Network Resilience

Resilience & Climate Adaption

Moving towards an *All-Hazards Resilience*?

John A. Lamb FCIHT

Objectives of the session

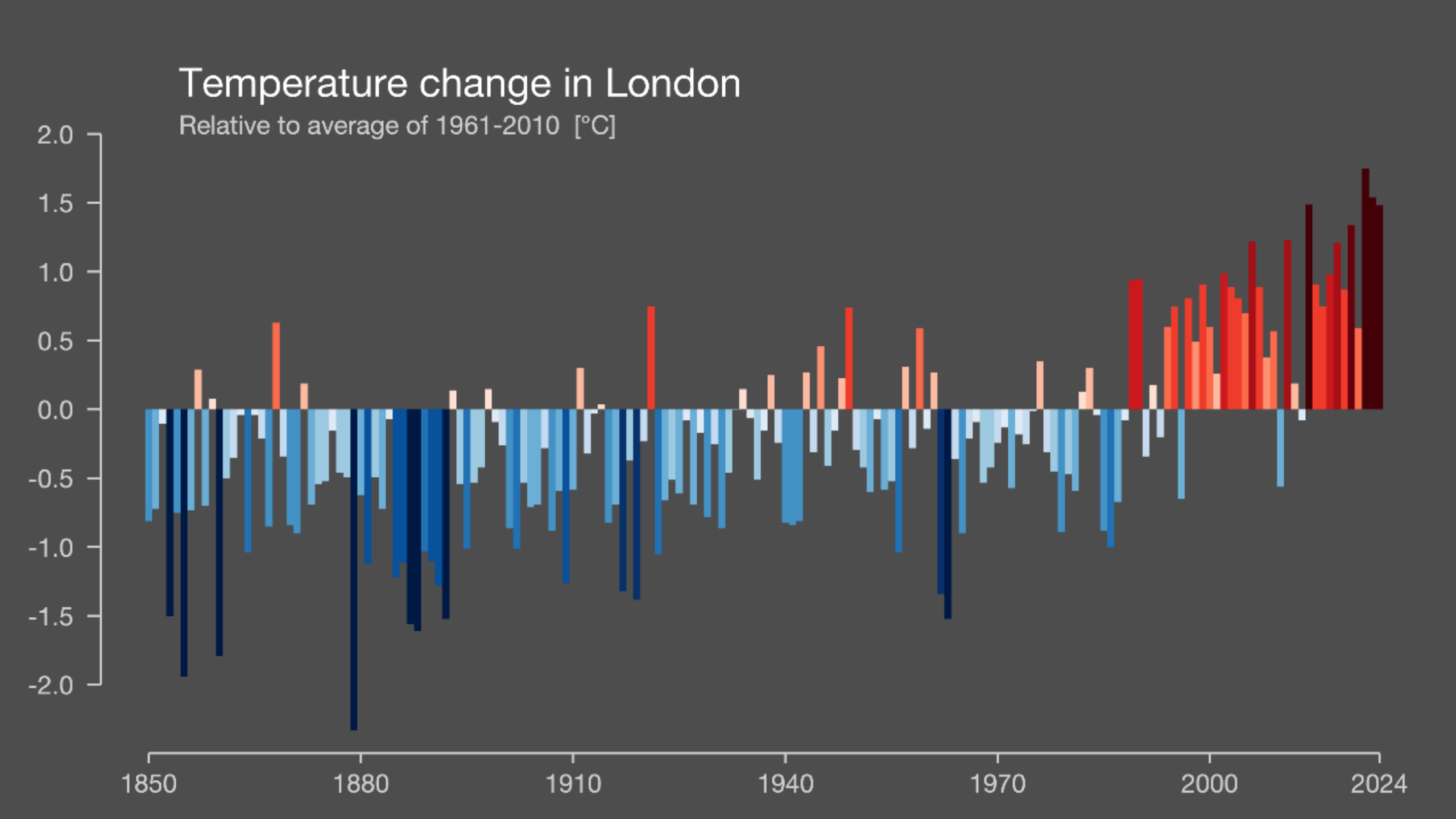
1. **Extreme Events are baked into Current Climate**
   Not a 'far off average' clear and present hazard
2. **A new Reality**
   Intense events – exceeding all previous records
3. **More Frequent & Concurrent Hazards**
   More frequent, and often multiple hazards (floods and gritters)
4. **Cascading Failures**
   Rail, Road, Bus and asset loss
5. **Preparing for your worst day**
   Not a far-off climate average – but an operational reality for our teams, services and the communities we serve.
6. **Reasonable worst-case scenario**
   London did not cope with 100mm in 2021. Belgium / Germany (2021) was 150mm – unfreeze sector minds and siren call to Government.

UKRLG Regional Workshops

- Over 200 UK Highways Authorities
  - 33 London, 32 Scotland, 22 Wales, 150+ in England

- 12 Regional events
  - Funded by DfT, leveraging input from Met Office, BGS/ Local Partnerships, Mining, Ringway & PIARC (UK)
  - Invite only for Highway Authority Directors *invited by/with DfT / D.A.'s*

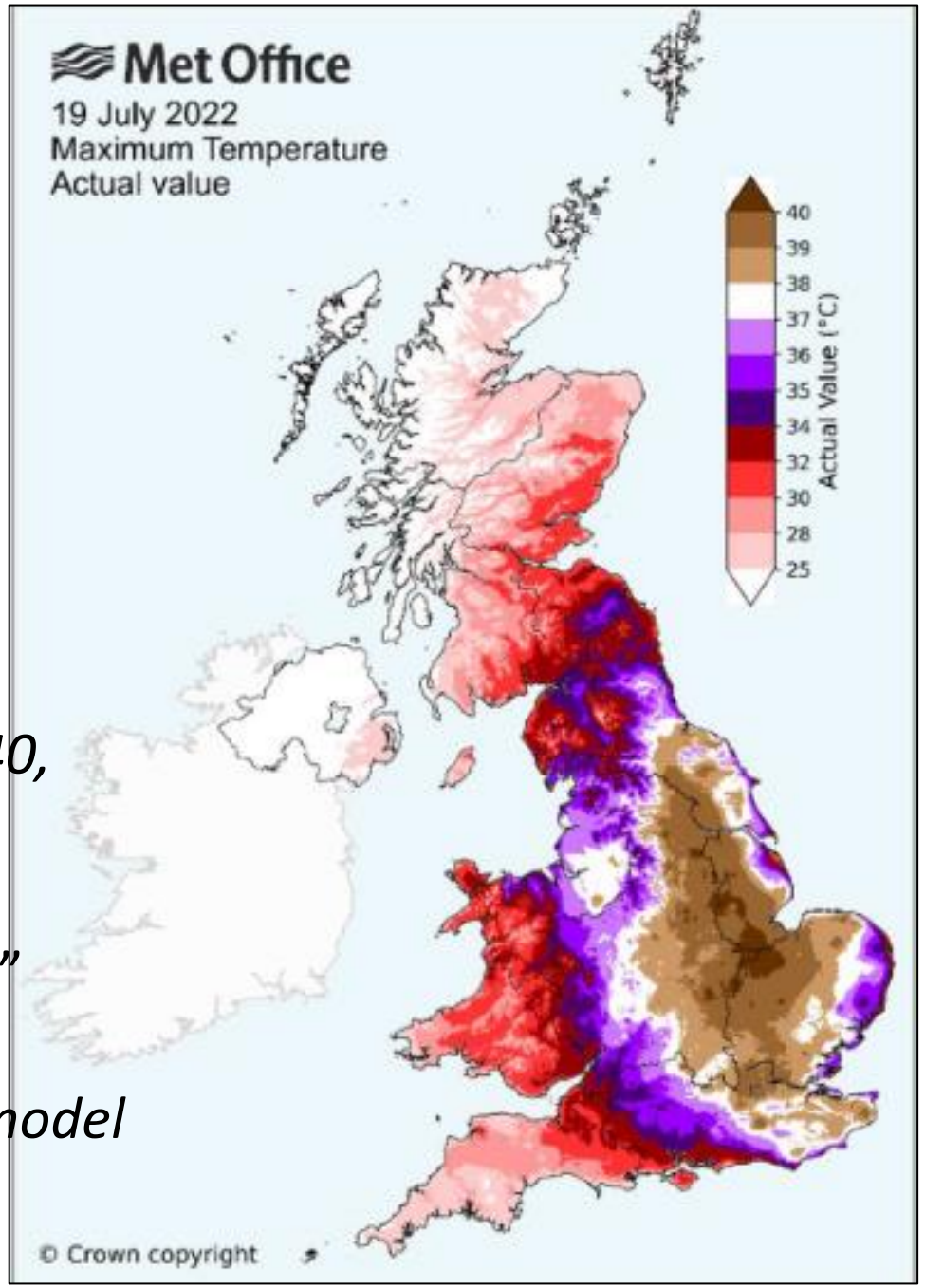
- Led by UKRLG The UK ABC Board - ***A**daptation, **B**iodiversity & **C**limate Resilience*


