Department for Transport

Met Office

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Transport hazard summary series

Surface water flooding

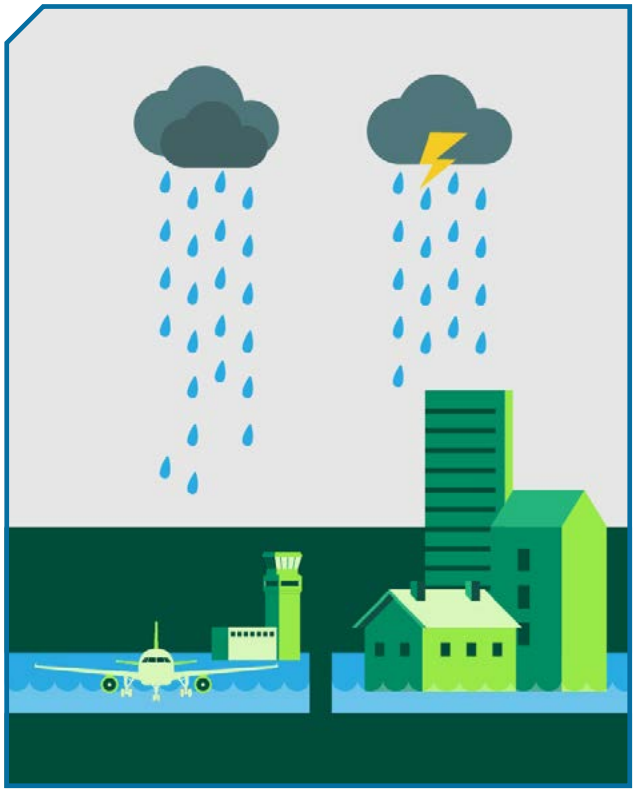
Surface water flooding occurs when rainwater overwhelms drainage systems, causing water to flow over or pool on the ground. This type of flooding can occur in both urban and rural areas and can significantly disrupt transport by blocking roads and railways and by flooding stations, ports and terminals. Surface water flooding presents unique challenges due to its rapid onset and unpredictable location. It is also difficult to forecast. Climate change is projected to increase the frequency and severity of surface water flooding events. In response the transport sector must become more resilient to address these challenges.

The Department for Transport, Met Office and partners have created this series of **transport hazard summaries** to explain natural hazards and other hazards that are not the result of malicious acts, their impacts and how they may change in the future. This summary will introduce what is meant by surface water flooding and how it can impact transport, and offers further information to help decision makers manage and adapt to these risks.

Over 3,500km of the UK rail network and 596 rail stations are in locations that should expect to be flooded by surface water once every 30 years.*

* UK Climate Risk, 'Transport Briefing', 2021, available at: **https://www.ukclimaterisk.org/wp-content/uploads/2021/06/CCRA3-Briefing-Transport.pdf**

What is surface water flooding?



Surface water flooding occurs when intense rainfall overwhelms drainage systems or the ground's capacity to hold water. The water rapidly accumulates on or flows over the surface, giving localised flooding. It can cause flash flooding, where torrential rain can very quickly turn roads or other slopes into fast flowing rivers.

Flooding can have different natural causes that can happen at the same time but are distinct. We have created separate **transport hazard summaries** focusing on river flooding, groundwater flooding and coastal flooding and erosion.

Figure 1:
Intense rainfall cannot drain quickly enough so pools, creating surface water flooding

Where does it occur?

It can happen anywhere as a result of intense rainfall. It is particularly disruptive in built-up areas where hard surfaces like roads and pavements stop rainwater soaking into the ground. The Environment Agency and Natural Resources Wales produce surface water flood risk maps for England and Wales showing where there is a high, medium or low likelihood of flooding.*,†

When does it happen?

It typically happens in summer due to sudden heavy showers and thunderstorms but can occur at any time of year during heavy rain often associated with storms. See the 'Storms' summary for further information.

How long does it last?

