M42 Junction 6 Improvement
Scheme Number TR010027
Volume 6

6.1 Environmental Statement
Chapter 15 (a) – Climate

Regulation 5(2)(a)

Planning Act 2008

Infrastructure Planning (Examination Procedure) Rules 2010

July 2019

Infrastructure Planning

Planning Act 2008

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

M42 Junction 6 Improvement

Development Consent Order 202[ ]

6.1 Environmental Statement
Chapter 15 (a) Climate

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15. Climate

15.1 Competent expert evidence

15.1.1 This chapter presents the results of an 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 greenhouse gas emissions and the vulnerability of the Scheme to climate change.

15.1.2 The competent expert responsible for the assessment is a Technical Director who holds the qualifications of BSc Chemistry, Resources and the Environment, and is a Registered Principal Environmental Auditor with the Institute of Environmental Management and Assessment, and a Chartered Environmentalist.

15.1.3 They have over 25 years of experience in the environmental impact assessment (EIA) of a wide variety of development types including major highway schemes, and have been involved in the development of carbon management strategies and climate change impact studies for major developers and public sector agencies.

15.2 Legislative and policy framework

15.2.1 The following legislation and planning policy is of direct relevance to the assessment of climate. Compliance with statute and policy relating to climate change and greenhouse gases (GHG) is addressed within the Planning Statement [**APP-173/Volume 7.2**].

15.2.2 Legislation and policy concerning the relationships between climate change, flood risk and water management are presented within Chapter 14 Road drainage and the water environment [**APP-059/Volume 6.1**].

Climate Change Act 2008

15.2.3 The Climate Change Act 2008 [REF 15-1] sets a legally binding target for the UK Government to reduce national GHG emissions from 1990 levels by at least 80% by 2050. The target is supported by series of five year carbon budgets and an independent committee to monitor progress [REF 15-2].

15.2.4 The assessment reported within this chapter has presented the likely effects of the GHG emissions of the Scheme within the context of the UK Government's five year carbon budgets.

National Policy Statement for National Networks

15.2.5 The National Policy Statement for National Networks (NPSNN) [REF 15-3] sets out how climate change should be taken into account when developing infrastructure.

15.2.6 Paragraph 5.17 of the NPSNN [REF 15-3] states that projects are required to provide "*evidence of the carbon impact of the project and an assessment against the Government's carbon budgets*". Evidence of mitigation is also required, for design and construction, to demonstrate that the carbon footprint is not 'unnecessarily high'.

15.2.7 Paragraphs 4.40 to 4.44 of the NPSNN [REF 15-3] also outline that mitigation is essential to minimise the most dangerous impacts of climate change, noting that new development should be planned to avoid increasing vulnerability to the range of impacts arising from this.

15.2.8 The potential impacts of climate change have been considered in the assessment, and through the design-development process in relation to the planning, location, design, build and operation of the Scheme, see Chapter 4 Scheme history and alternatives [**APP-049/Volume 6.1**]. The assessment has also applied the latest available climate change projections across the 60 year lifetime (design life) of the Scheme, as described in Section 15.3.

National Planning Policy Framework

15.2.9 The National Planning Policy Framework (NPPF) [REF 15-4] sets out the Government's planning policies for England, and provides a framework within which Local Planning Authorities can formulate development plans.

15.2.10 The NPPF [REF 15-4] states that the purpose of planning is to contribute to the achievement of sustainable development, and that positive improvements should be sought in the quality of the built, natural and historic environment, as well as in people's quality of life.

15.2.11 It further notes that new development should be planned for in ways that avoid increasing vulnerability to the range of impacts arising from climate change, and ways that can help to reduce GHG emissions.

15.2.12 These policy objectives have been accounted for in the design of the Scheme through the incorporation of drainage measures that have been designed and sized to accommodate future changes in road runoff resulting from climate change, as described in Chapter 3 The project [**APP-048/Volume 6.1**], and through the assessment of GHG emissions and climate change resilience reported within this chapter.

National Planning Practice Guidance

15.2.13 The National Planning Practice Guidance (NPPG) for Climate Change [REF 15-5] provides context to the NPPF [REF 15-4] and advises on how to identify suitable mitigation and adaptation measures to address the impacts of climate change.

15.2.14 This guidance has been considered in the assessment by predicting the GHG emissions that the Scheme would generate, their likely contribution to climate change, and by identifying measures to mitigate effects on (and arising from) climate change.

Movement for Growth: The West Midlands Strategic Transport Plan

15.2.15 The West Midlands Strategic Transport Plan [REF 15-6] sets out the approach, objectives, indicators and development principles for integrated transport across the West Midlands region. Its objectives include the:

a. reduction of transport related environmental impacts, including GHG emissions; and

b. maintenance and development of transport infrastructure for greater reliability and resilience to climate change impacts.

15.2.16 The plan [REF 15-6] contains policies that guide future transport planning and development, centred on the: use of low carbon infrastructure; use of durable materials; re-use of excavated and waste materials; incorporation of Sustainable Drainage Systems (SuDS); reducing runoff rates; avoiding increased flood risks; and future proofing infrastructure for climate change impacts.

15.2.17 These policies have been taken into account during the design-development of the Scheme, as described in Chapter 4 Scheme history and alternatives, and have accordingly been considered within the assessments reported within this chapter.

Solihull Local Plan: Shaping a Sustainable Future

15.2.18 The adopted Solihull Local Plan: Shaping a Sustainable Future [REF 15-7] identifies the need to reduce GHG emissions by improving accessibility and encouraging sustainable travel, and to support national and local targets to build resilience of the community and the environment to climate change.

15.2.19 Policy P9: Climate Change aims to ensure that all sections of the community are more resilient to the effects of climate change. This states that resilience throughout the anticipated lifespan of a development should be considered through a range of measures including location, design, materials, build and operation, and confirms that full account should be taken of national and local targets for reducing GHG emissions when considering the location and design of new development.

15.2.20 These local policy requirements have been addressed through the design-development process set out in Chapter 4 Scheme history and alternatives [**APP-049/Volume 6.1**], and through the outcomes of the GHG emissions and climate change resilience assessments reported within this chapter.

Solihull Council Climate Change Strategy

15.2.21 Solihull Metropolitan Borough Council's (SMBC) climate change strategy [REF 15-8] recognises that transport is a significant source of GHG emissions in the borough, and is also a key area that will be affected by climate change.

15.2.22 A key aim of the strategy [REF 15-8] relates to encouraging developers to take action on climate change, the objectives of which have been considered during the development and assessment of the Scheme.

North Warwickshire Local Plan

15.2.23 The North Warwickshire Local Plan (Submission Version) [REF 15-9] was formally submitted for independent examination in March 2018, and contains policies relating to climate change and sustainability.

15.2.24 As the study areas for the operational GHG emissions assessment and the in-combination impact assessment (see Section 15.5) extend into the boundary of North Warwickshire, relevant policies within this document have been considered in the assessment.

