

Discovery & Design Report

Severn 2100+

River Severn (Afon Hafren) Adaptation Pathways Pilot

Final Issue

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Glossary

Term	Definition
Adaptation	The process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustments to expected climate change and its effects [1] .
Adaptation action	Responses to key risks and opportunities. In this document they are strategic, flexible, and structured measures designed to mitigate fluvial flood risk, which is increasing due to climate change, forming the building blocks of adaptation pathways.
Adaptive capacity	Ability of systems, institutions, humans and other organisms to adjust to potential damage, take advantage of opportunities or to respond to consequences [2] .
Adaptation Pathways (APs)	A series of adaptation choices involving trade-offs between short-term and long-term goals and values (Note: These are decision-making processes to identify solutions that are meaningful to people in the context of their daily lives and to avoid maladaptation) [3] .
Adaptation planning	Iteratively planning, implementing and modifying strategies for managing resources in the face of uncertainty.
Benefits	Positive outcomes that arise from the project and actions.
Evaluation	The systematic assessment of an intervention's design, implementation and outcomes [4]
Focus areas	Sub-catchments that RS APP focused on testing and developing first iterations of adaptation pathways on (i.e. Warwickshire Avon and Upper Severn)
Indicators	Specific and measurable metrics, which are objectively verifiable, can be tracked over time and represents something that may influence pathways [5] . Note the term 'core' indicator has been used to represent the priority indicators.
Maladaptation	A process that results in increased vulnerability to climate variability and change, directly or indirectly, and/or significantly undermines capacities or opportunities for present and future adaptation [6] .
Multi-Criteria Analysis (MCA)	A structured approach used to evaluate and compare multiple options based on various criteria. It helps us assess alternatives objectively by considering different factors relevant to the decision context.
Monitoring	The collection of data throughout an intervention, both during and after implementation to improve current and future decision making [7] .
Monitoring and evaluation framework	A framework that indicates what will be monitored and evaluated (i.e. indicators) and the associated triggers and thresholds, who is responsible across each aspects of the framework, feedback framework, and information & data requires for the evaluation.
No / low regrets	Measures typically associated with 'low cost' options which perform adequately or exhibit robustness across a range of future scenarios, while minimising potential trade-offs [8] .
Objectives	The defined and measurable steps the vision is broken into which represent the intended results and impacts of a project or programme.

Glossary

Term	Definition
Portfolio	Groups of aggregated adaptation actions to enable development and appraisal at a catchment-scale.
Resilience	The capacity of social, economic, and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganising in ways that maintain their essential function, identity, and structure, while also maintaining the capacity for adaptation, learning and transformation [1] .
Risk	The potential for adverse consequences where something of value is at stake and where the occurrence and degree of an outcome is uncertain. In the context of the assessment of climate impacts, Risk results from the interaction of vulnerability (of the affected system), its exposure over time (to the hazard), as well as the (climate-related) hazard and the likelihood of its occurrence.
Scenario	Scenarios are plausible descriptions (or snapshot) of how the future may develop, based on a coherent and internally consistent set of assumptions about key relationships and driving forces (e.g. sea level rise). They are neither predictions nor a forecast.
Source - Hazard pathway – Receptor Model	Model for categorising adaptation actions: • Source: Techniques which manage the source of a flood. • Hazard Pathway: Measures that modify the pathway and/or change the probability of flooding. • Receptor: Measures which manage or modify receptors to increase their resilience to flooding.
Sustainability Appraisal (SA)	A systematic process that must be carried out during the preparation of plans and strategies; promoting sustainable development by assessing the extent to which the emerging plan, when judged against reasonable alternatives, will help to achieve environmental, economic and social objectives [9] .
Strategic Environmental Assessment (SEA)	A legal requirement for responsible authorities to appropriately consider the environmental effects of a plan or strategy that are subject to preparation and/or adoption by an authority at a local, regional or national level and which are required by legislative, regulatory or administrative provisions. An SEA considers only the environmental effects of a plan, whereas sustainability appraisal also considers the plan's wider economic and social effects [9] .
System	A set of elements or parts that are coherently organised and interconnected in a pattern or structure that produces a characteristic set of behaviours, often classified as its “function” or “purpose” [5] . Note system thinking is an approach used to map out the system and all the interconnections.
Theory of change (ToC)	A methodology for planning, participation, adaptation management, and evaluation that is used by [organisations] to promote social change.
Threshold	Point beyond which a system is deemed to be no longer effective (economically, socially, technologically or environmentally) [10] .
Triggers	Used for monitoring and occur when conditions change or are likely to change to an extent that they approach a threshold [10] .
Uncertainty	A state of incomplete knowledge that can result from a lack of information or from disagreement about what is known or even knowable. Uncertainty can be represented by quantitative measures (e.g. a probability density function) or by qualitative statements (e.g. judgment of experts).
Vision	A vision is a description of a preferred future state. It describes what a world or organisation should look like in the future, or what a project or initiative should achieve.
Vulnerability	The propensity or predisposition to be adversely affected [1] .

Purpose

The River Severn Adaptation Pathways Pilot (i.e. Severn 2100+) presents an innovative approach to managing flood risk across the River Severn (Afon Hafren), the UK's longest river network. Through collaboration across the Environment Agency, Arup and the River Severn Partnership (an award-winning group of 20+ regional stakeholders), this project has:

- Successfully pioneered an adaptation planning approach that enables resilience and adaptation in a changing climate and uncertain future.
- Piloted our approach to develop adaptation pathways in two areas of the Severn catchment.
- Developed insights that will help to embed adaptation planning approaches regionally and nationally across the Environment Agency and partner organisations.

This report describes the adaptation planning approach developed, and the outputs from its practical application. It acts as a guide for:

- Regional planners and decision-makers - presenting a best practice framework for long-term, strategic planning in the Severn catchment and emerging adaptation pathways.
- Broader practitioners interested in adaptation planning – the RS APP approach illustrates a replicable, scalable model for adaptation, including setting out how the Sustainability Appraisal (SA) process should be followed at each stage in the development of pathways. As the Severn 2100+ is a pilot project, a full SA has not been developed at this stage but should be undertaken for future adaptation pathway development.

Background to Severn 2100+

The National Flood and Coastal Erosion Risk Management (FCERM) Strategy for England [\[11\]](#) recognises that adaptation pathways are critical to ensuring we build a nation that is more resilient and adaptable to future uncertainties. In response, the Environment Agency is delivering an £8 million DEFRA resilience innovation programme [\[12\]](#) across four pilot locations in England – the Thames, Humber, Yorkshire and the Severn. The programme's objectives are to trial adaptation planning approaches in different locations to develop insights that will help to build adaptive capacity and capability for adaptation nationally.



Adaptation planning in the Severn Catchment

The River Severn (Afon Hafren in Welsh) and its tributaries support a region of 5 million people, are a haven for wildlife and are integral to our national water and food security, generating more than £7 billion annually in food production.

The region has a long history of flooding, with repeated flood events severely impacting local communities, landscapes, and ambitions for regional growth. These risks are increasing as our climate changes, our infrastructure ages and our population grows. Currently, more than 47,000 properties are at high risk of fluvial flooding, a number projected to rise by at least 13% over the next century.

In 2006, the Environment Agency developed the Fluvial Severn Strategy to help manage flood risk in the region. This work was successful in guiding flood risk management interventions across the catchment, providing a pipeline of works spanning over 10 years. However, many of the schemes the 2006 Strategy identified have been implemented and, nearly 20 years later, the landscape in which we operate and the risks we face have significantly changed.

In recent years, investment has been piecemeal following significant flooding. Specific, localised interventions have been constructed, but many schemes remain unviable due to challenges with deliverability, economic viability and funding shortfalls. As a result, many projects have been paused or abandoned. Our current approach is resulting in inaction at a time when our communities are facing increasing threats. It is no longer fit for purpose.

We need to fundamentally shift how we think about and manage flood risk to enable catchment-wide adaptation. We need an approach that is:

- Adaptive – managing flood risk in the face of future uncertainty.
- Strategic – cross-sector and catchment-wide to address water resources, quality, flooding and nature recovery at scale.
- Sustainable - maximising wider benefits and unlocking partnership funding and delivery.
- Collaborative – beyond a single organisation, recognising multiple organisations are impacted by water management in the catchment and we can achieve more working together.

Recognising the challenges faced, we have worked with partners to develop an approach that integrates these characteristics into a regional planning and decision-making approach.

Why do we need to act?



47,000

Properties at high risk of fluvial flooding



100,000 jobs

At risk due to fluvial flooding



13%

Increase in the number of properties at risk over the next century due to climate change



82,000 ha

Of agricultural land is currently at medium or high risk of fluvial flooding



1,200ha

Of environmental habitats is currently at high risk of fluvial flooding



£462 million

Of annual cost to the regional economy of not adapting to climate change in 50 years' time

Adaptation planning

Why do we need adaptation planning?

Trends like climate change pose increasing risks to people, communities, businesses and the environment. We need to adapt, but how future trends will unfold is highly uncertain. Most decisions on adaptation need to take place with appropriate recognition of uncertainties over long timescales. Making low-regrets near-term decisions that prepare us for a range of possible futures is therefore crucial.

What is adaptation planning?

Adaptation planning and adaptation pathways are decision-making tools and frameworks that help us to overcome future uncertainty and assist long-term planning. These approaches are underpinned by effective monitoring and evaluation to ensure plans remain agile to unfolding future conditions.

These approaches are most appropriate when:

- We need to plan long-term, but the future is uncertain.
- Trends are measurable as opposed to random, e.g. projections can be defined or there is a level of predictability, like the increasing magnitude of storm events.
- There is long-term resourcing and expenditure available to enable their implementation, including monitoring & evaluation.

Why is it beneficial?

Adaptation planning approaches have several benefits, they:

- Facilitate flexible and robust decision-making across long-term timeframes – helping communities and landscapes to remain resilient in the face of changing conditions.
- Support strategies and plans to remain agile to change through integrated monitoring and evaluation processes.
- Provide a stepwise approach to decision-making - identifying immediate actions that help to manage resources and target investment.
- Integrate transparency and accountability into decision-making processes.
- Supports the implementation of low-regrets interventions and avoid mal-adaptation.

Adaptation planning is an iterative framework for decision-making in uncertainty. It helps us to plan how and monitor when to act under different futures.

Adaptation pathways are a specific adaptation planning approach. They are sequences of potential actions that can be implemented in response to changing future risks and opportunities. An adaptation pathways map (Figure 1) provides insight into policy options, the sequencing of actions over time, potential lock-ins, and path dependencies.