It is often linked to intense rainfall that usually lasts less than 6 hours. The recovery phase after the rain has stopped can be much longer. It can take weeks if water needs to be pumped off a flooded road.

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* Environment Agency, 'Risk of flooding from surface water', 2025, available at: **https://www.gov.uk/government/publications/flood-risk-maps-for-surface-water-how-to-use-the-map/risk-of-flooding-from-surface-water-understanding-and-using-the-map**

† Natural Resources Wales, 'Flood Risk Assessment Wales Map' available at: **https://naturalresources.wales/flooding/check-your-flood-risk-on-a-map-flood-risk-assessment-wales-map/?lang=en**

What increases surface water flood risk?

- Hard, unabsorbent surfaces such as roads, pavements or hardened soil. Increasing development of urban areas or loss of vegetation is therefore increasing the risk.
- Old drainage systems struggling to cope with today's more intense rainfall.*
- Successive intense rainfall events can saturate the ground reducing its ability to absorb further rainfall even if it is less intense. This could become more pronounced as the frequency of intense rainfall increases with climate change.
- Blocked drainage channels, particularly during autumn and winter due to fallen leaves.
- Drainage from new building developments causing water to pool in unexpected areas.

How are surface water flooding events changing due to climate change?

- The UK is projected to experience more frequent intense rainfall events, where a lot of very heavy rain falls in a short space of time. For every degree of warming in the region, the intensity of extreme rainfall is projected to increase by 5% to 15%.
- Extreme UK downpours heavy enough to cause flash floods (more than 20mm of rain per hour), could be 4 times as frequent by the 2070s under a high emissions scenario. Events like this occurred around 12 times per year in the 1980s somewhere in the UK. This is projected to increase to around 49 by the 2070s.†
- Even for low and medium emissions scenarios, changes in extreme downpours are expected to be pronounced.†

Projections show a tendency for extreme years with record breaking rainfall events to arrive in clusters. These may then be followed by years or decades without, which poses a challenge for adaptation strategies.†

The number of people and amount of transport infrastructure exposed to frequent surface water flooding is increasing under all climate scenarios.‡

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* The UK Climate Resilience Programme, 'Future Drainage: Ensemble climate change rainfall estimates for sustainable drainage', 2023, available at: **https://www.ukclimateresilience.org/projects/future-drainage-ensemble-climate-change-rainfall-estimates-for-sustainable-drainage/**

† Kendon, E.J., Fischer, E.M., Short, C.J. and others, Nature Communications, 'Variability conceals emerging trend in 100yr projections of UK local hourly rainfall extremes', 14, 1133, 2023, available at: **https://doi.org/10.1038/s41467-023-36499-9**

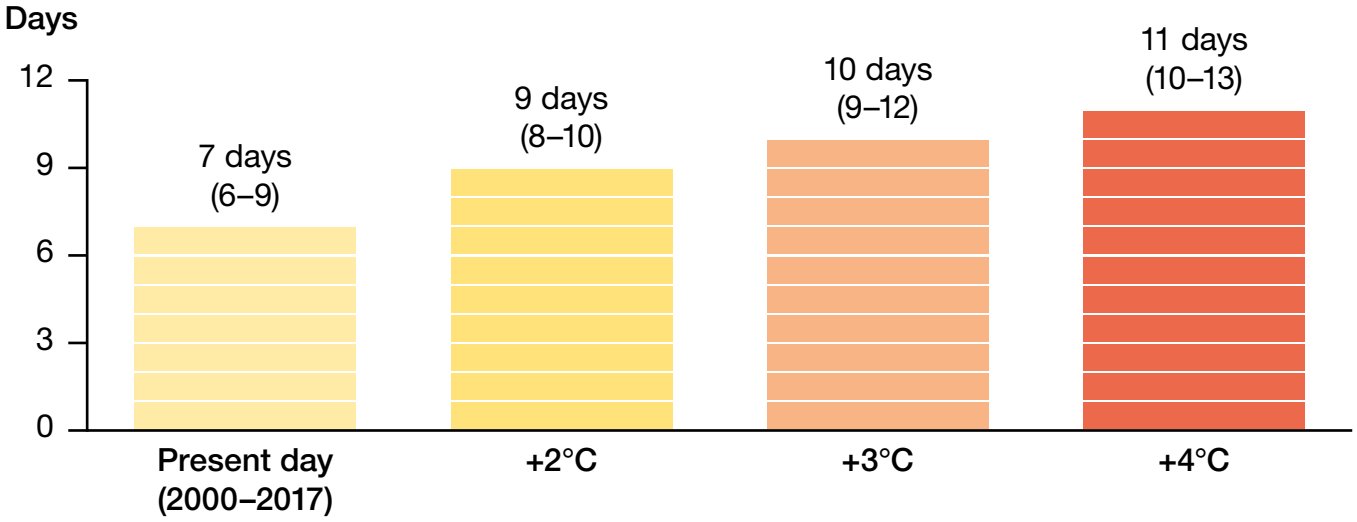
‡ Sayers, P.B, Horritt, M.S, Carr, S. and others, 'Third UK Climate Change Risk Assessment (CCRA3) Future Flood Risk Main Report', 2020, available at: **Future-Flooding-Main-Report-Sayers-1.pdf**