15.2.25 Policy LP31: Development Considerations indicates that development should meet the needs of residents and businesses without compromising the ability of future generations to enjoy the same quality of life that the present generation aspires to. Specifically, to manage the impacts of climate change through the design and location of development, including sustainable building design and materials, sustainable drainage, water efficiency measures, use of trees and natural vegetation and ensuring no net loss of flood storage capacity.

15.2.26 The assessments reported within this chapter provide the evidence to meet these local policy requirements, through the identification of mitigation measures towards climate change effects.

15.3 Assessment methodology

Scope of the assessment

15.3.1 A scoping exercise was undertaken in late 2017 to identify the matters to be covered by the climate assessment.

15.3.2 The outcomes of the scoping exercise were recorded in a scoping report [REF 15-10], which was consulted upon as part of a formal request to the Inspectorate for a scoping opinion. The scoping report [REF 15-10] included a summary of all assessment work undertaken as part of the design-development of the Scheme up to the point of its publication.

15.3.3 The Inspectorate's scoping opinion [REF 15-11] identified a number of additional overarching EIA and topic-specific matters that were subsequently brought into the overall scope of the assessment. These further considerations are detailed in Appendix 5.3 [**APP-119/Volume 6.3**] and include responses to the points raised, and identify where the relevant information is presented within this chapter and elsewhere in the Environmental Statement.

15.3.4 In addition to the matters raised in the scoping opinion [REF 15-11], the final assessment scope has also been shaped by the following:

a. design changes made to the Scheme in respect of its form and extent;

b. the type and availability of information relating to construction materials requirements for the Scheme (see Chapter 11 Material assets and waste [**APP-056/Volume 6.1**]), and its future predicted operational greenhouse gas emissions (see Chapter 6 Air quality [**APP-051/Volume 6.1**]); and

c. the outcomes of further desk-based surveys undertaken to establish the baseline conditions associated with climate, and to inform the identification of the likely significant effects of the Scheme.

15.3.5 Consideration has been given within the scope of the assessment to climate effects arising from the future maintenance and management of the Scheme, as this forms an important stage of the life cycle assessment of GHG emissions.

15.3.6 As reported within the scoping opinion [REF 15-11], the consideration of GHG emissions associated with the end of life stage of the Scheme have been scoped out of the assessment, on the basis that it is unlikely that the Scheme would be decommissioned in the future.

Assessment guidance

15.3.7 The following guidance has been used to inform the scope and content of the assessment, and to assist the identification and mitigation of likely significant effects. This builds upon the overarching EIA methodology and guidance presented in Chapter 5 EIA methodology and consultation [**APP-050/Volume 6.1**].

Design Manual for Roads and Bridges: Interim Advice Note 114/08

15.3.8 Guidance within the Design Manual for Roads and Bridges (DMRB) Interim Advice Note (IAN) 114/08: Highways Agency Carbon Calculation and Reporting Requirements [REF 15-12] has been used in the assessment to estimate the contribution that the Scheme's construction, maintenance and refurbishment activities would make to carbon emissions.

Carbon emissions calculation tool

15.3.9 The guidance within IAN 114/08 [REF 15-12] has been supplemented by the use of Highways England's carbon emissions calculation tool [REF 15-13], developed to enable the better management of carbon emissions associated with the strategic road network.

Design Manual for Roads and Bridges: Volume 11

15.3.10 Road user emissions have been calculated following guidance provided in DMRB Volume 11, Section 3, Part 1 – Air Quality [REF 15-14] using its regional assessment methodology.

Other guidance

15.3.11 The assessment has also referenced guidance and advice contained within the following documents:

a. World Business Council for Sustainable Development and World Resources Institute Greenhouse Gas Protocol [REF 15-15];

b. Environmental Impact Assessment Guide to: Assessing Greenhouse Gas Emissions and Evaluating their Significance [REF 15-16];

c. Environmental Impact Assessment Guide to: Climate Change Resilience and Adaptation [REF 15-17];

d. IEMA Principles Series: Climate Change Mitigation and EIA [REF 15-18];

e. Guidance on Integrating Climate Change and Biodiversity into Environmental Impact Assessment [REF 15-19]; and

f. PAS 2080:2016 Carbon Management in Infrastructure [REF 15-20].

Establishment of the baseline conditions

Desk studies

15.3.12 The following sources of data were obtained and reviewed as part of the assessment:

a. UK Climate Projections 2018 (UKCP18) [REF 15-21] – to identify the relevant climate projections for the appropriate geographic and timescale of the Scheme;

b. UK Climate Change Risk Assessment 2017 Evidence Report [REF 15-22] – to identify the climate change risks relevant to the Scheme and geographic area;

c. The Meteorological Office historic climate data [REF 15-23] – to identify the historic trends of relevant climate parameters for the appropriate geographic area of the Scheme;

d. UK Government GHG Conversion Factors for Company Reporting [REF 15-24] – to identify the appropriate GHG emission conversion factors for the GHG emission sources relevant to the Scheme; and

e. Inventory of Carbon and Energy Database [REF 15-25] – to identify the appropriate embodied carbon conversion factors for materials used in the construction of the Scheme.

15.3.13 In addition to the Scheme design and construction details presented within Chapter 3 The project [**APP-048/Volume 6.1**], reference was also made to the findings of the following assessments which have a direct relationship to the assessment of climate:

a. Chapter 6: Air quality [**APP-051/Volume 6.1**] (in relation to GHG emissions associated with vehicles);

b. Chapter 11: Material assets and waste [**APP-056/Volume 6.1**] (in relation to GHG emissions associated with construction of the Scheme); and

c. Chapter 14: Road drainage and the water environment [**APP-059/Volume 6.1**] (in relation to flood risk and climate change).

Identification and assessment of impacts

Greenhouse gas emissions

15.3.14 All GHG emissions contribute to global climate change. The UK has legally binding GHG emission reduction targets and therefore the level of significance has considered how the Scheme would contribute to the UK's ability to achieve its carbon reduction targets [REF 15-1] and meet the carbon budgets [REF 15-26].

15.3.15 Whilst the scope of the assessment covers the lifecycle stages of the Scheme, the GHG emissions 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 UK national GHG emissions inventory.

15.3.16 The first part considers construction of the Scheme, the majority of GHG emissions from which would be additional to the existing national GHG emissions inventory and are compared to the relevant UK carbon budgets.

15.3.17 The second part considers the operation and use of the Scheme, comprising GHG emissions resulting from mechanical and electrical energy use, for example road lighting and the impact from a variation in vehicle journeys. As at least part of the GHG emissions associated with the operation of the Scheme would be displaced from other parts of the road network (e.g. road users), they are not considered additional to the national GHG emissions inventory.