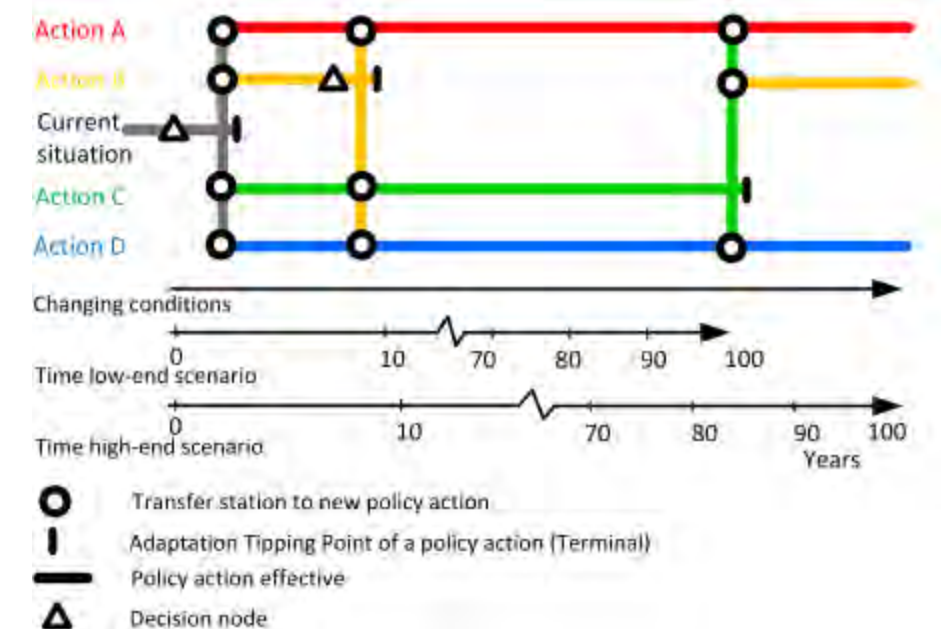


Figure 1: Example of an adaptation pathway [13].

Our approach to adaptation planning

Our approach to developing adaptation pathways for the Severn2100+ is outlined below. It is underpinned by national and international good practice and research, including the British Standard (BS 8631:2021) for Adaptation to Climate Change, the Thames 2100 programme and the Dutch Delta programme. The following sections of this document each correspond to a step of our approach - describing the methodology developed and how it was applied across two areas of the catchment.



How do we implement our plan?

Plan for implementation and monitor key indicators.



How do we know it's working?

Develop monitoring and evaluation plans that identify indicators of change and determine triggers and thresholds for when to act.



When do we need to act and in what sequence?

Assemble a route-map of adaptation actions to form adaptation pathways. Explore how these are influenced by different future scenarios. Evaluate and select the preferred pathway.



Where do we want to be in the future?

Determine a shared ambition and objectives. Understand the system being worked within and determine the boundaries of the project.



What is happening that could impact us?

Understand the risks and opportunities from current and future scenarios, including climate change



What can we do about it?

Consider the adaptation actions that respond to different risks and opportunities. Appraise their impact and identify the interdependencies between actions and across external systems.

Integrating sustainability into our approach

The Environmental Assessment of Plans and Programme Regulations 2004 (the “Strategic Environmental Assessment (SEA) Regulations”) outline requirements that need to be met during the development of certain plans or spatial strategies to ensure that environmental effects have been appropriately considered. The SA process incorporates the requirements of the SEA Regulations, but also considers broader social and economic effects in addition to environmental effects. It is a legal requirement for responsible authorities to undertake SEAs of plans and programmes that are subject to preparation and/or adoption by an authority at a local, regional or national level and which are required by legislative, regulatory or administrative provisions. While there is no legislative requirement to undertake an SEA for the Severn2100+, the Environment Agency determined that to align with good practice, a voluntary SA should be undertaken. This is in recognition that an SA is appropriate tool to ensure environmental, economic and social needs and requirements are systematically and robustly integrated into the development of adaptation pathways. To understand how an SA integrates with our AP approach, we have mapped each stage to the SA process below (Table 1).

Table 1: Table showing how, in practice, an SEA and SA, should be incorporated into the adaptation planning approach.

 Context & Ambition		 Risks & Opportunities	 Adaptation Actions	 Adaptation Pathways	 Monitoring & Evaluation	 Planning for implementation
Screening		Scoping	Options development	Assessment & Adoption	Monitoring	
- Confirm if there is a legislative requirement to undertake a SEA. - If not legally required, an SA should still be undertaken as best practice, and to fulfil the requirements of the Appraisal of Flood and Coastal Erosion Risk Management Policy Statement (2009).		- Scope the framework for the SA to highlight key sustainability issues of relevance to catchment. - Develop draft sustainability objectives. - Produce a scoping report and consult with key stakeholders.	- Develop a long list of adaptation actions considering sustainable solutions for water and nature. - Incorporate sustainability objectives into adaptation action appraisal to refine the long list to a short list.	- Appraise adaptation actions incorporating sustainability objectives. - Assess reasonable alternatives to form pathway options. - Identify preferred pathway/s. - Produce and consult on an Environmental Report. - Produce a Statement of Environment Particulars outlining how feedback provided during consultation has been considered.	- Define sustainability indicators based on the sustainability objectives to ensure key sustainability criteria are tracked. - Capture the sustainability indicators in a monitoring framework developed as part of the Environmental Report. - Monitor these indicators to understand the potential significant effects resulting from implementation of the pathways.	

Integrating sustainability into our approach

As Severn 2100+ is a pilot project, a full SA has not been developed at this stage. Rather, the principles of an SA have been considered or applied at each step of pathway development process, as described below in Table 2. However, a full SA should be undertaken for future adaptation pathway development

Table 2: Table showing how the Severn 2100+ pilot has incorporated sustainability throughout the steps of the adaptation planning approach.

	 Context & Ambition	 Risks & Opportunities	 Adaptation Actions	 Adaptation Pathways	 Monitoring & Evaluation	 Planning for Implementation
Screening	Scoping		Options development	Assessment & Adoption	Monitoring	
- Formal screening of an SEA was not carried out because of the pilot nature of the project - We adopted a high-level SA process to embed better environmental, social and economic outcomes into the APP.	- Developed catchment statements setting out the sustainability context including key issues and opportunities that the APP could influence. - Formed draft sustainability objectives.		- Draft sustainability objectives were integrated into a wider multi-criteria analysis assessment framework that was used to help screen adaptation actions to form pathways. - Adaptation pathways were developed under the scenario of maximising the benefits for water resources, water quality, flooding and nature recovery. This scenario is considered the most sustainable pathway and was prioritised. - No formal consultation has been undertaken on the pathways; hence they remain as pathway options rather than preferred pathways.		- Draft sustainability objectives informed the development of the monitoring and evaluation framework. - When a full SA is conducted, any additional sustainability indicators should be included within the M&E framework.	

Strategic planning directing the capital delivery pipeline

Strategic planning in the fluvial flood risk system is governed by:

- **National:** The National FCERM Strategy for England and the National FCERM Strategy for Wales – setting the vision and long-term delivery objectives for FCERM to guide local decision-making.
- **Catchment:** Flood Risk Management Plans (FRMP) – on a five yearly cycle, identifies flood risk management objectives and brings together mitigation measures at a river basin level.
- **Local:** RMAs produce Local FRMPs and FCERM Appraisal Guidance directs the production of local FCERM strategies for Complex Change projects (i.e. projects with long-term, large scale or interconnected problems that need options to be examined at a strategic level).

However, current approaches largely focus on existing flood risks and employ a ‘predict then act’ approach to resolve them. Alongside this, FRMPs are due to expire in 2027, leaving a gap in how strategic planning is undertaken across the EA. As a result, there is an opportunity to replace and improve catchment-level strategic planning to pro-actively and flexibly manage long-term risks, effectively target resources and maximise the value of investment. This would involve:

- The development of sub-catchment (or catchment) level adaptation pathways to robustly identify a long-term programme of low-regrets actions (or strategic opportunities). The pathways would direct when and where local action needs to be taken to ensure long-term resilience.
- An overarching regional resilience strategy or high-level plan that the adaptation pathways sit within. This would set a unifying vision and approach to adaptation pathway development, ensuring action across the catchment is co-ordinated and sub-catchment interdependencies considered.

The adaptation pathways would identify a prioritised programme of opportunities or projects (i.e. over 5-10 years), that sit within a long-term adaptive framework and present the strategic case for change (i.e. form the basis of a Strategic Outline Case (SOC)). These opportunities would:

- Identify where detailed sub-catchment scale studies or Complex Change projects need to be undertaken.
- Prioritise the development of capital schemes at an Outline Business Case stage.
- Identify what wider enabling activities are needed to unlock delivery.

Ultimately, the above would form the basis of a capital delivery pipeline that directs regional investment and enables regional climate resilience. Through engagement with regional partners, these processes could support co-ordinated action and align funding sources and wider opportunities, including Local Nature Recovery Strategies, to unlock multiple benefits for the region.

