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Trunk Road Adaptation Plan

Preparing Scotland's Roads for a Changing Climate

Transport Scotland

Ministerial Foreword

The impacts of climate change are unmistakably affecting how people, goods and services move throughout Scotland. The effects of flooding, landslips, scour, and high wind are already putting increased pressure on our Trunk Road Network with climate projections showing that extreme weather events will become increasingly more frequent.

The latest UK Climate Change Risk Assessment (CCRA3) identifies seven critical risks currently facing Scotland's transport infrastructure. In response, Transport Scotland is proactively tackling these challenges through our comprehensive Approach to Climate Change Adaptation and Resilience. This articulates our vision for a transport system that is well adapted and prepared for current and future impacts of climate change, safe for all users, reliable for everyday journeys, and resilient to weather-related disruption.

As the Scottish Ministers' single biggest asset, the Scottish Trunk Road Network stretches over 2,300 miles long. It is a geographically diverse network which includes over 2,000 bridges and over 1,800 culverts, footbridges and retaining walls.

These features make the Trunk Road Network increasingly vulnerable to the locked-in impacts of climate change which can contribute to the deterioration of assets, disruption to networks, and potentially hazardous incidents. This impacts the economic and social activities supported by the network. It is imperative to implement resilience measures that safeguard our assets, the road network, and the services they provide.

This Trunk Road Adaptation Plan serves as an action-oriented framework for adapting the Trunk Road Network in alignment with the Approach to Climate Change and Resilience's overarching vision. The Trunk Road Adaptation Plan builds upon previous studies, incorporating the most current climate change projections to evaluate key climate hazards and vulnerabilities across the network. This rigorous analysis and assessment has culminated in this comprehensive Adaptation Plan, outlining 43 recommended actions designed to strengthen resilience to the impacts of climate change.

The Trunk Road Adaptation Plan presents a pivotal moment in our climate adaptation journey, providing a clear and focused roadmap to guide our efforts over the next five years to ensure Scotland's Trunk Road Network remains safe, reliable and resilient in the face of a changing climate.

Fiona Hyslop

Cabinet Secretary for Transport

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Our Vision for a Well-Adapted Trunk Road Network

Scotland's Trunk Road Network (TRN) serves as critical 'lifeline' infrastructure, supporting strategic and local connectivity between towns, cities, and rural areas. It facilitates the movement of people, goods, and essential services across the country, and is especially critical in remote areas where alternative routes may be limited or non-existent.

Scotland's TRN makes up just 6% of the total road network but carries 35% of all traffic and 60% of HGVs in an average year[1]. Safeguarding this critical infrastructure is vital to keep Scotland moving and economically secure.

However, the impacts of climate change are increasingly threatening the reliability and resilience of this network. Flooding, landslips, scour, and storms are already placing pressure on the TRN and with global emissions continuing to rise, the latest climate projections[2] published by the Met Office, indicate that extreme weather events will become more frequent and severe. These disruptions pose unique challenges for trunk road users – particularly those in rural or remote regions – where even a single road closure can result in isolation, economic hardship, and reduced access to vital services.

As the impacts of climate change become a key driver of disruption across the TRN, it is imperative to understand both current and future vulnerabilities. Transport Scotland's Trunk Road Adaptation Plan (TRAP) provides a robust evidence base to assess where and how the network is affected. The TRAP sets out a blueprint for the development and implementation of targeted adaptation measures to safeguard infrastructure, protect communities, and ensure the continued delivery of essential transport services.

Transport Scotland's commitment to climate adaptation

Transport Scotland is responsible for delivering the Scottish Government's vision for transport and is a key player in the delivery of the climate adaptation plan for Scotland. We have a series of adaptation commitments, laid out across the following national strategies and plans:

- National Transport Strategy 2
- Strategic Transport Projects Review 2
- Scottish National Adaptation Plan 2024-2029 (SNAP3)

[1] Trunk road network | Traffic Scotland
[2] CCRA-Evidence-Report-Scotland-Summary-Final-1.pdf

Transport Scotland's **Approach to Climate Change Adaptation and Resilience** (ACCAR) provides the overarching framework for adaptation across our transport system and sets out strategic outcomes for Road, Rail, Aviation and Maritime transport networks.

The ACCAR sets out the following vision for: "A transport system which is well-adapted and prepared for current and future impacts of climate change, safe for all users, reliable for everyday journeys, and resilient to weather related disruption."

As reaffirmed in SNAP3, the TRAP plays a central role in delivering Scotland's climate adaptation vision by 2029, at which point it will be reviewed and updated in alignment with SNAP4. It is developed through the following guiding principles:

- **Safe**: Addressing road safety challenges, exacerbated by climate change, ensuring our roads are built to withstand more extreme events.
- **Reliable**: Maintaining a reliable road network is essential for effective management and to keep people and goods moving without delays
- **Resilient**: A focus on resilient infrastructure makes sure that our road network endures for years to come.