15.3.18 The GHG emissions operational assessment adopts a scenario-based approach:

a. the first scenario is a do-minimum scenario, assuming the Scheme is not implemented; and

b. the second scenario considers a do-something scenario, assuming the Scheme is implemented and the GHG emission reductions from embedded mitigation measures are taken into account.

15.3.19 A comparison of the GHG emissions for the do-minimum and do-something scenarios has been undertaken between the years 2023 and 2083 (which represents the 60 year design life, post opening of the Scheme in 2023), in accordance with DMRB guidance [REF 15-14].

15.3.20 Impacts have been assessed by comparing estimated GHG emissions arising from the Scheme with the relevant UK carbon budgets [REF 15-2], and the associated reduction targets.

15.3.21 Data input to the carbon emissions calculation tool [REF 15-13] was based on the following set of standard data quality principles detailed in the Protocol guidelines [REF 15-15].

a. age – the GHG assessment is based on activity data and GHG emissions factors applicable to the study period;

b. geography – activity data reflects the design of the Scheme. GHG emissions factors are representative of the UK construction industry and UK transport sector;

c. technology – the default solution was to apply data which is representative of the UK construction industry and transport sector;

d. methodology – activity data was gathered directly from the Scheme's engineering and design teams to enable consistency and completeness of data collection; and

e. competency – activity data was generated by the engineering and design teams in-line with applicable industry standards.

15.3.22 GHG emissions outputs from the carbon emissions calculation tool [REF 15-13] have been reported as tonnes of carbon dioxide equivalent (tCO_2e), and have considered the following gases:

a. carbon dioxide (CO_2);

b. methane (CH_4);
c. nitrous oxide (N_20);
d. sulphur hexafluoride (SF_6);
e. hydrofluorocarbons (HFCs);
f. perfluorocarbons (PFCs); and,
g. nitrogen trifluoride (NF_3).

15.3.23 GHG emissions arising from the construction activities, embodied carbon in materials and from maintenance, have been assessed using a calculation-based methodology using the following equation (aligned with the Protocol guidelines [REF 15-15]):

Activity data x GHG emissions factor = GHG emissions value

15.3.24 The emission factors used have been selected from the Department for Environment, Food and Rural Affairs and Department of Business, Energy & Industrial Strategy's UK Government GHG Conversion Factors for Company Reporting [REF 15-24] and the Inventory for Carbon and Energy Database [REF 15-25].

15.3.25 Road user emissions have been calculated using the regional assessment methodology within DMRB [REF 15-14] to estimate the contribution from traffic on the road. This is also referred to as 'road user carbon'.

15.3.26 The uptake of lower carbon fuels, electric vehicles, increased vehicle technology and the future decarbonisation of the grid are not accounted for within the assessment of operational GHG emissions; however, it is accepted that such technological advances and changes are likely to beneficially contribute to reducing GHG emissions in the future.

15.3.27 The UK Government's 'Road to Zero' strategy [REF 15-27] sets out a route map for the UK to move towards cleaner road transportation. The long term aspirations set out in this strategy are that by 2030 between 50% and 70% of new car sales and 40% of van sales will be ultra-low emission vehicles and by 2040 all new petrol and diesel cars and vans will be zero carbon. This is supported by a range of initiatives to increase the supply of low carbon fuels and to grow the electric vehicle charging network.

Climate change resilience

15.3.28 The identification and assessment of climate change resilience within EIA is an area of emerging practice. There is no single prescribed format for undertaking such assessments; therefore, the approach adopted to undertaking and reporting the assessment has drawn on good practice from other similar developments and studies.

15.3.29 The assessment has considered the strategic aims and objectives encompassed within the national and local policies and strategies summarised in Section 15.2, which collectively seek to minimise the adverse impacts of climate change whilst requiring new development to take climate change considerations into account.

15.3.30 A review of climate change resilience has been undertaken for the Scheme to identify potential climate change impacts, and to consider their potential consequence and likelihood of occurrence, taking account of the measures incorporated into the design of the Scheme (see Chapter 3 The project [**APP-048/Volume 6.1**).

15.3.31 The assessment has included all infrastructure and assets associated with the Scheme, and has assessed resilience against both gradual climate change and the risks associated with an increased frequency of severe weather events, referencing UKCP18 data [REF 15-21].

15.3.32 The types of receptor considered vulnerable to climate change are:

a. construction phase receptors (i.e. workforce, plant and machinery);

b. the highway assets and their operation, maintenance and refurbishment (i.e. pavements, structures, earthworks and drainage, technology assets, etc.); and

c. end users (i.e. members of the public and commercial operators).

15.3.33 The 60 year design life of the Scheme includes its construction and operational phases. As the construction phase would be much shorter in duration than the operational phase, and would be undertaken within the next ten years, future climate change is less relevant to the assessment of construction impacts and effects. Accordingly, the construction assessment has followed a descriptive based approach.

15.3.34 For the operational assessment, the likelihood and consequence of impacts and effects on receptors has been assessed based on a future time frame of operation (2080s).

15.3.35 Criteria used to determine the likelihood of an event occurring, based on its probability and frequency of occurrence, are detailed in **Table 15.1**.

Table 15.1: Measure of likelihood for climate change resilience assessment

Likelihood category	Description (probability and frequency of occurrence)
Very high	The event[2] occurs multiple times during the lifetime of the project (60 years) e.g. approximately annually, typically 60 events.
High	The event occurs several times during the lifetime of the project (60 years) e.g. approximately once every five years, typically 12 events;
Medium	The event occurs limited times during the lifetime of the project (60 years) e.g. approximately once every 15 years, typically four events.
Low	The event occurs during the lifetime of the project (60 years) e.g. once in 60 years.
Very low	The event may occur once during the lifetime of the project (60 years).

[2] The event is defined as the climate event (for example a heatwave) and the hazard (for example overheated electrical equipment) occurring in combination.

15.3.36 The consequence of an impact has been measured using the criteria detailed in **Table 15.2**.

Table 15.2: Measure of consequence for climate change resilience assessment

Consequence of impact	Description
Very large adverse	National level (or greater) disruption to strategic route(s) lasting more than one week.
Large adverse	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	Regional level disruption to strategic route(s) lasting more than one day but less than 1 week.
Minor adverse	Regional level disruption to strategic route(s) lasting less than one day.
Negligible	Operational Phase: disruption to an isolated section of a strategic route lasting less than one day.

15.3.37 The identification of the likely significant effects on receptors has been undertaken using professional judgement, and has involved combining the measure of likelihood with the predicted consequence of impact, and has been guided by the matrix in **Table 15.3**.

Table 15.3: Significance measure for climate change resilience assessment

		Measure of likelihood				
		Very low	Low	Medium	High	Very high
Measure of consequence	Negligible	Not significant	Not significant	Not significant	Not significant	Not significant
	Minor adverse	Not significant	Not significant	Not significant	Significant	Significant
	Moderate adverse	Not significant	Not significant	Significant	Significant	Significant
	Large adverse	Not significant	Significant	Significant	Significant	Significant
	Very large adverse	Not significant	Significant	Significant	Significant	Significant

In-combination climate change impact assessment

15.3.38 An in-combination climate change impact assessment has been undertaken to evaluate the combined impacts of future climate change and those associated with the Scheme.

