

MHA Lunch and Learn

Climate resilience through a data-driven climate risk tool

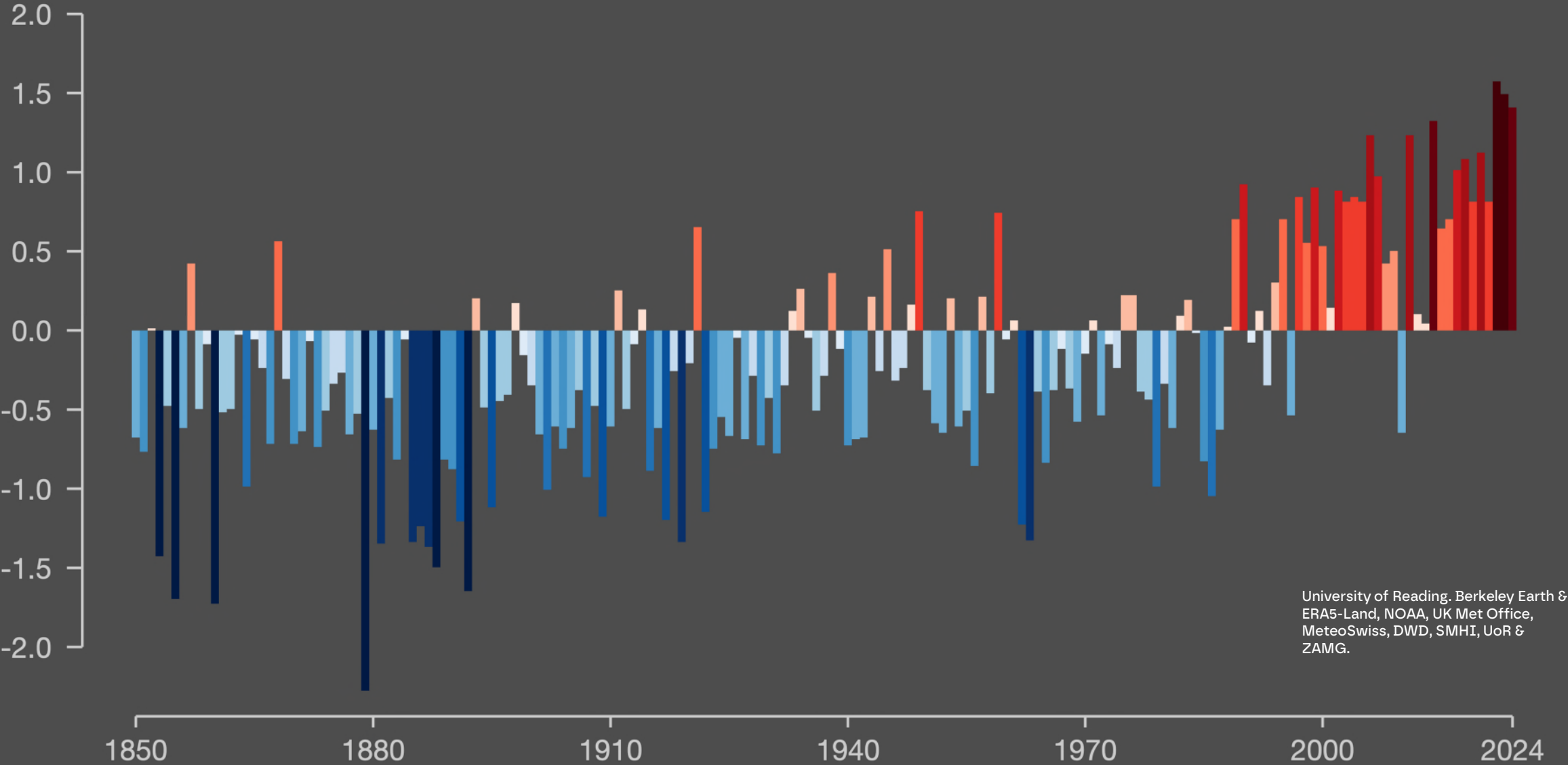
Thomas Bartle
September 2026



Life's better connected

Relative to average for 1961 – 2010 (°C)

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Europe's historic week of heat stress