Temperature change in London
Relative to average of 1961-2010 [°C]
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
1850
1880
1910
1940
1970
2000
2024

- *"There is* **a very small chance** *of exceeding 40°C by 2040,*
- *but by 2080 on a pathway to 4°C global warming at the end of the century, the frequency of exceeding 40°C*
    - *is similar to the frequency of exceeding 32°C today."*

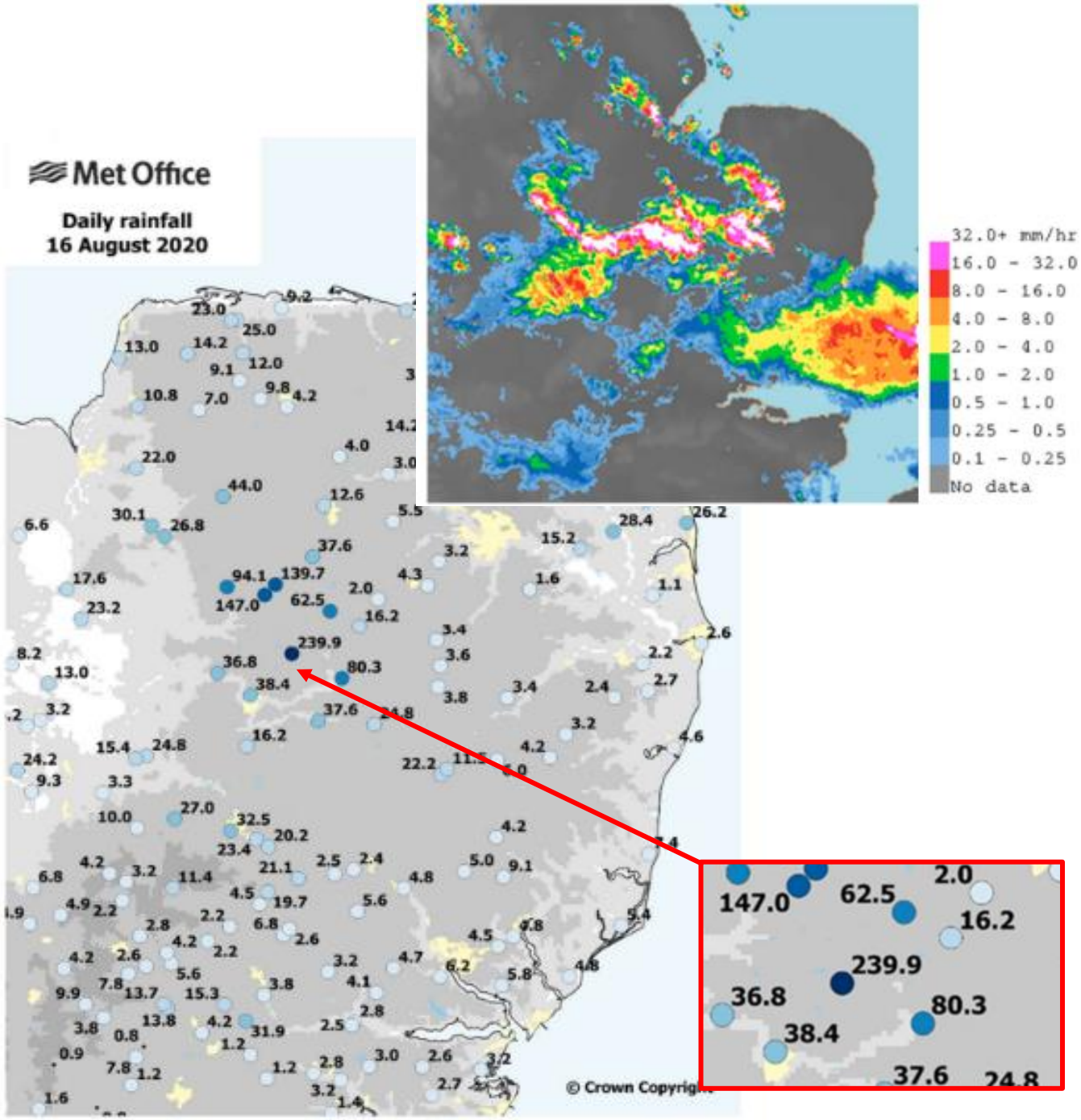
CCRA3 (2021: p.64)