15.3.39 Projected changes to average climatic conditions as a result of climate change and an increased frequency and severity of extreme weather events, have the potential to impact the ability of the surrounding natural environment to adapt to climate change.

15.3.40 Temperature and precipitation variables have been obtained from UKCP18 [REF 15-21] and analysed to identify potential climate hazards that may impact receptors. To understand the likelihood of future severe weather events, UKCP18 data [REF 15-21] has been used to develop probabilistic seasonal weather conditions for the 2020s (2010-2039), the 2050s (2040-2069) and the 2080s (2070-2099) time periods.

15.3.41 Potential climate hazards identified include increased average temperatures, more frequent and heavier precipitation events and an increase in the frequency of severe storms.

15.3.42 The likelihood of climate hazards leading to an in-combination impact has considered both the likelihood of an impact occurring, for example contaminant soil exposure due to ground movements, and the confidence levels associated with the change in climate hazard within the timescale, for example intense rainfall which would increase contaminant soil migration.

15.3.43 Likelihood of impact has been defined using the likelihood criteria outlined in **Table 15.4**, using UKCP18 data [REF 15-21] and professional judgement.

Table 15.4: Likelihood criteria for in-combination climate change impact assessment

Likelihood of impact occurring	Confidence of climate hazard occurring	
	Low	High
Low	Low	Medium
High	Medium	High

15.3.44 The consequence of in-combination impacts has been based on the change to the significance of the effect of the Scheme on resources and receptors within each relevant environmental topic, taking account of the mitigation measures reported within each relevant assessment, as shown in **Table 15.5**.

Table 15.5: Consequence criteria for in-combination climate change impact assessment

Consequence	Consequence criteria
High	The climate change parameter in-combination with the effect of the Scheme causes the significance of the effect of the Scheme on the resource/receptor, as defined by the topic, to increase from moderate to major.
Medium	The climate change parameter in-combination with the effect of the Scheme causes the significance of the effect of the Scheme on the resource/receptor, as defined by the topic, to increase from low to moderate.
Low	The climate change parameter in-combination with the effect of the Scheme causes the significance of the effect of the Scheme on the resource/receptor, as defined by the topic, to increase from negligible to low.

Consequence	Consequence criteria
Very low	The climate change parameter in combination with the effect of the Scheme does not impact the significance of the effect of the Scheme on the resource/receptor, as defined by the topic.

15.3.45 The significance of effect has been determined by combining likelihood and consequence, as presented in **Table 15.6**.

Table 15.6: Significance criteria for in-combination climate change impact assessment

Consequence	Likelihood		
	Low	Medium	High
Very Low	Negligible	Negligible	Minor
Low	Negligible	Minor	Moderate
Medium	Minor	Moderate	Major
High	Moderate	Major	Major

15.4 Assessment assumptions and limitations

Scheme design and limits of deviation

15.4.1 The assessment has been based on the Scheme description detailed within Chapter 3 The project [**APP-048/Volume 6.1**], and has taken into account the lateral and vertical limits of deviation defined on the Works Plans [**APP-007/Volume 2.3**] in order to establish a realistic worst case assessment scenario.

15.4.2 This scenario has identified and reported the maximum effect that any lateral and vertical deviation would realistically give rise to.

15.4.3 Notwithstanding any potential deviation, all climate mitigation measures incorporated into the design of the Scheme, as described in Section 15.8, would still be deliverable within the limits of deviation and would still fulfil their intended function.

Warwickshire Gaelic Athletic Association

15.4.4 Using professional judgement, the illustrative reconfiguration design options for the Warwickshire Gaelic Athletic Association (WGAA) facility in Figures 3.5a to 3.5e [**APP-069/Volume 6.2**] were appraised to take account of the variation in the physical extents, pitch layout, buildings, fencing and lighting provision across the options.

15.4.5 The objective of the appraisal was to identify whether one option would potentially give rise to different effects than another, in order to then identify the worst case for the purposes of the assessment presented within this chapter.

15.4.6 The appraisal concluded that the design variation between the options would not be of a level that would result in different types or significance of effect on climate receptors.

Baseline data

15.4.7 The assessment has been undertaken with reference to the baseline conditions recorded at the time of undertaking the assessment.

15.4.8 There is uncertainty regarding how global climatic trends will be reflected at the regional scale. To overcome these uncertainties, forecast climate change data has been used from UKCP18 [REF 15-21]. These projections provide an update to the UKCP09 projections, to provide climate projections out to 2100, facilitating the assessment of risk exposure to future climate conditions.

15.4.9 Any limitations associated with the approach adopted within the climate change assessment relate to any uncertainties already present within the UKCP18 data [REF 15-21] used in the assessment.

15.4.10 Where information to inform the assessment of climate effects was unavailable, assumptions were made using professional judgement and these are reported as part of the baseline conditions and impact assessment, where applicable.

Impact assessment and mitigation

15.4.11 The assessment has been based on information obtained from the appointed buildability contractor for the Scheme in respect of energy use, types and quantities of materials used and waste relating to the preliminary design of the Scheme, as described in Chapter 3 The project [**APP-048/Volume 6.1**].

15.4.12 The transportation of materials has the potential to contribute to GHG emissions. Data relating to the precise source(s) and/or location(s) of materials, and the associated transportation distances, were unavailable at the time of undertaking the assessment. Accordingly, professional judgement and conservative estimates have been applied to enable the calculation of GHG emissions associated with material transportation to be undertaken.

15.4.13 The assessment has considered the design life of the project, within which lifecycle stages have been assessed to determine the short, medium and long-term periods over which the climate projections apply i.e.2020s – short term (2010-2039), medium term – 2050s (2040-2069), and 2080s – long term (2070-2099).

15.4.14 The determination and assessment of consequence and likelihood has relied on professional judgement and evidence gathered for other environmental topic assessments with a relationship to climate, and has also been based on the implementation of the mitigation measures identified within those assessments.

15.5 Study area

Greenhouse gas emissions

15.5.1 The study area adopted for the GHG assessment covers all direct GHG emissions (those arising from construction and operational activities undertaken within the Scheme's Order Limits), and indirect GHG emissions (those associated with construction materials and the transportation of materials and waste).

15.5.2 As the assessment of construction GHG emissions focusses on construction activities, the spatial extents of this assessment comprise the area(s) within the Order Limits where construction works would be undertaken.

15.5.3 The study area for the assessment of operational GHG emissions includes both direct emissions arising from energy use within the Scheme's Order Limits, and emissions from road users on the road network within and beyond the Scheme's Order Limits, based on the extents of the Scheme's traffic model contained in the Transport Assessment Report [**APP-174/Volume 7.2**].