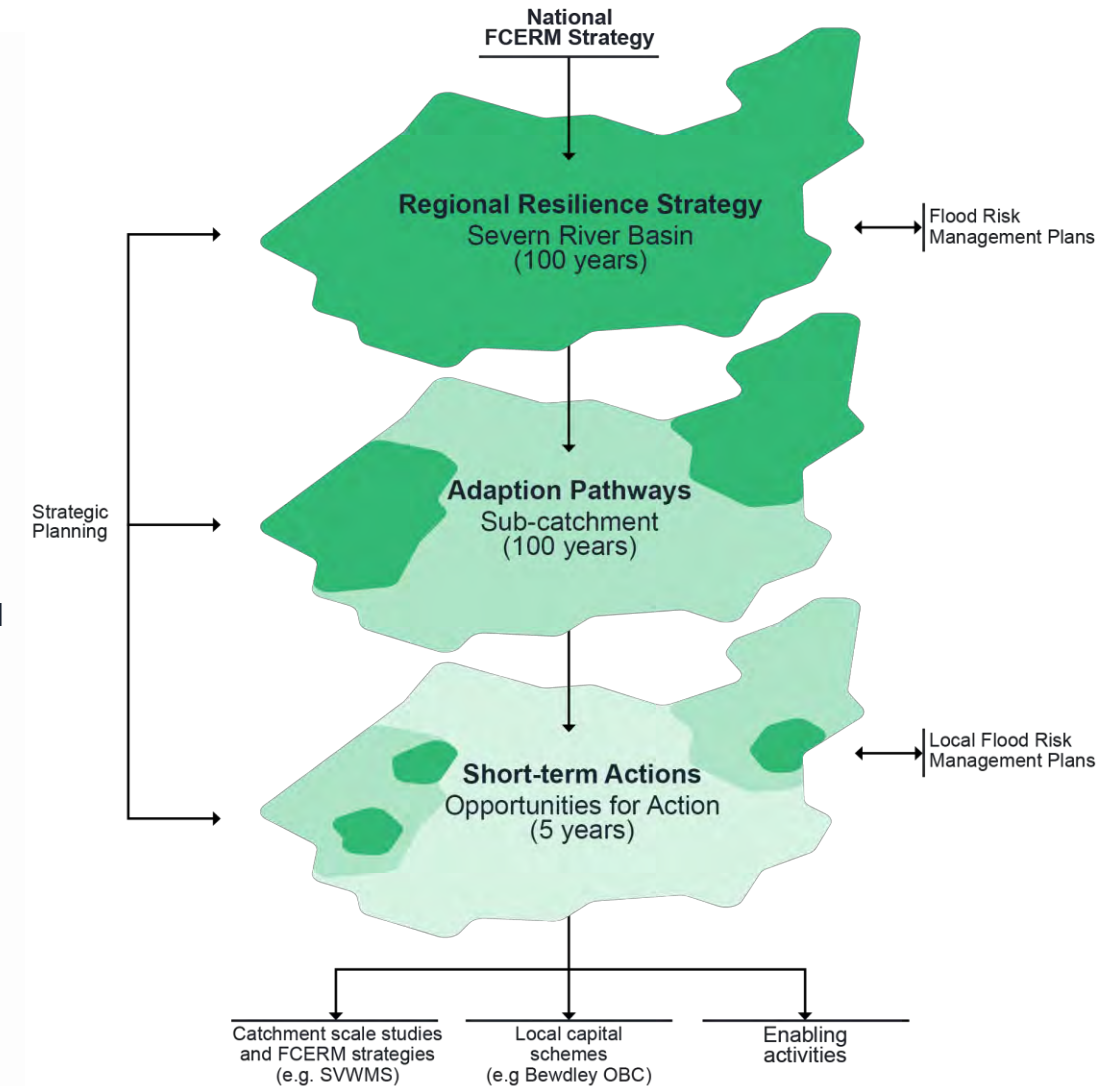


Figure 2: Graphic showing how national FCERM strategies and long-term adaptation pathways can inform a capital delivery pipeline.



Step 1

Context & Ambition

Overview

The purpose of this step is to understand the local context, establish the boundaries we are working within and define the end goal of our pathways. It is important to define these elements at the start of the process, as they set the precedence and end goal for the formulation of the adaptation pathways.

This chapter sets out:

- The methodology used to set the context and ambition.
- The context of the River Severn catchment, including details of the River Severn Partnership (RSP).
- The boundaries for the pathways.
- The ambition, outlined through a vision and objectives.
- Insights from delivering this step.

How should sustainability be considered at this step?

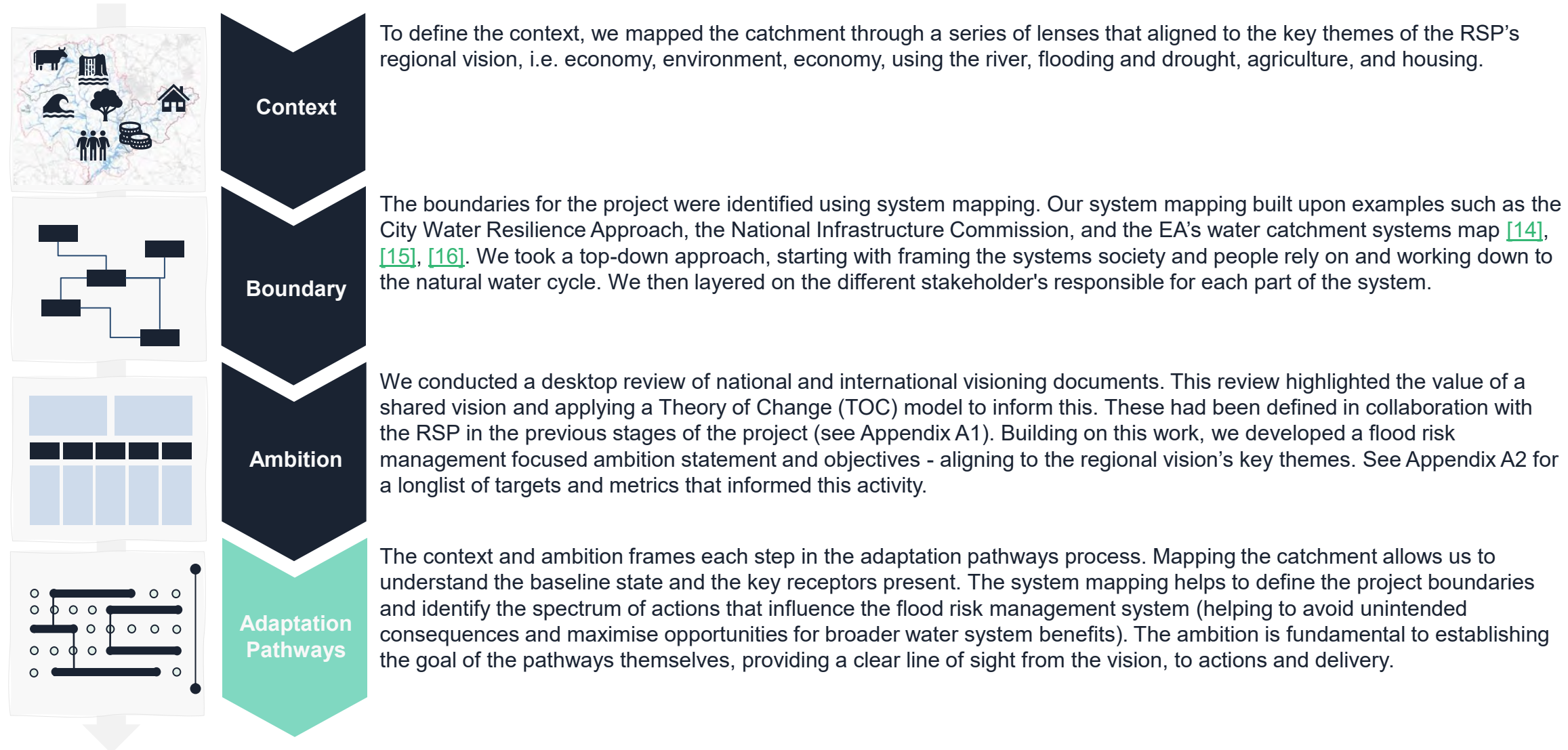
- Develop draft sustainability objectives.
- Produce a scoping report and consult with key stakeholders.





Methodology

For the context and ambition step of the adaptation pathways process, we have applied the following approach:





Context to the River Severn catchment

The River Severn catchment is formed of four distinct river systems – the Wye, the Teme, the Warwickshire Avon, and the Severn – covering over 11,000km² across England and Wales. These river systems span a diverse landscape and form an integral part of life for those who live and work around them.

Major settlements lie alongside the region's watercourses. Outside these urban centres, the wider catchment is predominantly rural with strong agricultural roots and natural landscapes that support important habitats.

The economic activity across the Severn contributes £30.8 billion Gross Value Added (GVA) annually to the UK economy [17]. Of this, income from tourism and food production is significant and the region is vital to the UK's food security. In 2022, milk and poultry production brought in £605m and £448m, respectively [18].

Our regional opportunities and challenges

Flood risk lies at the heart of the region's challenges, but it is not the only issue facing the region. The Severn is a vital source of public water supply for 6 million people and 100,000 businesses nationally. Yet water demands are increasing, as rainfall patterns are changing. In tandem, water quality issues are having a profound impact on aquatic habitats and protected river reaches – receiving national attention.

With local towns and hubs intrinsically linked to the region's river networks, without action these challenges will impact on regional ambitions for growth and the prosperity of those who live and work here. A resilient water system is critical.

Recognising this, the RS APP has sought to capitalise on opportunities to address multiple issues and unlock wider benefits, such as enhancing the natural environment, through flood risk management activities.

What are the focus areas & why were they selected?

We have focused on testing and developing first iterations of adaptation pathways for two sub-catchments (i.e. focus areas): the Upper Severn and the Warwickshire Avon. These focus areas have diverse landscape typologies and varying data availability. This allowed us to explore commonalities and differences in how adaptation pathways can be developed.



Figure 3: The River Severn catchment.



We have mapped the interactions and interdependencies between the River Severn and wider systems that society and people rely on, see Figure 4.

- Helped us to identify and be clear on the project boundaries.
- Highlighted where flood risk management interventions could impact on the wider water system (e.g. water resources and water quality) and environmental and infrastructure systems (e.g. energy and transport) and vice versa.
- Identified the importance of working with stakeholders that control different elements, and understand the dynamics, of the system. The RSP includes a large proportion of these stakeholders and therefore, provides a valuable forum to explore co-benefits and the effective delivery of actions.

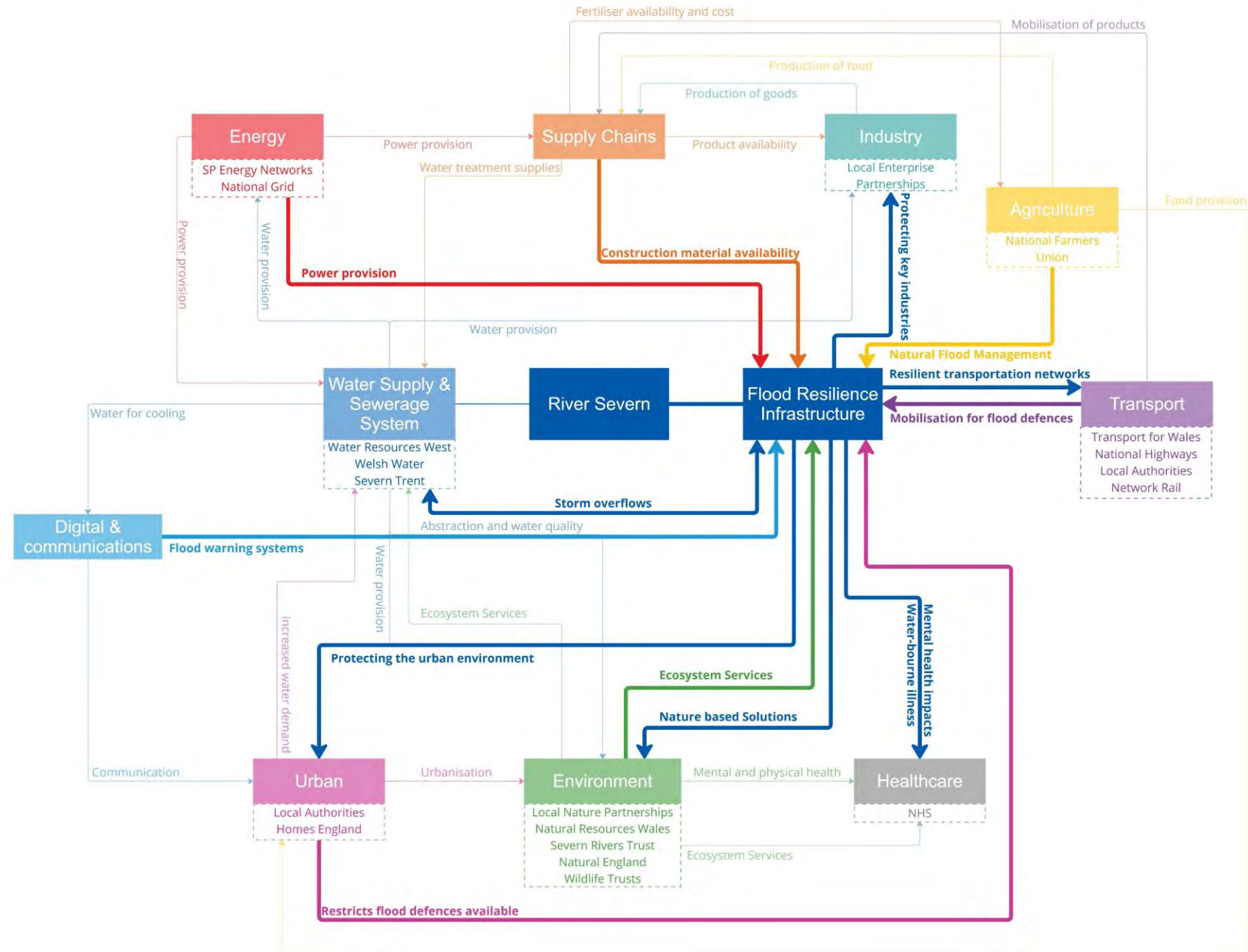


Figure 4: River Severn system mapping.