- And more recent (2025) probably *45°C in our climate model*



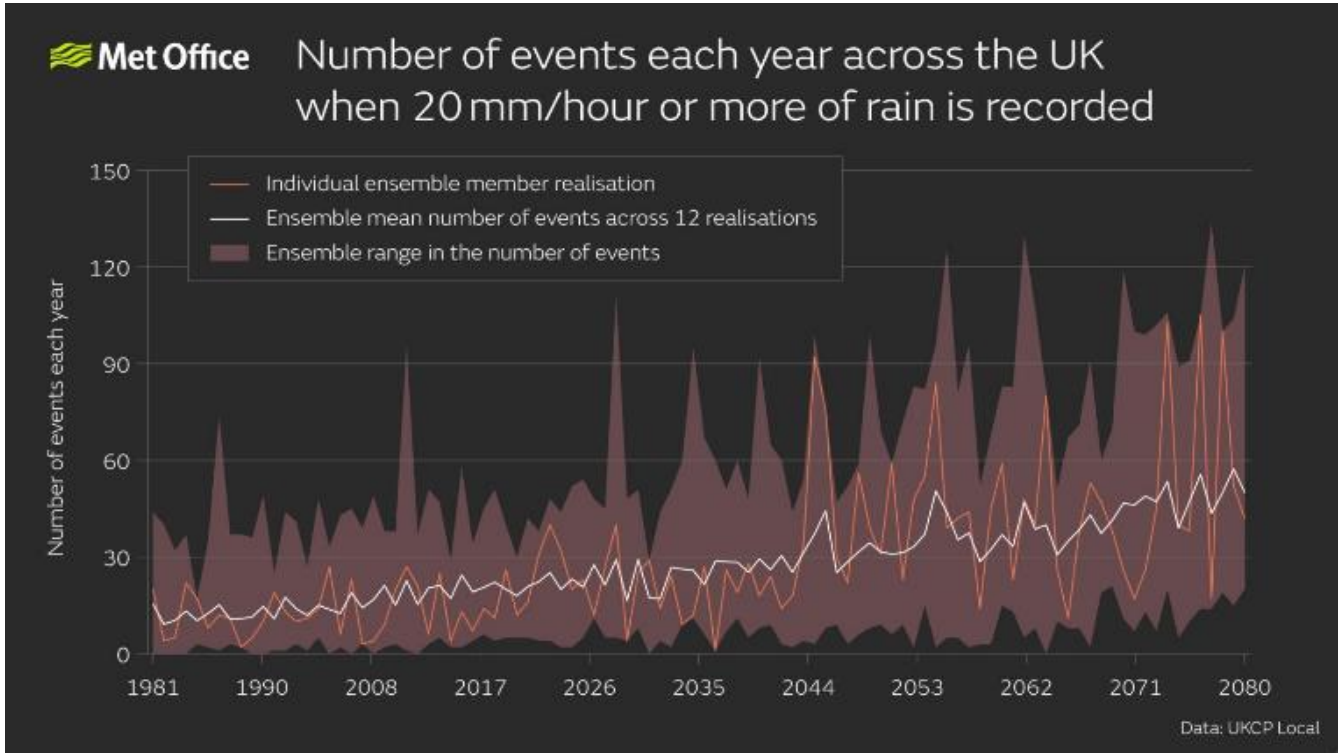
Extreme Rainfall:

- 5th Dec 2015: **341mm** Honister, Cumbria (standing UK 24hr record)
- 16th Aug 2020: **240mm** in just a few hours, East Wretham, Norfolk
- Jul 2021: **271.5mm** in 48hr Jalhay, Belgium (record)
- Oct 2024 Valencia, Spain: **771.8mm** in 24hrs (DANA)



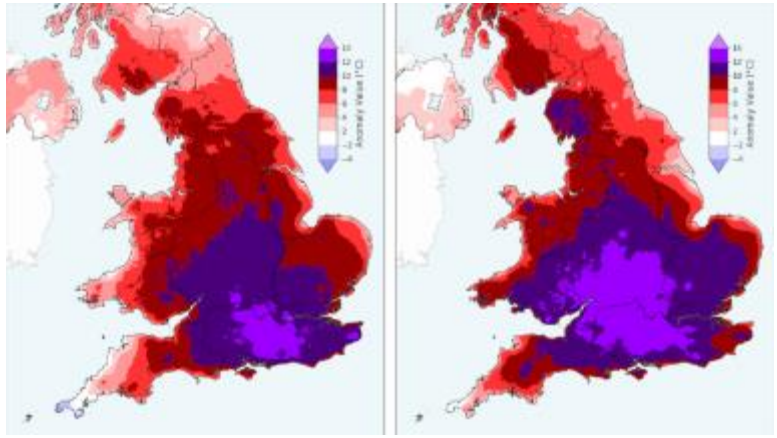
Variability conceals emerging trend in local hourly precipitation extremes

- Local extreme hourly precipitation **does not intensify *gradually*** with warming….
- …but through periods of **rapid intensification**, followed by pauses.
- Extreme years with lots of extreme rainfall events tend to cluster and this poses challenges for adaptation.
- **Extreme downpours about 4x more frequent** by 2070s, under RCP8.5.
- These increases are greatest in the north of the UK (up to 10x)



Kendon et al, 2023, Nature Comms

Climatic Trends - More frequent , *more extreme,* extremes



- **Heatwaves**
- **July 2022** UK exceeded 40°C for the first time on record in the UK.
- Recent summer heatwaves have been amongst the most severe on record, and each typically causes several thousand deaths.
- By **2050** hot summers could happen **every other year**

Heavy rainfall

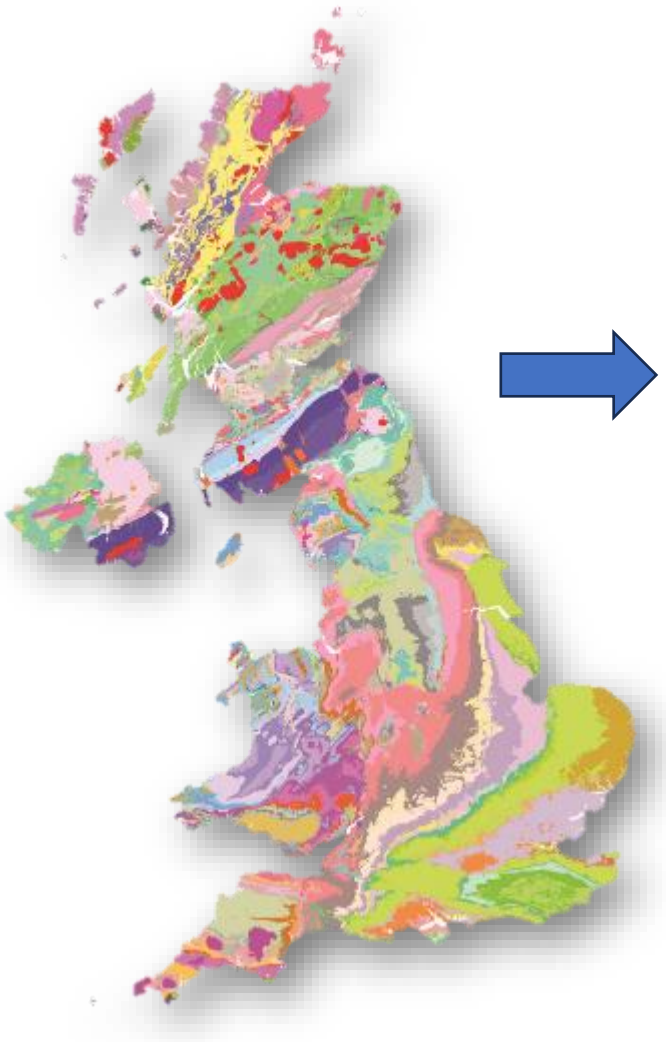
- **Storm Babet** brought
  - the wettest day on record in Angus
  - the wettest 3-day period on record in the Midlands
- By **2070**, winter rainfall events, similar to these, are expected to **increase by up to 25%**
- Summer thunderstorm rainfall is becoming more intense

