national highways

Climate change and the strategic road network

Fourth round adaptation reporting power

December 2024

Executive summary

Climate change is affecting the whole of our society and will have direct impacts on the transport sector. As the government-owned company responsible for building and maintaining the Strategic Road Network, we need to demonstrate how we are addressing the causes of climate change and preparing for its impacts.

How climate change affects us

The Strategic Road Network (SRN), England's 4,500 miles of motorways and major A-roads, includes assets of varying lifespans. Longer life assets such as bridges, tunnels, drainage, and earthworks will endure for many decades. We need to consider how climate change will affect them over a prolonged period. As the operator and maintainer of the SRN, we must ensure the network continues to serve the public effectively. It is critical that we take account of not just today's weather, but long-range climate change too.

We assessed how the climate in England will change through to the end of the century using the latest climate projections. This helps us better understand and evaluate the impact on our infrastructure, operations, customers, and staff. Key changes we are likely to experience include:

- An increase in the frequency and severity of extreme weather events
- Hotter and drier summers
- Wetter and warmer winters

The latest climate projections for the 2070s indicate that the UK may experience:

Rainfall

An increase in winter rainfall and more intense rainfall events in summer

Sea level

Rising sea levels which will vary depending on location, with the south-east experiencing the highest rises

Temperature

An increase in summer temperatures that may be between 0.9 and 5.4 degrees C warmer in a high emission scenario

Wind

A potential increase in wind speeds in the second half of the century, most likely during winter in a high emission scenario

Reports, such as the Climate Change Committee's (CCC) third independent assessment of climate risk, highlight the key risks to infrastructure assets posed by climate change. These include:

- Risks to bridges and other structures from flooding and erosion,
- Risks to subterranean and surface infrastructure from subsidence.

Droughts, flooding, extreme temperatures, and severe storms already pose significant risks to our services and the SRN. The likely changes (increasing risks) highlight the need for proactive adaptation measures.

National Highways and the Adaptation Reporting Power (ARP)

The Adaptation Reporting Power (ARP) under the Climate Change Act of 2008 requires reporting bodies, when requested, to present:

- their current and future climate risks;
- their proposals and policies to deal with these risks;
- an assessment of progress towards implementing the policies and proposals set out in previous reports.

We have reported in every adaptation reporting period so far: ARP1 (2011), ARP2 (2016), and ARP3 (2022).

We agreed to report in this voluntary fourth round of reporting (ARP4) and the findings are outlined here. Our ARP4 presents our latest climate change risk assessment, progress on adaptation actions, and areas for improvement. To ensure a consistent and best-practice approach to our ARP4 reporting we collaborated with:

- the Department for Environment, Food and Agriculture (Defra);
- Network Rail;
- Transport for London (TfL), amongst others.

Our strategies, plans, and standards to address climate risk

Adaptation to climate change remains a strong business priority for us. We have continued to embed climate change into our organisational strategies, funding decisions, and standards to ensure the SRN is resilient to climate impacts.

- Our long-term strategic plan to 2050, *Connecting the Country,* was published in 2023 and recognises the importance of making our network resilient to the impacts of climate change.
- We published our first *Task Force on Climate-related Financial Disclosures* (TCFD) report in 2023. It set out how we are identifying and managing climate risks and how we plan to further integrate climate-related risks and opportunities into strategic planning.
- Our *Environmental Sustainability Strategy* (ESS), published in 2023, emphasises building environmental resilience. Achievements so far under this strategy, which relate to climate resilience, include improving flood resilience at over 100 locations and delivering 95 biodiversity schemes.
- In the next financial year (2025-26), we will continue to collaborate with the Department for Transport (DfT) on defining the third Road Investment Strategy (RIS3), with planning already underway. RIS3 will build on RIS2, with a greater emphasis on embedding climate risk management and developing long-term adaptation plans to enhance the resilience of the SRN. As we develop our approach, goals, and funding for beyond 2026, climate-related risks and opportunities are integral to our discussions.
- Our *Strategic Business Plan* (2020 – 2025) presents our investment portfolio and our commitment to protecting communities and the environment. One of our priorities in the plan is to create a network resilient to a changing climate.
- We are currently updating the *Design Manual for Roads and Bridges* (DMRB) to incorporate climate risk and resilience considerations. In 2024, we published a new DMRB standard for the management of scour and other hydraulic actions on our structures. We will continue to update additional design and maintenance standards into 2025.

- While adapting to climate change has become an inevitable reality, it is still crucial to continue our efforts to cut greenhouse gas emissions to avoid future climate change. Our net zero ambition is set out in our *Net Zero Highways Plan* (2021).

Ensuring good governance of our climate action

Strong governance structures will equip us to better deal with climate risks and respond appropriately to regulators and stakeholders. In this round of reporting, we have strengthened our governance structure by appointing an Executive Director to be responsible for climate-related issues. We have also formed an Environmental Sustainability Steering Group, which oversees climate-related risks and integrates climate resilience into strategic planning.

Assessing our risk

In line with the findings from the third round of adaptation reporting (ARP3), this report re-emphasises our key risks related to increased precipitation, temperature changes, and combined climate impact drivers.

We have expanded our assessment to investigate risks to our operational 'Estates' function, which includes our buildings. Key areas of risk relate to:

- Increased precipitation resulting in risks to buildings from flooding. For example, potential disruptions in deliveries of essential goods or amenities, or to business-critical services such as our Regional Operating Centres (ROCs).
- Droughts resulting in an increased risk of fire on estate greenspaces.
- Increased temperatures. Newly identified key risks include expansion of concrete in buildings, failure of building mechanical and electrical services, and an increased risk of legionella.
- Increased likelihood of high winds and storms, including building power outages and wind-blown debris resulting in damages or health and safety risks.

Progressing towards a well-adapted SRN

We have made significant progress in enhancing the resilience of the SRN since our last reporting round. Our key achievements include:

- Asset Management: We continue to develop asset management strategies and plans which consider climate resilience, as well as undertake specific areas of work informed by the changing climate.
- Research and Innovation: We continue to study the impacts of climate change on our geotechnical assets, pavements, roads, and drainage systems. Additionally, we are reviewing and updating our asset deterioration models to enhance climate resilience.
- Updating Design Standards: In 2024, we published a new DMRB standard for the management of scour on our structures, including climate risk considerations. We also included several new robust pavement repair and maintenance options in our pavement surface standards to respond to freeze-thaw (due to be published in 2025).
- Assessing Interdependent Risks: We participated in Transport for London's (TfL's) collaborative interdependencies mapping study. This has enhanced our understanding of existing interdependencies, climate hazards, and potential actions to reduce interdependent climate risks.
- Climate Adaptation Roadmaps: We have strengthened our climate adaptation plans by developing internal adaptation roadmaps. The roadmaps set out the key activities we are

taking to enhance the resilience of the SRN and will be routinely updated to reflect progress against our adaptation planning and reporting.

Our next steps and planned actions

While this ARP4 report provides the latest assessment of our efforts to address climate change, we recognize that there is still much work to be done. A summary of our next steps for progressing climate adaptation is outlined below:

- Updating Risk Assessments: Conduct regional assessments of specific risks to various asset classes (including our soft estate), integrate new data, and finalize adaptation action plans for our Estates.
- Enhancing Governance: Strengthen governance structures to ensure climate risk is integrated into decision-making processes.
- Securing Funding: Develop long-term, evidence-based investment plans and secure funding for adaptation initiatives.
- Collaboration: Engage with stakeholders to understand interdependencies and develop coordinated adaptation strategies at regional and local levels.
- Monitoring and Evaluation: Establish indicators to monitor and evaluate the effectiveness of our adaptation measures.

As we plan for future RIS periods, we will continue to deepen our understanding of climate risks and refine our responses. Additionally, we will utilise our internal climate adaptation roadmaps to better monitor and evaluate our progress on adaptation over the coming years.

Contents

Abbreviations

Term	Definition
ADMM	Asset Data Management Manual
ARP	Adaptation Reporting Power
AMTG	Assessment Management Transformation Group
AMC	Asset Management Committee
CCRA	Climate Change Risk Assessment
CCRA3	Third UK Climate Change Risk Assessment
Defra	Department for Environment, Food and Rural Affairs
DMRB	Design Manual for Roads and Bridges
ESS	Environmental Sustainability Strategy
GGC	Greening Government Commitments
KPI	Key Performance Indicator
NbS	Nature-based Solutions
ORR	Office for Road and Rail
PAS 2080	Publicly Available Specification 2080
RCP	Representative Concentration Pathways
RIS	Road Investment Strategy
RIS2	The Second Road Investment Strategy
RIS3	The Third Road Investment Strategy
ROC	Regional Operations Centres
R&D	Research & Development
SRN	Strategic Road Network
TASG	Transport Adaptation Steering Group

TCFD	Task Force on Climate-related Financial Disclosures
TfL	Transport for London
TSCS	Thin Surfacing Course System
UKCP18	UK Climate Projections 2018

Glossary

Term	Definition
Adaptation	The process of adjustment to actual or expected climate change and its effects. Adaptation seeks to reduce risks, moderate harm, and take advantage of beneficial opportunities from today's changed climate conditions, and to prepare for impacts from future changes (Definition used by National Highways).
Adaptive Capacity	The potential or ability of National Highways to adjust to potential damage, to take advantage of opportunities, or to respond to consequences of climate change (Definition used by National Highways).
Cascading impacts	Cascading impacts occur when impacts in one or more parts of an interconnected system may trigger impacts in other parts of the system. For example, flooding can cause direct damage to power infrastructure which then cascades through to other sectors such as transport, increasing risk across the system (CCRA Technical Team).
Climate Hazard	The potential occurrence of a natural or human-induced physical event or trend that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems, and environmental resources (IPCC AR5). In accordance with ISO 14090:2019, hazard: 1. can be in terms of loss of life, injury or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems and environmental resources. 2. usually refers to climate-related physical events or trends or their physical impacts. 3. comprises slow-onset developments (e.g., rising temperatures over the long term) as well as rapidly developing climatic extremes (e.g., a heatwave or a landslide) or increased variability.
Climate Impact Driver (CID)	Physical climate condition, event or trend that directly affects society or systems.[1] CIDs can represent long-term average conditions such as average summer temperatures, a common event such as snow, or an extreme event such as a coastal flood. CIDs can have adverse *or* beneficial consequences, and these consequences are not universal. Therefore, the IPCC distinguish between the terms CID and 'hazard,' stating that 'hazard' is only appropriate if the consequence of a CID is determined to be *adverse* for a specific system or element of such system.[2]
Climate Impacts	Impacts generally refer to effects on lives, livelihoods, health, ecosystems, economies, societies, cultures, services and infrastructure due to the interaction of climate change or hazardous climate events occurring within a specific time period and the *vulnerability* of an exposed society or system. Impacts are also referred to as consequences and outcomes (ISO 14090: 2019, 3.8).

[1] https://www.ipcc.ch/report/ar6/wg1/downloads/faqs/IPCC_AR6_WGI_FAQ_Chapter_12.pdf
[2] https://www.ipcc.ch/site/assets/uploads/2021/02/Risk-guidance-FINAL_15Feb2021.pdf

Climate Risk	An effect is a deviation from the expected. It can be positive, negative or both. An effect can arise as a result of a response, or failure to respond, to an opportunity or to a threat related to objectives (ISO 14090: 2019).
Interdependency	Interrelationships between climate risks. They are important contributors to the overall level of climate risk and an important part of coordinated adaptation action. A single hazard can trigger knock-on impacts across multiple systems, sectors, and regions. One example is the interrelationship between water supply and energy. In the event of a flood which causes a power outage, a water company's assets may be resilient to flooding but the water supply may still be interrupted due to a loss of power.[3]
Resilience	The ability of infrastructure assets or a system and its component parts to anticipate, absorb, accommodate, and rapidly recover from the impacts of adverse and extreme weather conditions and gradual or erratic changes in weather patterns due to climate change (Definition used by National Highways).
Uncertainty	A state of incomplete knowledge that can result from a lack of information or from disagreement about what is known or even knowable. It may have many types of sources, from imprecision in the data to ambiguously defined concepts or terminology, incomplete understanding of critical processes, or uncertain *projections* of *human behaviour*. Uncertainty can therefore be represented by quantitative measures (e.g., a probability density function) or by qualitative statements.[4]
Vulnerability	The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt (IPCC, 2018: Annex I: Glossary [Matthews, J.B.R. (ed)]. For infrastructure assets, vulnerability includes the risk of damage, or total loss of the asset, during, or immediately following, a severe weather event.

[3] https://assets.publishing.service.gov.uk/media/64ba74102059dc00125d27a7/The_Third_National_Adaptation_Programme.pdf

[4] https://www.ipcc.ch/sr15/chapter/glossary/

1. Introduction

1.1 Who we are – National Highways

We are the arms-length, government-owned company responsible for planning, designing, building, operating, maintaining, and improving England's Strategic Road Network (SRN). This network comprises of motorways and major A-roads as well as assets such as bridges, tunnels, signage, and 30,000 hectares of soft estate.