Approach to Climate Change Adaptation and Resilience

Transport Scotland's ACCAR outlines the key climate risks affecting Scotland's transport system and sets out our strategic outcomes for Road, Rail, Aviation and Maritime transport networks, whilst recognising our varying levels of influence.

The ACCAR sets out Transport Scotland's current approach to adaptation and resilience in relation to climate change, highlighting the key messages and urgency scores for infrastructure risks, derived from the Climate Change Committee (CCC). Through delivery of the strategic and sub-outcomes we will address all 7 risks relating to transport under the Independent assessment of UK Climate Risk (CCRA3), which provides evidence to inform the UK Government's UK Climate Change Risk Assessment 2022 (UKCCRA3).

Sub-Outcome 1.1 of the ACCAR commits to developing a Trunk Road Adaptation Plan.

Vulnerable Locations Operations Group

Established in 2021, the Transport Scotland Vulnerable Locations Operations Group (VLOG) serves as a dedicated mechanism for embedding climate adaptation within the operational and strategic frameworks of the Transport Scotland's Roads Directorate.

Since its inception, the VLOG has identified strategic areas of adaptation focus, determined how available funds are best allocated to overcome adaptation risks to the TRN, and has facilitated collaboration between stakeholders and dissemination of information across internal and external partners, ensuring alignment with broader Transport Scotland policy objectives. The VLOG has delivered targeted adaptation initiatives to enhance resilience across the TRN, whilst actively seeking out and evaluating innovative approaches to improve its management and maintenance.

Looking forward, Transport Scotland, through the VLOG, will oversee the delivery of the actions set out in this plan, the majority of which will be undertaken by Transport Scotland in partnership with the Operating Companies. The VLOG forum members will monitor progress of activity, including the prioritisation of actions and the evaluation of their effectiveness.

The climate risk assessment within this plan identifies specific geographic areas most vulnerable to climate-related risks. To support the management of these high-risk areas, a Priority Database Matrix tool has been developed. This tool enables the prioritisation of activity to be undertaken to better support these vulnerable geographic locations. Delivering the TRAP actions through the VLOG will ensure climate resilience remains central to transport infrastructure policy and practice. Actions will be prioritised through a structured approach that considers climate risk as the primary factor - balanced against a multitude of other considerations, including feasibility, cost, and operational impact.

Stakeholder engagement in focus

The TRAP has been developed through close engagement with stakeholders, including through workshops and targeted interviews. These have helped ensure the TRAP is informed by diverse perspectives, and a solid evidence-base.

Delivery partners

Transport Scotland will lead the majority of actions within this adaptation plan, reflecting its primary responsibility for the Trunk Road Network. Delivery will be supported by Operating Companies to ensure coordinated implementation across the network. The success of this plan will also be dependent on our continued collaboration and partnerships with the Scottish Government, National Highways, the Department for Transport, Scottish Environment Protection Agency, the Met Office, Scottish Water, local authorities, and academic and research institutions to support evidence-based decision-making and coordinated action.

The TRAP Approach

The TRAP is based on the most up to date climate change projections (UKCP18) and risk assessments, building on previous studies undertaken. It is based on best practice

in climate risk assessment and adaptation planning, in line with international standard ISO14092:2021. The TRAP is structured around three key outputs: (1) baseline screening, (2) future climate risk assessment and (3) adaptation planning, as seen in **Figure 1**.