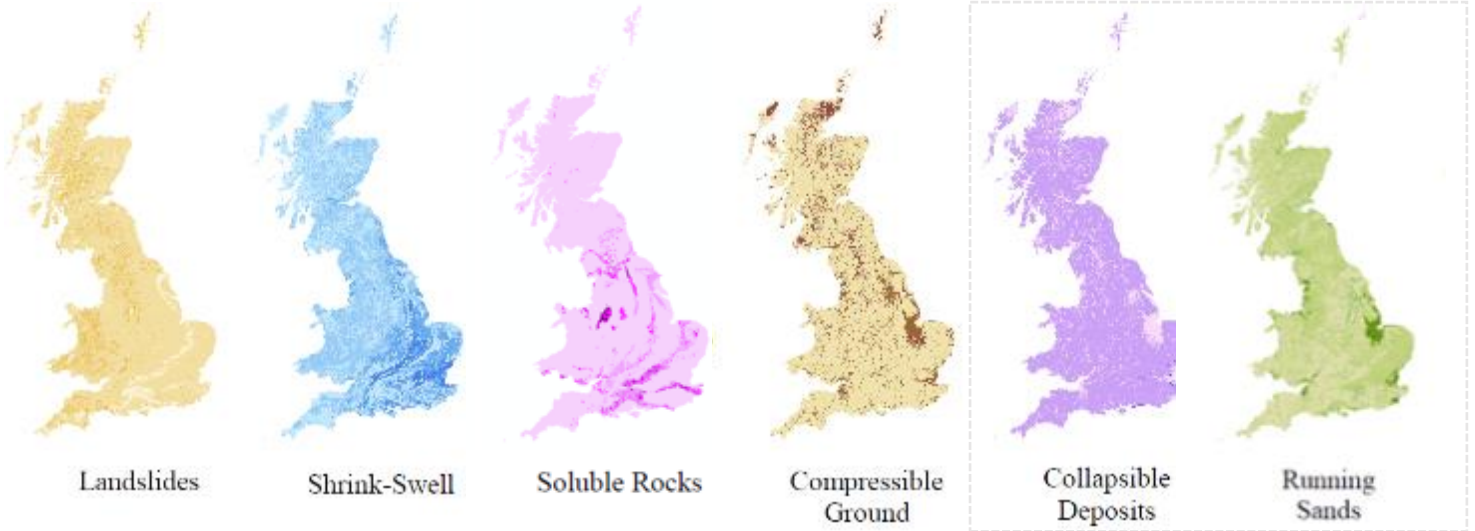
Wildfires

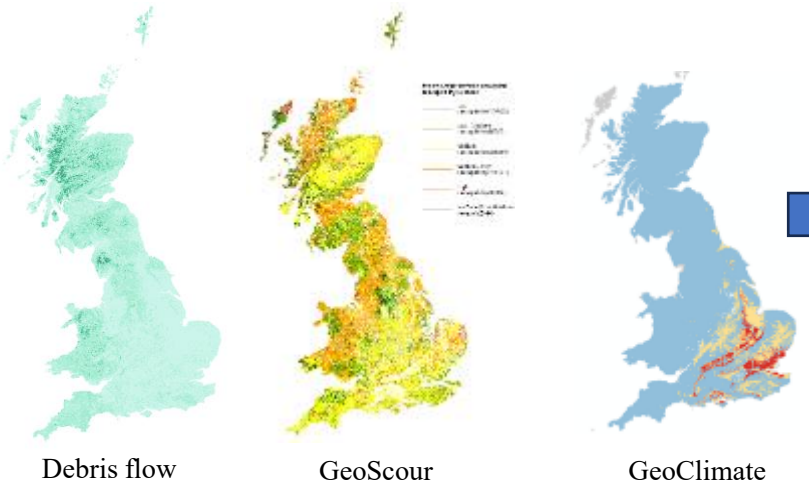
- **UK wildfires has been increasing** in recent years
- **5 times more likely** by 2100 due to increases in high temperatures and low summer rainfall; conditions highly conducive to wildfires

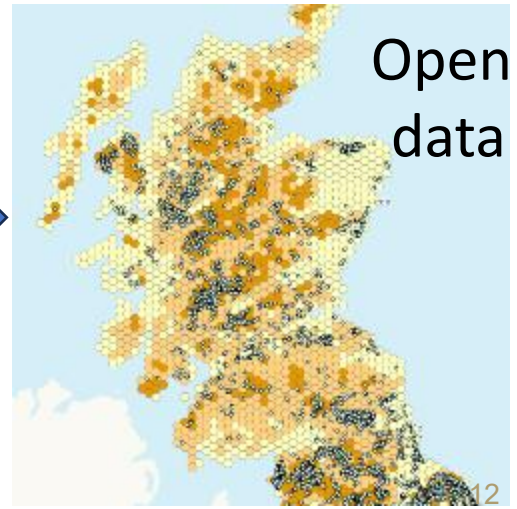
GEOLOGICAL HAZARDS AND THE INFRASTRUCTURE NETWORK

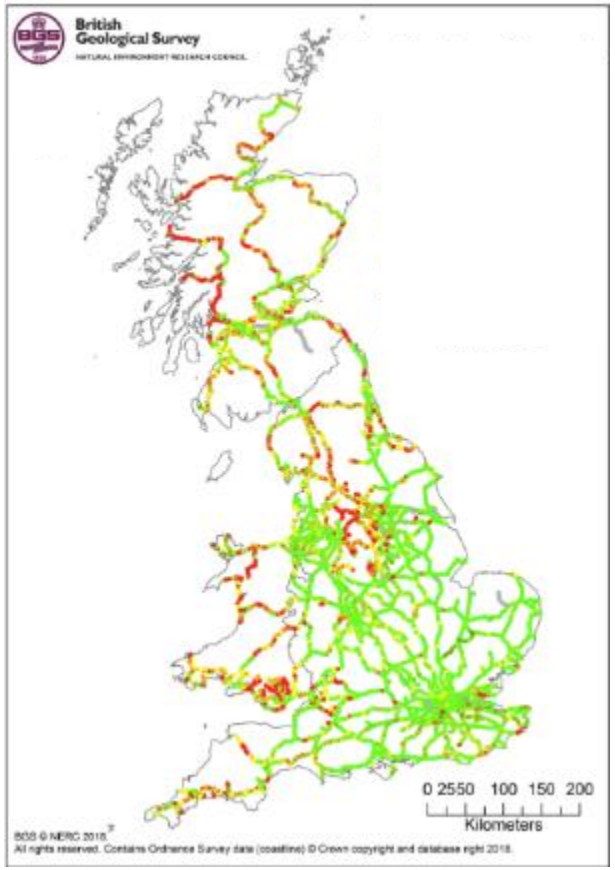
Mapping susceptibility to geological hazards