Our three imperatives of safety, customer, and delivery remain our focus and matter not only today for our customers, our people and supply chain, but for future generations. These imperatives underpin everything we do.

- **Safety** – This is our main priority, and we want everyone using our network to get to where they want to go safely and reliably. We have a long-term ambition that no one should be harmed on our network. This involves ensuring our network is dependable and durable in a changing climate.
- **Customers** – We strive to keep our roads running safely and smoothly while keeping customers informed and prepared. We aim to ensure our assets are well maintained whilst protecting the surrounding environment.
- **Delivery** – We are committed to managing and improving the SRN to make journeys safer and more reliable. We seek to deliver value for money as we invest in new routes, extra capacity, and a programme of works to make sure our roads and assets are safe.

Our Licence sets out our duties and obligations and states that National Highways should:

"Adapt its network to operate in a changing climate, including assessing, managing and mitigating the potential risks posed by climate change to the operation, maintenance and improvement of the network."

1.2 What is ARP4?

The Climate Change Act 2008 gave the Secretary of State the power to require reporting authorities, including us at National Highways, to produce a report detailing their climate change adaptation plans and optionally revisit these plans every five years. This is known as the Adaptation Reporting Power (ARP). We previously reported in 2011 (ARP1), 2016 (ARP2), and 2022 (ARP3).

This report is our submission under the fourth round of reporting (ARP4). For APR4, we updated our climate change risk assessment, considering the transport sector risks identified in the third UK Climate Change Risk Assessment (CCRA3). We reviewed the evidence on climate change and evaluated National Highways' specific impacts (including those identified in our last climate change risk assessment) and engaged with internal stakeholders from across the organisation for input. We also collaborated with Defra, Network Rail, TfL, and other stakeholders to make sure we are reporting in line with best practice and a consistent approach. This consistent approach will enable Defra to draw conclusions and understand interconnected risks across reports in the fourth ARP period more easily.

Our ARP4 report presents the following:

- Our updated climate governance structure and strategies to support our climate resilience.
- Our updated climate change risk assessment.
- The findings of our updated climate change risk assessment and the significant climate risks threatening the safe operation of England's SRN.
- Our progress against previously identified adaptation actions.
- New actions and areas for improvement we have identified.

1.3 Our role in Climate Change Adaptation

The SRN has a lifespan of several decades, during which the UK is committed to achieving Net Zero. Despite this ambition, the SRN will remain subject to the impacts of climate change locked in by historic and ongoing greenhouse gas emissions. Climate change is already affecting the SRN, with severe weather events becoming more frequent and intense. For example, in 2023/24, the UK experienced 11 named storms causing widespread disruption across the network.

Further changes in the UK's climate and extreme weather events have the potential to cause significant disruption to the SRN which poses a risk to our three corporate imperatives: safety, customer, and delivery.

The SRN includes assets with varying lifespans. As longer life assets such as bridges, tunnels, drainage, and earthworks endure for many decades, it is critical that we take account of not just today's weather but long-term climate change.

Since we are part of an integrated national transport system, prolonged and frequent disruptions on our network can have significant impacts on the UK as a whole. The criticality of climate risks impacting transport infrastructure arises from the interconnectedness of infrastructure systems and the resultant likelihood of cascading risks and failures. We must work collaboratively and embed future climate trends into our planning for the long-term maintenance and development of the network.

Whilst improving our ability to cope with the impacts of climate change, enabling a more resilient SRN that continues to connect the country safely and reliably, many adaptation measures deliver multiple co-benefits. For example, natural flood management. Working with nature to slow and store water to reduce flood risk, may help prevent damage to bridge foundations through reducing standing water. It also prevents the overwhelming of drainage and provides an amenity for communities and promote biodiversity.

As a major transport infrastructure operator, we have an important role in leading by example and influencing our supply chain and other key stakeholders on climate adaptation.

2. Our Strategy, Standards and Funding

We want our roads to work more harmoniously with the communities that live alongside them, and the built, natural and historic environments that surround them. Every aspect of our business has a part to play in improving environmental performance, alongside ensuring we meet our statutory obligations. As such, we have embedded climate change into our organisational strategies, standards, and funding.

Our Vision: A connected country. A thriving environment.

Our 2050 vision is to provide a road network that supports the country's transport needs but also protects and strengthens the natural environment and community wellbeing.

Our economy, livelihoods and wellbeing are dependent on the natural world, and we have a moral and economic duty to protect, restore and enhance the environment. We must manage what we take today and ensure we leave a thriving planet for future generations.

2.1 Strategic Climate Commitments

Connecting the country: Our Long-term strategic plan to 2050

Connecting the Country was published in 2023 and sets out our 2050 vision that the SRN meets customers' needs by connecting the country safely and reliably, delivering economic prosperity, social value, and a thriving environment. This strategic plan brings together our existing strategies and aligns our investment planning process with government policy and direction. Existing strategies are:

- Route strategies
- Net zero highways
- Digital roads
- Customer service

Asset resilience is one of the nine focus areas identified in the strategic plan and feeds into investment planning for future Road Periods to 2050. The plan recognises the importance of making our network resilient to the effects of climate change.

Asset resilience

Ageing assets:

Large parts of our network were built in the 1960s and 1970s

~70%

of concrete road km are over 35 years old

Coping with extreme weather:

35%

wetter winters by 2070

5.4ºC

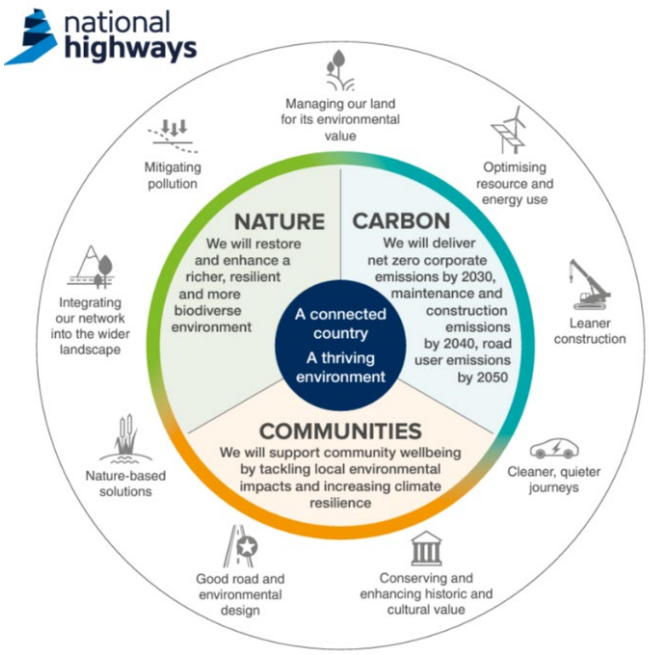
increase in max temperature by 2070

Design, build, finance and operate (DBFO):

10%

increase in network under our director control in the third road period from the return of sections previously managed through DBFO

Environmental Sustainability Strategy, 2023



Our *Environmental Sustainability Strategy* (ESS), 2023, defines three strategic priorities: Nature, Carbon, and Communities. It identifies the need to build-in environmental resilience to a changing climate. The strategy wheel on the left shows the vision of 'a connected country…a thriving environment' at the heart of the ESS. Of the nine priority areas of the strategy, climate resilience relates to the following in particular:

- Good Road and Environmental Design; building environmental resilience across the network and wider landscape to become more resilient to the effects of climate change.
- Nature-Based Solutions (NbS); habitat connectivity, biodiversity, flood management and increasing climate change resilience of land and communities.

In relation to climate risks and adaptation, we have:

- Improved flood resilience at more than 100 vulnerable locations.
- Delivered 95 biodiversity schemes including habitat connectivity and enhancement, new habitat creation and the planting of hundreds of hectares of species-rich grassland.

Future actions identified in the ESS most relevant to climate risk and adaptation include:

- Mapping the risk of future flooding to the SRN for climate change scenarios and identifying opportunities to increase resilience. This means that we will have comprehensive information and data on flood risks and be able to use that information in decision-making to create an SRN and communities that are more resilient.
- Publishing a report on opportunities for delivering multiple benefits and agree and implement a programme of NbS in the RIS3 period. NbS will help us adapt to the changing climate.

Climate Related Financial Disclosures

In 2023, we published our first Task Force on Climate-related Financial Disclosures (TCFD) report summarising our progress against the four pillars: governance, strategy, risk management and metrics and targets. It sets out how we are identifying and managing climate risks and how we plan to further integrate climate-related risks and opportunities into strategic planning over the coming years.

By publishing our TCFD report ahead of the requirement becoming mandatory, we demonstrated our commitment to adopting best practice and being proactive in addressing climate change. Climate-related financial disclosures, following TCFD recommendations, are now mandatory for public bodies, and we published our second update in our annual report and accounts 2024.

Net Zero Highways Plan, 2021

Our goal to become net zero is set out in “Net zero highways: our 2030 / 2040 / 2050 plan,” which is an ambitious programme putting roads at the heart of Britain’s net zero future. Our targets are outlined in Figure 1 below:

Figure 1. National Highways’ Net Zero targets.

Our Net Zero Plan has been integrated into our ESS, reflecting the interconnected nature of environmental issues. A priority for us is to work harmoniously to adapt to climate impacts in a way that supports sustainable development and net zero ambitions.

Additionally, we are compliant to Publicly Available Specification 2080 (PAS 2080:2023), a global standard for managing whole-life carbon in buildings and infrastructure. This framework, updated in April 2023, unites organisations and their partners around a common decarbonisation goal. Originally developed in 2016 by the Construction Leadership Council’s Green Construction Board and the British Standards Institute (BSI), compliance means we can capably deliver low-carbon solutions.

A programme to implement the goal of net zero highways recognises that roads are a vital part of zero carbon travel. Our Net Zero Plan is underpinned by science and aligns with the Paris Agreement, working to limit global temperature rises to 1.5°C above pre-industrial levels. The independent Science Based Targets initiative (SBTi) has recently validated our ambitious net zero targets, serving as confirmation that our targets are in line with the most current climate science. We are proud to be the world's first national road network operator to receive this accreditation.

2.2 Funding

Road Investment Strategy

We operate in five-year investment periods, delivering the governments’ Road Investment Strategy (RIS) in each period. The second Road Investment Strategy (RIS2) covers financial years 2020/21-2024/25. It sets out the strategic vision, performance specification, and investment plan for the SRN. From 2023 to 2024, we delivered a number of key projects to reduce climate risk, improving flood resilience at 18 locations. At the same time, we have continued developing a collaborative programme to address flooding and water quality with the Environment Agency (EA). This programme has a combined value of £23 million.

The long-term strategic vision for the network in 2050 includes:

> In 2050: The SRN is resilient to climate change and incidents, such as flooding, poor weather conditions and blockages on connecting transport networks.

In the next financial year (2025 – 2026), we will have an interim year, where we will continue to collaborate with DfT to define and agree RIS3. RIS3 will be used as an opportunity to build on progress made in RIS2, with more emphasis on embedding climate risk management and developing long-term adaptation plans to boost the SRN's resilience in future road periods. Beyond 2026, climate-related risks and opportunities are a central focus for us as we develop our goals, approaches, and funding for future years.

Strategic Business plan and delivery plan

Climate related risks are strategically important; we must be preparing for a changing climate by adapting to future conditions whilst we build and maintain our roads.

Our Strategic Business Plan (2020 – 2025) describes our portfolio of investment and our commitment to protecting the environment and communities. This is supported by our delivery plan (2020-2025) which sets out how government funding is invested into the SRN until the end of the financial year.

One of our Strategic Business Plan priorities is:

'Creating a network resilient to a changing climate.'

The actions in our ARP3, and in this ARP4, are contributing towards achieving the aim of the Strategic Business Plan and Delivery Plan.

2.3 Standards and Implementation

Design Standards and Asset Management

We are updating DMRB and including climate risk and resilience in several new and updated standards. For example, in 2024 we published a new DMRB standard for the management of scour on our structures – CS 469 Management of scour and other hydraulic actions at highways structures. We have also included several new robust pavement repair and maintenance options in our pavement surface standards (CC 205 and CM 231), due to be published in 2025. This is in response to freeze-thaw risk.

It is important for us to ensure our design and maintenance standards address current and future climate change. When we review our standards, we check that they account for the latest climate projections and information. At present, we are working with design, engineering and climate experts to better account for the impacts of climate change. This includes geotechnical assets and ground related hazards, bridge design and the future flood resilience for the SRN.

2.4 Embedding Adaptation

Asset Management

In June 2024, we achieved certification against the requirements of the international standard in asset management, ISO 55001.Our focus on addressing climate change and environmental sustainability through a robust asset management system was identified by the auditors.