1

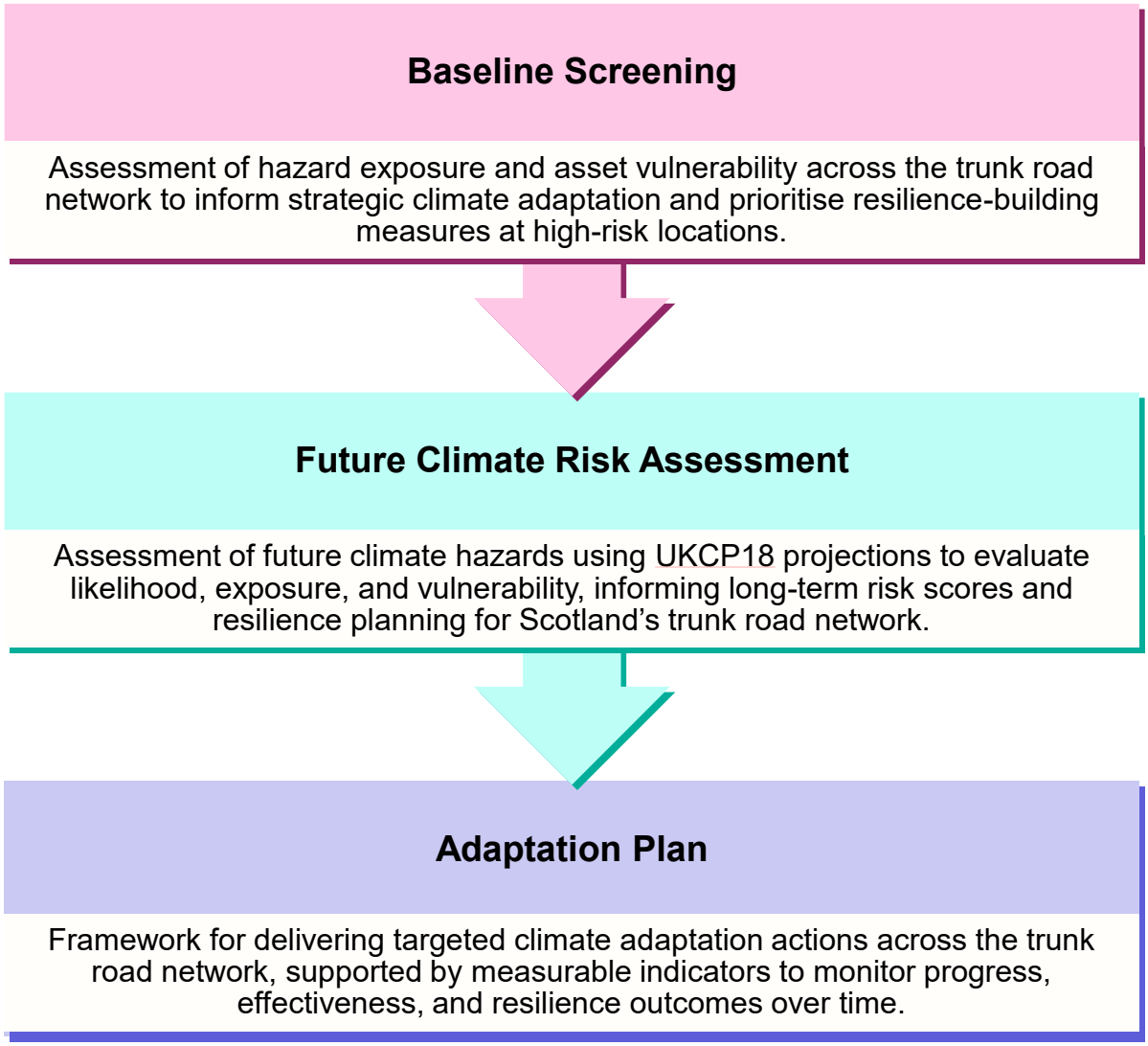

Figure 2: TRAP Design Structure

Baseline Screening

A Baseline Screening Assessment was conducted to identify sections of the TRN with the highest exposure to **present day** climate hazards. By evaluating both hazard exposure and asset vulnerability, the screening assigned high-level risk scores to areas of the Scottish TRN to inform strategic prioritisation of adaptation measures across the network.

Building on the transport risks identified in the CCRA3, the baseline screening applied Geographical Information Systems (GIS) mapping to overlay climate hazard data with

the TRN, enabling a spatial analysis of exposure and vulnerability across the network. Asset age and condition of road structures were also factored into the assessment to understand how structurally sensitive they may be to the impacts of climate change.

The baseline screening of climate risks is used to identify the areas across the network that are most vulnerable to different climate hazards under present day climatic conditions. This assessment facilitated the development of the TRAP through the identification of areas at higher risk due to higher exposure or local asset vulnerability. The results inform which parts of the network require the most attention with regard to minimising future disruption and cost associated with severe weather-related disruptions, and where adaptation actions can be applied at scale at multiple locations. A detailed climate screening report has been developed for internal use.

Validation for the independent baseline screening was supported through internal stakeholder engagement, analysis of our incident database, and a review of previously identified vulnerable structures. **Figure 2** shows the outputs of the Baseline Screening for the TRN as a whole. As shown, surface flooding, landslides and river flooding were amongst the highest scoring risks, with assets such as road surface and structures demonstrating high levels of exposure and vulnerability.