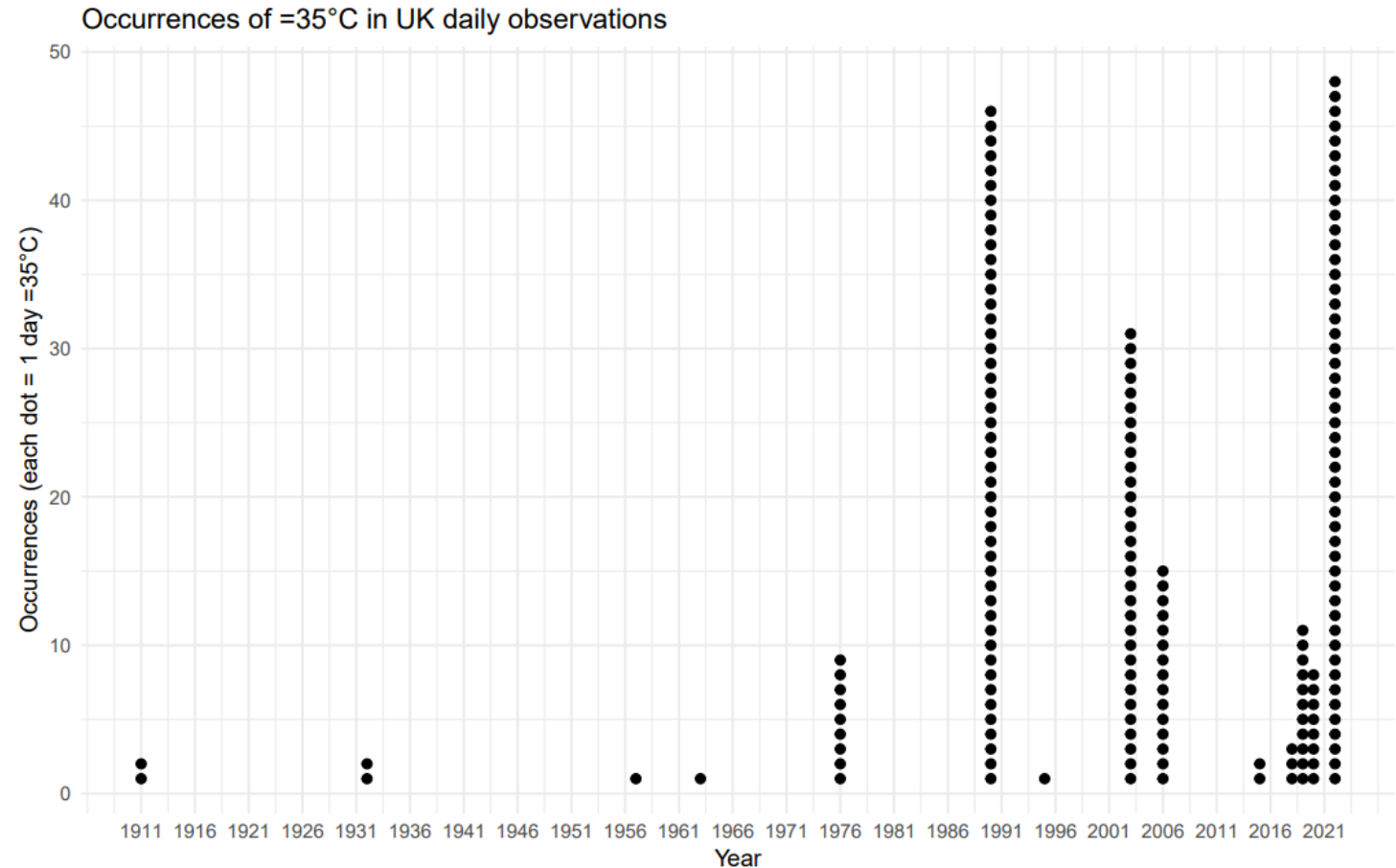
Data shows 45% of 854 cities analysed have broken – or are forecast to break – historic heat stress records (Wet Bulb Globe Temperature).



- The last decade has been 1.24°C warmer than 1961-1990 average
- Days with temperatures 5°C above the average has doubled
- For 8°C above average it has trebled
- For 10°C it has quadrupled.

Analysis from weather observations since 1853 shows:

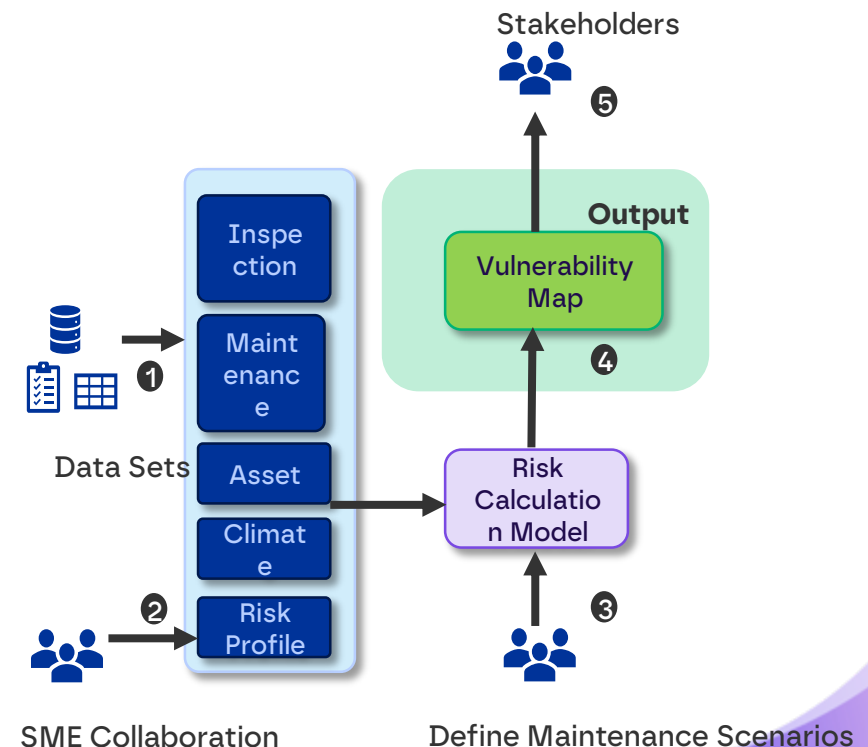
- Before 1975, temperatures 35°C and above occurred only 6 times
- Since 2020 this has occurred over 110 times



Produced by Amey using Met Office MIDAS data.

Climate-Informed Asset Forecasting

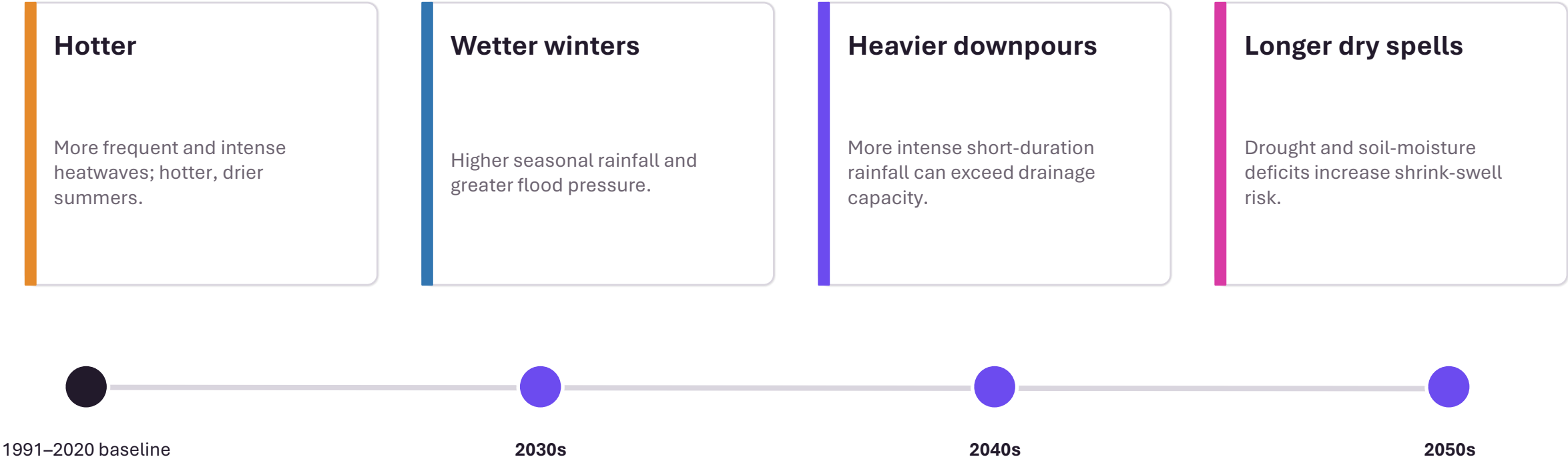
- We developed a climate-informed machine learning model to forecast future infrastructure defects across gullies and drainage, carriageways, structures and Public Rights of Way under multiple climate scenarios.
- The model combined historical asset, traffic and weather data to predict future defect burden at over 12,900 sites.
- A Random Forest and hurdle modelling approach to account for the low-frequency nature of defects.
- Forecasts were produced for the period 2030-2059 under four climate scenario ensembles,
- More than 18.6 million site-month predictions across 4 future climate scenarios.
- Results indicated a potential 30-year defect burden of approximately 35,000-36,000 defects for gully and drainage assets.
- The outputs provide evidence-based support for asset prioritisation, budget stress testing and adaptation planning.