Asset Class Strategies

To develop the maturity of our asset management processes, we have created asset class strategies to cover the ambition and direction for each of our key assets. Each asset class strategy has objectives for management, maintenance and renewal. They describe the actions required to further enhance the services we provide to our customers. Environmental sustainability considerations, including climate resilience, are central to how we are improving the management of our assets.

Our key assets are:

- Drainage
- Structures
- Pavements
- Geotechnics
- Soft estate

In 2023, we formally recognised our soft estate as a key asset class to be governed by the same processes as our other key asset classes. We are working to ensure interoperability between the soft estate and other assets. This will improve the resilience of the network and identify new areas of vulnerability.

We will continue to review our asset class strategies to ensure they are fit for purpose.

Asset Class Handbooks

Asset class handbooks contain guidance to enable consistent planning and delivery across the lifecycle for each of our key assets. They support colleagues to make informed and consistent decisions. The development of these processes further embeds sustainability principles into the planning and delivering our work.

The risks and actions for each of the assets identified and assessed in ARP3 and ARP4 are integrated into the asset class strategies and handbooks.

Climate Change Adaptation Plans and Roadmaps

Our adaptation plans are not static. They are routinely updated to reflect progress against and updates to new data, activities, and information. In 2024, we actively engaged with our engineers, asset managers, and other stakeholders through targeted workshops. These workshops assessed progress against previously identified adaptation actions, intended outcomes of each action and developed areas for further improvement.

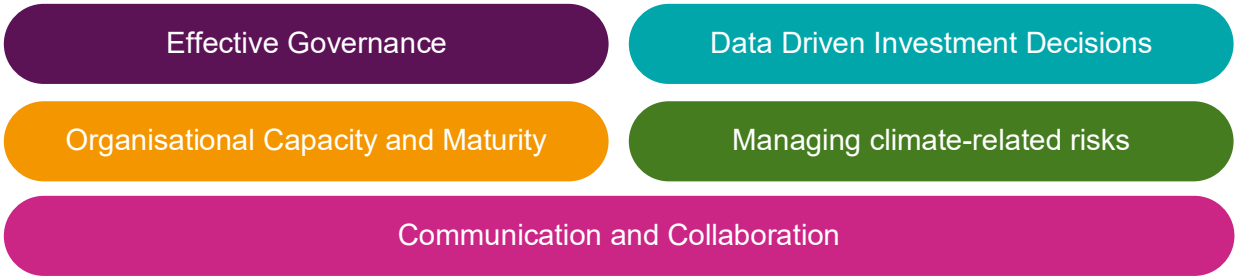
The adaptation plan reported in ARP3 was used to inform the development of our internal Climate Adaptation Roadmaps. The roadmaps provide timelines and ownership for implementation of our updated adaptation actions. The implementation of the roadmaps will be governed by the Asset Management Transformation Programme.

Our roadmaps are divided into two focus areas:

1. **Asset Resilience Roadmaps** focus on our key asset classes, as well as actions that cover multiple asset classes.
2. **Adaptive Capacity Roadmaps** focus on our internal management, business processes and decision-making around climate risk and resilience.

Actions within the **Asset Resilience Roadmaps** are categorised into four main activity types:

Actions within the **Adaptive Capacity Roadmaps** centre on five themes:



The roadmaps help us actively manage and communicate our climate adaptation plans now and in preparation for future RIS periods. We will routinely update them to reflect progress and any changes to our adaptation planning. We will also continually review our approach to ensure our decision-making is robust.

We are committed to understanding the risks of a changing climate and taking appropriate action so we can make the SRN more resilient.

3. Climate Change Governance

3.1 The importance of good governance

Our performance is monitored by the Office for Road and Rail (ORR) and the consumer watchdog body, Transport Focus. Both organisations provide advice to the Secretary of State for Transport on our activities.

With good governance structures in place, we are better equipped to deal with risks and respond appropriately to stakeholders and regulators. Adapting to climate change requires clear lines of reporting, accountability, and escalation to ensure we are making progress. We have a clear division of responsibilities between the Chairperson, Chief Executive and members of the Board and Executive Teams.

3.2 Climate governance at National Highways

Our TCFD report sets out how climate related risks are governed at National Highways. The Board is accountable to DfT, for all aspects of our company performance. Several strategic, financial, or significant matters are reserved for approval by the Board. These include setting environmental direction, policy, and performance standards.

Key roles in corporate governance include:

- The Audit and Risk Committee ensures our organisation has efficient and effective risk management, internal control, and governance arrangements, which it oversees on behalf of the Board. This includes risks and controls relevant to climate resilience.
- We work closely with the Board in developing our strategies including our Environmental Sustainability Strategy.
- Our Executive team, reporting to the Board, is the main overseer of climate-related risks. In 2024, we appointed an Executive Director to represent and be responsible for climate-related issues as part of their role.

Corporate risks and performance reporting

Our risks are linked to our corporate strategic outcomes, objectives, and Key Performance Indicators (KPIs). We group all risks under our three imperatives: safety, customer service, and delivery.

Our principal (or 'corporate') risks are owned by our Executive Team and monitored by the Board. Executive Directors also own risks relevant to their area of responsibility and delegate the management of these to the appropriate functions within our business. Risks that sit at this level are known as secondary risks and are linked directly to the relevant principal risk(s) held on our corporate risk register.

Each of our directorates own a directorate risk register which captures the key risks to the organisation and scores these according to their impact and likelihood. The risk register is a framework for managing risks at a corporate and directorate level in the organisation.

Environment is a core element of our risk assessment process, and all risks are evaluated against a set of environmental impact and likelihood statements.

We currently recognise 13 principal risks that encompass all key areas of our business. Our principal environment risk focuses on failing to meet government targets (including climate targets). Recognising that risks are interlinked; several principal risks are exacerbated by climate-related impacts.

Secondary environment risks, including climate-related risks, sit within and are managed through directorate, programme, and project risk registers. Those that are climate-related focus on the impact that adverse weather events may have on our network, our customers, and our ability to manage the risk now and in the future.

Climate Risks occur across risk categories, these are further outlined in our 2023 TCFD report. For example:

The breadth of our risks highlights the need to consider climate change as a cross-cutting risk.

We are currently reviewing our risk registers comprehensively through the lens of climate resilience and amending ratings where necessary. Ensuring that climate change impacts are considered across all directorate risk registers.

Delivering climate action

In addition to our corporate governance structures and roles, there are numerous groups and committees that oversee and help deliver climate action.

Environmental Sustainability Steering Group

Our Environmental Sustainability Steering Group was established in 2023 to ensure a more joined up approach to managing challenges and opportunities around sustainability and the environment.

Climate related issues, including both physical and transition risks, are governed through our Environmental Sustainability Steering Group. This group presents papers to our Executive team on climate matters, ranging from climate risk and impacts to our net zero commitments and TCFD.

Environment and Sustainability is one of our transformation themes. This is being delivered through the Environmental Sustainability division, who work with the Executive team and the

Executive Transformation Committee to define our approach to managing climate resilience as we develop RIS3.

Environmental Sustainability Carbon and Climate Team

In 2021, we established a Central Carbon Team to deliver our Net Zero Plan. In 2023, we established dedicated resources in the Environmental Sustainability division to facilitate and coordinate the development of tactical climate change adaptation planning across the organisation, supporting the development of operational plans, and further embedding our understanding of climate risks and climate risk management into our existing processes. We recognise the criticality of both climate change mitigation and adaptation, and we are working on this through our Carbon and Climate Team.

Asset Management Committee

The Asset Management Committee (AMC), a subgroup of our Executive Committee, is the escalation route for seeking Executive decision-making, strategic oversight and endorsement for all asset management-related activity and issues.

Asset Management Transformation Group

We understand that the asset decisions we make may affect future service provisions; therefore, we plan and account for evolving changes to the climate.

The Assessment Management Transformation Group (AMTG) has representatives from multiple directorates and reports into the AMC. A focus area for the AMTG has been in the development of the strategic asset management plan (SAMP; initial version July 2023, revised April 2024) with a suite of internal asset management policy documents.

The AMTG oversees the management of climate risks to our assets and governs the planning and implementation of the adaptation roadmaps. The group is accountable for the end-to-end asset management approach across our organisation as well as the change activity associated with delivering our road investment objectives. This new governance arrangement helps to ensure effective delivery of progress on adaptation.

4. Our Approach to Climate Change Risk Assessments

In 2021, we produced a climate change risk assessment (CCRA) using the latest climate projections from the Met Office (UKCP18), the findings of which were reported in ARP3. In 2024, we reviewed and updated the CCRA following the same approach. The methodology reflects best practice in climate change risk assessment, using UKCP18 and aligning with international standards for climate adaptation and risk assessment (ISO14090:2019 and ISO14091:2021). It aligns with the approach developed in collaboration with Defra and other surface transport sector organisations who are reporting to Defra under the fourth adaptation reporting power, including Network Rail and TfL. The common methodology provides a standardised approach for the land transport sector, enabling Defra to more easily assess the risks across the sector and draw conclusions from across our reports.

Our updated CCRA also supports us to meet our obligations under the Greening Government Commitments (GGC). The GGC sets out actions that UK government departments and partner

organisations need to take to reduce their impact on the environment and requires them to conduct a climate change risk assessment.

Our risk assessment methodology follows four steps (shown in Figure 2) and is defined by the following equations:

Exposure x Sensitivity = Vulnerability (Likelihood)

Likelihood (Vulnerability) x Consequence (magnitude of impact) = Risk

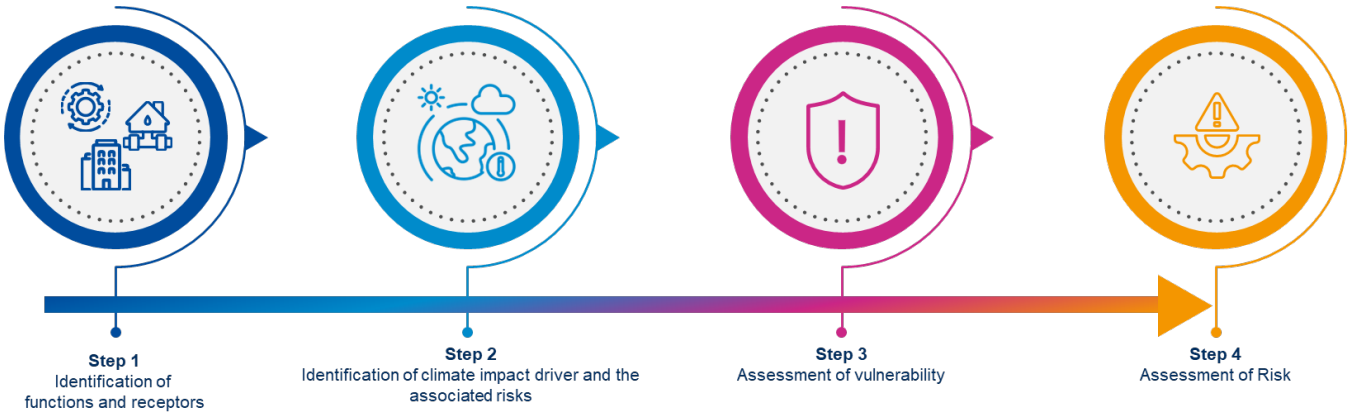


Figure 2. Our approach to climate change risk assessments.

For ARP4, we focused on the identified national-level risks in our CCRA. Updates to the regional-level CCRA will commence in 2025.

In updating the CCRA for ARP4, we added the Estate business function and assessed the vulnerability and associated risks to our buildings. However, our adaptation plans for our Estate business function are not yet finalised and will be completed as part of the updated regional risk assessment work commencing in 2025.

In addition, through asset and service-based workshops with our engineers and asset managers, we identified new risks, updated previous risks based on the implementation, and updated our adaptation plans.

Our updated CCRA provides a single, consistent assessment of our asset-based risks across the business, which will be continually developed with evolving and updated climate data. It provides an understanding of the impact of climate on our network now and in the future. Furthermore, it gives an important evidence base for supporting project development and adaptation prioritisation.

Step 1: Identification of functions and receptors

Review of previous CCRA functions and receptors

As part of our ARP3 submission, we conducted an evaluation of how our organisation is impacted by climate change through an extensive literature review and consultation process with our teams, with a focus on key asset classes to be used in the assessment.

To understand whether the CCRA reported in ARP3 was still accurate and relevant, we conducted a series of risk review workshops with our key asset teams in 2024. These workshops involved the review of risks to the following receptors: Estates (buildings), Customers, Staff & Operations, Drainage, Geotechnics, Pavements, and Structures.

Updating of Functions and Receptors

During the review of our ARP3 risk assessment, we identified that risks classified as 'Soft Estate' were risks posed by the soft estate themselves, rather than climate risks to the soft estate. Therefore, we have removed soft estate as a receptor from the updated CCRA and re-assigned the risks to their respective function and receptor, as shown in table 1 below.