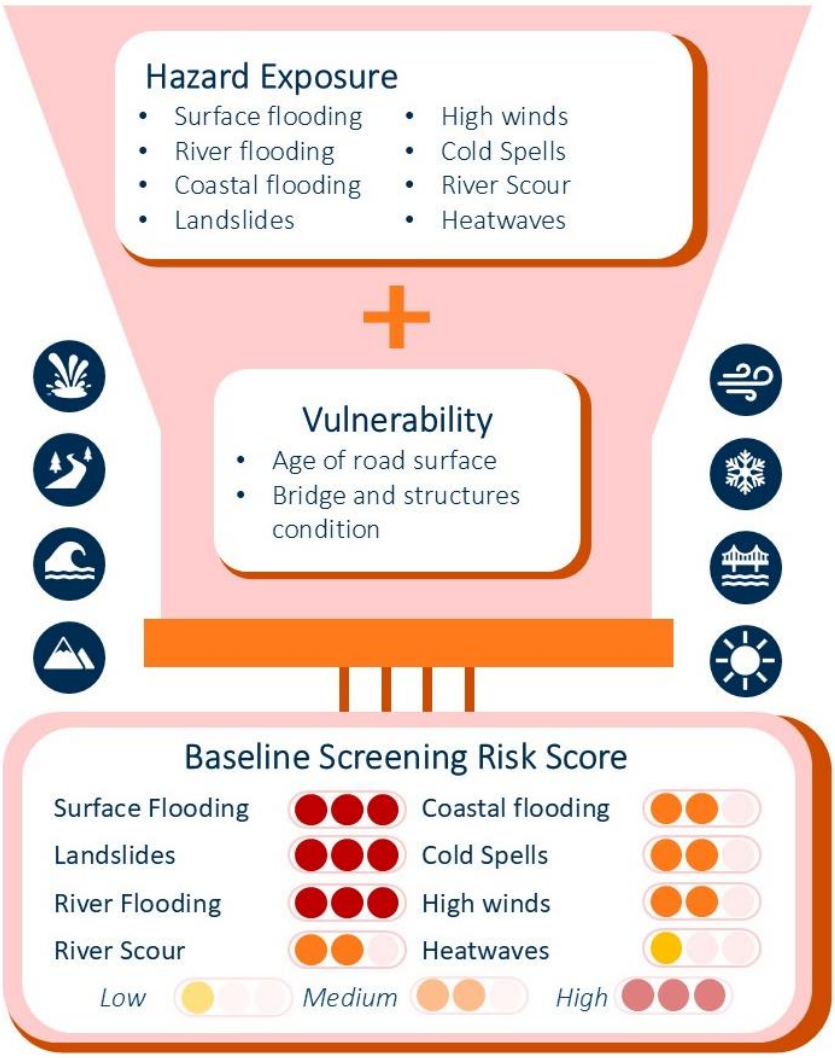

Figure 3 Baseline climate risk inputs and result score card

From the risk screening outputs at the TRN level as a whole, areas exposed to several climate hazards were assessed to identify specific potential vulnerable locations across the network. Two examples of the risk scores for eight climate hazards, considering hazard, exposure, and asset vulnerability, assessed across 2km side 'hexes,' are presented in **Figure 3** below.

Assessment Factors:

- **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.
- **Vulnerability:** propensity or predisposition to be adversely affected.
- **Exposure:** presence of people, livelihoods, species or ecosystems, environmental functions, services and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be affected.

Risk and risk score (A)	
Extreme heat	Low
Cold spells	Very low
River flooding	Low
Surface water flooding	Low
Coastal flooding	Very low
River scour	Very low
Landslides	Low
High winds	Medium

Risk and risk score (B)	
Extreme heat	Low
Cold spells	Medium
River flooding	Very low
Surface water flooding	Very low
Coastal flooding	Very low
River scour	Very low
Landslides	Medium
High winds	Very high

Figure 3: Example of trunk road network baseline climate risk screening multi-hazard score in Skye

Future Climate Risk Assessment

The TRN is highly vulnerable to climate related hazards and is already experiencing the locked-in impacts of climate change, including more frequent weather-related disruptions and escalating damage to the network infrastructure.

The baseline screening assessment provided an understanding of our current exposure and vulnerability to climate risk on the TRN. The future climate risk assessment builds on the baseline screening, develops the risks identified and assesses them in terms of likelihood and impact. This will estimate the likelihood of a risk event occurring based on analysis of event probability and relevant climate drivers, alongside any assumptions that can be made where climate hazards will have an impact on the TRN.

The Met Office's most up to date model, UKCP18 climate datasets, were used to assess climate hazards. The datasets provide updated observations and climate projections for a **medium-high scenario in the 2050s and 2080s**. This allows us to visualise the projected frequency of hazardous climate conditions and the magnitude of their effect.

Development of the future climate risk assessment was further strengthened through analysis of SEPA flood map data[3], engagement with Dynamic Coast (University of Glasgow) and a comprehensive literature review. Once the forecast data was compiled, risk scores were assigned for nine key hazards: surface water flooding, river flooding, coastal flooding, cold spells, high winds, river scour, landslides, extreme heat, and cascading risks.