Ambition

Building on the RSP's regional vision, we worked with the RSP to define a fluvial flood risk focused ambition, with supporting objectives against each RSP theme (opposite). We defined this as **maintaining or improving our flood resilience in light of climate change**, while enhancing wider benefits across all the themes that are important in the catchment.

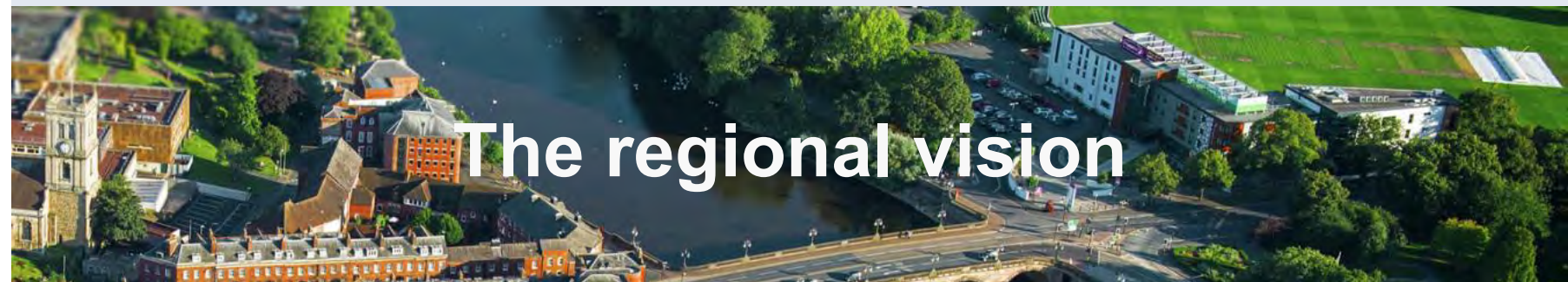
The River Severn Partnership

Following significant and repeated flooding, the RSP was established in 2019 to bring together partners around a collective mission to enable regional resilience, recognising the unique role the river network plays in achieving this.

The RSP comprises 22 organisations across England and Wales, including flood risk management authorities (RMAs), local government, environmental non-governmental organisations (eNGOs), water companies and academia. It helps to shape regional action and support collaboration.

Extensive work was undertaken with the RSP to develop a regional vision, accompanied by a collaborative charter setting out how they would work together to achieve it. As part of the RS APP, we have held quarterly workshops to pilot the adaptation pathways approach.

For further information, please see the [RSP website \[19\]](#).



The regional vision

To make the Severn catchment Britain's most vibrant, resilient and sustainable river network

Vision core themes and flood risk objectives

						
Flooding and drought	Using the river	Economy	Environment	People	Housing	Agriculture
Reduce the annual damages to infrastructure and support the health and livelihoods of the people who live in our region	Develop opportunities to celebrate and enhance the potential of the river network by optimising water resources, supporting riverside communities, creating jobs, supporting navigation and visitor tourism.	Enhance the resilience of businesses and critical infrastructure.	Enhance and conserve the resilience of natural landscapes, watercourses, wildlife and environmentally designated sites.	Support improved resilience of social, commercial and industrial services, infrastructure and built assets	Enhance resilience of communities and homes.	Support improved resilience of agricultural land.

Our insights from applying our approach are outlined below:



- Understanding the local context through broad characteristics, related to the RSP vision themes, helped to determine the full scale of impacts and opportunities across the catchment.
- The systems mapping has identified the key stakeholders that interact with the Severn water management system and highlighted who should be engaged with.
- The boundaries provide clarity of our sphere of influence, where external systems can impact our activities, and informs optioneering in future phases.
- A clearly defined overarching vision for the region, shared by the regional group (i.e. the RSP), was crucial in setting the overarching direction and end goal for the adaptation pathways.
- Aligned to this, it is important to clearly define the ambition for fluvial flood risk management, e.g. establishing whether we are seeking to maintain the status quo or improve flood resilience. This provides clarity to practitioners on what decisions to take.



Step 2

Risks & Opportunities

Overview

Understanding the risks and opportunities, both current and future (across a range of scenarios), helps us to form responses and capitalise on opportunities to achieve our desired ambition.

This chapter sets out:

- The methodology to identify risks and opportunities
- The identification of key trends impacting the region and the development of scenarios to explore these.
- The mapping of current and future risks and opportunities within the focus areas.

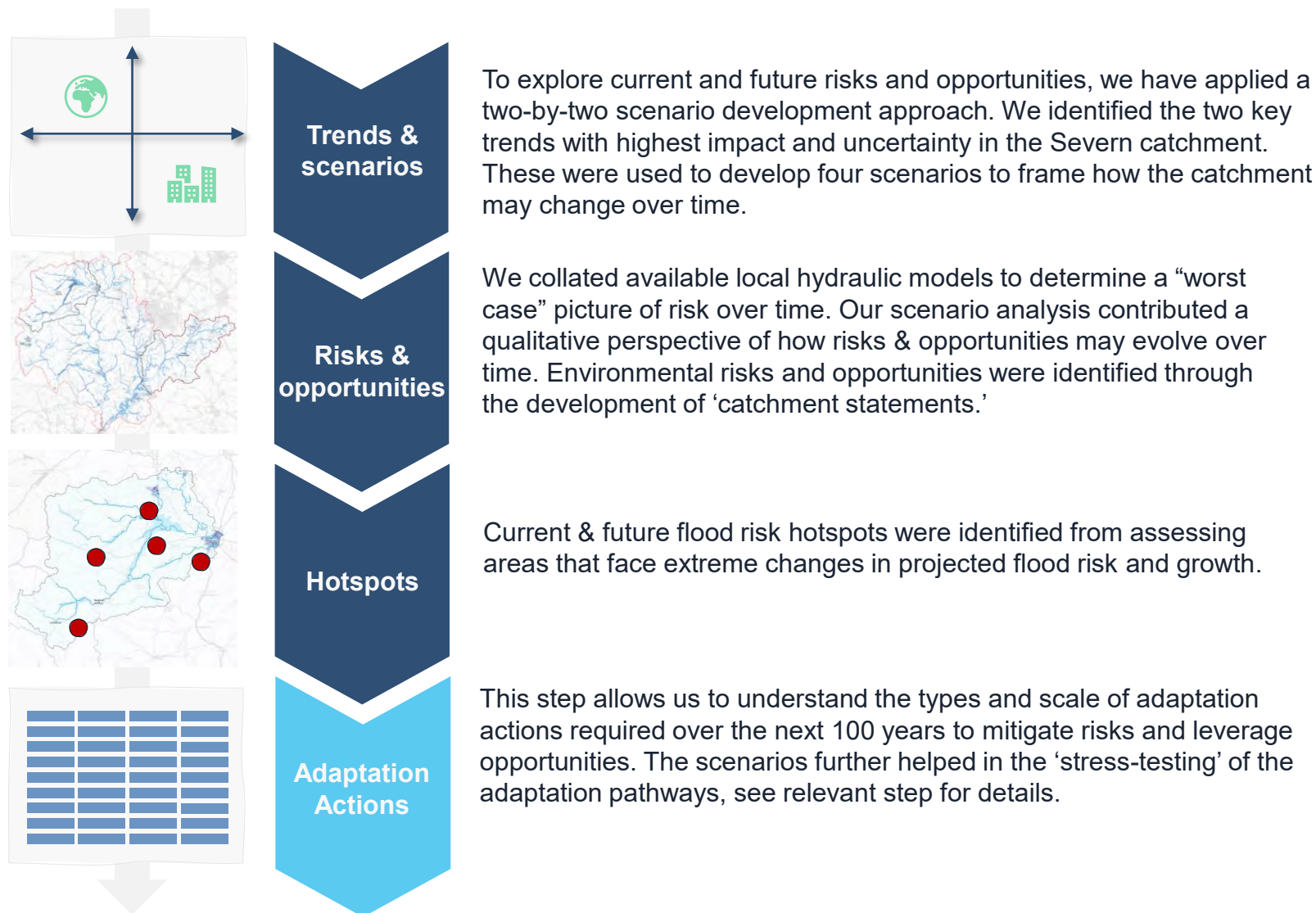
How should sustainability be considered at this step?

- Scope the framework for the SA to highlight key sustainability issues (or risks) and opportunities of relevance to the catchment.



Methodology

For the risk and opportunities step of the adaptation pathways process, we have applied the following approach:



What are scenarios?

Trends, such as climate change, create a range of potential risks and opportunities to physical, environmental, social and organisational systems. However, uncertainties inherent in estimating future trends and their impacts can make it difficult to factor these into decision-making.

Scenarios are a valuable tool to help us explore these uncertainties, consider their impacts and engage effectively with stakeholders. The Environment Agency describe scenarios (or planning scenarios) as a plausible description (or snapshot) of how the future may develop, based on a coherent and internally consistent set of assumptions about key relationships and driving forces (e.g. peak flow uplifts).



Figure 5: Flood barriers at Bewdley, England overtopping in February 2020.



Key trends

From a longlist of applicable trends, as described in Appendix B1, we collaboratively prioritised them to identify the two trends (i.e. climate change and growth) with the highest uncertainty and impact on flood risk across the Severn catchment. We explored high and low projections of each trend:



Climate Change

The UK seeks to limit global warming to 1.5°C as part of the Paris Agreement. The UKCP18 projections show that across the UK we will likely experience milder, wetter winters and hotter, drier summers, rising sea levels and increased frequency and intensity of extreme weather events [20]. Across the Severn catchment, the Department of Environment, Food, and Rural Affairs (Defra) predicts up to 96% uplifts in peak river flows by 2080 [21]. See Appendix B3 for further detail.