Table 1. Changes to soft estate risk report from APR3 to APR4

ARP3 soft estate-related risks	ARP3 risk code	ARP4 updated risks	ARP4 risk code
Unsafe driving conditions due to smoke from wildfires.	ST7	Smoke caused by wildfires leading to unsafe driving conditions.	ST7
Management of soft estate through increased irrigation to decrease vegetation desiccation and fire risk.	ST9	N/A – This risk has been deleted as it is an action as opposed to a climate risk.	N/A
Management of soft estate to decrease hazards from tree windthrow.	W9	Hazards such as fallen lighting columns, debris, fallen trees and tree windthrow caused by high winds leading to unsafe working conditions.	W9
		Hazards such as fallen lighting columns, debris, fallen trees and tree windthrow caused by high winds, leading to unsafe driving conditions.	W11 (new)
Blocking of drains by leaves.	W1	Tree windthrow caused by high winds leading to blocked drains.	W1

Additionally, we identified our 'Estates' function, accounting for our buildings, as a new receptor group and have included it in our updated CCRA for ARP4.

Revised functions and receptors

Our final list of functions and receptor types assessed in the updated CCRA and reported in ARP4 is outlined in Figure 3 below.

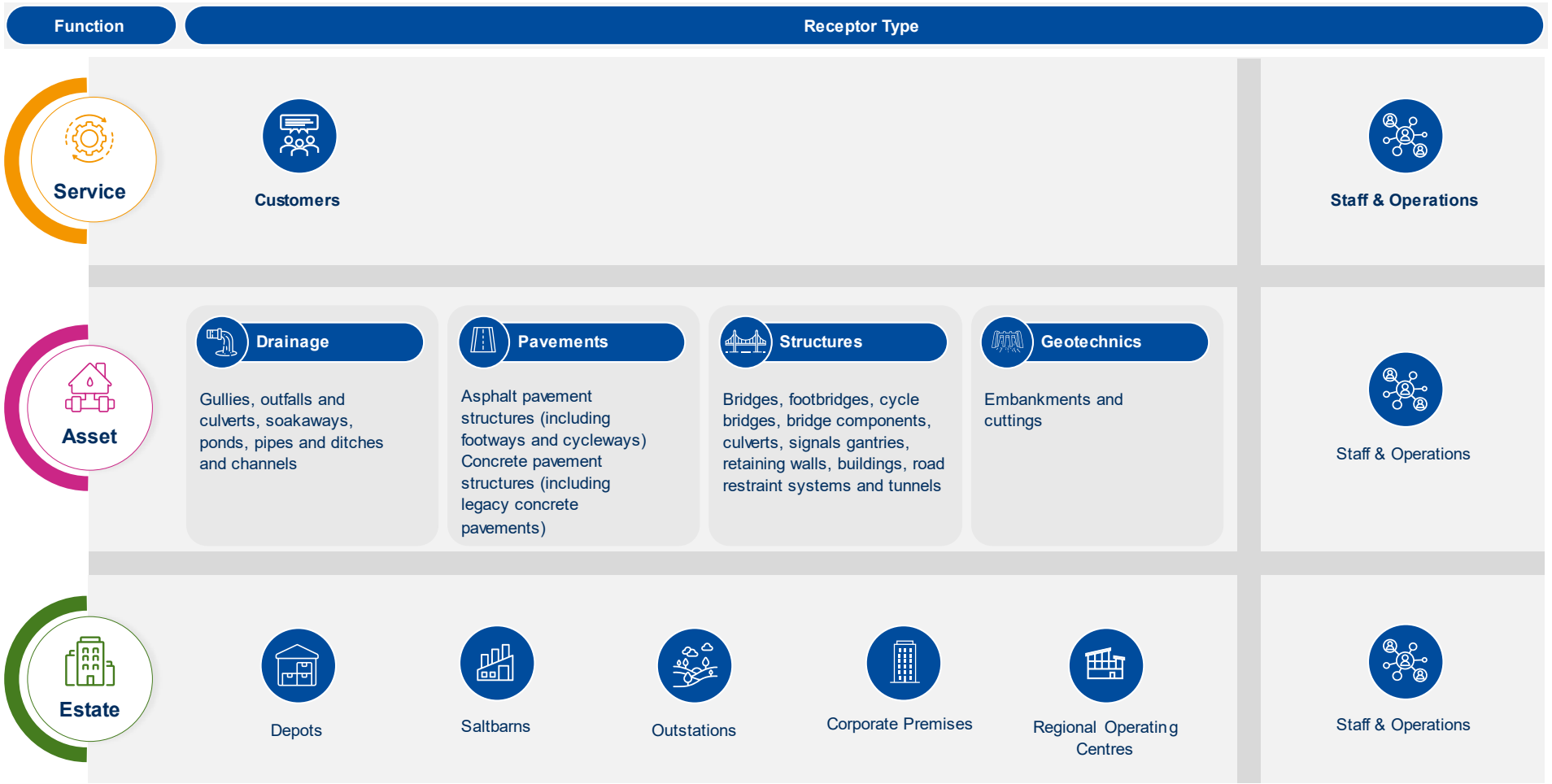


Figure 3. National Highways Functions and Receptor Types assessed in ARP4.

There are many interrelations between our assets, for example drainage risks are closely related to those of geotechnics, pavements, and structures. Therefore, we have taken a systems approach to identifying and assessing risks and opportunities in which we considered the interconnections and interactions between various components within our network and services, rather than focusing on individual parts in isolation.

Step 2: Identification of relevant climate impact drivers and associated risks

Identification of climate impact drivers

We reviewed and assessed how specific climate impact drivers ('physical climate conditions, events or trends that directly affects society or systems'[5]) may affect our assets and operations. The impact drivers are broken into two categories: extreme events and slow-onset processes and trends, as shown in Figure 4 below.

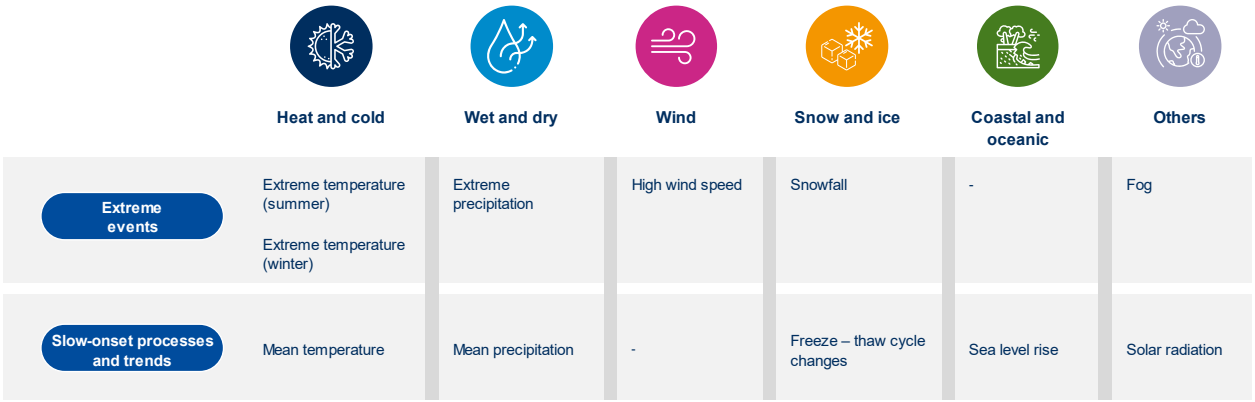


Figure 4. Climate Impact Drivers used in our climate change risk assessment.

Identification of climate risks

We conducted a series of risk review workshops with our key asset teams (aligned with the receptors identified in Figure 3). These workshops supported our understanding of whether the conclusions reported in ARP3 remain a true representation of our risks. At each workshop, the previous CCRA risks and their descriptions were reviewed and discussed to determine if they were still accurate. Our staff also identified several new risks based on recent extreme weather events, experiences, or incidents.

The risk descriptions provide an explanation on the cause of the hazard and the possible consequence to the receptor. Creating a formula for the risk description allowed for better identification of hazards that have both direct and indirect impact on our services and operations. In addition, these descriptions allowed for continuity between our asset teams.

Our complete, updated CCRA is presented in Appendix A, with descriptions of all identified climate risks.

[5] https://www.ipcc.ch/report/ar6/wg1/downloads/faqs/IPCC_AR6_WGI_FAQ_Chapter_12.pdf

Step 3: Assessment of vulnerability

To assess vulnerability, our methodology considers the exposure and sensitivity of each of our receptor types across the asset, service, and estate functions.

Exposure x Sensitivity = Vulnerability (Likelihood)

We used the UK Climate Projections 2018 (UKCP18) to conduct the assessment (at 25km^2 resolution) using the reference time of 1981-2010. UKCP18 provides probabilistic climate projections aligned to Representative Concentration Pathways (RCPs) and provide a range of possible trajectories of how global land use and emissions of greenhouse gases may change through to 2100. In accordance with DEFRA requirements, we used RCP 4.5 (50th percentile) and RCP 8.5 (90th percentile) for our assessment as they roughly align to a future world where global average temperatures are 2°C and 4°C above preindustrial levels, respectively.

To assess exposure, regional climate projections were derived across short, medium, and long-term time periods (2030s, 2050s, and 2080s). For our updated CCRA, national averages were then calculated for each climate variable to estimate national-level changes over each assessed time period.

- **Exposure** was rated on a 6-point scale from 'negligible' to 'very high' based on the magnitude of change for each assessed climate variable over the 2030s, 2050s, and 2080s under RCP 4.5 and RCP 8.5.
- The **Sensitivity** assessment considers the characteristics of each receptor which may make it vulnerable to a change in climate. Scores for each risk were rated either low, medium, or high. These scores are based on the current state of the receptors, prior to any mitigation measures.

We reviewed each of our sensitivity scores, and if necessary, updated them at the risk review workshops held with our engineers and asset managers. This ensured that our sensitivity scores reflect current receptor conditions. Exposure and sensitivity scores were then combined in a matrix to ascertain how each receptor type was vulnerable to the different climate variables and associated risks, thus resulting in a vulnerability rating for each risk. We then carried the vulnerability, or 'Likelihood,' rating into Step 4, (i.e., the probability of each hazard occurring).

Step 4: Assessment of risk

Risk considers the probability of each risk occurring and the magnitude of impact if the event were to happen.

Likelihood (Vulnerability) x Consequence (magnitude of impact) = Risk

Likelihood ratings, the probability of each risk occurring, ranged on a 5-point scale from 'highly unlikely' to 'almost certain.' The consequence assessment captured the magnitude of impact of the climate related risks through different lenses (finance, service continuity, health & safety, and legal). We assigned a consequence rating of 1 to 5 (from minimal to catastrophic) for each climate risk, for each asset class. Working with our engineers and asset managers, we updated the consequence ratings for each risk during ARP4 to ensure they are accurate and up to date.

Consistent with the precautionary approach, we then took the highest consequence rating for each risk forward to be combined with the likelihood rating to undertake the final calculation of risk, providing either a minor, moderate, major, or severe risk rating. The major and severe risks are

summarized in the remaining report as 'key' risks.[6] However, risks that are not classed as 'key' for the purpose of this assessment (because their risk score was either 'minor' or 'moderate') are still captured in the detailed risk assessment (Appendix A).

Figure 5 below shows the total number of risks reported in ARP3 versus ARP4, while Figure 6 shows how the number of 'key risks' has changed between ARP3 and ARP4.

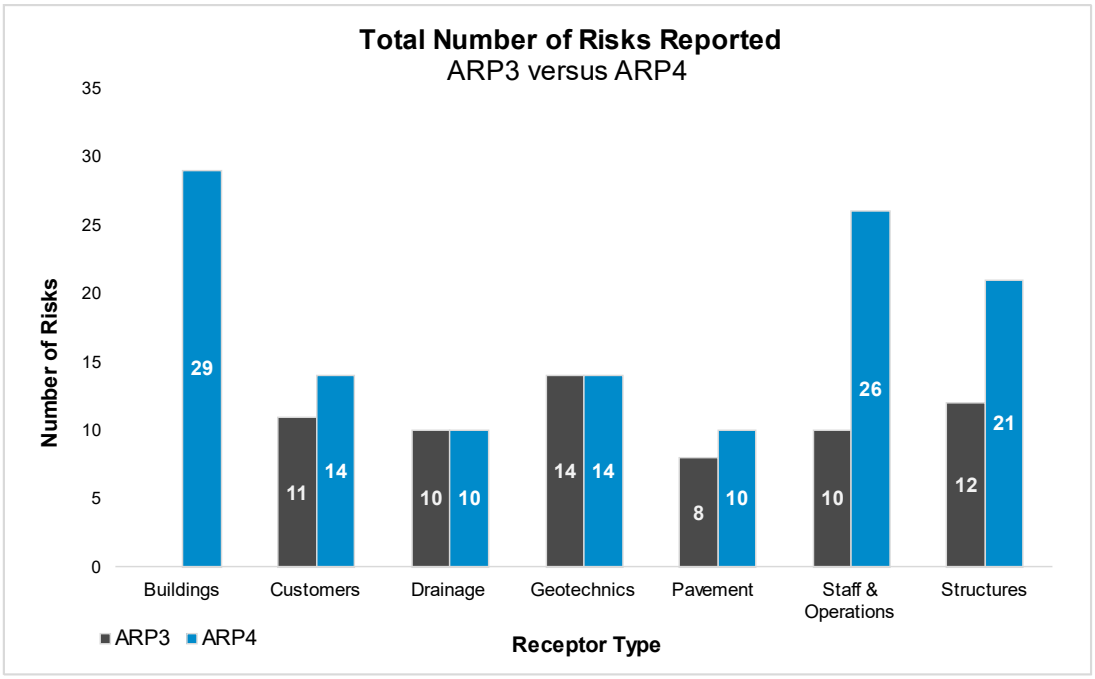


Figure 5. Total Number of risks reported for each receptor type in ARP3 versus ARP4.