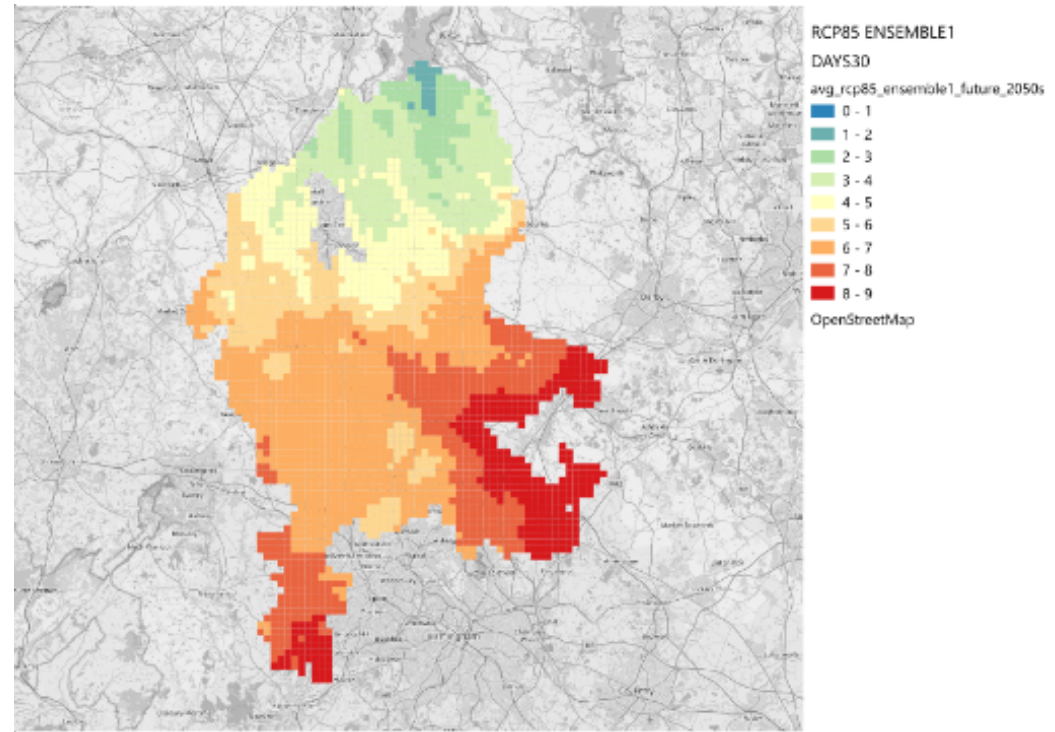
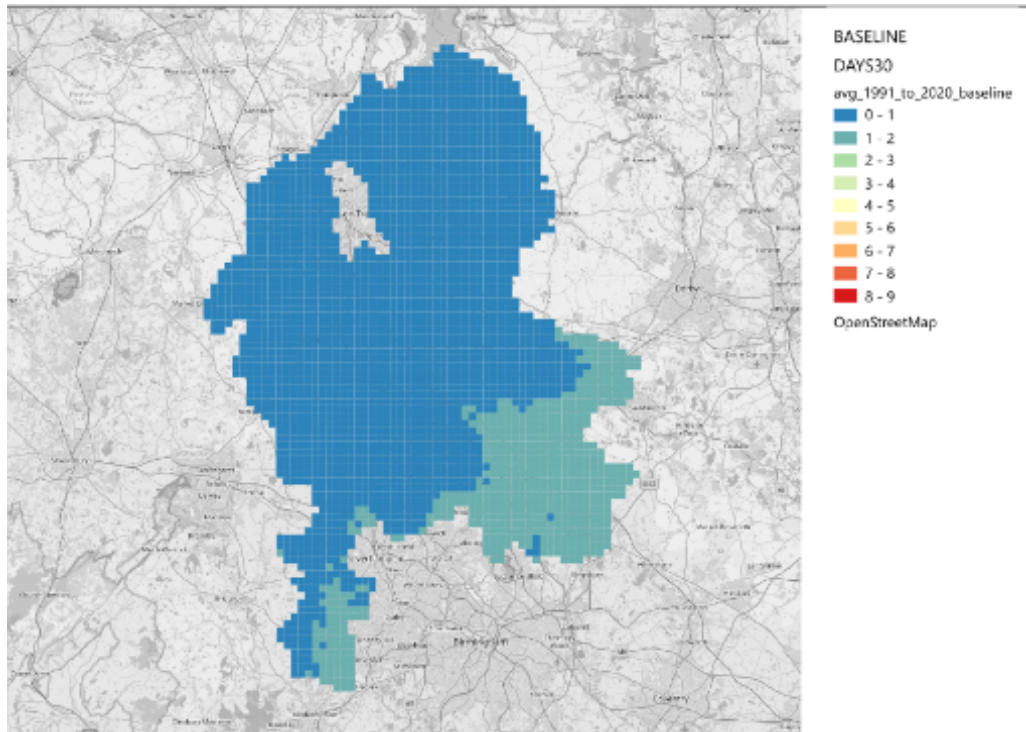
Strategic decision pathway

Understand portfolio pressure → identify scenario-robust hotspots → apply engineering and operational review → convert priorities into inspections, interventions and budgets



Assessment uses a 1991–2020 baseline and evaluates future hazards across overlapping 2030s, 2040s and 2050s periods.