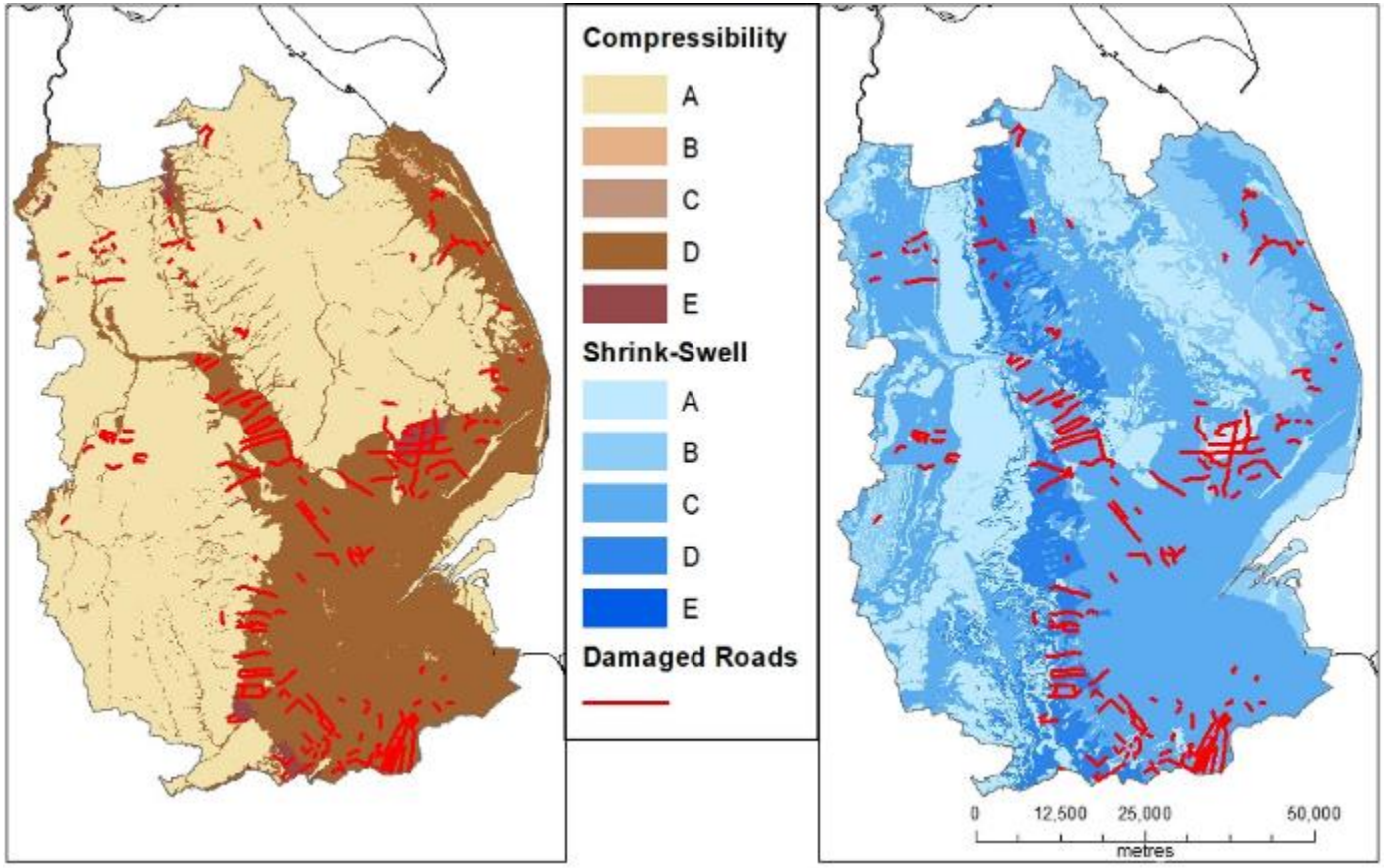






Outside Party Slope landslide susceptibility for the rail network

 Freeborough et al 2019



Sites recorded (red lines) by Lincolnshire County Council as requiring remedial work due to **drought damage** during 2011–2012.

 Harrison et al 2023

Key recommendations from extreme-weather reviews

- The critical importance of **Suitably Qualified, Experienced and Empowered People** in delivering Highways emergency management.

- The need for consistent **Rapid Impact Assessment**

- The need for **Mutual Aid** contingencies to be developed **on a regional / national basis**, and in conjunction with the **private sector**.

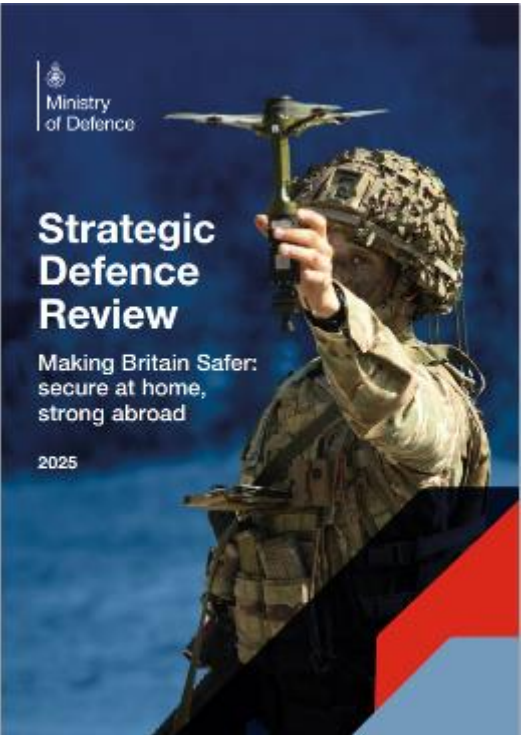

KIER
REILLY
REILLY

"…the ability to anticipate, assess, prevent, mitigate, respond to, and recover from natural hazards, deliberate attacks, geopolitical instability, disease outbreaks, and other disruptive events, civil emergencies or threats to our way of life."