The assessment estimated the **likelihood** and **impact** of each hazard affecting the TRN. Summary scoring for each risk was undertaken using the risk scoring matrix in **Figure 4**.

[3] SEPA Flood Maps

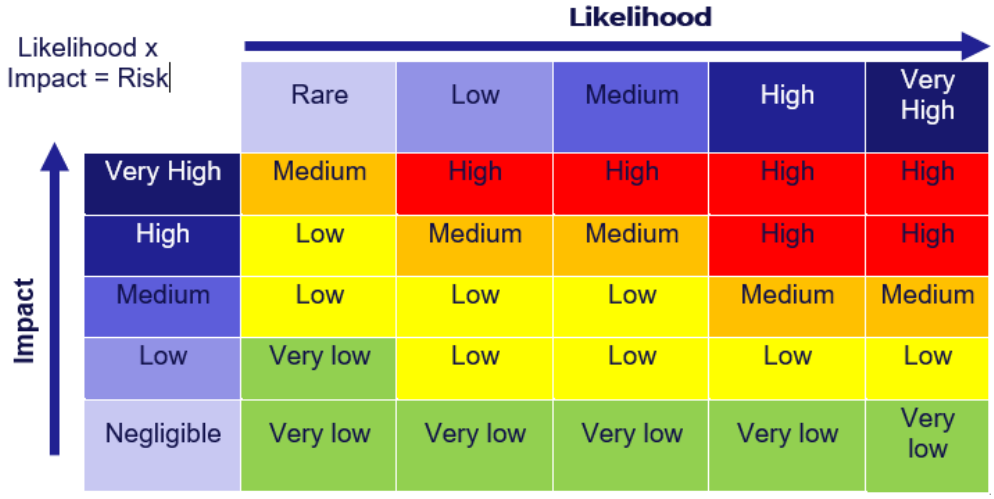

Figure 4: Risk assessment scoring matrix

A **summary of key risks is presented in Figure 5 for the 2050s,** based on a medium to high emissions scenario (RCP6.0). This scorecard outlines how climate risk will change across the trunk road network by the 2050s, based on the UK's latest climate change projections (UKCP18).

Hazard	Impact of hazard	Risk
Surface water flooding	Increase in surface water flooding in Scotland due to heavy rainfall	High
River flooding	Increase in river flooding in Scotland due to heavy rainfall	High
Landslides	Increase in landslide events in Scotland due to continuous increased heavy rainfall	High
River scour	Increase in river scour conditions in Scotland due to climate change	High
Coastal flooding	Increase in coastal flooding and erosion in Scotland due to sea level rise	Medium
Heavy snow fall & ice	Decrease in heavy snow fall and ice events in Scotland due to climate change	Medium

Cascading failures	Increase in cascading failures in Scotland triggering impacts across the trunk road network	Medium
High winds	Increase in extreme wind conditions in Scotland due to climate change	Low risk
Extreme heat	Increase in extreme heat (>30°C) in Scotland due to climate change	Very low risk

Figure 5: Climate Risk Scorecard for 2050s

Key risks included increased surface water flooding, river flooding, river scour and landslides due to climate change damaging assets, causing network disruption, and resulting in safety risks. The risk ratings are identified with current levels of adaptation e.g. investment in flood defences and maintenance of drainage systems.

Future climate risk scores were informed by threshold analysis of UKCP18 climate projections. A comprehensive dataset which outlines the future climate risk assessment for each of the hazards can be found in **Annex A** as an accompanying document.

Adaptation Plan

Guided by the findings of the present-day baseline screening and future climate risk assessment, an action plan has been developed to support a well-adapted TRN - one that is safe, reliable and resilient to the impacts of climate change.

The following actions and enablers were co-developed alongside key stakeholders during collaborative workshops and targeted interviews.

The framework identifies priority areas across the network and sets out targeted adaptation tools to address the most significant risks. These are grouped into **action** and **enabler** themes to address the most significant risks in a structured and strategic manner.

Trunk road adaptation indicators will track progress, supporting continuous improvement, strengthening accountability, and enabling timely course correction where required.

The below themes set out key steps for Transport Scotland and delivery partners. Actions and enablers are set out under short (2025-2027), medium (2026-2028) and long term (2027-2029) timeframes to demonstrate prioritisation of delivery.

Themes

The adaptation framework is structured around two themes (actions and enablers) each consisting of three subthemes. Our adaptation actions focus on what we are and will continue to do to deliver resilience and our adaptation enablers are what will help us to do it.