Days above 30°C



- **Days above 30°C increase across the whole area, shifting from rare baseline events to a regular summer hazard.**
- The largest increase is in the south and east; northern areas remain lower but also rise clearly.
- The maximum increase in days above 30°C in the 2050s is 8.1; the minimum is 1.5 days. The average increase across SCC is 5.4 days.

1

Drainage

Rainfall intensity, cumulative wetness, blockage and hydraulic exceedance

2

Carriageways

Heat, thermal range, moisture ingress and wet-dry cycling

3

Structures

Flooding, scour, groundwater change and thermal movement

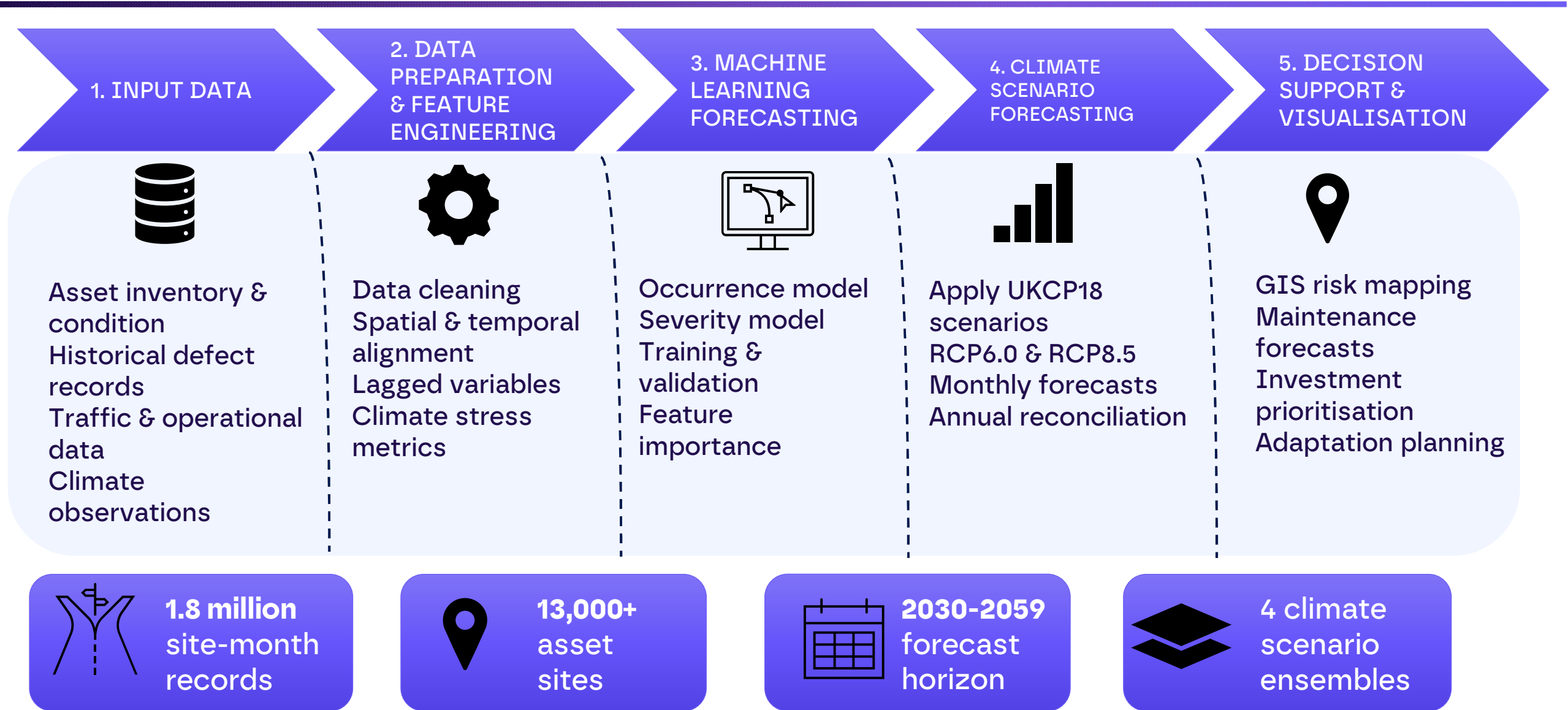
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Public Rights of Way

Erosion, waterlogging, drought cracking and vegetation change

Climate-Informed Forecasting Methodology

Integrating climate science, asset intelligence and machine learning to forecast future maintenance demand



2. Data Architecture & Feature Engineering

Capturing the interaction between climate stressors and asset performance

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DATE SOURCES



Climate data (UKCP18)

- Rainfall
- Temperature
- Heatwaves
- Dry days



Asset data

- Asset type
- Route hierarchy
- Flood susceptibility



Operational data

- Traffic flows
- Maintenance history
- Network criticality

FEATURE ENGINEERING



Temporal alignment



Lagged variables



Rolling climate stress metrics



Climate shock indicators



Asset vulnerability features



Recursive forecasting features

HOW CLIMATE CHANGE DRIVES EFFECTS



1. Extreme rainfall



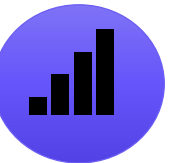
2. Drainage saturation



3. Water accumulation



4. Defect formation



5. Maintenance demand

3. Machine Learning Forecasting Architecture

Separating defect occurrence from defect severity to predict future maintenance demand

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Model Performance (RMSE)

1. Defect Occurrence Model

Random Forest Classifier

Predicts probability of one or more defects

Output: Probability (0-1)