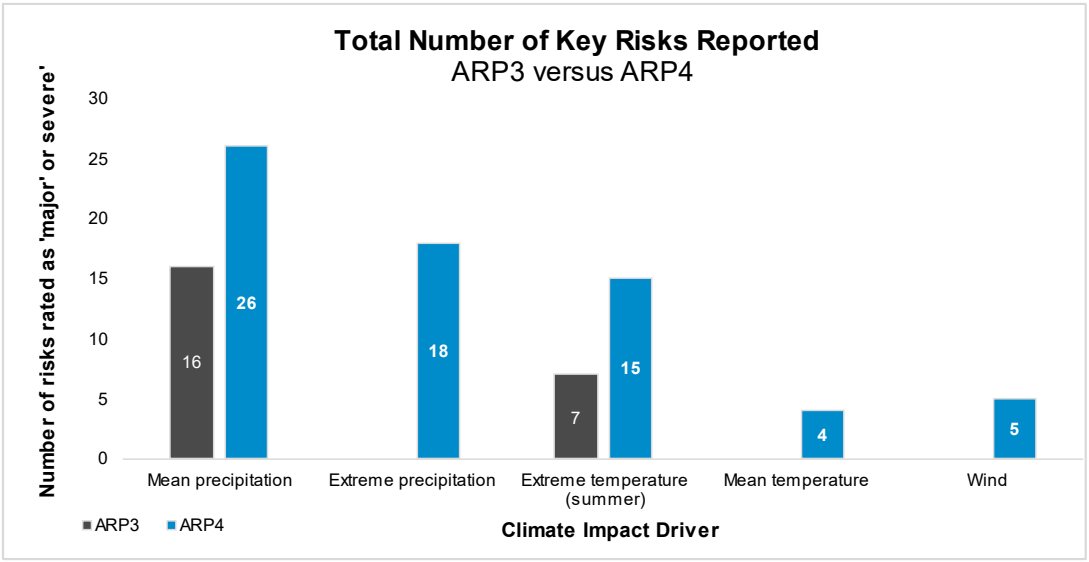


Figure 6. Total number of 'key' risks reported for each climate impact driver in ARP4 versus ARP3

[6] Includes newly identified and amended risks in ARP4 with a rating of 'major' or 'severe' in the 2050s under RCP8.5. A list of all risks is available in Appendix A.

Future Actions

To build on our risk assessment in the coming years, we will:

- Conduct a more comprehensive assessment of specific risks to the soft estate asset class, as defined by National Highways Asset Data Management Manual (ADMM), to better define actions that ensure the soft estate assets themselves are resilient to climate change.
- Undertake a comprehensive review and integrate cultural heritage assets, hard landscaping, and roadside technology into the CCRA.
- Further review climate risks beyond asset classes.
- Update regional-level climate risk assessments, including finalising our adaptation action plans for our Estates (buildings).
- Develop an assessment of interdependent risks across the surface transport system.

5. Asset and estate risks and adaptation actions

Our assets' lifespan commonly exceeds 15 years, meaning decisions made now have far-reaching consequences. To meet our corporate objectives and maintain reliable and efficient journeys, we must identify and embed adaptation measures now.

In this section, we outline the risks identified in the updated CCRA and the related adaptation actions from our Asset Resilience Roadmaps. This includes a summary of the risks by hazard, progress over the last three years, updates from ARP3, and areas of improvement, alongside additional actions identified as part of ARP4. Where possible, we have highlighted progress for specific receptor groups.

It is important to note that progress against our adaptation action plan over the next 5 years will be subject to the details of the funding settlement agreed with the Department for Transport for RIS3. However, we will continue to increase our understanding of climate change risks and potential impacts to the SRN, using that intelligence to prepare a long-term adaptation plan to be implemented over multiple road periods.

Cross-asset actions

There are several adaptation actions which support us to better plan for the impacts of climate change across multiple assets.

Actions carried forward from ARP3:

Ongoing	Next 1-5 years
	Standard: Influence climate change-related developments in the second-generation Eurocodes.

Actions identified for ARP4:

Ongoing	Next 1-5 years
Research and Innovation: Our Severe Weather & Winter maintenance division continue to use data and digital simulations to better understand and plan for potential impacts of extreme weather events on our network.	
	Research and Innovation: Research the climate change risk to electronic digital assets.
	Strategy: Develop and implement adaptation pathways for key asset classes.
	Strategy: Produce long-list of costed options for multi-road period adaptation investment programme.
	Strategy: Propose and agree adaptation investment case multi-road period portfolio, to begin implementation in RIS4.
	Data and metrics: Incorporate asset deterioration models into Strategy & Planning future Road Investment Decision Support Tool.

In line with ARP3, for asset-based risks and adaptation actions, we have organised our actions around the following climate impact drivers:

	**Precipitation** (increased mean precipitation in winter and extreme precipitation in summer and winter);
	**Temperature** (increased mean temperature in summer and changes in extreme temperature in summer and winter);
	**Combined** (the interaction between different climate variables, e.g. between temperature and precipitation);
	**Other** (e.g. wind, lightning, sea level rise, fog and freeze thaw).

5.1 Precipitation

How will the climate change in the future?

It is projected that extreme precipitation events will increase in intensity and severity, potentially increasing the likelihood of surface water flooding. Whilst summers are projected to be drier in all regions of England, when it does rain, storms are expected to be more intense.

Climate projections for the 2070s under a high emissions scenario state that summer precipitation will change by between -47% to +2% and by -1% to +35% in winter compared to the 1981-2000 baseline. Wetter winters, with periods of prolonged rainfall, can result in a higher chance of flooding from rivers as well as groundwater flooding.

Key risks to our assets

Risks reported in ARP3
• Overwhelming of drainage due to fluvial (river) and pluvial (surface) and groundwater flooding. • Fluvial flooding and high river flows. • Ground saturation affecting the stability of assets. • Destabilisation of earthworks due to standing water. • Waterlogging of pavement surface.
Additional risks identified in the updated CCRA* for ARP4
• Flooding of ground floor or basement plant and switch rooms caused by extreme precipitation leading to failure of power systems. • Waterlogging and groundwater flooding caused by increased frequency and duration of precipitation, leading to degradation of pavement foundation and overlying layers. • Delayed deliveries of essential goods/amenities to estate caused by flooding, leading to disrupted business continuity. • Fluvial flooding of sites located near rivers/water bodies caused by high water levels from increased rainfall, leading to damage to infrastructure assets and closure of roads. • Surface water overland flows caused by high intensity rainfall events on saturated ground, leading to damage to infrastructure assets, and closure of roads. • Prolonged drought caused by decreased mean rainfall, leading to increased risk of fire on estate greenspaces. • Waterlogging and saturated grounds caused by higher levels of rainfall leading to surface degradation to onsite pavements and car parks. • Fluvial flooding, surface water overland flows, and scour caused by extreme precipitation leading to damage that can result in structure failure, collapse, or total loss of a structure. • Standing water caused by extreme precipitation leading to damage and destabilisation of structures. • Ground saturation caused by extreme precipitation leading to damage and destabilisation of structures. • Formation or enlargement of underground voids (e.g. scour holes) caused by movement of water from extreme precipitation, leading to damage and destabilisation of structures. • Surface water overland flows from roads or nearby land, caused by movement of water from extreme precipitation, leading to debris flow (e.g. vehicles, woody debris, or any other debris), causing structure damage.

*Includes newly identified and amended risks in ARP4 with a rating of 'major' or 'severe' in the 2050s under RCP 8.5. Details of each risk are available in Appendix A.

Key actions to mitigate precipitation risks

We have focused on publishing and updating design standards and specifications, improving maintenance programmes, investing in Research and Development (R&D) to further explore specific climate variables and risks, and implementing asset management actions, monitoring these, and improving our adaptive management.

Geotechnics and Drainage

Actions implemented:

- **Research and Innovation:** Commissioned a study on the links between geotechnics and drainage and supported ongoing R&D into the impacts of climate change on geotechnical assets.
- **Data & metrics:** Developed asset deterioration models that allow for more accurate predictions for geotechnical asset failure that may result from subsidence. The findings of these models are available to industry to promote sector wide alignment and understanding of the impacts of the predictions.
- **Data & metrics:** Developed and implemented a weather-normalised drainage performance metric. This includes continuous review of the evidence of frequency of events as a result of climate change.

Case Study 1: Little Don and Irwell (2021)

In 2021, in partnership with the Don Catchment Rivers Trust and the Mersey Rivers Trust, we at National Highways contributed £420,000 to 13 natural flood management projects aiming to tackle flooding in the Little Don, River Etherow, and River Irwell catchments. Each project developed a guiding set of principles and explored how to work with farmers and landowners to reduce flood risk on sections of the SRN known to be particularly vulnerable to flooding, using nature-based solutions. This included flood risk mitigation measures such as creating storage ponds or planting woodland and hedgerows to regulate the flow of surface water runoff.

Actions carried forward from ARP3:

Ongoing	Next 1-5 years
Standards: Continue to update our drainage design standard (CG 501) in alignment with National Planning Policy Framework climate allowance.	
Research and Innovation: Research future strategic flood risk and resilience of SRN assets.	
	Research and Innovation: Research the impact of drainage on ground-related hazards and geotechnical assets.
Strategy: Review maintenance plans annually to ensure known issues are addressed.	

Additional actions identified for ARP4:

Ongoing	Next 1-5 years
Research and Innovation: Develop collaborative programme with the EA to address flood risk (including climate change)	
Research and Innovation: Employ Nature-Based Solutions (NbS) to address flooding risk.	
	Data & metrics: Identify flooding hotspots resulting from climate change events and their commonality
	Data & metrics: Develop understanding of severe weather on legacy drainage assets.
	Data & metrics: Develop understanding of severe weather on legacy drainage assets.
Strategy: Establish Drainage Strategy Working Groups.	
	Strategy: Develop and implement multi-RIS drainage programme to update the design, capacity, and maintenance of drainage assets.

Structures

Actions implemented:

- **Standards:** In April 2024, we published and implemented our new 'CS469 - Management of scour and other hydraulic actions at highway structures' standard.

Actions carried forward from ARP3:

Ongoing	Next 1-5 years
Standards: Monitor and review standards on design of highways structures for hydraulic action.	

Additional actions identified for ARP4:

Ongoing	Next 1-5 years
	Research and Innovation: Research flood damage to infrastructure assets to prioritise at-risk assets.

Pavements

Actions carried forward from ARP3:

Ongoing	Next 1-5 years
	Data & metrics: Continuing to monitor pavement conditions for damage from weather events (e.g., surface flooding) using the established techniques and reporting metrics and analysing trends over time. This will help us to determine whether future climate conditions may alter pavement surface characteristics based on current observable trends.
Standards: Continuing to monitor operational feedback regarding problematic weather conditions for laying pavement materials and the applicability of current standards and specifications. This will enable us to specify (through standards) the asphalt or construction techniques that facilitate asphalt to be laid in future likely conditions.	

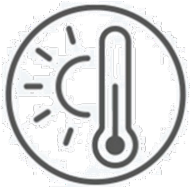
No additional actions have been identified as part of ARP4.

Case Study 2: Future Flood Resilience Project

This project involves investigating the strategic flood risk to the SRN arising from fluvial, coastal, tidal, surface water, and ground water flooding to identify areas of high potential future flood risks across the network based on the latest climate projections for the UK. Through producing a future flood risk map of the SRN, we will be able to be proactive and better-informed in our decision-making and planning. We will also be able to identify and prioritise assets at risk from flooding, ultimately improving the operational resilience of all asset classes and recovery from severe weather events.

5.2 Temperature

How will the climate change in the future?



Climate change projections show that all parts of England will be warmer particularly during the summer with an increase in the frequency of heatwaves. Cold weather events will become less frequent but will continue to occur.