Resilience

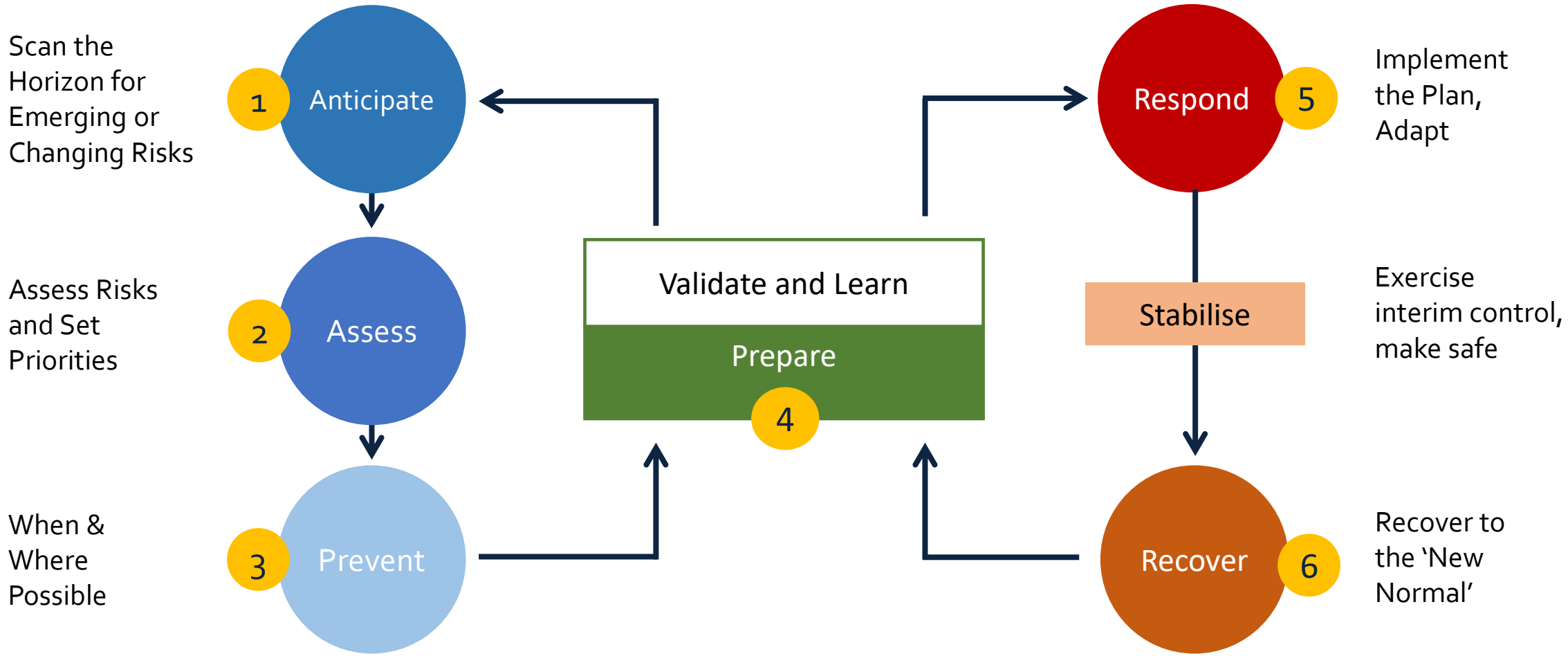
Resilience

"Resilience is a '**whole of society**' endeavour, so we must be more transparent and empower everyone to make a contribution."



"With multiple threats and challenges facing us now, and in the future, a **whole-of-society** approach is essential.

The Resilience Cycle



Domains of Resilience

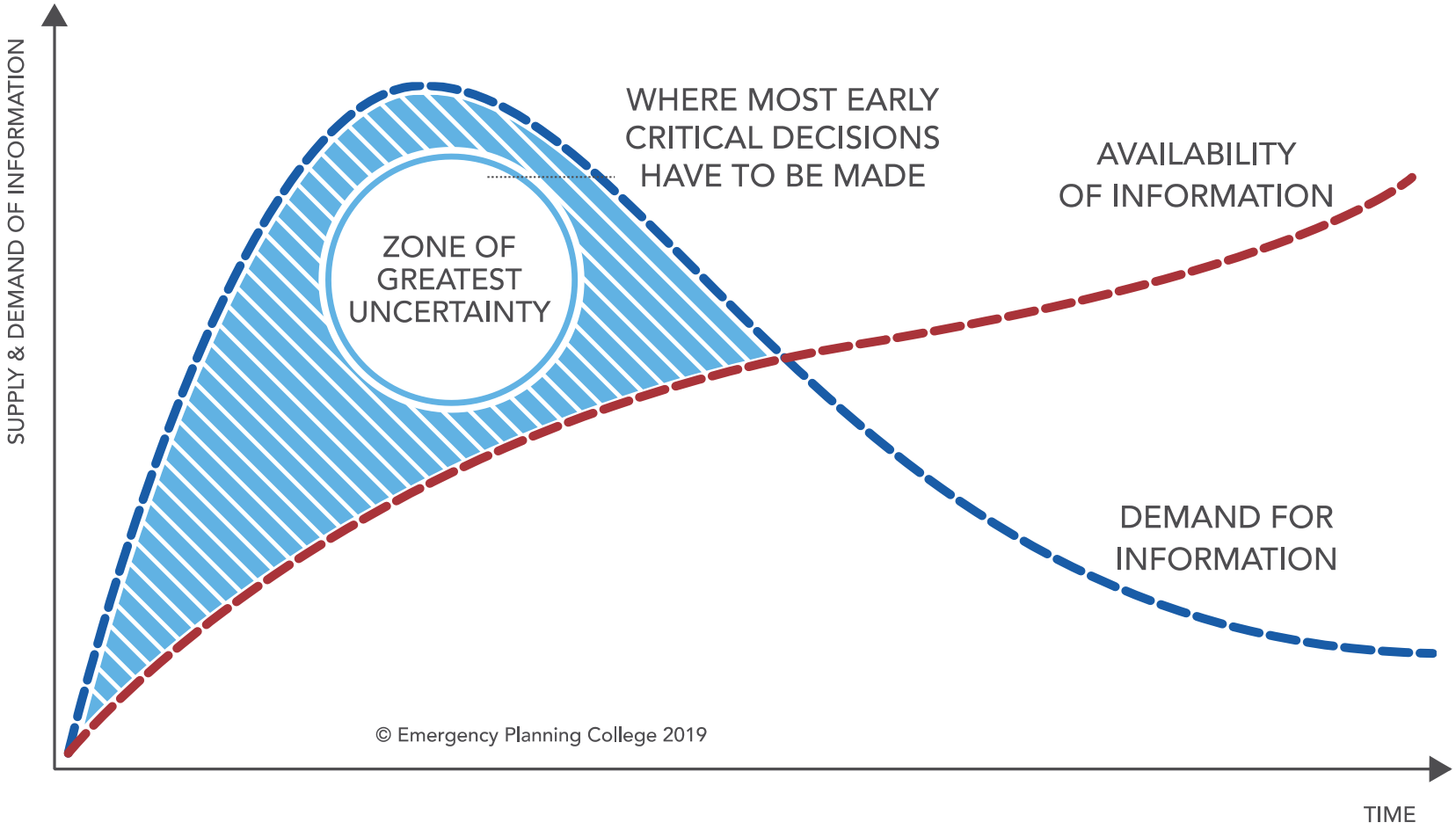
1. **Robustness**
   physical resistance, up to design standard (e.g. high-spec materials)
2. **Reliability**
   continuity under a variety of conditions
3. **Redundancy**
   substitution (e.g. safe diversion routes, fall-back options)
4. **Resourcefulness**
   the ability to apply material (i.e., monetary, physical, technological, and informational) and human resources to meet established priorities and achieve goals
5. **Rapidity**
   meet priorities and achieve goals in a timely manner
6. **Recovery**
   recover from disruption, 'build back better'

FEMA

Highways as 'Lifelines'

- "Lifelines are the most **fundamental services** in the community that, **when stabilized**, enable all other aspects of society to function
- Lifelines are the **integrated network** of assets, services, and capabilities that are used day-to-day to support the recurring needs of the community
- When disrupted, **decisive intervention** is required to stabilize the incident"