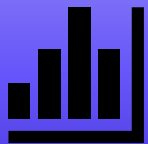
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2. Defect Severity Model

Random Forest Regressor

Predicts defect count when defects occur

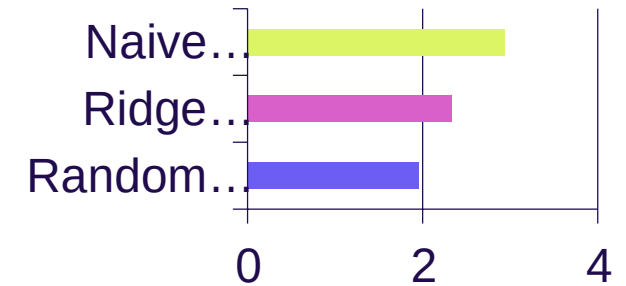
Output: Expected count



EXPECTED DEFECT BURDEN

Climate-conditioned prediction of future maintenance demand

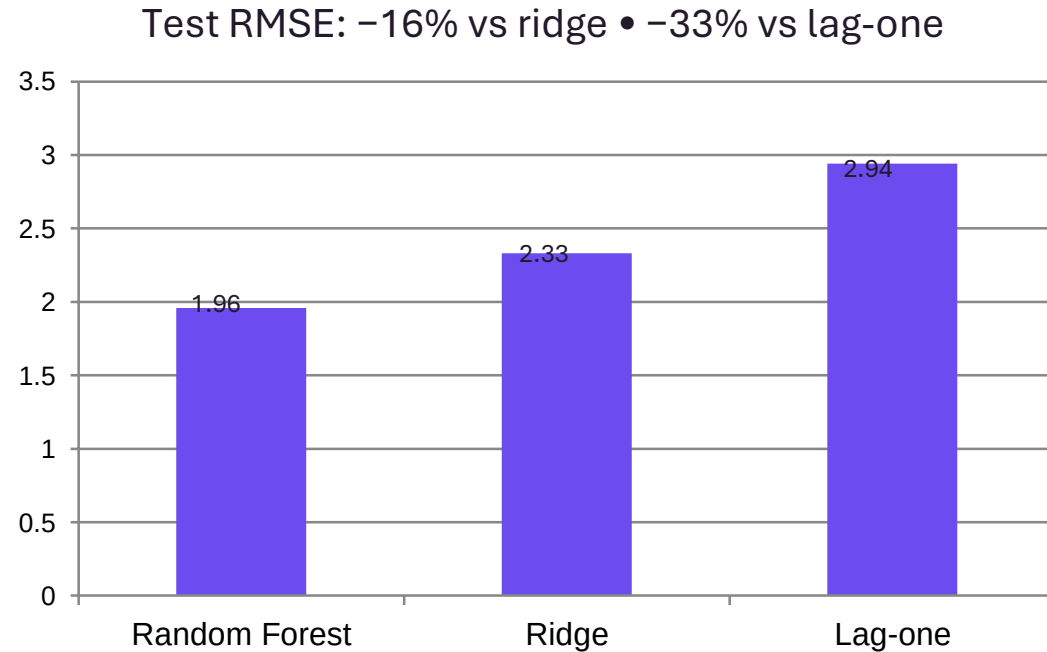
RMSE



Validation Approach

- Time-based split
- Rolling-origin testing
- Independent test period
- RMSE, MAE & tolerance metrics

Captures nonlinear climate impacts | Handles sparse defect datasets | Represents delayed climate effects | Robust validation | Scalable across asset classes



Headline accuracy is conditional severity only; occurrence calibration must be assessed separately before operational sign-off.