Under a high emission scenario, it is projected that by 2070, summers will be warmer by between 0.9°C to 5.4°C and winters will be warmer by between 0.7°C to 4.2°C.

Key risks to our assets

Risks reported in ARP3
• Expansion and 'blow-ups' of concrete pavement surfaces. • Thermal action and failure of expansion joints and bridge bearings on structures. • Melting and deformation of asphalt surface course. • Sub-optimal conditions for laying of new/replacement pavement.
Additional risks identified in the updated CCRA* for ARP4
• Overheating of plant rooms caused by extreme high temperatures leading to damage or failure of essential plant equipment. • Overheating within buildings caused by extreme high temperatures leading to disruption or failure of building mechanical and electrical services. • Thermal stress caused by extreme high temperatures leading to expansion/blow out of concrete structures in buildings. • Thermal stress caused by extreme high temperatures leading to formation of thermal cracks in building brick. • Thermal stress on timber caused by extreme high temperatures leading to warping, cracking, or deformation in our salt barn building.

*Includes newly identified and amended risks in ARP4 with a rating of 'major' or 'severe' in the 2050s under RCP 8.5. Details of each risk is available in Appendix A.

Key actions to mitigate temperature risks

We have focused on addressing the risk from temperature changes through our design standards, monitoring, and adaptive management.

Structures

Actions implemented:

- **Research and Innovation:** Reviewed expansion joint failure analysis reports and asset data to assess whether failures are associated with extreme temperatures, or attributable to other causes. The review provided a better understanding of the impact of extreme temperature on bridge expansion joints but found none of the reasons for failure were caused by extreme temperatures. The reasons for failure were either due to installation problems or because the expansion joints had reached the end of their working life.

Actions carried forward from ARP3:

Ongoing	Next 1-5 years
	Research and Innovation: Research the effect of climate change on bridge design.

No additional actions have been identified as part of ARP4.

Pavements

Actions implemented:

- **Research and Innovation:** Reviewing the resilience of sealants/terminations for concrete pavements. We completed a desktop study to understand compression failures in concrete roads due to extreme weather. We are currently developing an evaluation method to identify high risk locations and developing an asset management strategy to mitigate the risk of compression on the SRN.
- **Standards:** Evaluated and, where appropriate, implemented key recommendations where specification thresholds are likely to be exceeded for Thin Surfacing Course System (TSCS) as a result of climate change. TSCS is the preferred surfacing option and this type of surfacing covers over 50% of the SRN.

Actions carried forward from ARP3:

Ongoing	Next 1-5 years
	Standards: Continue to monitor operational feedback regarding problematic weather conditions for laying pavement materials and the applicability of current standards and specifications. Recommendations can be made in the SHW, linking to BSI standards such as BS 594987 as to the appropriate material choices to adopt to match particular weather conditions for example laying asphalt in elevated ambient temperatures, if this is highlighted as a problem in feedback. BS 594987 is currently under review, looking at conditions for laying.
	Research and Innovation: Review Resilience of concrete pavement and sealant and terminations. This will result in a rollout of evaluation methods within the operation directorates.

No additional actions have been identified as part of ARP4.

5.3 Combined

How will the climate change in the future?

A number of risks and impacts to our assets and functions result from the interaction of two different climate impact drivers: temperature and rainfall.

Key risks to our assets

Risks reported in ARP3
• Shrink-swell cycles leading to destabilisation of geotechnical assets (due to mean temperature and precipitation changes) • Ground shrinkage destabilising drainage assets (due to mean temperature and precipitation changes) • Structural integrity affected by changes in earth pressure (mean precipitation changes and warmer, drier summers)
Additional risks identified in the updated CCRA* for ARP4
• Land/ground shrinkage caused by decreased rainfall leading to decreased structural stability of building foundations. • Soil shrinkage and swelling caused by prolonged dry periods and increased precipitation leading to settlement cracking in footways and cycle tracks, especially in regions with shrink/swell susceptible soils

*Includes newly identified and amended risks in ARP4 with a rating of 'major' or 'severe' in the 2050s under RCP 8.5. Details of each risk is available in Appendix A.

Key actions to mitigate combined risks

We have focused on addressing the risk from combined climate impact drivers through our design standards, monitoring, and adaptive management.

Geotechnics and Drainage

Actions implemented:

- **Research and Innovation:** We are updating our geotechnical hazard mapping to incorporate climate change trends and impacts using the Met Office's UKCP18 climate change impacts analysis. For example, to improve our management of shrink-swell hazards (damage arising from the volume changes caused by changes in the moisture content of clay-rich soils) we must better integrate climate impacts into our shrink-swell susceptibility ratings for geotechnical assets.
- **Data & metrics:** Asset deterioration models for geotechnical assets have been developed using climate change modelling derived from data from the ACHILLES (assessment, costing and enhancement of long life, long linear assets) programme. The Achilles programme was a 4-year EPSRC funded research programme (2018 – 2022) aiming to examine how infrastructure assets can be better maintained and monitored for future resilience. These models have been shared with wider industry.

Actions carried forward from ARP3:

Ongoing	Next 1-5 years
	Data & Metrics: Integrate climate change impacts into shrink-swell susceptibility ratings.

Additional actions identified for ARP4:

Ongoing	Next 1-5 years
	Research and Innovation: Increase the maturity of our Geotechnics Resilience Assessment Framework by assessing ground-related hazards against network performance goals and providing clarity on how condition, performance, maintenance and renewal will affect business performance. We will produce guidance on options for asset life extension and the application of adaptive pathways to address uncertainties in geotechnical related decision making in the context of climate change.
	Research and Innovation: Conduct research to identify measures to reduce vulnerability, improve robustness and speed up recovery from geotechnical asset failures.
	Research and Innovation: Conduct research to understand the interactions between geotechnical and drainage assets in adapting to climate change.

Structures

Actions implemented:

- **Data & metrics:** Integrated climate change data into shrink-swell susceptibility ratings though British Geological Society (BGS) mapping layers.

Actions carried forward from ARP3:

Ongoing	Next 1-5 years
	Standards: Monitor and review standards on design of highways structures for hydraulic action.

No additional actions have been identified as part of ARP4.

5.4 Other

The updated CCRA identified risks related to other climate impact drivers that are not covered in the analysis of precipitation and temperature.

How will the climate change in the future?

Sea level is projected to increase across England. For example, sea level is expected to rise by between 0.53m to 1.15m in London by the end of the century under a high emissions scenario. Extreme coastal water levels are also expected to increase.[7] Many actions we have taken, or are planning to take, to address risks resulting from precipitation and flooding also apply to risks resulting from sea level rise.

Near surface wind speeds are projected to increase for the second half of the 21st century, this is predominantly likely during the winter.[8] Winds associated with major winter storms are projected to increase in frequency. Whilst precipitation is projected to increase during the winter, snow cover is projected to decrease by almost 100% except in mountainous regions in the north and the west. Additionally, the frequency of fog in the UK is anticipated to decline across the UK, but with regional variation and considerable uncertainties.[9]

Key risks to our assets

Risks reported in ARP3
• Wind action damaging structures • Scour from storm surges causing damage to the structure resulting in structure failure • UV light causing surface course to degrade • Freeze-thaw and frost heave damaging the pavement and causing it to break up • Increase in wildfires due to increased intensity and frequency of hot spells and decreased precipitation • Tree windthrow
Additional risks identified in the updated CCRA* for ARP4
• Power outages caused by high winds/storms, leading to disruption of business continuity • Power outages caused by high winds/storms leading to disruption of EV charging for business fleet

*Includes newly identified or amended risks in ARP4 with a rating of 'major' or 'severe' in the 2050s under RCP 8.5. Details of each risk is available in Appendix A.

[7] https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/research/ukcp/ukcp18_headline_findings_v3.pdf

[8] https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/research/ukcp/ukcp18-fact-sheet-wind_march21.pdf.

[9] Kendon, E.J., Ban, N., Roberts, N.M., Fowler, H.J., Roberts, M.J., Chan, S.C., Evans, J.P., Fosser, G. and Wilkinson, J.M., 2017. Do convection-permitting regional climate models improve projections of future precipitation change?. Bulletin of the American Meteorological Society, 98(1), pp.79-93.

Case Study 3: Hull Tidal Defence (A63, 2017-2022)

Climate projections estimate that water levels on the Humber River could rise as much as 1 meter in the next 80 years, coupled with high spring tides that can cause water levels to rise by up to 3 meters. The 4-mile-long River Hull Tidal Surge Barrier is a critical asset protecting over 100,000 properties in the City of Hull from tidal inundation. It also protects the A63 and A1033, reducing the risk of road closures and flood-related disruptions to the road network. From 2017-2022, National Highways has contributed £3m to the Hull tidal defence scheme in partnership with the Environment Agency.

While the COVID-19 pandemic made construction of the scheme more time consuming than originally planned, the new defences were completed in 2022. Overall, the new defences have improved the seafront path for multiple users in Hull and the surrounding Estuary. They also include innovative designs in part as a nod to the City's maritime history (St Andrew's Quay is in the shape of a boat hull). Additionally, the scheme, alongside two others that protect Hull (including the Holderness Drainage scheme), were delivered through the Living with Water Partnership, which bought together all the stakeholders impacted by flooding in the area.

Key actions to mitigate these risks

Our focus to address additional risks has been on design standards, R&D, and monitoring/adaptive management.

Geotechnics and Drainage

Actions implemented:

- **Research and Innovation:** Continuing to deliver a collaborative programme of flooding schemes with the EA to support flood alleviation for the SRN and nearby communities. With six schemes successfully completed and seven currently in progress, this programme is improving resilience to flooding whilst providing environmental enhancements for example through improved water quality and biodiversity.
- **Data & metrics:** Developed asset deterioration models to predict geotechnical asset failure including sensitivity to climate change.

No actions carried over from ARP3.

Additional actions identified for ARP4:

Ongoing	Next 1-5 years
	Data & metrics: Update the Geotechnical & Drainage Management Service to include a hazard layer for climate change impacts.

Structures

Actions carried over from ARP3:

Ongoing	Next 1-5 years
	Data & Metrics: Monitor wind action impacts on structures.

Additional actions identified for ARP4:

Ongoing	Next 1-5 years
	Research and Innovation: Research the effect of climate change on bridge design.
	Standards: Develop a managed structural adaptation standard.
	Strategy: Produce a climate risk management plan for major bridges and structures.

Pavement

Actions implemented:

- **Standards:**
  - Continuing to review maintenance standards, including use of flexible asphalt for durable pothole repairs. Reviewing freeze-thaw maintenance and the impact of climate change on the frequency of freeze-thaw cycles. We are updating CC 205 Maintenance of pavements with an asphalt surfacing and CM 231 Pavement surface repairs with further robust repair options for potholes, which form partly as a result of freeze-thaw action.
  - Continuing to influence and keep abreast of climate change related developments in the second-generation Eurocodes. This is achieved by committee membership, working group participation and by providing feedback on proposed documents.
  - Reviewing climate related changes in the second-generation Eurocodes for their impact on DMRB documents. If a significant event causes concern that the requirements and assumptions in DMRB documents may not be adequate, undertake research to establish whether this is the case.

Actions carried forward from ARP3:

Ongoing	Next 1-5 years
Research and Innovation: Conducting trials of long-life bitumen which is more UV-resistant. We have completed a research project with University of Nottingham which assessed whether increased UV reaching the pavement surface is a likely outcome of climate change. This work has contributed to the assessment of early life performance of longer-life binder products.	
Research and Innovation: Investigate the resilience of asphalt surfaced pavements (roads, footways, and cycle tracks). We will review the impact of climate change on the performance, maintenance and design of footways and cycle tracks and implement recommendations for potential adaptations.	
Standards: Monitoring feedback on problematic weather conditions on laying pavement.	
Standards: Review impact of sub-optimal conditions for laying new/replacing pavement.	

Additional actions identified for ARP4:

Ongoing	Next 1-5 years
	Research and Innovation: Conduct further research into managing fire risk in proximity to roads.
	Standards: Adapt standards and specifications for robust pavement design solutions to meet the future needs of the network.

Soft Estate

Although soft estates have not formed part of our assessment to date, we have identified some key actions to carry forward into our adaptation planning. These include:

Additional actions identified for ARP4:

Ongoing	Next 1-5 years
	Research and Innovation: Ensuring interoperability between the soft estate and other assets to improve climate resilience of the network.
	Strategy: Identify areas of climate vulnerability across the soft estate and develop resilience plans.
Strategy: Embed climate resilience requirements into contracts – ensuring that contracts include climate resilient landscape design, planting, and long-term management.	

6. Customers and workforce risks and adaptation actions

Our updated CCRA identified risks specifically in relation to our customers (people using the SRN) and workforce (direct employees including traffic officers and those who are employed through our supply chain). Weather hazards can cause unsafe driving conditions for our customers and unsafe working conditions for our workforce on the ground.