Projections considered:

- High climate change (RCP 8.5*): High atmospheric concentrations of green house gases result in hot and dry summers with severe heatwaves, droughts and flash flooding. Mild, wet winters with high river levels. The RCP8.5 (central allowance) closely represents a 4°C increase by 2100.
- Low climate change (RCP 4.5*): Lower concentrations of greenhouse gases result in warmer temperature averages and steady changes in precipitation patterns across summer and winter, but to a lesser extent. The RCP4.5 (central allowance) closely represents a 2°C increase by 2100.

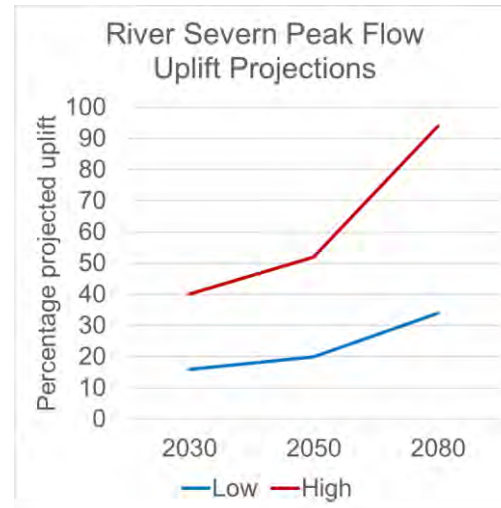


Figure 6: Uncertainty in peak flow uplift projections in the River Severn catchment over time, utilising central and high climate change allowances [22].



Growth

The Office of National Statistics (ONS) and local (development) plan projections provide an indicate likely steady growth across the Severn Catchment, and continued de-urbanisation into the catchment, which ramped up following COVID-19, is forecast to continue. However, there is uncertainty whether this trend will continue, considering that growth may not happen everywhere at the same rate. See Appendix B4 for further detail.

Projections considered:

- High growth: Increased urbanisation, food and housing demand, lead to increased development and pressure on land use decisions (e.g. development versus food production). Projections were estimated based on a review of the local (development) plans.
- Low growth: Housing supply will likely catch up with projected need. Population growth may be slow (or negative) and result in a more dispersed population across the catchment. Projects were estimated based on historical ONS census data.

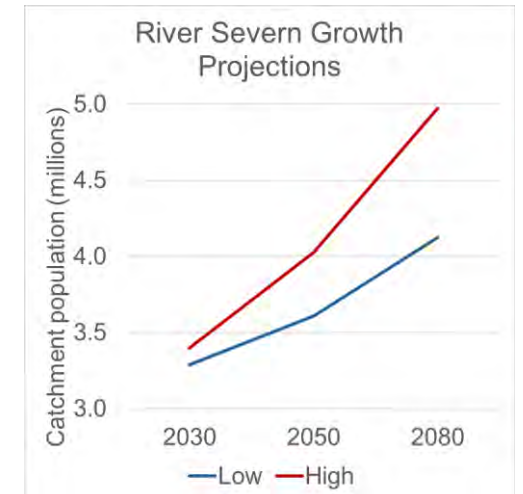


Figure 7: Population growth projections across the River Severn region from 2030 to 2080, using local (development) plans and ONS projections [22], [23].

*Representative Concentration Pathways (RCPs) are projections of how the climate may change in the future associated with specific concentrations of GHG against total radiative forcing targets up to 2100.



Scenarios

Based on the trends, we developed four plausible future scenarios of what the catchment could look like in 2100 using a two x two matrix approach (see Appendix B2 for details). The Rapid Action scenario has been used throughout this step to inform a quantitative assessment of future risks.

In 2100, the Severn Catchment...



Figure 8: Our four scenarios. Photos were developed using Microsoft Co-Pilot.

Risks & Opportunities

Upper Severn

The Upper Severn focus area is approximately 2500 km² and lies across Wales and England. It contains key urban towns and hubs, including Shrewsbury, Oswestry and Welshpool. Outside of these, the catchment is predominantly rural. Many settlements lie along the Rivers Severn and Vyrnwy and are at significant risk of fluvial and surface water flooding.

Considering changing risk over time (based on flooding and growth projections), we have identified six risk hotspots across the Upper Severn: Caersws, Shrewsbury, Y Trallwng (Welshpool), Llansantffraid-ym-Mechain (including Llanymynech), Meverley, and Meifod.

The map opposite represents future flood risk across the area in 2080. We have explored three hotspots in further detail to inform the development of the adaptation pathways, as illustrated opposite. These were selected due to their location (upstream and downstream within the catchment), their relative, projected changes in risk over time, and the availability of local hydraulic modelling.

The following pages set out the headline risks and opportunities across the Upper Severn focus area based on a 1-in-100 year flood extents in 2080, utilising climate change uplifts from local hydraulic models (see Appendix B5 for further detail).

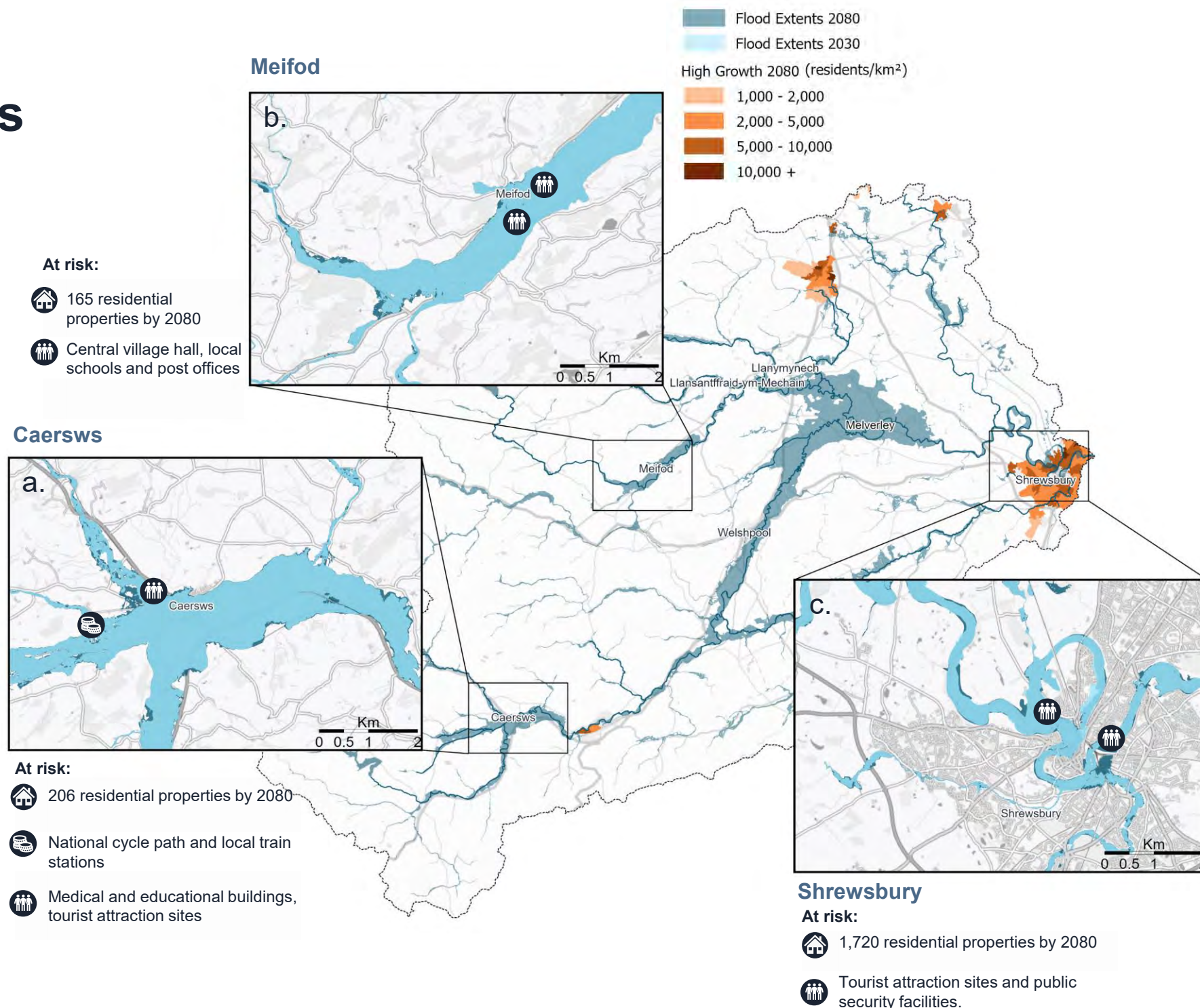


Figure 9: Map of the Upper Severn focus area with the three hotspots indicated (Caersws (a), Meifod (b), and Shrewsbury (c)).



Economy

Upper Severn

Risks

By 2080, climate change is expected to bring significant economic impacts to the region. A 1-in-100 year event in 2080 is projected to affect 25km of railways, including the Cambrian Line, and key roads including the A5 at Montford Bridge, A483, A4870, A489, and A495. This will restrict access and disrupt the transport of people and goods between England and mid-Wales, particularly between Shrewsbury and Oswestry.

Agriculture and tourism sectors will be significantly impacted. Professional services, tourist facilities, and transport hubs are particularly vulnerable in Shrewsbury. Two areas (near Newtown and Welshpool) fall under the 20% most deprived threshold (according to the index of multiple deprivation) in the UK and will face significant increased flood risk over time. This will likely increase economic disparities.