1.35

test MAE • positive-count rows

0.31

test R^2 • positive-count rows

54.6%

within 1 defect

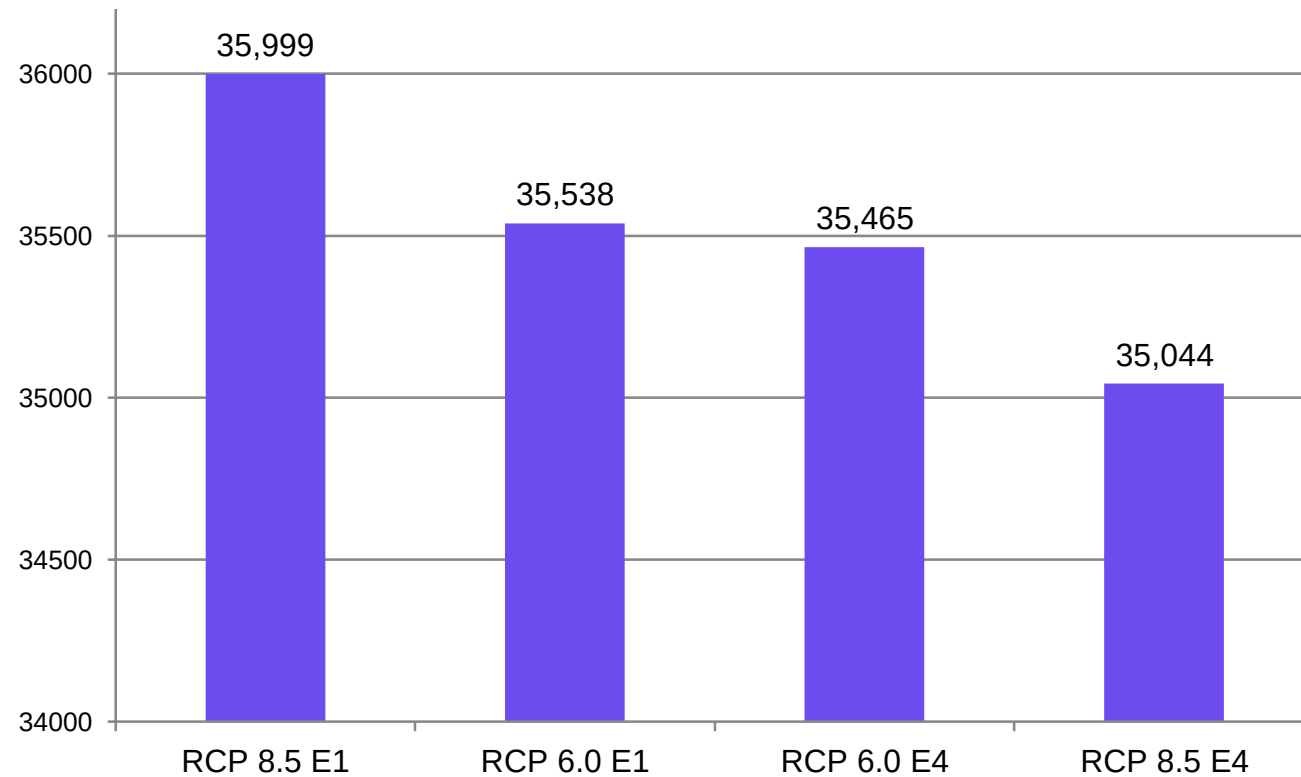
80.2%

within 2 defects

Key limitation

Precision was 1.00, but recall only 0.12: flagged extremes were credible, while most true extremes were missed.

Reconciled expected defects, 2030–2059



955 defects

highest to lowest spread

2.7%

relative spread

Decision implication

Annual means were 1,168–1,200 defects. Reconciliation factors were bounded 0.85–1.15; average adjustments were –0.65% to –1.21%. Use ranges, annual profiles and rank stability.

RISK ZONE	DOMINANT HAZARD	MOST VULNERABLE ASSETS
Staffordshire Moorlands & western catchments	Extreme rainfall, flooding, erosion	Drainage • structures • culverts • PRow
Trent Valley corridor	Combined heat and flooding	Carriageways • drainage • structures
Central urban areas	Heatwaves and thermal stress	Carriageways • drainage
Eastern & south-eastern Staffordshire	Drought and shrink-swell	Carriageways • earthworks • PRow
Major river corridors	Flooding and scour	Drainage • structures • culverts

$$\text{Risk} = \text{Consequence score} \times \Sigma \text{Forecasted event count}$$

Calculated for each site and selected reporting period, then joined back to the GIS asset layer

01 AGGREGATE

Sum expected events

Add reconciled site-month expected counts over each five-year reporting window.

02 WEIGHT

Apply consequence

Multiply forecast burden by the relevant asset or location consequence score.

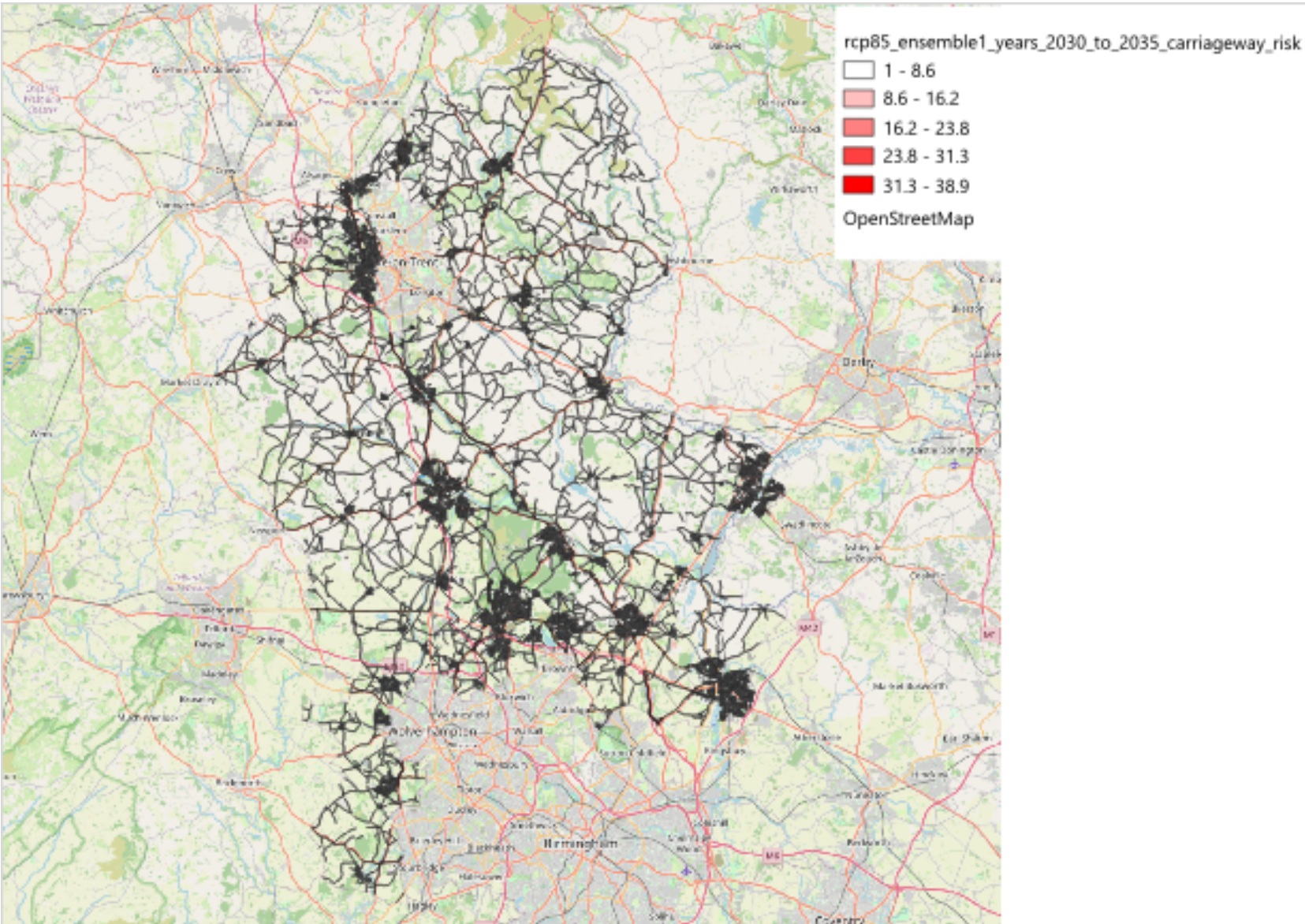
03 MAP

Create priority layer

Join risk values to the GIS asset layer; produce one view per asset class and window.

