Department for Transport

Met Office

BGS

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Transport hazard summary series

Reservoir dam collapse

Reservoir dam collapses are very unlikely but high-impact events. In the UK, many dams are more than a century old, and climate change could accelerate the deterioration of dam structures by increasing the severity of some extreme weather events. Partial dam failures due to extreme rainfall in the past 20 years in the UK show that a collapse is not impossible. A total dam collapse can be sudden, sending a large, destructive wave of water downstream with very little warning, threatening lives and causing major damage to transport infrastructure. Given the significance of potential impacts, the transport sector needs to prepare for the possibility of such events.

The Department for Transport, Met Office and partners, including the British Geological Survey, 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 reservoir dam collapse and how it can impact transport. It offers further information to help decision makers prepare for this risk.

Around 2.6 million people in England are potentially at risk from reservoir dams collapsing and causing flooding which could endanger life.*

* Environment Agency, 'Reservoir safety reform programme', 2025, available at: **https://www.gov.uk/government/publications/reservoir-safety-reform-programme/reservoir-safety-reform-programme**

What is a reservoir dam?

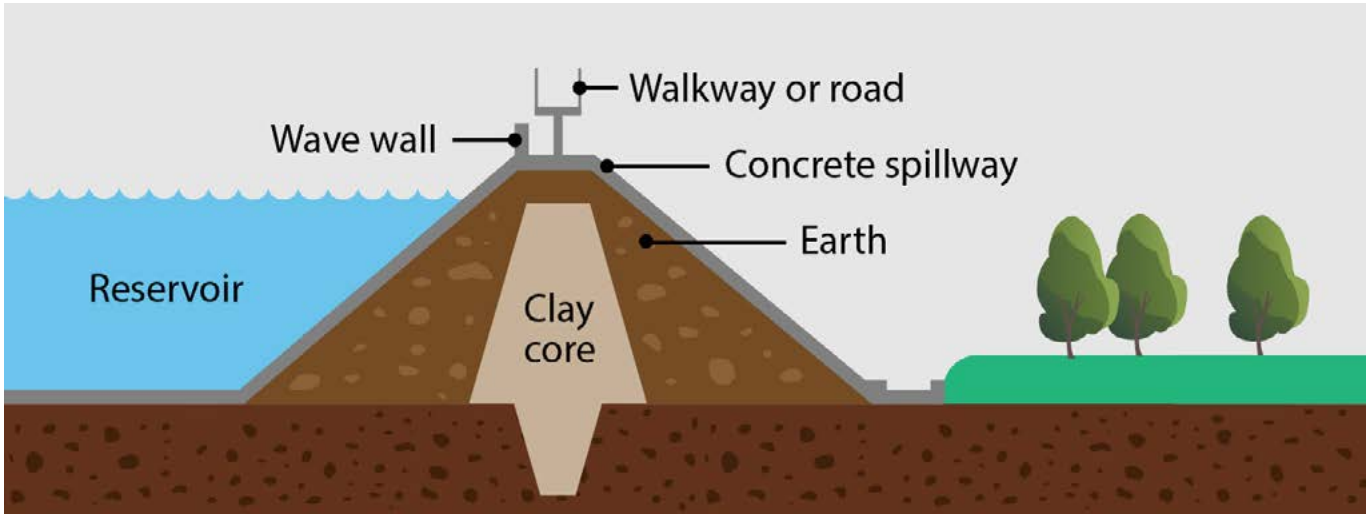
A dam acts as a retaining wall, controlling the flow and release of water from a reservoir into a downstream river. There are many different types and designs of reservoir dams, with embankment dams, shown in Figure 1, being the most common in the UK.

What could happen if a dam collapses?

Many roads, railways, stations, ports and airports are situated downstream from dams and are at risk if a collapse occurs. A dam collapse can happen quickly due to the force of water in the reservoir, releasing a deep, fast-moving flow that can destroy infrastructure and endanger lives. Clean-up and repairs would likely take months or even years. The failure of part of a dam, or the threat of collapse, can lead to evacuations and precautionary closures that disrupt travel and emergency access.