Key risks to our customers and workforce

Climate Impact Drivers	Risks reported in ARP3	Additional risks identified in the updated CCRA* for ARP4
Precipitation	• Disruption and road closures from flooding.	• Surface water and poor visibility caused by extreme rainfall leading to unsafe working conditions (e.g., increased incident management) • Increased risk of fire on estate greenspace caused by drought leading to health & safety risks to staff. • Surface water onsite caused by increased rainfall leading to health & safety risks to staff.
Temperature	• Unsafe driving conditions due to extreme temperatures. • Unsafe working conditions and decreased productivity due to extreme temperatures.	• Increased water temperatures in external water bowsers and roof tanks caused by extreme high temperatures, leading to increased risk of legionella.
Other		• Hazards such as loose roof tiles, debris, fallen trees, and tree windthrow caused by high winds, leading to health & safety risks. • Hazards such as loose roof tiles, debris, fallen trees, and tree windthrow in car parks caused by high winds leading to damage to cars.

*Includes newly identified and amended risks in ARP4 with a rating of 'major' or 'severe' in the 2050s under RCP 8.5. Details of each risk is available in Appendix A.

Key actions to address risks

Many of these risks are dealt with through our processes for managing health and safety risks or dealing with weather-related risks.

- Continuing to monitor and consider opportunities to input climate considerations to guidance.
- Continuing to assess risk and issue severe weather alerts as appropriate.
- Review and update regional resilience, emergency, winter, and severe weather plans. Work with our resilience teams to ensure these align with climate risks and explore where further research may be needed.

7. Improving our organisational adaptive capacity

As operator and maintainer of the SRN, we at National Highways must further embed climate risk and adaptation considerations into our organisational processes and procedures for long-term development. This section sets out actions and outcomes from our Adaptive Capacity Roadmaps. We developed them by assessing our progress against previously identified adaptation actions and identifying specific areas for improvement over the next 1-5 years. These actions will improve the timeliness and effectiveness of the decisions we make that impact our resilience to climate change as we continue to operate and maintain the SRN. The planning and implementation of these actions will be overseen by the Asset Management Transformation Programme.

Effective governance

Our current approach to climate risk governance is set out in our TCFD report . We aim to fully integrate climate risk and adaptation into our governance, ensuring climate risk is built into all relevant decision making and activities. We will enable a culture where our people understand and take ownership of their contribution to climate adaptation.

We will commit to continual improvement through monitoring and evaluation of our adaptation plans. To do this, we will develop both quantitative and qualitative impact indicators of success to measure performance over time.

In 2024, we formally appointed an Executive Director to take ownership of climate-related issues which will provide strong leadership and a clear direction for adaptation.

	Actions	
	Started & Ongoing	**Next 1-5 years**
Effective Governance	Appoint an Executive Director to be accountable for climate-related issues.	Clearly communicate the ownership and governance of climate risks across the organisation, defining where accountability and responsibility lies.
	Embed climate adaptation and resilience planning in cross-directorate asset management forum.	Identify senior leaders responsible for adaptation across all directorates.
	Establish an adaptation monitoring and evaluation framework.	

These actions will enable us to:

- Have robust leadership and oversight of climate change risks and adaptation;
- Ensure consistent processes for managing climate risks across the organisations;
- Embed climate risks into our processes and decision-making;
- Ensure continual improvement through effective monitoring and evaluation; and
- Make data-driven investment decisions.

Effective adaptation requires investment

We will develop long-term, evidence-based investment plans using quantitative data that will improve decision-making for investment in adaptation.

	Actions	
	Started & Ongoing	**Next 1-5 years**
Data-driven investment decisions	Develop organisational KPIs/PIs to monitor adaptation progress and performance and support investment in future adaptation needs of the network.	
	Incorporate appraisal of climate risks and opportunities into investment processes.	
		Develop an adaptation budget for RIS4.

These actions will enable us to:

- Make investment decisions based on robust, trusted data;
- Ensure prioritisation of adaptation measures in investment decision-making; and
- Ensure investment in adaptation measures take full account of the risks posed by climate change.

Organisational capacity and maturity

In the future, we want our people to have the skills and knowledge required to be able to understand and act on climate adaptation. To achieve this, we will analyse the skill gaps and training requirements for colleagues across the business and implement specific climate adaptation training to increase capacity across the organisation. This will also provide us with a better understanding of our organisational adaptation maturity and areas for improvement. We will then develop targeted strategies for continual improvement to ensure we are making the best decisions to protect us from climate risk.

In 2024, we upskilled key roles through climate risk and adaptation training, aligned with international standards ISO14090:2019 and ISO14091:2021. The training boosted our organisational knowledge of climate risk and adaptation processes. By developing wider training materials and upskilling asset managers, engineers, risk managers and strategic planning teams and additional personnel across the organisation, we aim for all colleagues to have a baseline knowledge of climate change risk and adaptation.

	Actions	
	Started & Ongoing	**Next 1-5 years**
Organisational Capacity & Maturity	Align climate risk and adaptation action with ISO14090:2019 & ISO 14091:2021.	
	Implement and reassess annual our organisational maturity improvement actions identified from our assessment of our own adaptive capacity using the Climate Capacity Diagnosis & Development (CaDD) tool.	
	Select training of key sustainability roles.	Conduct a skills gap analysis to determine organisational training needs.

These actions will enable us to:

- Be confident our people have the right skills and knowledge to deliver adaptation across our organisation; and
- Better understand our organisational adaptive capacity and have clear plans to improve our adaptation maturity.

Managing climate-related risks

We aim to have robust processes to identify, assess and manage physical risks and a clear view of the financial impacts of risks under different climate scenarios.

Our current approach to climate risk management is set out in our TCFD report. We manage all corporate risks, including climate risks, through our enterprise risk management framework which we are currently updating to include specific actions required to manage climate risks.

	Actions	
	Started & Ongoing	**Next 1-5 years**
Managing Climate Risks	Fully embed physical climate risks into Enterprise Risk Management and Corporate Risk Management processes.	Review management of physical climate risks during Major Projects & Operations scheme delivery.
	Develop processes to enable full compliance with HMT TCFD reporting requirements.	Improve process for assessing risk and issuing severe weather alerts.
	Publish climate change risk assessment under ARP4.	Produce region-specific climate change risk assessments and adaptation plans in preparation for ARP5.

These actions will enable us to:

- Ensure our adaptation plans are region-specific;
- Better understand our current and future physical risks regionally; and
- Provide an integrated approach to climate risk management across National Highways.

Communication and collaboration

The SRN is part of a wider land transport infrastructure system, and we do not operate in isolation. Therefore, responding to climate change is not something we can do on our own. Active engagement with our stakeholders and partners is essential to develop a network that is resilient to the effects of climate change. Collaboration to understand and act on interdependencies and cascading climate risks is an ongoing part of developing resilience.

We will continue to actively engage and collaborate with relevant organisations (e.g., Infrastructure Operators Adaptation Forum (IOAF) and the Department for Transport's Transport Adaptation Working Group (TAWG)) to understand interdependencies and existing processes to manage current and future climate risks.

	Actions	
	Ongoing	**Next 1-5 years**
Communication & Collaboration	External engagement to improve understanding of interdependencies and develop targeted resilience action plans.	
	Engage in research to inform identification of effective adaptation measures (e.g. CEDR ICARUS and DARe National Hub).	
	Support the development of national resilience standards and long-term climate resilience strategies.	Incorporate national resilience standards into DMRB, through existing and/or new standards.

These actions will enable us to:

- Strengthen partnerships with transport stakeholders, such as DfT, Network Rail, TfL, and local government to co-develop resilience;
- Improve internal collaboration to address climate risks to our organisation;
- Share best practice and research across the industry, with input from academia; and
- Contribute to research to inform the identification of new adaptation solutions for the transport system.

Case Study 4: Improving the uptake of climate change adaptation in the decision making processes of road authorities (ICARUS) (completed 2024)

National Highways, along with the national road authorities (NRAs) of Denmark, Ireland, Netherlands, Norway, Sweden, and Switzerland, co-funded the CEDR Climate Change Resilience Call 2021. The project, ICARUS, aimed to enable NRAs to build and implement business cases for climate resilience via adaptation, balancing the service levels that the road network needs to achieve with the costs and benefits for enhancing resilience. The project's main objective was development of practical tools and recommendations to enable NRAs to embed adaptation in the decision context of the organisation, thereby closing the 'tactical gap' to define how asset-specific interventions impact on network performance requirements. The project also produced a library of potential adaptation measures to assist in adaptation planning that is publicly available.

8. Interdependencies

Interdependencies refer to systems or organisations which are connected to, or rely on, another system or organisation to fully operate.

As part of an integrated national transport infrastructure system, disruptions on our network can significantly impact the country. Understanding and managing interdependencies with other organisations and infrastructure sectors is essential for improving the resilience of the national transportation network.

Vulnerabilities within transport infrastructure can cause problems for other infrastructure systems. For example, due to the interconnected nature of infrastructure systems, flooding on the SRN can lead to delays and disruptions on other transport networks or the limit travel of essential vehicles, such as emergency service vehicles.

Cascading risks could also be significant to us. A cascading risk refers to a situation where a failure or disruption in one area triggers a series of subsequent failures in interconnected systems or processes. Cascading risks can lead to widespread consequences, as the initial risk propagates through various channels, amplifying its impact across different sectors. For example, storms can cause power outages resulting in communications failures and safety risks on the SRN due to lack of signage.

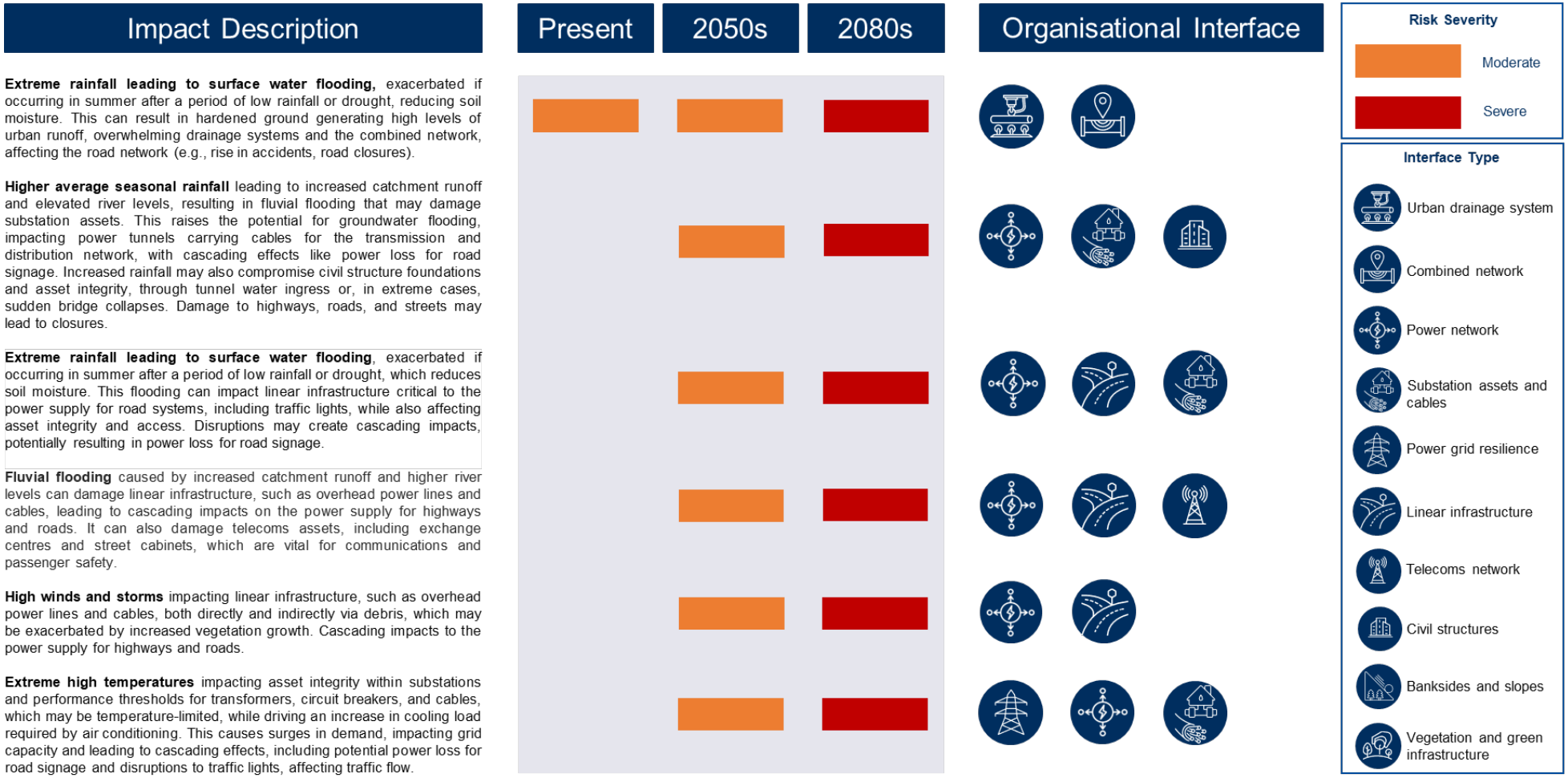
8.1 Mapping interdependencies

We are part of Transport for London's Transport Adaptation Steering Group (TASG). Through this group, we continue to work together with TfL, Network Rail, High Speed 2, and others to deliver a consistent approach to adaptation and identify interdependencies.