Situational Awareness

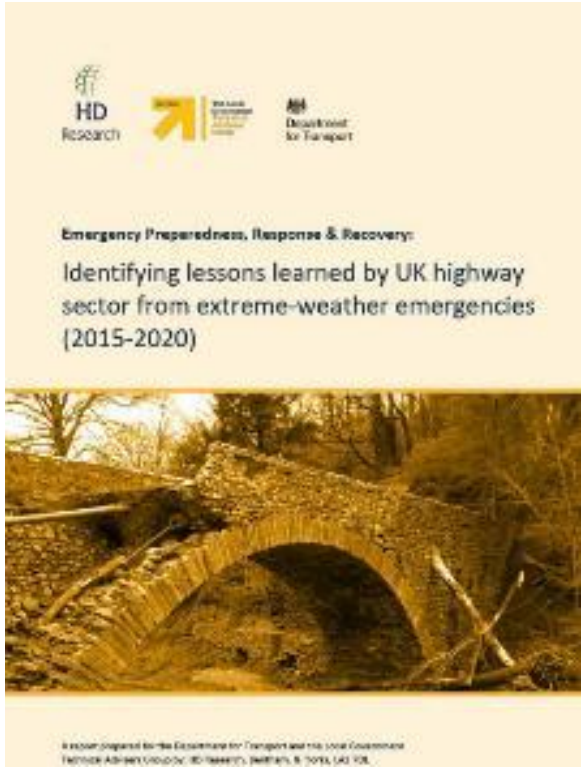


INSIGHT from the EPC


(M25)
Sevenoaks
A25
London
(A22)
Copyright: Ringway 20

Key recommendations from extreme-weather reviews

- The critical importance of **Suitably Qualified, Experienced and Empowered People** in delivering Highways emergency management.
- The need for consistent **Rapid Impact Assessment**
- The need for **Mutual Aid** contingencies to be developed **on a regional / national basis**, and in conjunction with the **private sector**.

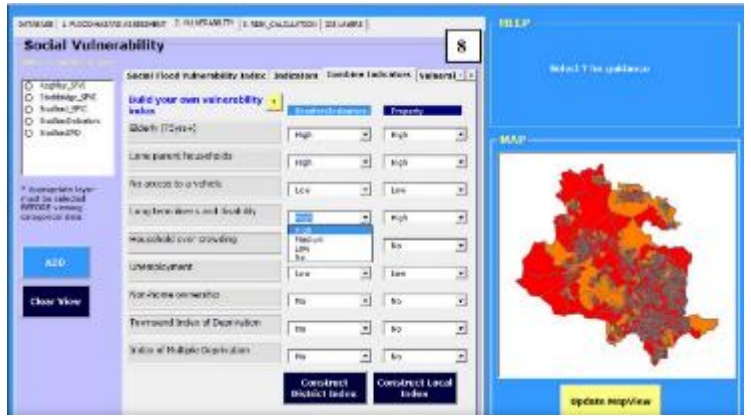


Stormchain
Restoring Community Lifelines

Impact =

x

+



x

Damage

Consequences

Duration

StormchainRIA Summary Report - Local Highway Authority

Stormchain
Restoring Community Lifelines

Time/Date Report Created:	12 Jun 2025 08:49(GMT)	Report printed by:	Hugh Deeming
Incident Name:	Storm Zander - Test		
Reporting Authority:	United Kingdom	Current Cost Estimate:	£ 572,490
Assets to be assessed (provisional*):	18		

** Provisional number of inventoried assets, plus number of assets found and/or reported at this time as damaged for which RIA has been actioned.*

Highways Operating Picture at Time of Report:

Local summary

Incident storm zander - test has occurred in united kingdom

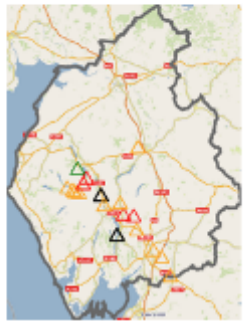
As a result of this event 18 assets have been identified for inspection and RIA tasks have been issued. So far 18 RIAs have been fully noted, and from the assessments undertaken 2 total failure(s) of an asset have been identified. Further details are included below in this report and links to individual asset reports (which include images and a more precise map location) are also provided.

Access to the StormchainRIA website (registered account and password required) is provided here: Launch StormchainRIA

WARNING: If you are viewing this report as a PDF in a web browser, launching StormchainRIA from this link will close the report.

Note: An overview map is provided below, however accessing stormchainria will allow users full (read only) map search functionality and access to additional data layers.

Location Overview of Incident Area and Assessments



Asset VDR Key:
- Total Failure
- Severe
- Limited and Moderate
- None
- Not Assessed: Inaccessible
- Damage suspected but not visible

12 Jun 2025 08:49

Visible Damage Rating (VDR)

Rating	Total	Damage Status
Total Failure	2	Complete loss of structural integrity (collapse) and/or danger from damaged aligned services
Severe	4	Structure badly damaged, with impact on structural integrity
Moderate	3	Structure is damaged, but retains integrity
Limited	8	Minor damage only
None visible or suspected	1	No damage visible or suspected
Suspected, but not visible	0	Damage is reasonably suspected but not currently visible (e.g. possible bridge scour obscured by high river flow)
Awaited	0	RIA has been assigned but inspector has not yet completed assessment

Consequences Rating

Rating	Total	Repair Priority
Extreme	2	Significant to extreme immediate impact on community. Expedited repair of asset is critical for community functioning
significant	5	Repair of asset is critical for community recovery (requires expedited repair and focussed management and community support)
Moderate	4	Repair is important for community recovery, but managed temporary options are acceptable in short/ medium term.
Limited	0	Repair can be dependent on broader recovery programme
Minor	9	This asset repair should not be prioritised above business as usual
Awaited	0	Assets awaiting consequence assessment

Impact Rating Matrix

Consequences for the Community		1 - None visible or suspected	2 - Limited	3 - Moderate	4 - Severe	5 - Total Failure	6 - Damage suspected but not visible (e.g. bridge scour)
5	Extreme	0 x20	0 x25	0 x30	0 x45	2 x50	0 x45
4	Significant	0 x10	0 x20	0 x25	3 x40	0 x45	0 x40
3	Moderate	0 x3	1 x15	2 x15	1 x25	0 x30	0 x25
2	Limited	0 x2	0 x10	0 x10	0 x10	0 x10	0 x10
1	Minor	1 x1	7 x1	1 x1	0 x1	0 x1	0 x1

Damage to Asset

NB: The top left cell is Red Rated, even though there is no visible damage reported. This covers possible occasions when a blanket closure has been placed (e.g. all bridges closed until inspected). Having the Red Rating here draws the RIA Manager's attention to the fact that this asset needs to be reopened ASAP.

Warning: Only assets with both a damage and consequence ratings are included in the matrix asset counts and only rated assets can contribute to the Total Impact Score.

Total Assets Identified for Assessment:	18
Damage Rated but No Consequence Rating:	0
Consequence Rated but Damage Not Rated:	0
Neither Damage nor Consequence Rated:	0
Total Fully Rated Assets:	18
Total Impact Score (for Rated Assets):	299

Damage rating 6 applies where damage is reasonably suspected but a substantive visual inspection is not possible at this time (e.g. inspection of bridge foundations during high flow).