The Environment Agency has created reservoir flood maps which show where water may go in the unlikely event of a dam collapse.*

Figure 1: Schematic of an embankment reservoir dam.† The design is similar to the Toddbrook Reservoir dam shown in the case study on page 5.



An embankment dam stores reservoir water behind an earth mound with a watertight clay core. Concrete spillways release excess water, while wave walls on top help protect the structure from water overtopping the dam. These components are susceptible to changes in the weather and climate.

* Environment Agency, 'Reservoir flood maps: when and how to use them', 2021, available at: **https://www.gov.uk/guidance/reservoir-flood-maps-when-and-how-to-use-them**

† BBC, 'Whaley Bridge: How safe are Britain's dams?', 2019, available at: **https://www.bbc.co.uk/news/uk-england-derbyshire-49196766**

Why do dams collapse?

The failure, or total collapse, of a dam can occur for many reasons. Many of the dams in the UK are over 100 years old and have exceeded their design lifespan. Without regular maintenance and monitoring, their condition can deteriorate over time, weakening the dam and increasing the risk of collapse. There are several factors that increase the likelihood of dam collapse.

Extreme rainfall: Heavy rain is the most common cause of a dam collapse. If the water level in a reservoir rises above what the dam was designed to hold, water can spill over the top and damage its surface. Large volumes of water can also damage the spillway, allowing water to seep into the dam's structure.

Drought and wet-dry cycles: Long dry periods can crack the clay cores and slopes of some dams, letting water in when rain returns. Repeated drying and wetting can gradually weaken the structure.

Erosion and water pressure: Water can build up inside the dam and the ground beneath. The pressure of water can force the soil apart, making sections of the dam move and crack. These cracks can let water leak through, washing material away and gradually weakening the structure.

Wind and wave action: Strong winds can create waves that push water over the dam. Repeated wave overtopping can wear away surfaces and embankments and increase the risk of collapse.

External forces: Nearby land-use changes can affect the stability of the dam. For example, urbanisation upstream can increase the volume and speed of runoff flowing into a reservoir.

Owners of dams that are considered high risk are required to carry out regular inspections and must maintain emergency flood plans. These include communication with downstream communities if damage is found. Local resilience forums maintain plans for offsite actions, including evacuation and recovery plans.*

* Reservoirs Act 1975, available at: **https://www.legislation.gov.uk/ukpga/1975/23/contents**

Are dam collapse events changing due to climate change?

Climate change is projected to lead to an increase in extreme rainfall and drought.* These natural factors cause damage to dams and could increase the risk of a dam collapse as global temperatures increase.

Extreme rainfall: 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. An increasing number of days on average each year are projected to see intense or prolonged heavy rainfall with increasing global warming.†

For every degree of warming in the UK, the intensity of extreme rainfall is projected to increase by 5% to 15%. Even for low and medium emissions scenarios, changes in extreme downpours are expected to be pronounced.‡ See the 'Surface water flooding' transport hazard summary for more detail.

Drought: The severity of droughts is expected to worsen for all lengths of drought, whether they last 3, 6, 12 or 36 months.† Drought can lead to low water levels, which may increase the risk of cracking in the structure of embankment dams. See the 'Drought' transport hazard summary for more detail.

Repeated wet-dry cycles: Repeated drying and heavy rain cause some soils to shrink and swell, leading to cracks, settlement and instability that can shorten an embankment dam's lifespan. The UK climate is projected to become wetter in winter and drier in summer. These wet-dry cycles could intensify, accelerating the weather-driven deterioration of earthworks such as embankment dams.§

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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**

‡ 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**

§ Briggs, K.M., Helm, P., Smethurst, J. and others, Transportation Geotechnics, 'Evidence for the weather-driven deterioration of ageing transportation earthworks in the UK', 2023, available at: **https://www.sciencedirect.com/science/article/pii/S2214391223002039**

Case studies

Toddbrook Reservoir: In 2019, an earth embankment dam at Toddbrook Reservoir, Derbyshire, completed in 1841, narrowly avoided collapse.* Over four days, around 160mm of rain fell, sending large volumes of water down the auxiliary spillway. The intense flow created a void underneath the spillway that caused sections of the concrete surface to break apart and collapse. Emergency services rapidly lowered the reservoir's water level and used helicopters to drop hundreds of tonnes of material onto the damaged spillway, preventing a breach.