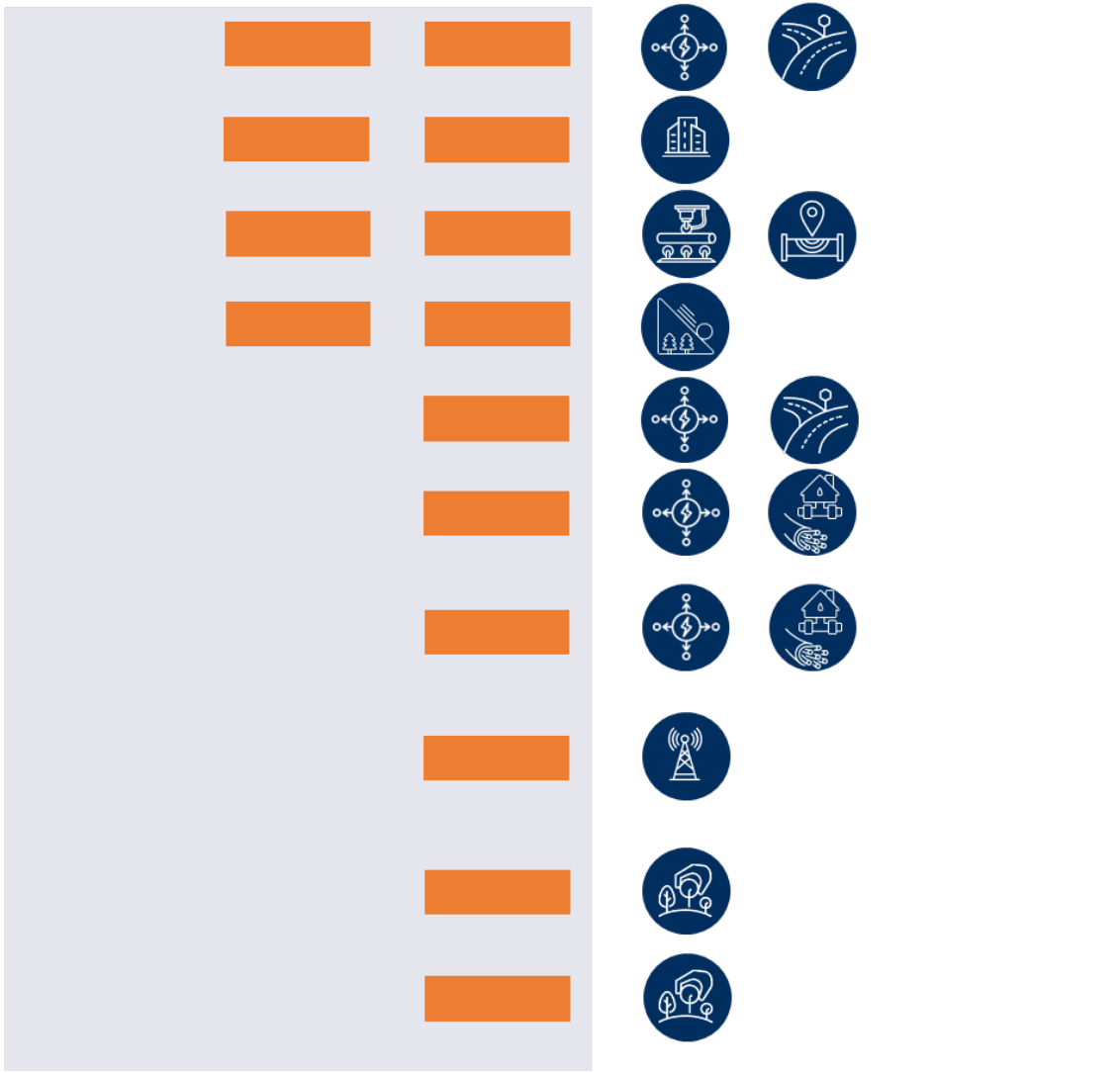
We were actively involved in TfL's collaborative interdependences mapping study. This project combined system mapping with an upstream climate interdependency risk assessment for Greater London, drawing on guidance from the UK government and Defra. We took part in stakeholder engagement throughout the project to co-develop an understanding of existing interdependencies, climate hazards, and potential actions to reduce climate interdependency risks. Many of these findings and actions will be relevant outside of London and for the wider road sector. Using this systems-based approach to co-develop an understanding of interdependencies with stakeholders from across multiple sectors helps to highlight opportunities to co-fund investments in climate adaptation, benefitting multiple organisations.

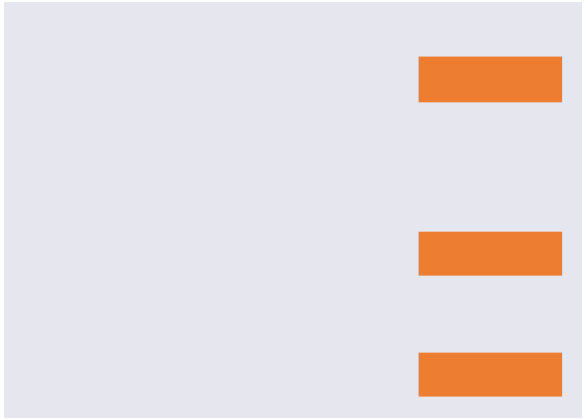
Figure 7 below presents the results of the interdependency mapping study for National Highways. One 'moderate' risk was noted for the present day, where surface water flooding could impact urban drainage systems, resulting in overwhelmed systems and impacts to the road network (e.g., rise in accidents, road closures, etc.). By the 2080s, 19 significant risks emerge, with 6 scoring as 'severe' and as 13 'moderate'.

Figure 7. Interdependencies mapping for National Highways, adapted from TfL interdependencies report.



Impact Description	Present	2050s	2080s	Organisational Interface
High temperatures leading to sagging transmission lines, which can affect the resilience of the power network, potentially causing minor cascading impacts on the power supply for highways and roads.				
Tidal flooding if flood defence assets are overtopped, leading to damage to foundations and asset integrity, with potential damage to highways, roads, and streets, possibly resulting in closures.				
Tidal locking limiting outfalls and sluices from drainage and sewer networks, contributing to surface water flooding and impacting highways and roads, with resulting access closures and diversions.				
Higher rainfall may increase landslide risk if banksides are not managed appropriately, potentially leading to landslides that impact highways and roads.				
Lightning strikes impacting linear infrastructure and staff incident response, with possible cascading effects on the power supply for highways and roads.				
Larger diurnal or short-term temperature variations causing ground movement, which impacts structural foundations and substation asset integrity, with cascading effects including potential loss of power for road signage.				
Storm surges, sea level rise, and extreme tides, separately or in combination, causing tidal flooding if flood risk management assets are overtopped, impacting asset integrity and access, with cascading impacts including loss of power for road signage.				
Extreme rainfall leading to surface water flooding, which can be exacerbated if it occurs in summer after a period of low rainfall or drought, reducing soil moisture. This can lead to damage to telecoms assets, such as exchange centres and street cabinets, which are critical for maintaining communications and ensuring passenger safety.				
Extreme heat impacting telecoms assets, such as underground cables and the cooling requirements for exchange and data centres. This can affect communications systems and compromise passenger safety.				
An increase in green infrastructure to provide shading can lead to tree roots causing the creation of potholes on roads. While the impacts to health and safety may be minor, there is a significant increase in maintenance required to prevent vegetation from obstructing roads.				



Impact Description	Present	2050s	2080s	Organisational Interface
High temperatures and drought conditions leading to wildfires that impact substation assets and underground cables, with potential damage from extreme heat, fire, or smoke, exacerbated by vegetation growth and die-off. Low rainfall and drought also reduce soil moisture and vegetation cover, compromising slope stability and increasing the risk of landslides. These impacts can lead to damage to highways and roads, as well as cascading effects, including loss of power for road signage.				
Increased length of the growing season and vegetation cover leading to tree roots causing potholes on roads, with a rise in maintenance required to prevent vegetation from falling onto roads. Additionally, the extended growing season coinciding with autumn/winter storm events increases the risk of leaf fall, reducing tyre adhesion and causing delays, especially if roads are closed due to fallen trees.				
Increased wind speeds from storms lead to more trees falling onto roads, resulting in debris on carriageways, road closures, and disruption				

8.2 Next Steps and Actions

To improve our understanding of interdependencies and increase the resilience of the SRN and organisations dependent on the SRN, we will:

- Continue to engage around interdependencies for progressing adaptation. This includes engagement with relevant organisations (e.g., TASG) to understand the strength of the interdependencies and existing processes to manage emerging climate risks.
- Further develop our understanding of new interdependencies as they emerge, working with stakeholders to share evidence.
- Encourage and enhance the sharing of good practice and research on climate interdependencies through forums such as the IOAF.

Case Study 5: Midlands Severe Weather Exercise (2023)

The Design Manual for Roads and Bridges (DMRB) standard GM 704, *Operational requirements for severe weather*, requires an annual exercise to test the Severe Weather Plan. The plan is the documented response to severe weather, including mitigation measures and escalation procedures. In 2023, we undertook a joint severe weather exercise with the East and West Midlands to test and demonstrate the preparedness and capabilities of National Highways, our supply chain, and our external partners, building on lessons learned from the previous weather events. The purpose of the exercise was also to gain a shared understanding of the responsibilities and capabilities of key stakeholder partners.

The exercise focussed on two distinct scenarios, an extreme cold and extreme heat event, based on the relevant key weather and climate risks to the Midlands region. It considered current weather, but highlighted that further work was needed to understand the impact of a changing climate on preparedness and effective response to severe weather.

Attendees of the exercise included Foresight Solutions, Amey, Staffordshire County Council, BBV A50 DBFO, COLAS, Coventry City Council, Derby City Council, Derbyshire County Council, Birmingham City Council, Lincolnshire County Council, M40 DBFO, M6 Toll, North & Mid Wales Trunk Road Agency, and Transport for West Midlands.

9. Conclusion

This report follows 13 years after our first ARP report, which set our ambition to understand the impacts of climate change on the SRN. Through an iterative process, we have reviewed and reported on our progress against the risks identified in ARP3 and identify new risks and opportunities for adaptation action.

For ARP4, we updated our climate change risk assessment and evaluated national-level risks to our asset classes, staff, and customers. We expanded our risk assessment to include our 'Estates' function, covering the buildings that support network operation and maintenance. Through asset- and service-based climate risk review workshops with our staff, we identified new risks, revised risk scores based on recent extreme weather events, and updated our adaptation plans.

Our key climate-related risks will likely result from changes in precipitation (accounting for droughts and flooding), increases in temperature (accounting for an increase in frequency, intensity and duration of hot spells), and more extreme and frequent severe weather (such as high winds and storms). Our most significant risks include:

- **Precipitation** - risks to buildings from flooding, disruptions in deliveries of essential goods or amenities, and droughts resulting in an increased risk of fire on estate greenspaces.
- **Temperature** - newly identified key risks include thermal stress affecting building structures, disruption, or failure of building mechanical and electrical services due to extreme temperatures, and an increased risk of legionella in building water bowsers and roof tanks.
- **High winds and storms** – newly identified key risks related to building power outages and wind-blown hazards (such as loose roof tiles, debris, and fallen trees) resulting in damage to cars and car parks, as well as presenting health and safety risks to our staff and customers.

Since publishing ARP3, we have significantly advanced our adaptation efforts through engagement with our engineers, asset managers, and other internal and external stakeholders. Through this collaboration, we have developed our internal Climate Adaptation Roadmaps. These roadmaps outline specific adaptation actions, timelines, and ownership for key activities, to ensure a structured approach to enhancing asset resilience and internal management processes. Key actions we are carrying forward include ongoing research and innovation projects related to climate adaptation, updating our standards to incorporate climate risks, and improving data and metrics for monitoring. Furthermore, we aim to evaluate our climate adaptation progress and develop strategic adaptation pathways for our assets, subject to funding.

By implementing our Climate Adaptation Roadmaps, we are taking a crucial step forward in building our resilience to climate change. They are designed to provide a mechanism for actively managing and communicating our climate adaptation actions, both now and in the future.

In continuing to adapt to emerging climate risks and monitoring and evaluating our progress, we aim to ensure the long-term sustainability and safety of our network, contributing to a more resilient SRN.

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