Actions

Our adaptation plan actions are the concrete steps or interventions we will take to reduce vulnerability across the Trunk Road Network and actively respond to the impacts of climate change.

Safety Enhancement

In light of increasingly variable climate conditions, we will enhance our current safety measures to protect the trunk road network and its users from emergency risks.

Timeframe	Adaptation Measures
0-2 years	Implement **climate-resilient road design standards**, including a review and implementation of updated design standards for road and culvert design to consider more intense rainfall events in the Design Manual for Roads and Bridges (DMRB).
	Carry out increased **public engagement**, to advise and communicate risks to the road network from climate hazards. This includes escalating warnings beforehand, managing expectation during an event and advising when services are restored.
	Improve **signage and road markings** including greater provision of variable-message sign (VMS) in higher risk areas.
	Increase understanding of **snow/ice/road surface/vehicle interactions** to enhance efficacy of gritting operations. This should also include a **review of grit management**.
	Enhance **pro-active information flow** to government and stakeholders during a weather-related incident to enable optimal use of internal/control room resources.

1-3 Years	Review and, if necessary, increase **provision of shelter locations** with facilities, life supplies and evacuation routes in areas at risk of isolation.
	Review the provision and performance of infrastructure such as 'wind baffles' on vulnerable structures and bridge expansion joints.

Reliability Improvement

The following actions outline measures to ensure the reliability of our TRN, minimising the number and frequency of disruptions and reducing the impacts of delay when they occur.

Timeframe	Adaptation Measures
0-2 years	Improving adaptive management through the review, development and implementation of plans and strategies that provide a **response framework** during a **disruptive climate hazard event**, for example a Scour Management Strategy.
	Improve **diversion planning** onto local road networks including consideration of concurrent local impacts and utilise adaptive traffic management systems.
	Promote comprehensive entries to the **Disruption Risk Register** and **Incidents Database** in Transport Scotland's Asset Management Performance System (AMPS), including input of causes related to climate hazards, time disrupted, immediate cost of response and repairs, and also downstream (cascading) impacts.
	Integration of weather forecasting systems for early warning alerts into current processes: • Met Office Services, MetDesk, Winter Hub, DATEX II, SEPA SMS alert system • SEPA PREDICTOR Flood forecasting pilot for improving approach to surface water flood forecasting. • Landslide/Rainfall correlation investigation to inform elevating risk levels

1-3 Years	**Adaptive management systems** aligned and informed by **adaptation monitoring framework**. For example, proactive maintenance of structures in flood prone areas ahead of predicted heavy rainfall events
	Build in adaptation actions to Operating Company contracts to ensure that adaptation actions are effectively cascaded in a timely manner for identifying risks, organisational agreements, agreeing diversion routes and reviewing performance indicators to ensure they are fit for purpose.

Resilience Building

The below actions aim to strengthen our resilience to extreme weather events including floods, storms, and heatwaves.

Timeframe	Adaptation Measures
0-2 years	Continued rollout of **weather-resistant asphalt** - almost 35% of the TRN has been resurfaced with asphalt more resilient to cold weather, extreme rainfall, and warmer temperatures.
	Monitor landslide-prone slopes, liaise with weather forecasters, undertake landslide patrols during risk periods, deliver appropriate **landslide risk reduction** measures.
	Prioritise maintenance and renewal activities in areas where there are **known resilience issues**. This includes directing operations and maintenance to address higher risk sites in areas that may often be overlooked.
	Promotion of **nature-based solutions** at the catchment scale. Incorporating **green infrastructure** for natural flood, landslide, wind, and heat management helps to improve the climate resilience of the network, adjacent non-trunk infrastructure and neighbouring communities.
	Development of business cases for future investments should consider climate change risks and exposure, based on **HM Treasury Green Book and Orange Book** principles, as well as carbon emissions trade-offs. Policy opportunities should be explored to ensure decisions around the location of new infrastructure consider future climate change impacts.

	Improve **resilience incident response** procedures and processes after events occur.
1-3 Years	In locations of noted vulnerability, strengthen **bridges** and **embankments** to withstand extreme weather events and scour risk, or **elevate** road, bridges, and structures out of risk areas.
	Prioritise investigation of **coastal defence structures** in high-risk locations including trial of **Dynamic Adaptive Planning Pathways (DAPP) approach**. DAPP represents an approach to prioritising adaptation options in the face of uncertain and evolving climate-related challenges.
	Retrofitting of **drainage systems** to cope with increased precipitation, including promoting Sustainable Drainage Systems (SuDS). This also provides an opportunity to address non-point source pollution runoff.
	Develop **Dynamic Adaptive Planning Pathways (DAPP)** templates to communicate and evaluate different management schemes for specific vulnerable locations with trigger points informed by adaptation monitoring framework.
3-5 Years	The remit of the **Vulnerable Locations Operational Group** will be i) scaled to identify and implement catchment management solutions; and ii) consider Vulnerable Locations across all climate hazards.