Concern over a possible collapse of the dam prompted the evacuation of about 1,500 people. This could have sent a flood wave several metres deep into the town, threatening homes, bridges and roads. An independent review into the incident reported that it was caused by a poor design of the spillway and lack of maintenance. Subsequent repair work has required repeated road closures around the area.

Ulley Reservoir: In 2007, an earth embankment dam at Ulley Reservoir, South Yorkshire, suffered spillway damage that put the dam at risk of collapse.† Around 100mm of rain fell in two days, sending large volumes of water down the spillway channel. The water overtopped the spillway walls, collapsing sections and eroding parts of the dam's embankment.

Approximately 1,000 people were evacuated and nearby roads, including sections of the M1 motorway, were closed as a precaution in case the dam collapsed.

Llyn Eigiau: In 1925, the concrete dam at Llyn Eigiau, Conwy, North Wales, collapsed after heavy rain weakened its poor-quality structure. About 1.5 million cubic metres of water surged downstream, overtopping and destroying a second downstream dam. The resulting flood swept through Dolgarrog village, killing 16 people and destroying key infrastructure such as the local power station.‡

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* Department for Environment, Food and Rural Affairs, 'Toddbrook Reservoir incident 2019: independent review', 2019, available at: **https://www.gov.uk/government/publications/toddbrook-reservoir-incident-2019-independent-review**

† Environment Agency, 'Post-incident reporting for UK dams: 2007 Annual Report', 2008, available at: **https://assets.publishing.service.gov.uk/media/5a7c1835ed915d210ade18cc/geho0408bnsh-e-e.pdf**

‡ Department for Environment, Food and Rural Affairs and Environment Agency, 'Lessons from historical dam incidents', 2011, available at: **https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/290812/scho0811buba-e-e.pdf**

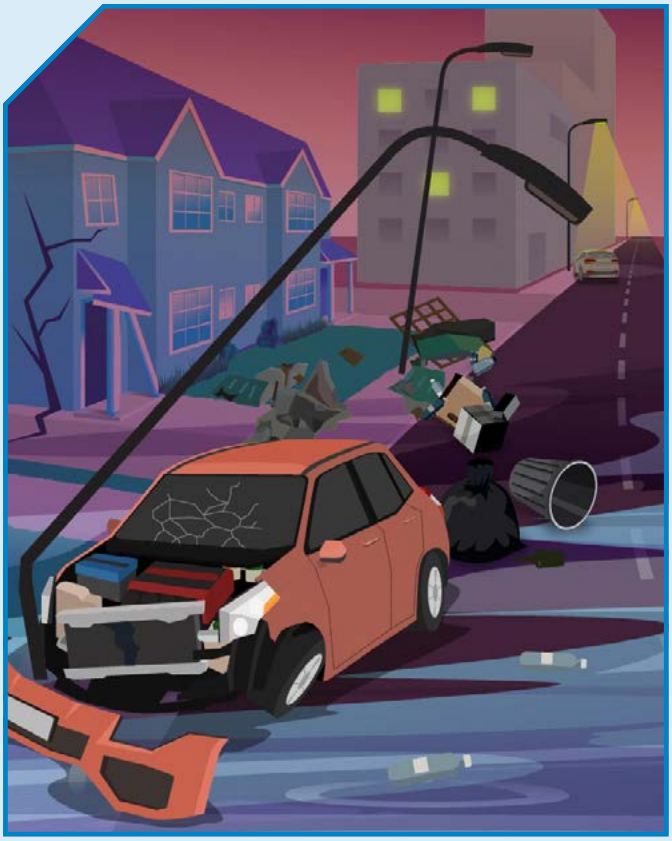
Direct transport impacts due to a reservoir dam collapse

Human health and safety

- A life-threatening flood wave can sweep away people and vehicles within minutes.
- Any sudden onset of collapse would give little time for emergency evacuation.
- Collapsed roads and bridges can isolate communities and hamper emergency crews.