Climate change resilience

15.5.4 The study area adopted for the climate change resilience assessment comprises the Scheme's Order Limits, which captures all highway assets and infrastructure associated with the Scheme, including all temporary works.

In-combination climate change impact

15.5.5 The study area for the in-combination impact assessment comprises the Scheme's Order Limits and the surrounding natural environment that is predicted to be impacted by the Scheme, as defined within the environmental topics presented within **Table 15.14**.

15.6 Baseline conditions

Greenhouse gas emissions

Current baseline

15.6.1 The baseline conditions for GHG comprise those associated with the do-minimum scenario, which assumes that the Scheme would not be implemented but does account for the future use and maintenance of the existing road network.

15.6.2 The baseline conditions for the do-minimum scenario were identified based on the modelling the volumes of traffic currently on the existing road network, and its predicted use (accounting for increases in traffic and associated congestion) through to year 2083. This established the baseline against which the Scheme was subsequently compared, in order to identify any variation in GHG emissions over time.

Future baseline

15.6.3 The opening year baseline (year 2023) consists of GHG emissions from road users along with emissions arising from operational energy use e.g. for lighting, signs and other mechanical and electrical sources.

15.6.4 The data related to the current and future baseline noted above presented as part of the assessment of significant effects, and is detailed in **Table 15.11**.

15.6.5 As noted in Section 15.3, technological advances and decarbonisation of the grid are expected to beneficially reduce GHG emissions in the next 20 to 30 years; however, these reductions are not taken into account within the assessment.

Climate change resilience and in-combination climate change impact

15.6.6 A review of available information sources has been undertaken to establish the current baseline conditions for climate and extreme weather, and those that may exist in the future.

Current baseline

15.6.7 A review of recent and current climate of the region associated with the Scheme has identified evidence of gradual warming and increases in average annual precipitation amounts.

15.6.8 SMBC's climate change strategy [REF 15-8] emphasises the importance of using future climate change projections, for example those in the UKCP18 [REF 15-21], to assess resilience of developments and minimise future risk.

15.6.9 The UK Climate Change Risk Assessment [REF 15-22] presents the argument that the UK's transport infrastructure is already being affected by severe weather events, specifically through flooding and changes to extreme weather event frequency and severity.

15.6.10 The Scheme and the nearest Meteorological Office Weather Station (Coleshill Weather Station) are located within the Midlands Meteorological Office district region. Historic climate observations for this region [REF 15-23] between the period of 1981 and 2010 indicates that the:

a. average annual maximum daily temperature was 13.8°C;
b. warmest month on average was July (mean maximum daily temperature of 21.8°C);
c. coldest month on average was February (mean daily minimum temperature of 1.2°C);
d. mean annual rainfall levels were 712.4mm;
e. wettest month on average was October (73.1mm of rainfall on average for the month);
f. driest month on average was February (43.8mm of rainfall on average for the month);
g. windiest month on average was January; and,
h. least windy month was August.

15.6.11 The Meteorological Office baseline climate averages for the Midlands region [REF 15-23] identify gradual warming (although not uniformly so) between 1969 and 2018, with increased rainfall also. Information on mean maximum annual temperatures (°C) and mean annual rainfall (mm) is summarised in **Table 15.7**.

Table 15.7: Climate averages for the Midlands region

Climate period	Climate variables	
	Mean maximum annual temperatures (°C)	Mean annual rainfall (mm)
1969-1978	12.817	728.04
1979-1988	12.606	797.32
1989-1998	13.512	744.48
1999-2008	13.97	843.01
2009-2018	13.846	783.2

15.6.12 For transport infrastructure, the UK Climate Change Risk Assessment [REF 15-22] identifies two key risks:

a. changes in extreme weather conditions, which will affect infrastructure, in particular through storm damage, flooding and high temperatures; and

b. flooding of transport, including roads and rail is likely to increase, affecting both urban and rural access routes.

Future baseline

15.6.13 UKCP18 data [REF 15-21] indicates a projected increase in annual temperatures and increased seasonality in rainfall in the West Midlands, with wetter winters and drier summers expected.

15.6.14 Climate change projections for the area surrounding the nearest Meteorological Office Weather Station to the Scheme (Coleshill Weather Station) have been assessed under the UKCP18 [REF 15-21] Representative Concentration Pathway 8.5 (RCP8.5), at the 10%, 50% and 90% probability levels.

15.6.15 **Table 15.8 and Table 15.9** provide a summary of projections for changes to climate conditions, including projections for temperature and precipitation for the 2020's (2010-2039), the 2050's (2040-2069) and the 2080's (2070-2099) time periods. Annual, summer (June, July and August) and winter (December, January and February) temporal projections are included in this summary, with the results presented as anomalies relative to the 1981-2010 average.

Table 15.8: Project changes to the Temperature Variable (°C)

Climate Variable	Time Period		
	2020's	2050's	2080's
Mean annual air temperature anomaly at 1.5m (°C)	+0.8 (+0.3 to +1.3)	+1.9 (+0.9 to +2.9)	+3.6 (+1.9 to +5.5)
Mean summer air temperature anomaly at 1.5m (°C)	+1.0 (+0.4 to +1.6)	+2.4 (+0.9 to +3.9)	+4.7 (+2.2 to +7.5)

Climate Variable	Time Period		
	2020's	2050's	2080's
Mean winter air temperature anomaly at 1.5m (°C)	+0.7 (-0.1 to +1.4)	+1.7 (+0.5 to +2.9)	+3.0 (+1.1 to +5.0)
Maximum summer air temperature anomaly at 1.5m (°C)	+1.1 (+0.3 to +2.0)	+2.7 (+0.9 to +4.7)	+5.4 (+2.1 to +8.9)
Minimum winter air temperature anomaly at 1.5m (°C)	+0.6 (-0.2 to +1.4)	+1.6 (+0.4 to +3.1)	+3.0 (+1.0 to +5.3)

Table 15.9: Project changes to Precipitation Variables

Climate Variable	Time Period		
	2020's	2050's	2080's
Annual precipitation rate anomaly (%)	+1 (-3 to +5)	-1 (-6 to +4)	+0 (-5 to +6)
Summer precipitation rate anomaly (%)	-6 (-22 to +9)	-21 (-45 to +4)	-33 (-62 to -1)
Winter precipitation rate anomaly (%)	+5 (-4 to +14)	+9 (-4 to +23)	+20 (+1 to +42)

Potential impacts

15.6.16 To assess the GHG emissions arising from the construction and operation of the Scheme, a lifecycle assessment approach was applied using available design, construction and transportation data (see Chapter 3 The project [**APP-048/Volume 6.1**]).

15.6.17 The likely key GHG emission sources considered in the GHG emissions assessment are described in the following sections for both the construction and operation phases of the Scheme.