How are surface water flooding events changing due to climate change?

Climate change is projected to significantly alter rainfall patterns in the UK. Drier UK summers are expected overall, but the likelihood of intense downpours in summer will increase. This will lead to a greater risk of natural and man-made drainage systems being overwhelmed and more surface water flooding events as a result. The increased risk of surface water flooding is not confined to summer, as winters are expected to become wetter on average.*

An increasing number of days on average each year are projected to see intense or prolonged heavy rainfall with increasing global warming, as shown in Figure 2.†

Figure 2: The projected average occurrence of days with heavy rainfall of more than 80mm per day for different global warming levels†



- Between now and the middle of the century, continued climate change is largely inevitable.
- Global warming of 2°C is reached by most emissions scenarios by the middle of the century.
- In the second half of the century, a wide range of global warming levels remain possible.
- 4°C of global warming is reached only by the higher emissions scenarios, and not until later in the century.‡

Emissions scenarios and global warming levels are explained in 'The changing climate' transport hazard summary. You can check your yearly chance of surface water flooding both now and between 2040 and 2060 on the Environment Agency's surface water flood risk maps for England (please see the Further reading section for more details).

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* Met Office, 'UKCP18 Climate Change Over Land', available at: **https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/research/ukcp/ukcp18-infographic-headline-findings-land.pdf**

† Hanlon, H.M., Bernie, D., Carigi, G. and others, Climatic Change, `Future changes to high impact weather in the UK', volume 166, article number 50, 2021, available at: **https://link.springer.com/article/10.1007/s10584-021-03100-5**

‡ Climate Change Committee, 'Proposed methodology for the Fourth Climate Change Risk Assessment – Independent Assessment', 2024, available at: **https://www.theccc.org.uk/publication/proposed-methodology-for-the-ccra4-advice/?chapter=3-proposed-methodological-approach-for-ccra4-ia**

Case studies

In July 2021, London experienced two significant surface water flooding events caused by intense storms. These storms brought heavy rainfall within very short timeframes, causing widespread disruption across the city. Major incidents were declared a few hours after the initial peak in rainfall, as water accumulated rapidly. On 12 July, some areas of London experienced nearly 100mm of rainfall in just two hours which is more than double the average rainfall for the entire month of July.* The extreme rainfall, combined with a high tide in the Thames river, reduced the capacity of water to drain out of the sewers, significantly worsening the flooding.†

Extensive flooding led to submerged roads across London, causing widespread congestion and gridlock. Many vehicles were stranded, damaged or abandoned, particularly in low-lying areas. Emergency response was severely delayed due to road closures and impassable routes.*

Over 30 London Underground stations were either fully or partially closed due to flooding, causing substantial disruption to the city's transport network. Flooded tracks and platforms resulted in significant delays, cancellations and service suspensions across both underground and mainline rail services, severely impacting commuters and travel across the city.*

While direct flooding at London airports was not widely reported, access to airports such as Heathrow, Gatwick and London City Airport was significantly affected. Road and rail disruptions complicated journeys for passengers and airport staff, leading to logistical difficulties.