Vehicle and service operations

- Fast-flowing water can float cars and lorries. As little as 30cm of water can start to move vehicles.
- Flooding can short-circuit engines, electrified rails and signalling, stopping services until repairs can be made.
- Debris left on roads and rail lines requires extensive clean-up, causing extended closures.
- When a dam shows signs of damage, at-risk transport routes, including those critical for emergency response, may be closed for safety, causing prolonged disruption.



Infrastructure

- Floodwaters can travel several kilometres downstream, as seen by historic collapses such as Llyn Eigiau in 1925 (see case study on page 5). Debris released by the collapse or carried by the floodwater can strike bridges, roads, rail lines and other infrastructure, blocking routes and damaging structures. Clearing and repairing infrastructure can take a long time, disrupting services for prolonged periods even after the flood has receded.
- The sudden release of water from a dam collapse can rapidly remove soil, sand, gravel and other material from embankments and the ground around roads, railways and other infrastructure, undermining their stability.

Interdependencies: Flooding from a dam collapse can affect a wide area, disrupting multiple sectors at once. Power outages from flooded substations can halt electric trains, disable signalling systems and cut power to street lighting, making roads unsafe at night. Communications infrastructure such as mobile phone towers or underground data cables may also fail, hampering emergency response and transport operations.

Hazards associated with subsidence and soil degradation

Extreme heat and drought

Hot weather and drought can dry out clay cores and embankments, causing cracking and shrinkage that can weaken an embankment dam.

Subsidence and soil degradation

Subsidence can weaken a dam by causing the ground beneath or around it to sink or shift, increasing the chance of cracks, leaks and eventual collapse.

Storms and flooding

Heavy rain can quickly fill the reservoir, increase structural stress and cause water to flow over the top of the dam. Strong winds can create large waves that spill over the dam, wearing away concrete and soil, weakening the structure and increasing the risk of collapse.

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

Although reservoir dams themselves are typically owned and operated by third parties, transport organisations need to prepare for the possibility of reservoir dam collapse and the potential for climate change to increase the risk. Examples of effective measures include:

- identifying transport infrastructure at risk in the event of a reservoir dam collapse using the reservoir flood maps provided by the Environment Agency
- collaborating with local resilience forums, which are made up of representatives from local public services such as the police and fire and rescue, to ensure evacuation plans are in place
- ensuring plans are in place to maintain access to critical transport routes for emergency services and recovery teams during and after an incident
- ensuring emergency equipment such as portable barriers, lighting and signage is ready for quick deployment

Questions for decision makers

- Which assets would be affected by the flooding from a reservoir dam collapse, and how many daily users rely on them?
- On being made aware of potential dam collapse, which roads and rail corridors are designated for closure and how quickly can diversions be implemented?
- What diversion routes exist if a main corridor remains closed for months?
- Could a co-ordinated response drill be conducted with emergency services for a dam-collapse scenario?
- Are you aware of dams whose collapse could affect your transport system's operation, and do you communicate regularly with the owners or operators?

Further reading

Dam information – The British Dam Society

Developing a multi-agency flood plan – Department for Environment, Food and Rural Affairs

Lessons from historical dam incidents – Department for Environment, Food and Rural Affairs and the Environment Agency

Modes of dam failure and monitoring and measuring techniques – Flood and Coastal Erosion Risk Management Research and Development Programme, and Environment Agency

Reservoir flood maps: when and how to use them – Environment Agency

Toddbrook Reservoir Independent Review Report – Department for Environment, Food and Rural Affairs

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.