5-year windows 2030–34 • 2035–39 • ... • 2055–59

Colours rank relative intensity within that asset class—not across asset classes.

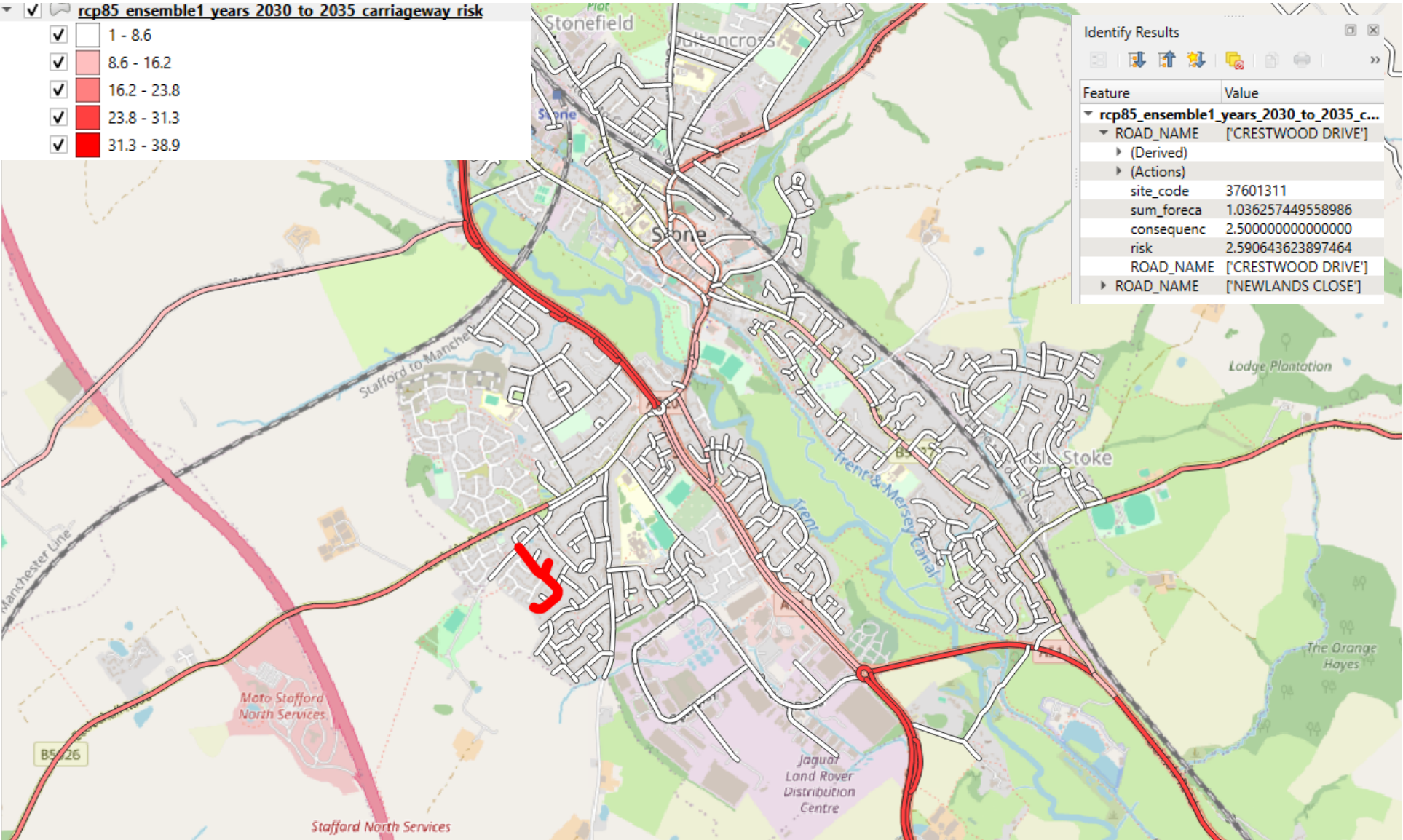


HEATMAPS

Heatmaps have been produced for each of the four asset classes, in 5-year intervals, and for high and medium emission scenarios.

To the left is shown a county-wide heatmap for carriageway risk between 2030-2035, under RCP8.5 ensemble 1.