12 Jun 2025 08:49

Stormchain
Restoring Community Lifelines

Asset Type	Visible Damage Rating	Impact Score	Location	Asset Status	Diversion Required	Current Cost Est.	UID - Click for Site Report
Road Structure	Total Failure	50	54.5041203N -3.0455740W	Closed To All Traffic	Yes	£300,000	3715
Road Structure	Total Failure	50	54.5588596N -2.9420138W	Closed To All Traffic	None Av.	£100,000	3902
Bridge	Severe	40	54.4285109N -2.8567885W	Closed to all traffic pending safety/ stabilisation measures	None Av.	£25,000	1232
Embankment	Severe	40	54.4344888N -2.9021642W	Closed To All Traffic	Yes	£9,000	1240
Bridge	Severe	40	54.5467048N -3.1542069W	Closed To All Traffic	Yes	£18,500	1245
Road Structure	Severe	35	54.5665882N -3.1343388W	Open To Public With Restrictions	No	£100,000	3793
Wall/Retaining Wall - public	Limited	15	54.5157856N -3.1828042W	Open To Public With Restrictions	No	£4,000	1250
Bridge	Moderate	15	54.6794532N -2.8099372W	Open To Public With Restrictions	No	£3,000	3332
Road Structure	Moderate	15	54.4683454N -3.0258164W	Open To Public With Restrictions	No	£5,000	1242
Culvert greater than 0.9m in diameter	Limited	1	54.2088383N -2.8041207W	Open To Public With Restrictions	Unknown	£450	1233
Trees	Limited	1	54.2774291N -2.8508562W	Open To Public With Restrictions	No	£840	1235
Wall/Retaining Wall - private	Limited	1	54.5024701N -2.7119422W	Open To All Permitted Traffic	Unknown	£0	1237
Wall/Retaining Wall - public	Limited	1	54.3778310N -2.8178525W	Open To Public With Restrictions	No	£1,700	1239
Wall/Retaining Wall - public	Limited	1	54.4756540N -2.9222060W	Open To Public With Restrictions	No	£1,200	1241
Bridge	Limited	1	54.5168874N -3.2084219W	Open To Public With Restrictions	No	£400	2797
Bridge	Moderate	1	54.5226526N -3.2215577W	Closed To All Traffic	Yes	£2,400	1251
Culvert less than 0.9m in diameter	Limited	1	54.5315334N -3.2568059W	Open To Public With Restrictions	No	£1,000	1252
Bridge	None visible or suspected	1	54.6015027N -3.1912587W	Open To All Permitted Traffic	Unknown	£0	1231

12 Jun 2025 08:49

Stormchain Internal URN: 2902

Individual Asset Damage Report.

Stormchain
Restoring Community Lifelines

Time/date report created (GMT):	31 Jul 2025 15:59		
Incident Name:	Storm Zander - Test	Report created by:	Hugh Deerring
Reporting Authority:	United Kingdom	Report printed by:	Hugh Deerring
Asset URN:		Visible Damage Rating:	Total Failure
Stormchain Internal URN:	2902	Consequence Rating:	Extreme
Stormchain Version ID:	3884	Impact Score:	50
		Current Cost Estimate:	£ 100,000

Live link to StormchainRIA (registration and password required): https://uk.stormchain.org/crm/

Note: accessing StormchainRIA will allow users full map search functionality (Read-only)

Stormchain Internal URN:	3810
Stormchain Version ID:	3811
Asset Location	OSGR:
	Lat/Long: 51.2508202,-0.0666884
	W3W:
Location Description	Near the junction of Salisbury
Road Details	Class: A
	Number: 25
	Name: Godstone high street
	Resilient Network: Yes
Safe to Proceed	Yes
Asset Type	Road Structure
Asset Description	Road structure compromised
Asset URN (LA Inventory)	
Damage Assessment	Collapse (Sinkhole) - Carriageway
Damage Description	
Visible Damage Rating	Total Failure
Damage to Networks	"Gas - No Smell","Electric - Buried","Water - Main","Water - Foul","Water - Surface","Telecom/Fibre - Buried"
Detail of "Other" Damage to Networks	Total collapse 2 visible holes one in the carriageway and another in a private drive. Approx size first hole 25m x 8m second hole 8m x8m depth of both is roughly 5m. Both of the holes are actually connected and the only thing holding the tarmac up is a large gas main
Specialist Assessment	
Detail of "Other" Specialist Inspections	
Traffic Measures Required	"Full Carriageway Closure","Footway Closure","Safety Barrier / Cones"
Traffic Measures Description	Hera's fencing has been installed to cover the whole area off. Geterman on both sides of the closures. Diversion put out and other smaller cut through roads have been shut to stop diverted traffic using it as road is unsuitable
Diversion Route Required	Yes, medium diversion (greater than2km - less than 10km)
Approved Diversion Route Operating	No
Consequence Rating	Extreme
Consequence Rating Reason	multi agency disruption and assets effected. Residents have been evacuated from there homes within a certain radius. Main A road will be shut for the foreseeable future. Costs unknown at this present time awaiting survey of complete damage
Impact Score	50
Repair Task	Complex repair project
Current Cost Estimate	£ 0
Current Status of Asset	Closed To All Traffic
Safe for Users	No
Actions Required to Reopen	Complete investigation of the sinkhole. Repair all utility assets that are damaged as well as complete reconstruction of the road once the sinkhole has been backfilled
Current Comment/Message	SGN, UKPN, SES water on site

Stormchain
Restoring Community Lifelines

Impact Rating Matrix

Consequences for the Community			1 - None visible or suspected	2 - Limited	3 - Moderate	4 - Severe	5 - Total Failure	6 - Damage suspected but not visible (e.g. bridge scour)
	5	Extreme	x20	x25	x25	x45	✔ x50	x45
	4	Significant	x10	x20	x25	x40	x45	x40
	3	Moderate	x2	x15	x15	x25	x20	x25
	2	Limited	x1	x10	x10	x10	x10	x10
	1	Minor	x1	x1	x1	x1	x1	x1

Damage to Asset

NB: The top left cell is Red Rated, even though there is no visible damage reported. This covers possible occasions when a blanket closure has been placed (e.g. all bridges closed until inspected). Having the Red Rating here draws the RIA Manager's attention to the fact that this asset needs to be reopened ASAP.

Impact Score 50

Damage rating 6 applies where damage is reasonably suspected but a substantive visual inspection is not possible at this time (e.g. inspection of bridge foundations during high flow).

Moving from Decarb to Adaptation

- Considerable focus on Decarbonisation – Nationally
- £30m DfT Live Labs2 to decarbonise how we maintain our roads
  - Projects include
    - bio-ethanol from verge grass
    - Place based decarbonisation
    - A Net Zero carbon road
    - Rethinking street lights whilst enhancing visual acuity
- Where is the Adaptation
  - Funding right now for supporting learning & training – multi hazard
  - Rapid Impact Assessment as the basis of Shared Situational Awareness
  - Building the longer-term business case
    - What assets and where according to different hazards?
    - Where are the most hazard prone locations?
- The drivers to act are already here – where is the action? Who leads on this? What is the consequence

One Last Thing

Support MHA+
Engage with UKRLG
Get Connected with PIARC

Thank you