Another example of a major surface water flooding event is the 2012 autumn floods, where a rapid succession of heavy rainfall events on saturated ground resulted in severe widespread flooding, together with failure of critical transport infrastructure.‡

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* Greater London Authority, 'Surface Water Flooding in London', 2022, available at: **https://www.london.gov.uk/sites/default/files/flooding_progress_report_final_1.pdf**

† Greater London Authority, 'Data challenges of the July 2021 Flooding', 2022, available at: **https://www.ciwem.org/assets/pdf/assets/uploads/Fiona_Barbour_paper.pdf**

‡ Jaroszweski, D., Hooper, E., Baker, C., Chapman, L., and Quinn, A., 'The impacts of the 28 June 2012 storms on UK road and rail transport', Meteorological Applications 22(3): 470 to 476, 2015, available at: **https://doi.org/10.1002/met.1477**

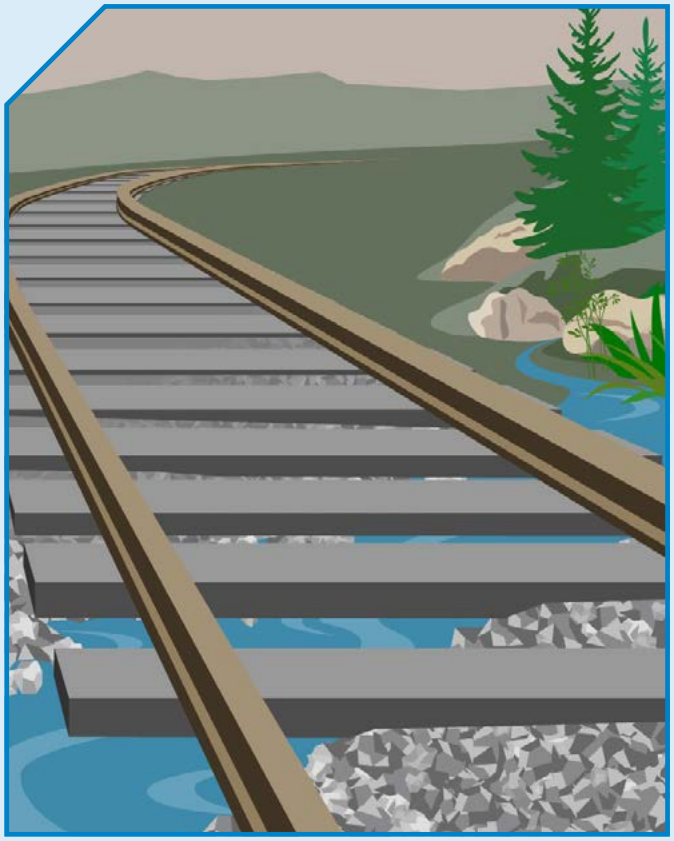
Direct transport impacts due to surface water flooding

Human health and safety

- People in vehicles can become trapped or swept away by fast-moving floodwaters, with underpasses and underground transport hubs or car parks being especially dangerous due to rapid water accumulation.
- There is risk of injury and fatalities from colliding with debris carried in floodwaters.
- Floodwater can overwhelm sewerage systems, potentially leading to the spread of pollution and disease.
- Disruption to transport networks can threaten the response time of emergency services.

Vehicle and service operations

- Roads and railways can be damaged, destroyed or made impassable due to flooding, forcing closures and service cancellations.
- Port and airport operations are dependent on road access, with closures disrupting freight as well as both staff and passenger travel.
- Floodwaters can damage vehicles and rolling stock, leading to repairs, increased maintenance costs or reduced lifespan.
- Surface water reduces traction on tyres and runways, increasing the risk of skidding and need for longer stopping distances.