Construction

Greenhouse gas emissions

15.6.18 Potential impacts likely during construction of the Scheme are presented in **Table 15.10**, and have been categorised in line with the carbon emissions calculation tool [REF 15-13] and guidance set out in PAS 2080:2016 [REF 15-20].

Table 15.10: GHG emission sources – construction phase

PAS 2080 lifecycle stage	Carbon tool reporting category	Activity	Description of emissions source
Product phase	Embodied carbon in raw materials	Use of products and/or materials required to build the Scheme.	Embodied GHG emissions within the construction materials.
Construction process phase	Fuel, energy and water	Energy and water consumption used for the construction of the Scheme.	GHG emissions from grid electricity. GHG emissions from fuel consumed. GHG emissions from the provision of water and treatment of wastewater.
	Business and employee travel	Transportation of construction workers to the site.	GHG emissions arising from the fuel consumed for worker commuting.
	Waste and waste transport	Waste generated and transported during the construction phase.	Emissions arising from the treatment of waste. Emissions arising from the transportation of the waste to the disposal facility.

Climate change resilience

15.6.19 During construction, receptors are likely to be vulnerable to a range of short term (2020s) climate risks. Potential impacts during the construction phase are likely to include:

a. inaccessible construction site(s) due to severe weather events associated with flooding, snow and ice, and storms restricting working hours and delaying operations;

b. health and safety risks to the workforce during severe weather events;

c. increased frequency and severity of unsuitable conditions, for example due to very hot weather or very wet weather during construction activities involving laying pavement materials and the delivery of construction plant, thereby increasing the need to repeat certain works; and

d. increased frequency and severity of damage to construction materials, plant and equipment, including damage to temporary buildings/facilities such as offices, compounds, material storage areas and worksites, temporary access, temporary bridges and haul routes.

Operation

Greenhouse gas emissions

15.6.20 Potential impacts likely during the operational, maintenance and use phases of the Scheme are set out in **Table 15.11** below.

Table 15.11: GHG emissions impacts – operational phase

PAS 2080 lifecycle stage	Activity	Primary emission impacts
Operational phase	Operation of the associated road and lighting, overhead gantries etc.	GHG emissions from energy consumed (grid electricity and fuel).
Maintenance phase	Maintenance including re-surfacing.	Embodied emissions associated with re-surfacing materials.
Use phase	Vehicle journeys within the whole road network.	GHG emissions per vehicle km.

Climate change resilience

15.6.21 Once operational, the Scheme has the potential to be impacted by a changing climate and, in particular, more frequent severe weather events, in the medium to long term (2050s and 2080s respectively).

15.6.22 Potential impacts on the Scheme likely to occur during the operational phase include:

a. material and asset deterioration due to high temperatures;

b. overheating of electrical equipment, for example information and communication systems;

c. health and safety risks to road users;

d. changes in travel patterns of network users;

e. longer vegetation growing seasons resulting in increased periods of tree fall and increased maintenance and management requirements;

f. damage to roads from periods of heavy rainfall;

g. flood risk (surface, groundwater, fluvial and snow/ice melt) on the network and damage to drainage systems with the potential for increased runoff from adjacent land contributing to surface water flooding;

h. increased slope instability as a result of prolonged/heavy precipitation leading to subsidence;

i. storm damage to structures; and

j. inaccessibility of the network during severe weather events.

15.7 Design, mitigation and enhancement measures

15.7.1 Highways England is committed to reducing carbon emissions from activity on its network by implementing the following mitigation hierarchy:

a. avoidance/prevention – to maximise potential for reusing and/or refurbishing existing assets;

b. reduction – through the application of low carbon solutions including technologies, materials and products to minimise resource consumption; and

c. remediation – applied to further reduce carbon through on or off-site offsetting or sequestrations.

15.7.2 The Scheme has been designed, as far as possible, to avoid and minimise impacts and effects relating to GHG and climate change through the process of design-development (see Chapter 4 Scheme history and alternatives [**APP-049/Volume 6.1**]), and by embedding mitigation measures into the design of the Scheme.

15.7.3 A number of standard mitigation measures have also been identified, which would be implemented by the appointed Contractor to reduce the impacts and effects that construction of the Scheme would have on GHG emissions.

15.7.4 No compensation or enhancement measures have been identified as being required.

Embedded mitigation measures

15.7.5 Through the design-development and assessment processes, a range of mitigation measures have been incorporated into the design of the Scheme to reduce carbon emissions and provide climate change resilience.

15.7.6 Embedded measures comprise the following:

a. the incorporation of SuDS to handle road runoff and provide resilience against potential future flood events associated with climate change (see Chapter 3 The project [**APP-048/Volume 6.1**]);

b. the use of energy efficient road lighting to reduce energy consumption during operation of the Scheme (see Chapter 3 The project [**APP-048/Volume 6.1**]);

c. the incorporation of variable messaging systems (VMS) to provide resilience during severe weather events (see Chapter 3 The project [**APP-048/Volume 6.1**]);

d. the specification and installation of highway equipment capable of withstanding high temperatures (including electrical equipment comprising information and communication systems, bridge joints and paved surfaces) arising from severe weather events (see Chapter 3 The project [**APP-048/Volume 6.1**]);

e. the retention of existing highways infrastructure (East Way bridge structure, Clock Interchange and M42 motorway overhead gantries and emergency refuge areas) within the Scheme design to reduce GHG emissions associated with demolition activities and the transportation of associated arisings off-site (see Chapter 11 Material assets and waste [**APP-056/Volume 6.1**]);

f. the reuse, where possible, of materials and arisings generated from construction works, to minimise GHG emissions associated with their transportation off-site and from the importation of materials to site (see Chapter 11 Material assets and waste [**APP-056/Volume 6.1**]);

g. the inclusion of new or diverted footpaths and cycleways at strategic points across the Scheme (including across A45 Coventry Road and across Green Man Trail) to preserve and improve non-motorised user connectivity and journeys, thereby promoting alternative non-motorised modes of transport to reduce GHG emissions (see Chapter 3 The project [**APP-048/Volume 6.1**]);

h. the implementation of emergency systems and response plans, including the identification of suitable network redundancies and diversion routes, to respond to severe weather events; and

i. the implementation of management and inspection procedures for road systems, drainage systems and landscaping to maintain or lengthen lifetime of assets.

15.7.7 Further details of how these embedded mitigation measures have been considered in the assessment are presented within **Table 15.15**.

Standard mitigation measures

15.7.8 The Outline Environmental Management Plan (OEMP) [**APP-172/Volume 6.11**] details the best practice measures that would be undertaken during construction of the Scheme to mitigate temporary effects relating to GHG emissions and climate change.

