) (Last accessed November 2023).

[48] National Highways' Carbon emissions calculation tool.