Infrastructure

- Flooding of transport buildings such as stations, ports and airports as well as storage facilities can cause closures, cancellations and longer-term damage.
- Floodwaters can damage road surfaces and destabilise sections of railway tracks by washing away the material forming the trackbed and leaving behind debris.
- Underground infrastructure, such as London Underground stations, may rapidly flood, forcing station closures.
- Flooding can disrupt travel and freight operations on rivers and canals by rapidly changing water levels, causing suspension of operations.

Interdependencies: Flooded power substations can cause widespread outages, stopping electric trains, trams and traffic signals, and severely impacting airport operations. Disruptions to communication networks can severely impact operations, for example traffic management, causing increased congestion and reduced transport network efficiency.

Hazards associated with surface water flooding

Extreme heat and drought

Extreme heat and drought can lead to dry, parched and compacted soil which can prevent rainwater soaking into the ground. As a result, it runs off or pools on the surface, increasing flood risk.

Groundwater flooding

Higher groundwater levels reduce the capacity for water to be absorbed by the ground, increasing the risk of surface water flooding.

Landslides and earthwork failures

Soil erosion from flooding can carry away earth and cause landslides, as well as undermine earthworks, increasing their risk of failure.

Pollution incidents

Surface flood water can carry pollutants from transport networks, such as fuel, oil or rubber debris polluting nearby water bodies.

River flooding

If heavy rainfall causes surface water flooding and the excess water eventually flows into rivers, this increases the risk of river flooding.

Storms

Intense rainfall overwhelms drainage systems and where water is unable to drain away, it accumulates on or flows over the surface, resulting in localised flooding.

Subsidence, soil degradation and sinkholes

Surface water flooding can contribute to soil erosion and destabilisation, potentially leading to subsidence.

Wildfire

Wildfires can burn away vegetation that holds soil in place and retains water, leading to an increase in surface water flooding.

Further information on these hazards can be found in our series of Transport hazard summaries: **https://www.gov.uk/government/collections/transport-hazard-summaries**

Risk mitigation and adaptation

Transport infrastructure needs to become more resilient to deal with the increased risk of surface water flooding due to climate change. Examples of effective measures include:

- implementing green infrastructure, sustainable drainage systems and natural flood management and investing in community level flood defence schemes
- designing infrastructure to safely route and store surface water when drainage systems are overwhelmed
- retrofitting existing drainage systems and transport infrastructure to handle increased rainfall
- improving maintenance plans for existing drainage systems such as roadside gullies

Questions for decision makers

- Where on your network could flooding quickly become deep and dangerous, for example in underpasses or low-lying junctions?
- Which key routes, freight hubs or emergency-service access roads could be blocked by surface water flooding, and what operational or engineering measures will keep them open?
- Do you have plans in place to communicate transport disruption and safety messages to the public?
- What personnel and equipment will you need to respond to flood incidents and are responsibilities well defined during a large-scale flooding event?
- Are plans in place to evacuate stranded travellers and ensure the safety of vulnerable people?
- How can you use weather and surface water flooding forecasts and risk assessment tools to better identify and monitor locations vulnerable to surface water flooding?

Further reading

Environment Agency long-term flood risk maps – GOV.UK

Flood forecasting centre information – GOV.UK

Long-term flood risk maps – Natural Resources Wales

National assessment of flood and coastal erosion risk in England 2024 – GOV.UK

Reducing the risk of surface water flooding – National Infrastructure Commission

Surface Water Flooding: All You Need to Know – The Flood Hub

Third UK Climate Change Risk Assessment (CCRA3) Future Flood Risk – Sayers and Partners

What causes flash floods? – Met Office

Climate information and risk assessment

See 'The changing climate' and 'Transport hazards, risks and resilience' transport hazard summaries for more information on identifying and planning for risks to transport and where to find climate data, including more detail on projected changes on a regional level.