Number of commercial & industrial buildings at risk

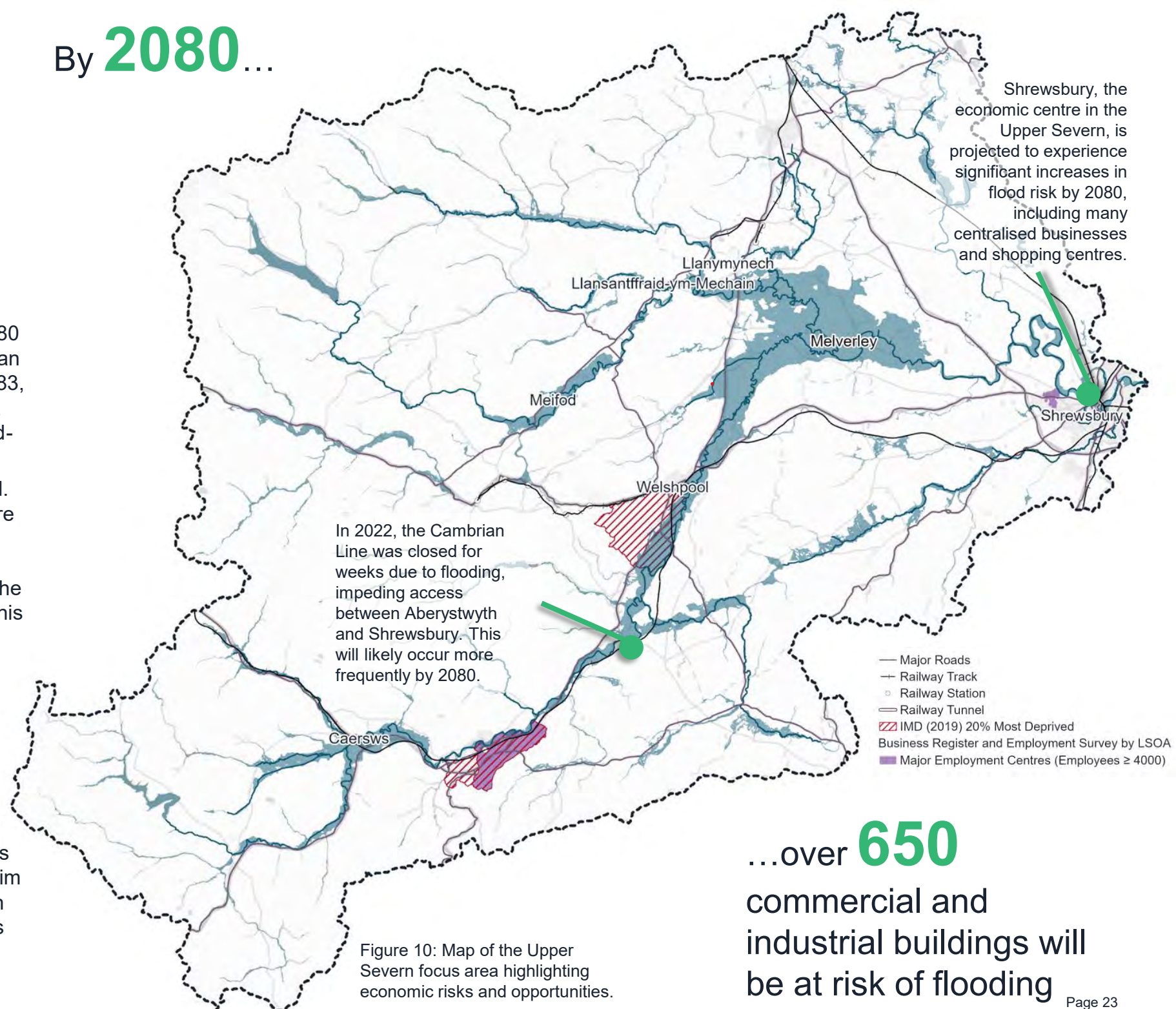


	2030	2050	2080
	550	630	680

Opportunities

Mitigating and adapting to climate change can present opportunities to drive green skills and employment. Initiatives like the Marches Forward Environmental Investment Zone aim to leverage the rural nature of the catchment to attract green finance. Warmer summers could boost recreational activities and tourism.

By **2080**...



...over **650**
commercial and
industrial buildings will
be at risk of flooding



Environment

By **2080**...

Upper Severn

Risks

Flooding in the Upper Severn could impact 10 internationally important nature conservation sites, including Eryri (Snowdonia) National Park, Shropshire Hills National Landscape, Y Berwyn National Nature Reserve, and Llanymynech and Llyndys Hills Site of Special Scientific Interest (SSSI) by 2080. Increased surface-water runoff may lead to more combined sewer overflow spills and affect water quality. This could harm wildlife and contribute to reduced Water Framework Directive (WFD) status.



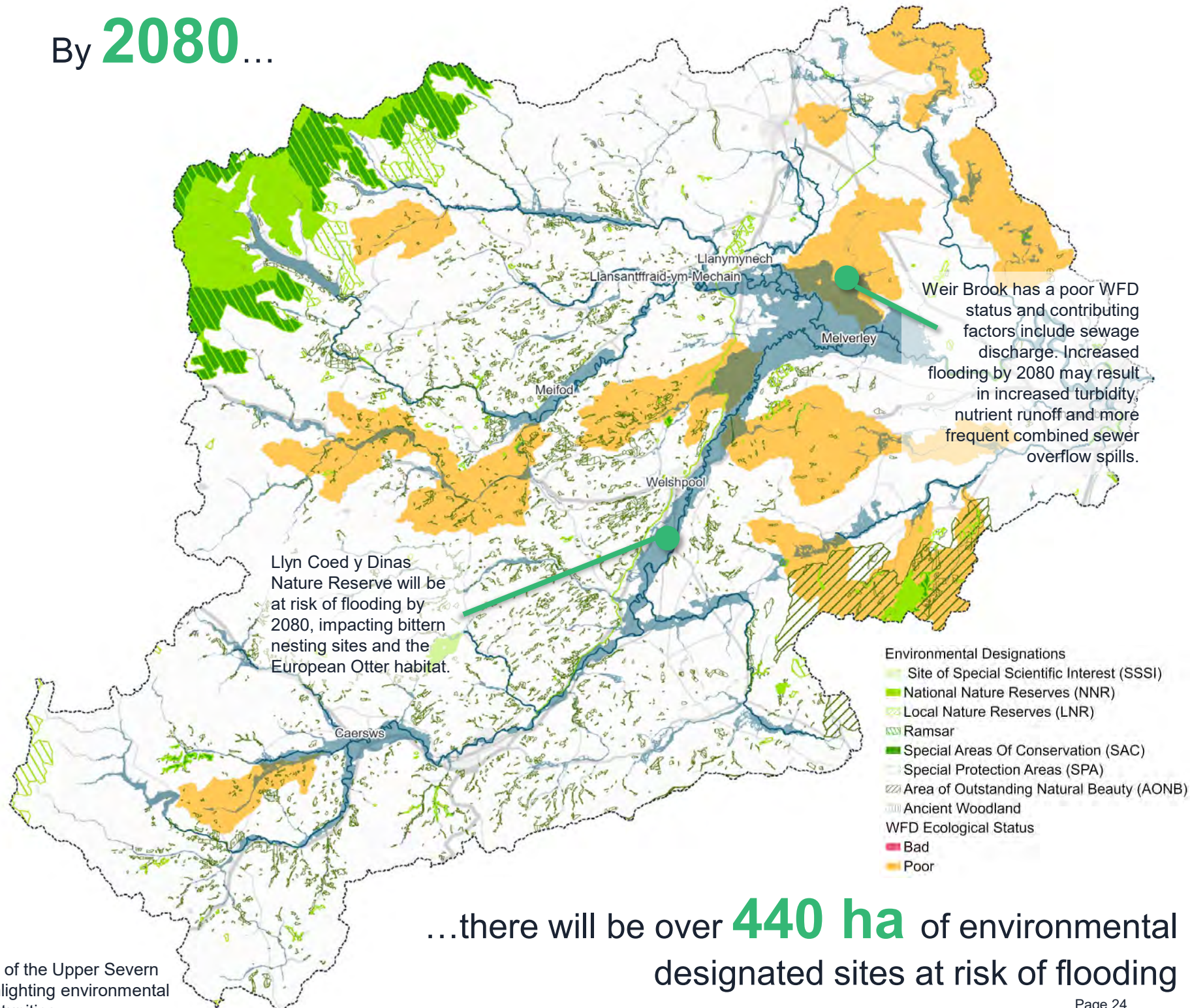
Ha of environmental designations at risk

	2030	2050	2080
	370	430	440

Opportunities

Adopting a nature-positive approach in the Upper Severn, such as river restoration and woodland creation, can enhance species diversity, sequester carbon (contributing to the UK's net zero goals), boost biodiversity, and attract ecotourism. Wetter winters may improve aquifer recharge, balancing water supply and demand. Retrofitting Sustainable Drainage Systems (SuDS) in urban areas like Shrewsbury and Oswestry can enhance urban biodiversity and mitigate the urban heat island effect.

Figure 11: Map of the Upper Severn focus area highlighting environmental risks and opportunities.



People

Upper Severn

Risks

Flooding is projected in areas with higher median ages, which could leave increased proportions of the elderly vulnerable. Communities across the area, including professional services, tourist facilities, and transport hubs, are at risk. In wider areas, key village amenities such as churches, post offices, schools, surgeries, and community centres are also at risk of flooding. Flooding may impact daily lives e.g. by posing a risk to life, impacting health and impacting well-being, increased isolation, impacts to employment and lost school days.