15.7.9 Standard measures relating to GHG emissions focus on:

a. the appointed Contractor developing and implementing a management plan to reduce energy consumption and associated GHG (carbon) emissions, to include measures relating to the consideration of renewable and/or low or zero carbon energy sources and the recording of savings achieved;

b. the recording and reporting of energy consumption and materials use on an ongoing basis during construction, using the carbon emissions calculation tool [REF 15-13];

c. implementing measures to manage material resource use during construction, including using materials with lower embedded greenhouse gas emissions and water consumption, using sustainably sourced materials, and using recycled or secondary materials;

d. the specification of energy-efficient construction lighting and durable construction materials to reduce energy consumption; and

e. the sustainable reuse of soil and aggregate materials won from excavation and demolition activities, where feasible, to minimise GHG emissions associated with the importation of materials to site and embodied carbon associated with additional materials.

15.7.10 Standard measures relating to climate resilience comprise the identification, selection and use of construction materials with superior properties that offer increased tolerance to fluctuating temperatures associated with climate change.

15.7.11 Further details of how these standard mitigation measures have been considered in the assessment are presented within **Table 15.13**.

15.8 Assessment of significant effects

15.8.1 The prediction of impacts and the assessment of effects has taken account of the embedded and standard mitigation measures identified within Section 15.8.

Construction

Greenhouse gas emissions

15.8.2 Based on the lifecycle stages of the Scheme (as summarised in **Table 15.10** and **Table 15.11),** the assessment has identified that embodied carbon associated with materials use would be the biggest contributor to the carbon footprint of the Scheme. This is attributed to the fact that materials comprising steel, concrete and bitumen generally have high embodied carbon contents, depending on the specifications used.

15.8.3 As the transportation of materials would also contribute to the carbon footprint of the Scheme during the construction phase, professional judgement has been used to generate conservative estimates on which transport related GHG emissions has been based. **Table 15.12** presents the breakdown and comparison of emissions from each activity during the construction phase.

Table 15.8: Breakdown of GHG emissions by construction activity

Reporting category	Emissions (tCO_2e)	% of construction emissions
Embodied carbon in raw materials and the transportation of materials	151,303	86%
Fuel, electricity and water	5,883	3%
Business and employee travel	3,763	2%
Waste and waste transport	15,738	9%
Total	**176,686**	**100%**

15.8.4 In line with the requirements of the NPSNN [REF 15-3], the assessment of the Scheme's net tCO_2e construction GHG emissions impact against the UK Government's five year carbon budgets up to 2030 [REF 15-2] has been undertaken:

a. 3rd UK carbon budget (2018 to 2022) = 2544 $MtCO_2e$;

b. 4th UK carbon budget (2023 to 2027) = 1950 $MtCO_2e$; and

c. 5th UK carbon budget (2028 to 2032) = 1765 $MtCO_2e$.

15.8.5 The construction period for the Scheme is programmed to run from 2020 to 2023; this period falls within the 3rd and 4th UK carbon budget periods.

15.8.6 **Table 15.14** presents the findings of this assessment alongside the operational impacts described in the following section.

Climate change resilience

15.8.7 The assessment has identified that climate resilience impacts and effects on the Scheme during the construction phase are not expected to be significant, due to the relatively short duration and nature of the construction activities associated with the Scheme.

15.8.8 The frequency and severity of impacts from climate change are predicted to increase over long-term timeframes (2080s); however, the construction period is in the near future and shorter in duration. Accordingly, these impacts have not been considered further in the assessment.

Operation

Greenhouse gas emissions

15.8.9 A comparison of operational road user GHG emissions between the 'do-minimum' and 'do-something' scenarios for 2023 and 2083 are presented in **Table 15.13**.

Table 15.9: Comparison of road user emissions for the do-minimum vs do-something scenarios

Reporting category	Year 2023 (tCO_2e)	Year 2083 (tCO_2e)	60 year design life (tCO_2e)
Do-minimum	242,628	273,965	16,189,260
Do-something	244,311	285,505	16,800,772
Variation	**+1,683**	**+11,540**	**+611,513**

15.8.10 In relation to the UK Government's five year carbon budgets up to 2030 [REF 15-2], operation of the Scheme has been assessed over a 60-year period and would commence in 2023; this date falls within the 4th UK carbon budget period.

15.8.11 **Table 15.14** presents the net tCO_2e associated with operation during the 4th and 5th carbon budget period.

Table 15.10: Construction and operational phase GHG emissions (compared to UK carbon budgets)

Project Stage	Net tCO_2e	Relevant Carbon Budgets
Construction	88,343	3rd UK carbon budget (2018 – 2023)
	88,343	4th UK carbon budget (2023 – 2027)
Operation	18,625	4th UK carbon budget (2023 – 2027)
	34,623	5th UK carbon budget (2028 – 2032)

15.8.12 The assessment of the total design life operational emissions over the 60 year period estimates these to be in the order of 17,132,015 tCO_2e.

15.8.13 The NPSNN [REF 15-3] states that it is very unlikely that the impacts of a road project would, in isolation, affect the ability of Government to meet its carbon reduction plans. For the purposes of identifying to what extent the Scheme may impact the UK 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.

15.8.14 The assessment has identified that the emissions arising as a result of the Scheme represent less than 0.006% of the total emissions in any five year UK carbon budget during which they would arise. Accordingly, the assessment has concluded that the GHG emissions impact of the Scheme would not have a material impact on the UK Government meeting its carbon reduction targets.

Climate change resilience

15.8.15 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 to the road network, taking account of the identified embedded and standard mitigation measures.

The findings of the assessment are presented within **Table 15.15**, and these have concluded that no significant effects would occur to the Scheme in respect of climate change.

Table 15.15: Summary of impacts and effects from climate change on the Scheme – operational phase (2080s)

Receptor	Climate event	Impact (climate event & hazard occurring together)	Embedded and standard mitigation measures	Likelihood	Consequence	Significance
End-users (members of public, commercial operators, etc.) The assets and their operation, maintenance and refurbishment (i.e. pavements, structures, earthworks & drainage, technology assets, etc.)	Severe weather events	Health and safety risks to road users, and disrupted and/or inaccessible network.	Installation of appropriate emergency systems being in place. VMS specified as part of the design. 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.	Low	Moderate adverse	Not significant
	Increased frequency of heavy precipitation events	Damage to roads, cuttings and drainage systems due to flooding.	Emergency response and contingency plans in place. Incorporation of SuDS, where appropriate. Road design includes future climate change allowances to improve its resilience.	Medium	Minor adverse	Not significant

Receptor	Climate event	Impact (climate event & hazard occurring together)	Embedded and standard mitigation measures	Likelihood	Consequence	Significance
			Use of attenuation features to detain runoff from all events expected to occur with 1% annual probability or more frequently. Regular sweeping and cleaning to remove debris. Regular maintenance of assets to detect deterioration and damage.			
	Increased frequency of dry spells and heavy precipitation events	'Summer Ice' – 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 incredibly slippery and dangerous (similar to ice on the road).	Regular maintenance of drainage systems.	Medium	Minor adverse	Not significant
	Increasing average temperatures and increasing frequency of hot days and heatwaves.	Material and asset deterioration due to high temperatures.	Use of construction materials with superior properties which offer increased tolerance to fluctuating temperatures. Regular maintenance of assets to detect deterioration and	Medium	Minor adverse	Not significant