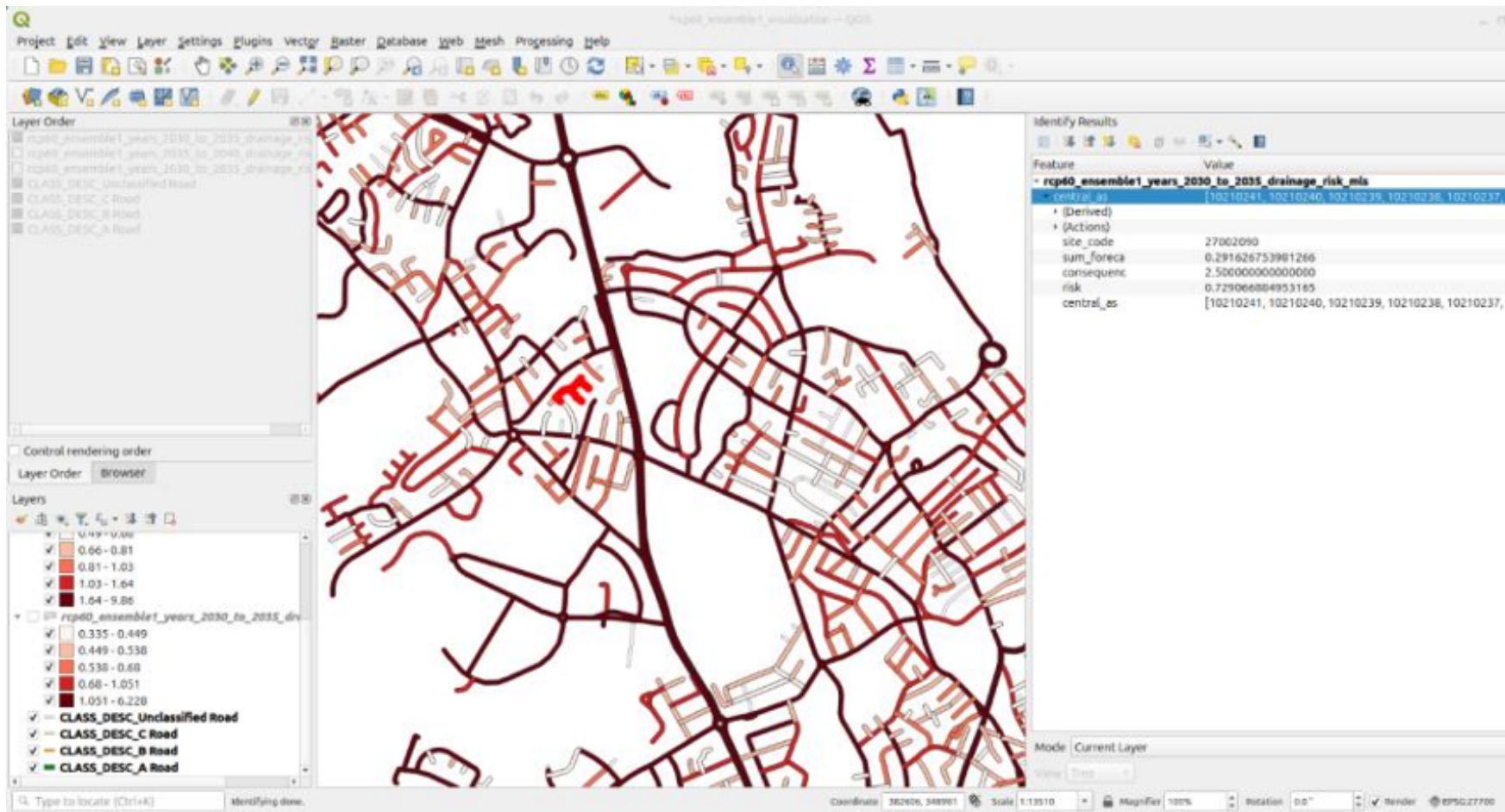
On the following slide is shown a zoomed in heatmap with the relevant results.



HEATMAPS

To the left is shown a zoomed-in heatmap for carriageway risk between 2030-2035, under RCP8.5 ensemble 1.

As can be seen, any road on the network can be selected, and a corresponding risk score will be displayed.



READ WITHIN ONE ASSET CLASS

Each colour scale is local to that asset class and five-year window; colours are not cross-asset benchmarks.

HIGHER INTENSITY = TWO SIGNALS

A hotspot combines higher forecast event burden with a higher consequence score.

USE AS A SPATIAL SHORTLIST

Prioritise recurring hotspots across windows and scenarios, then test them with local evidence and asset-owner review.

The map does not replace engineering review, local flood-risk evidence or operational judgement.



Proactive maintenance

Risk-based cleansing, trigger inspections and early repairs

Resilient renewals

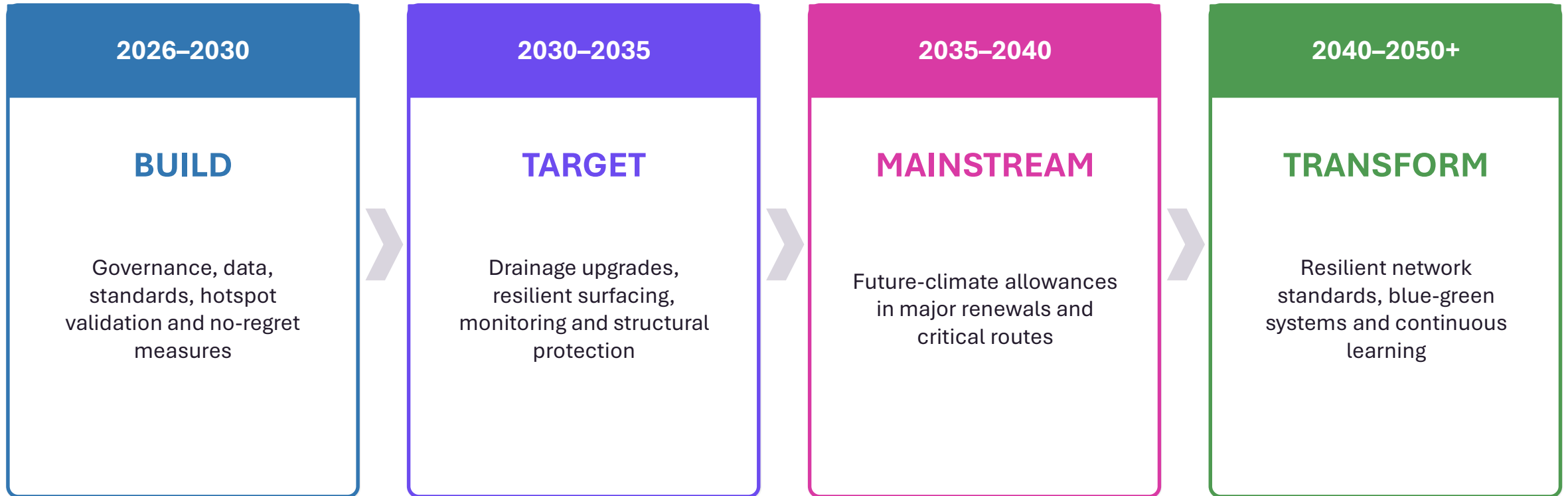
Future-climate design allowances and durable materials

Smart monitoring

Water levels, blockages, structures and earthworks

Blue-green infrastructure

SuDS, attenuation, swales, rain gardens and planting



- 1 Start with decisions**
Define the operational choice before selecting climate, asset and model inputs.
- 2 Combine hazard with consequence**
A hotspot matters when exposure, condition, criticality and service impact intersect.
- 3 Focus validation**
Use models to rank portfolios and target expert review—not to prescribe works.
- 4 Build an adaptive pathway**
Sequence no-regret operations, targeted upgrades and future standards.
- 5 Bring the room in**
Where could this approach transfer to your work—and what evidence would you need?

Thank you

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