Enablers

Our adaptation plan enablers are the interconnected levers that help create the conditions necessary for adaptation actions to be possible, effective, and scalable.

Engagement & Partnership

Effective collaboration with Operating Companies is central to tackling the diverse challenges posed by climate change, while also unlocking opportunities to share resources and coordinate resilience efforts across the public sector.

Timeframe	Adaptation Measures
0-2 Years	Provide support to **Scottish Road Research Board** (SRRB) and wider engagement on climate research programmes and Natural Hazards.

	Implementation of **joint working** with SEPA, Scottish Water, local authorities, landowners, and environmental organisations to deliver catchment-scale solutions via the establishment of a Drainage Working Group. **Collaborative catchment schemes** promote holistic solutions, identify co-benefits, and avoid maladaptation through participation in the in the **River Basin Management Planning** (**RBMP**) group.
	Produce a guide to support **private landowners** with managing climate hazards that could impact TRN infrastructure and work together to implement best-practice **adaptation strategies** that reduce risks such as flooding and landslides.
	Enhance public advice around use of **winter tyres** and **snow chains** in vulnerable communities and locations during significant events. Engagement with the public to advise against travel in cold spells to reduce risk to road users from **hazardous road conditions**.
	Ensure that climate adaptation is embedded in **procurement, business cases** and **supply chains** for new procurement schemes under Major Projects.
1-3 Years	Engage in a national risk assessment of weather-related **cascading infrastructure failures** in the Scottish National Adaptation Plan (SNAP3), as well as specific policies and/or actions to plan for, and manage, risks from interdependent infrastructure.
	Consider **prioritised maintenance** in more vulnerable locations and improve methods for inspection and reporting.
	Explore options to develop guidance for local authorities on developing climate change risk assessments and **adaptation plans for local roads**.

Research & Understanding

By filling identified knowledge gaps, we can strengthen our understanding of climate risk and foster innovation for the development of technologies and materials needed to future-proof Scotland's road infrastructure.

Timeframe	Adaptation Measures
0-2 years	Continued collaboration with **University and Research bodies** to develop new insights into the effects of scour on structures across the network, and novel techniques for monitoring the river characteristics that lead to scour events.
	Investigate wider **interdependent impacts** to Scotland economy and communities including transport modelling disruption estimates. This could include an assessment of the economic and social costs of disruptions to Scotland, which will support awareness on the effect of wider adaptation challenges, using transport modelling of traffic disruption.
1-3 Years	Outputs from the TRAP should be fed to the VLOG for assessment and **prioritisation**. Identified areas of high risk and vulnerability should be added to a longlist, followed by a prioritisation and short list of priorities. Specific vulnerable locations can then be assessed in further detail.
	Development of a centralised **Geographical Information System** (GIS) interface by AMPS which is updated from Disruptions Risk Register, Incidents Database, and Vulnerable Locations (all hazards). This will help to provide more holistic insights into the problem areas of the TRN and inform the cost benefit relating to business cases.
	An investigation of **coastal change** in vulnerable areas should be completed near the TRN including **erosion risk, sea-level rise,** and **road service levels**. This will help to inform a dynamic adaptive approach to management schemes, including the potential for **managed retreat** in the long-term. This assessment can initially be informed by Trunk Road Climate Risk Assessment and Dynamic Coast outputs.
	Inspection of **bridges** during hot temperatures should be completed to assess **expansion risk potential**. The full impact of more frequent warm days (>25°C) and hot days (>30°C) on TRN assets, particularly aging swing bridges, is unknown.

3-5 Years	**Electrical equipment** and **ITS infrastructure** that services the TRN should be reviewed to ensure assets are able to function in higher temperatures to avoid overheating and short-circuiting of vital connections.

Monitoring & Evaluation

Establishing a comprehensive monitoring framework is critical to accurately evaluate climate impacts and assess the effectiveness of adaptation recommendations.

Timeframe	Adaptation Measures
0-2 years	Regular monitoring of climate impacts on trunk roads through current systems including the **Disruption Risk Register** and **Asset Management Performance System Incident Data** to contribute to adaptation monitoring framework.
	Transport Scotland reports on its objectives under the most recent Scottish National Adaptation Plan and accompanying monitoring framework.
	Continuing to monitor ACCAR outcomes that contribute towards the three key outcomes: safe, reliable, resilient. This includes regular monitoring of climate impacts on the Scottish TRN, alongside other transportation modes and reporting on **adaptation investment**.
1-3 Years	A **benefits mapping exercise** to clearly demonstrate how certain activities deliver benefits and ultimately contribute to project and organisational ambitions e.g. objectives and key performance indicators (KPIs).