Number of public buildings and services at risk

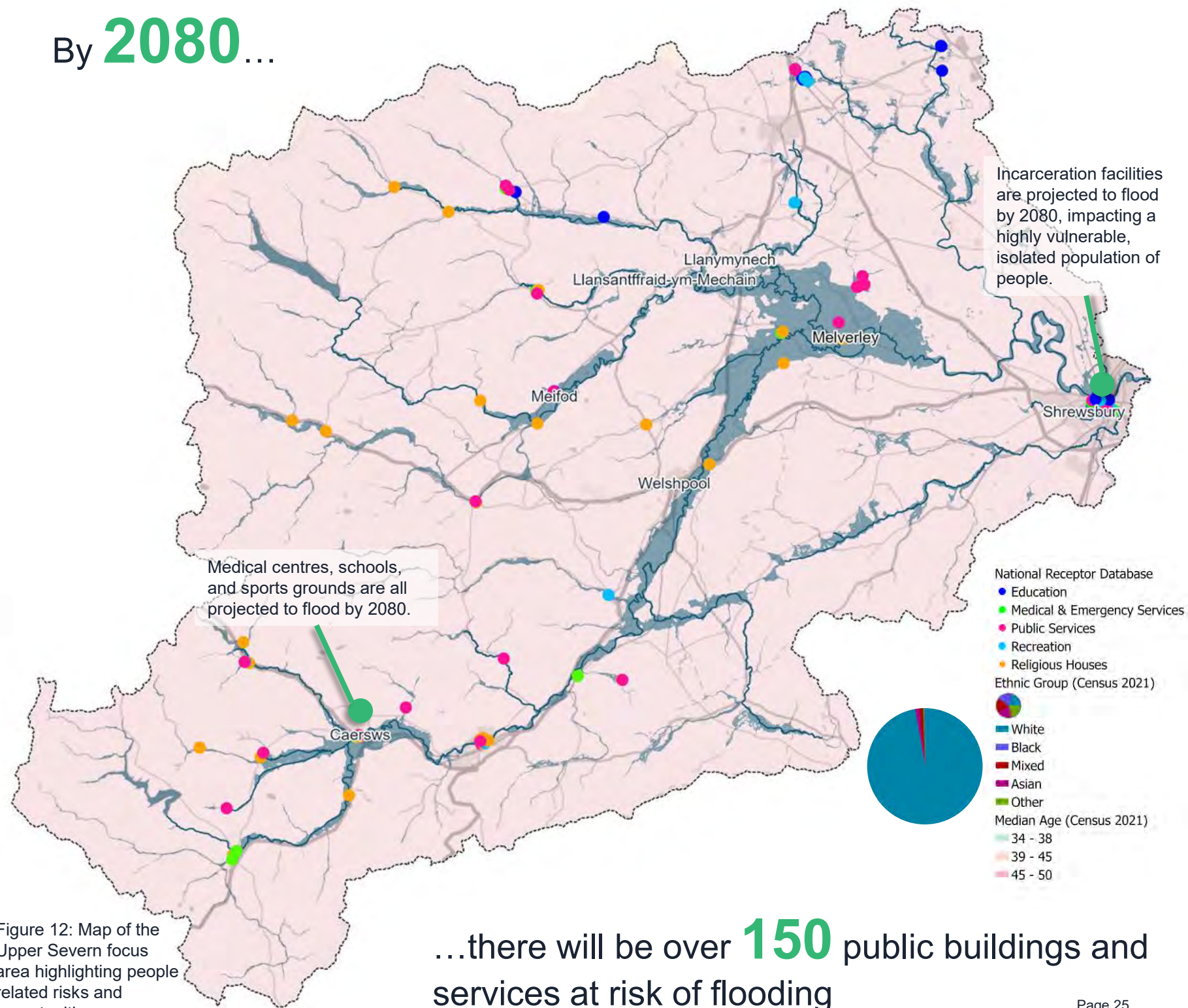


2030	2050	2080
100	140	150

Opportunities

In the Upper Severn, there are opportunities to improve access to nature and landscape restoration through managing flood risk through natural processes. Linking railway cycle paths with Flood Storage Areas (FSAs) like the Severn Way Walk can reconnect the region and create open access areas for community use. There are strong flood community action groups in places like Minsterley, Pontsbury, and Carno, seeking to ensure that FRM is tailored to community needs and supports resilience.

By **2080**...



...there will be over **150** public buildings and services at risk of flooding



Housing

Upper Severn

Risks

In the Upper Severn, a projected 33% increase in properties affected by flooding is expected from 2030 to 2080, particularly in Caersws, Shrewsbury, Y Trallwng (Welshpool), Llansantffrain-ym-Mechain (including Llanymynech), Meverley, and Meifod. For a 1 in 100 year event, properties are projected to increase from 4,661 to 6,221. This is a conservative estimate that does not account for future growth and development.



Number of residential properties at risk

2030	2050	2080
4,600	5,800	6,200

Opportunities

There are opportunities to deliver sustainable housing growth, including water-resilient homes and SuDS. Future planning reforms can ensure that land protected for housing complements flood risk management plans. The Marches Forward initiative [\[24\]](#) focuses on connecting communities across the region, enabling more dispersed, strategic and well-connected developments outside of flood risk areas.

By **2080**...

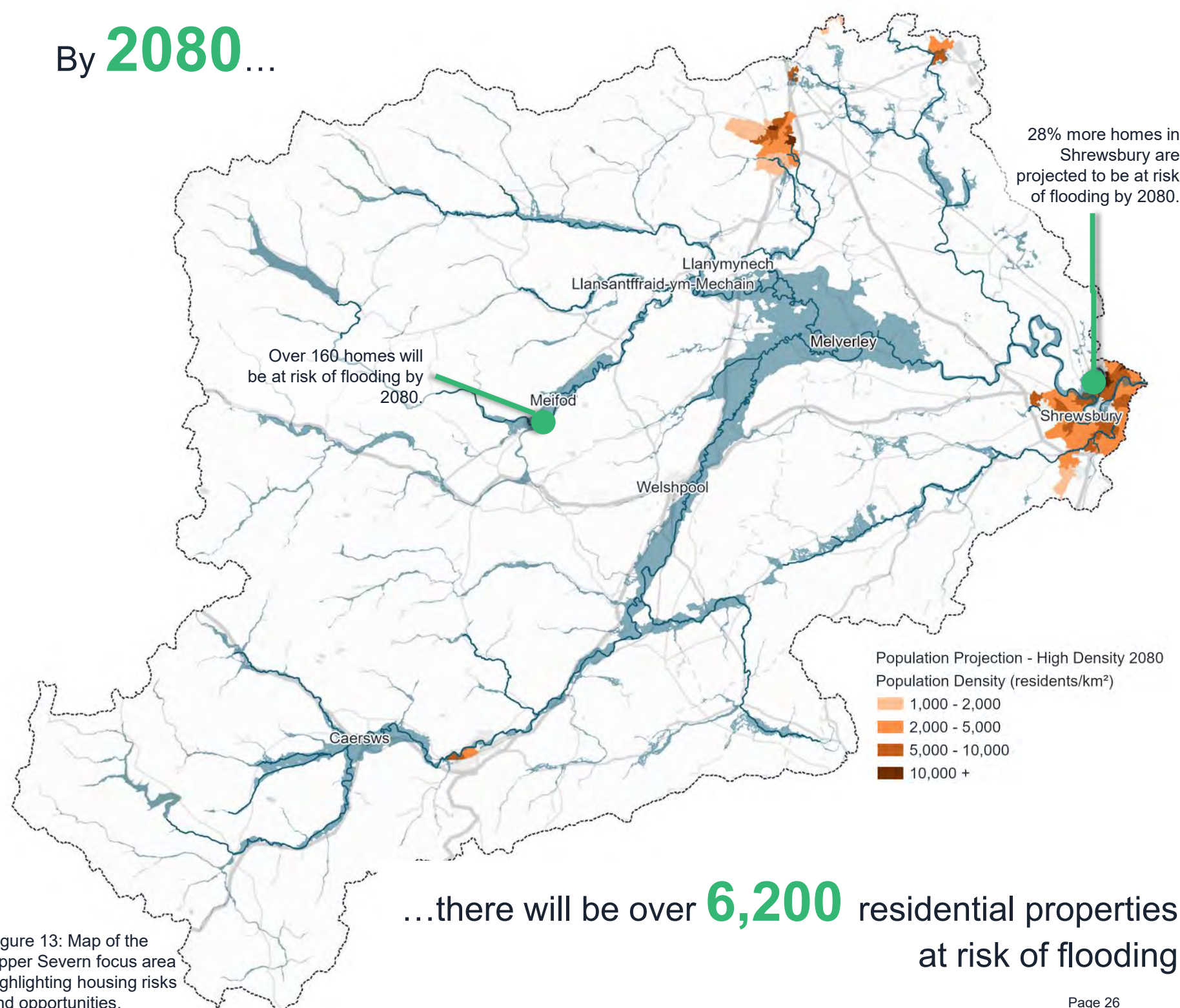


Figure 13: Map of the Upper Severn focus area highlighting housing risks and opportunities.



Agriculture

Upper Severn

Risks

The Upper Severn catchment is crucial for local and national food production. By 2080, 13% more good to excellent quality agricultural land is expected to be impacted by flooding. Large areas of this high-quality agricultural land are located around Shrewsbury and Oswestry. Flooding here could disrupt food production and export activities.



Ha of quality farmland at risk

	2030	2050	2080
	13,300	14,800	15,000

Opportunities

Perennial crops like olives and grapes may be suitable for the region due to warmer temperatures and longer growing seasons. This could support agrotourism opportunities.

Maximising high-yield agricultural farmland, whilst also incentivising farmers' contributions to wider flood resilience measures such as Natural Flood Management (NFM) could support flood mitigation.

By **2080**...

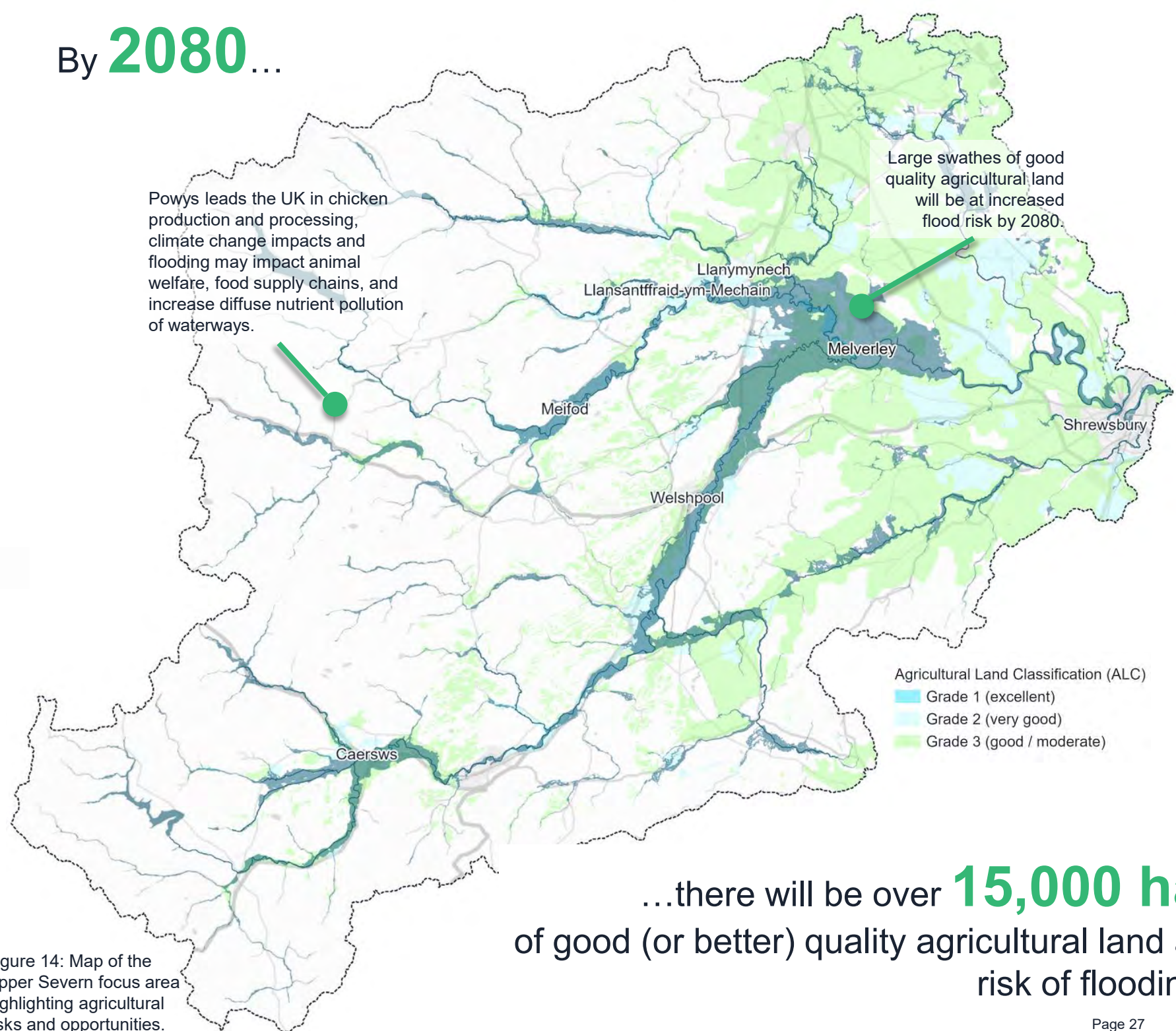


Figure 14: Map of the Upper Severn focus area highlighting agricultural risks and opportunities.