Receptor	Climate event	Impact (climate event & hazard occurring together)	Embedded and standard mitigation measures	Likelihood	Consequence	Significance
			damage.			
	Severe weather events	Increased slope instability leading to subsidence and landslides.	Emergency response and contingency plans in place. Requirement for regular slope stability/geotechnical surveys, especially for clay embankments vulnerable to moisture fluctuations.	Medium	Minor adverse	Not significant
	Severe weather events	Damage and disruption to power supply and other linked infrastructure.	Emergency response and contingency plans in place. Installation of appropriate emergency systems being in place. VMS specified as part of the design. 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 comprising information and communication systems	Emergency response and contingency plans in place. Installation of equipment capable of withstanding high temperatures.	Medium	Minor adverse	Not significant

Receptor	Climate event	Impact (climate event & hazard occurring together)	Embedded and standard mitigation measures	Likelihood	Consequence	Significance
	Gradual climate change Severe weather events	Traffic related rutting and migration of materials	Use of construction materials with superior properties which offer increased tolerance to fluctuating temperatures. Regular maintenance of assets to detect deterioration and damage.	Low	Minor adverse	Not significant
	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 superior properties which offer increased tolerance to high temperatures. Regular maintenance of assets to detect deterioration and damage.	Low	Minor 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.	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	Regular maintenance of assets to detect deterioration and damage. Regular sweeping and cleaning	Medium	Negligible	Not significant

Receptor	Climate event	Impact (climate event & hazard occurring together)	Embedded and standard mitigation measures	Likelihood	Consequence	Significance
		with an increased magnitude and frequency of storm events may result in tree fall and increased maintenance and management requirements.	to remove debris. Regular maintenance of the soft estate.			
	Severe weather events	Signs, tall structures and high-sided vehicles at risk from increasing wind speeds	Road user warning systems in place in areas exposed to high winds. Effective vegetation maintenance. Regular surveys, management and monitoring of street lighting to ensure asset stability.	Low	Minor adverse	Not significant
	Severe weather events	Reduced safety and visibility as a result of standing water	Road user warning systems in place. Regular maintenance and cleaning of drainage systems. Emergency response and contingency plans in place.	Low	Minor adverse	Not significant
	Gradual climate change	Safety risks due to snow and ice.	Road user warning systems in place. Ensure effective, essential	Very Low	Minor adverse	Not significant

Receptor	Climate event	Impact (climate event & hazard occurring together)	Embedded and standard mitigation measures	Likelihood	Consequence	Significance
			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.			
	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 which offer increased tolerance to fluctuating temperatures. Regular maintenance of assets to detect deterioration and damage. Regular sweeping and cleaning to remove debris.	Low	Minor adverse	Not significant
	Gradual climate change	Reduced pavement deterioration from less exposure to freezing, snow and ice.	Regularly reviewed and updated winter maintenance plans. Regular monitoring and maintenance of pavement condition.	Low	Negligible	Not significant

Receptor	Climate event	Impact (climate event & hazard occurring together)	Embedded and standard mitigation measures	Likelihood	Consequence	Significance
	Gradual climate change	Reduced need for snow clearing and road salting.	Regularly reviewed winter maintenance plans.	Low	Negligible	Not significant

In-combination climate change impact assessment

15.8.16 The outcomes of the assessment of the likelihood and consequence of in-combination impacts, and the significance of in-combination effects during the construction and operational phases of the Scheme, are presented within **Table 15.16.**

Table 15.16: Summary of potential in-combination impacts and effects

Receptor	Potential in-combination impact	Likelihood	Consequence	Significance	Mitigation
Natural landscapes	Increased frequency and severity of drought events may adversely affect flora, fauna, and water features affecting loss of environmental features and disruption of field pattern.	Low	Low	Negligible	No mitigation measures required.
	Increased temperature and frequency and severity of heat waves may lead to increased frequency of forest/grass fires. This may result in loss of trees, biodiversity and aesthetic changes to landscape character.	Low	Medium	Minor adverse	No mitigation measures required.
	Areas of high elevation may experience land slippage, partly due to increased rainfall. This could result in changes impacting on the composition of views.	Low	Medium	Minor adverse	No mitigation measures required.
Drainage systems and the water environment	Increased winter rainfall is likely to support the hydrology of the two Bickenhill SSSI units by maintaining groundwater levels into the spring and supporting the establishment of MG4 grass communities.	Medium	Very low	Negligible	No mitigation measures required.
	Increased rainfall may affect peak discharge rates from the road, which can impact receiving waterbodies. If the capacity of the provided attenuation treatment train is exceeded (i.e. storage tanks, wetlands/reed-beds and swales). The treatment train can be bypassed due to overcapacity (i.e. from an extreme weather event), there is potential for waterbodies to receive untreated and polluted road runoff and to suffer morphological impacts.	Low	Very low	Negligible	No mitigation measures required.
	Increased rainfall can lead to increased frequency and duration of all sources (fluvial, surface water, artificial sources, groundwater and drainage infrastructure).	Medium	Very low	Negligible	No mitigation measures required.

Receptor	Potential in-combination impact	Likelihood	Consequence	Significance	Mitigation
	Increased frequency and severity of heavy rainfall events during construction may adversely affect controlled waters (groundwater/surface water and the lateral migration of contaminants through aquifers).	Low	Medium	Minor adverse	No mitigation measures required.
Human health	Increased temperatures or precipitation may affect people's travel choices. Warmer temperatures may lead to more cycling/walking and more rain may lead to the opposite for short local trips.	Low	Very low	Negligible	No mitigation measures required.
	Increased frequency and severity of drought events may adversely affect magnitude and duration of dust generation during construction.	Low	Medium	Minor adverse	No mitigation measures required.
Soils	Increased frequency and severity of drought and high temperatures during construction may adversely affect soil quality from degradation and/or loss of soil resource.	Low	Medium	Minor adverse	No mitigation measures required.

15.9 Monitoring

15.9.1 As no significant effects have been identified for the climate assessment, no monitoring of significant effects is proposed.

15.9.2 The OEMP [**APP-172/Volume 6.11**] sets out monitoring to be undertaken during the construction stage to ensure that the mitigation measures embedded in the Scheme design are appropriately implemented, a requirement of which will be the use of the carbon emissions calculation tool [REF 15-13] to record and report energy consumption on an ongoing basis during the construction phase of the Scheme. No other specific monitoring activities would be required.

15.9.3 It is not considered practical to monitor GHG emissions from road users during the operational phase of the Scheme.

15.10 References

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