Adaptation in Practice

The following case studies from the VLOG demonstrate the practical delivery of climate adaptation best practice, showing how risk-based approaches are being applied to manage localised climate impacts and strengthen infrastructure resilience.

Case Study A: All North-West 4 Rock Slopes

The “All NW 4 Rock Slopes” project was made up of four individual sites within the North-West trunk road unit comprising of the following locations: A85 Loch Awe, A82

Corran Ferry, A830 Loch Eilt and A830 Rannochan. Each of these sites had experienced unstable slopes leading to rockfall onto the TRN.

The likely failure mechanisms at all sites appear to be linked to the detachment of overhanging or partially loosened blocks, with root penetration into discontinuities acting as a key contributing factor. At all locations, heavy rainfall and associated build-up of water pressures may have exacerbated instability also due to the potential for sudden weather-related changes that can rapidly accelerate slope failure.

The works comprised of vegetation clearance, scaling of loose rock, and installation of rockfall protection systems. At A82 Corran Ferry (**Images 1 & 2**), face support netting (25m x 11m) was installed following rock removal between retaining walls. At A85 Loch Awe, vegetation was cleared and loose rock scaled from a previously failed netting area. At A830 Loch Eilt, stabilisation included removal of boulders, scaling, and installation of both rockfall drapery (12m x 20m) and face support netting.

Images 1 & 2: A82 Corran Ferry Rockfall (left) and completed works (right)

Targeted night closures were carried out to safely remove unstable boulders using netting, Nonex, and 50-tonne airbags. At A830 Rannochan, two unstable blocks were controlled and removed, with all material safely disposed of offsite.

The scheme was constructed between 24th February 2025 and 17th July 2025, with a total cost of approximately £315,000. By integrating future climate projections into the prioritisation and design process, the project not only addressed the immediate operational challenges of slope instability and rockfall onto the TRN, but also strengthened the slopes to withstand future extreme weather events, improving long-term resilience.

Case Study B: Crimond Carriageway (A90)

A 500-metre stretch of the A90 east of Crimond was found to have no formal drainage infrastructure, instead draining directly onto the adjacent verge. This resulted in persistent surface water flooding on the carriageway during rainfall events, creating significant safety concerns. The property on the northbound side regularly experienced flooding due to overflow from the adjacent ditch network, with the southbound field frequently ponded and encroached onto the carriageway, prompting multiple complaints and reports of disruption.

The initial proposal was to install a new carrier pipe within the northbound verge, directing flow down the access road at the eastern end of the scheme and out falling into the ditch network downstream of the affected property. However site visit investigations and discussions with the property owner revealed that that there was very little flow within the ditch (**Image 3**). The water level remained at half capacity weeks after significant rainfall, suggesting limited flow likely caused by shallow topography and elevated water levels in the nearby loch. These issues rendered the proposed new connection unfeasible, and a direct outfall to the loch was also ruled out due to topographical limitations.

Image 3: Ditches were created after investigations found no formal drainage infrastructure

Instead, a revised solution was developed involving the installation of three separate infiltration systems within the southbound verge. These systems were spaced with breaks between to increase the upstream attenuation and were designed to allow a future connection between the systems, and an outfall into the ditch network should

subsequent improvements be made. To further mitigate flooding in line with the increased rainfall marked by climate projections, on-site material was used to construct a bund around the lowest point of the field, increasing storage capacity. Additionally, a controlled overflow was installed to enable gradual discharge preventing overtopping onto the carriageway. The results are shown in **Images 4 & 5**.

Images 4 & 5: Collection of images showing before and after of rainfall on the road and at the ditches of the road

This solution avoided trenching through the carriageway, which had been resurfaced the year prior, preserving recent investment and minimising disruption. Construction works were completed in March 2024, with a total budget spend of approximately £93,000. The scheme demonstrates the importance of site-specific investigation and adaptive design in delivering effective, climate-resilient drainage solutions.

Next steps

Transport Scotland is committed to delivering our vision for a well-adapted transport system in Scotland and will continue to take steps to embed adaptation and resilience across our organisation. Establishing this framework for climate adaptation of the trunk road network marks a significant step towards achieving this vision.

Over the duration of the plan, we will work collaboratively with stakeholders to implement the actions contained within the framework. We will ensure also that TRAP

remains responsive to emerging climate risks and technological advancements. The delivery of adaptation measures arising from the recommendations will be continually monitored and evaluated through a framework of indicators to assess effectiveness and drive future improvements. We will also report annually on the progress of the TRAP through the SNAP3 statutory reporting mechanism.

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