Risks & opportunities

Warwickshire Avon

The Warwickshire Avon is approximately 2500 km² and extends from the source of the River Avon near Coventry, to its confluence with the River Severn near Tewkesbury. The watercourse bisects the focus area. South of the River Avon is largely rural and characterised by low-lying, undulating hills. The rest of the focus area is fairly urbanised, with dispersed, densely populated areas.

There is a long history of flooding across the catchment, but traditional flood defence schemes have typically been challenging to justify economically.

Stretches of the Warwickshire Avon are navigable and thus, are marked by a series of assets, which may require more maintenance and degrade faster with increasing frequencies of flood events. These are being investigated as part of a separate project, the Avon Weirs & Sluices.

Considering changing risk over time (based on flooding and growth projections), we have identified 13 risk hotspots across the Warwickshire Avon: Coventry, Rugby, Royal Leamington Spa, Warwick, Henley & Arden, Wootton Wawen, Wellesbourne, Stratford-upon-Avon, Alcester, Pershore, Shipston-on-Stour, Broadway, and Sedgeberrow.

The map opposite represents future flood risk across the area in 2080. We have explored three hotspots in further detail to inform the development of the adaptation pathways, as described opposite. These were selected due to their location (upstream and downstream within the catchment, along both the River Avon and major tributaries (including the Arrow and Alne)), their relative, projected changes in risk over time, and the availability of local hydraulic modelling.

The following pages set out the headline risks and opportunities across the Warwickshire Avon area based on a 1-in-100 year flood extents in 2080, utilising climate change uplifts from local hydraulic models (see Appendix B5 for further detail).

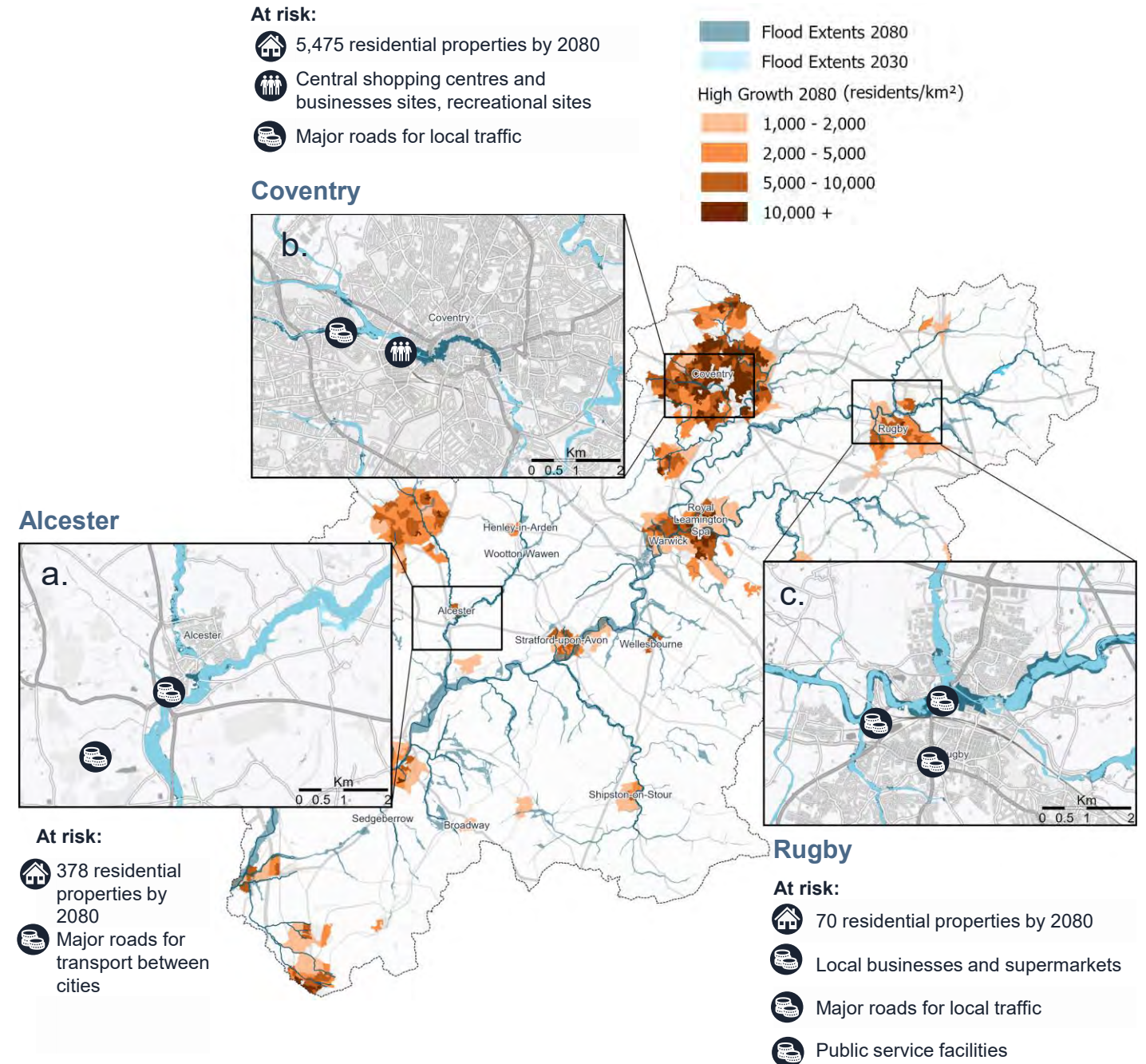


Figure 15: Map of the Warwickshire Avon focus area with the three hotspots indicated (Alcester (a), Coventry (b), and Rugby (c)).

Economy

Warwickshire Avon

Risks

By 2080, extensive flooding is expected to impact key railway lines, including the Chiltern Line, North Warwickshire Line, Cotswold Line, and the Birmingham to Bristol Line. Major motorways, including the M5, M42, and M40, are also at risk. This could disrupt services, commuters and businesses.

The tourism and hospitality sectors in urbanised areas such as Royal Leamington Spa, Warwick, and Stratford-upon-Avon could be adversely impacted. However rural areas are also likely to face significant disruptions, with impacts to the farming economy and rural hospitality services.

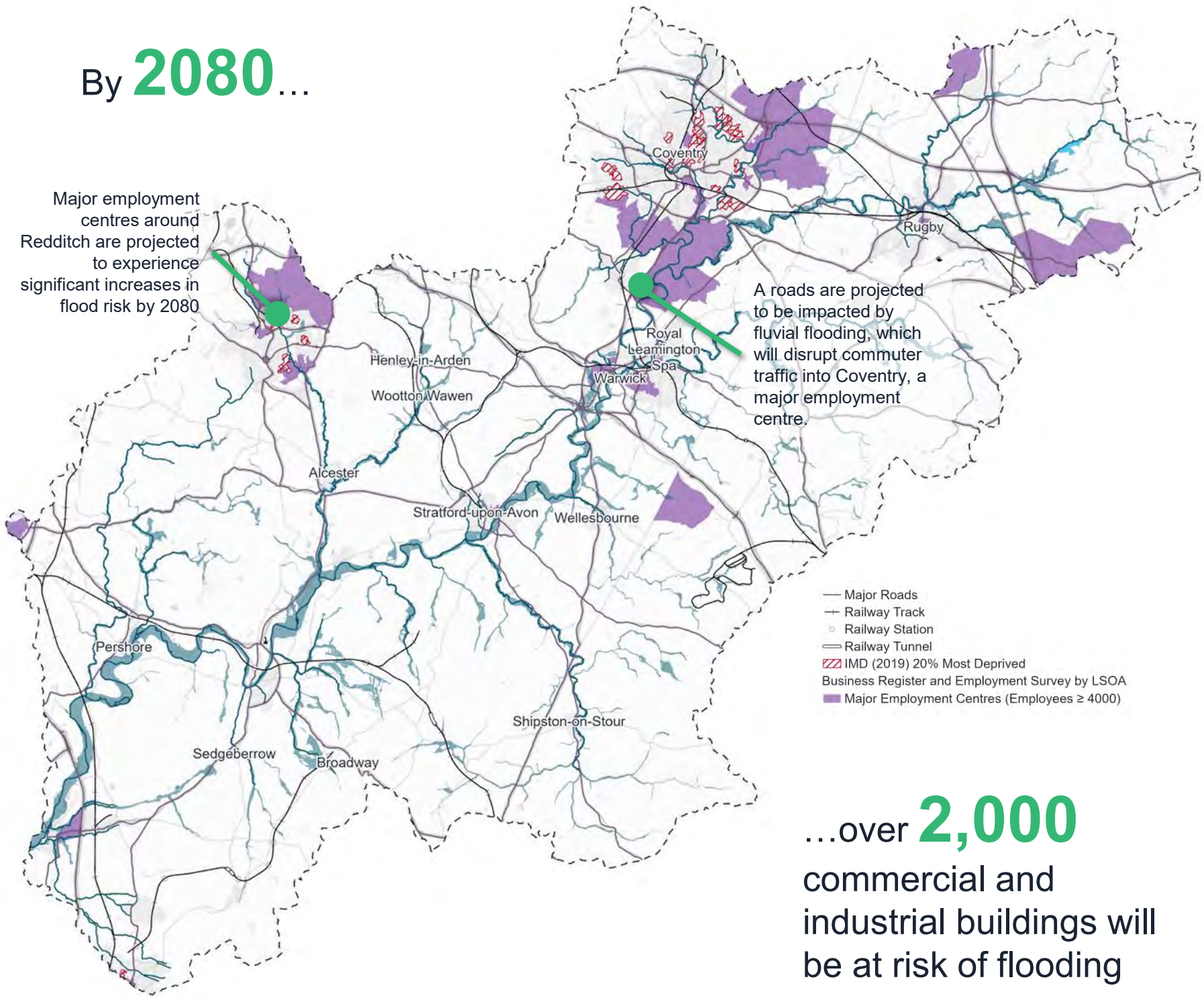


Number of commercial & industrial buildings at risk			
	2030	2050	2080
	870	1,900	2,000

Opportunities

Increased average summer temperatures and more warm days could boost economic activity through increased tourism. The Nature For Water [\[25\]](#) initiative aims to develop watershed investment programs focusing on nature-based solutions, presenting an opportunity to access green funding. The potential Severn to Thames transfer scheme [\[26\]](#) represents opportunities for regional development that could provide employment opportunities.

By **2080**...



...over **2,000** commercial and industrial buildings will be at risk of flooding



Environment

Warwickshire Avon

Risks

Approximately 900 ha of environmentally designated areas, including Tiddesley Wood and Brandon Marsh SSSI, are at risk of flooding for 1-in-100-year event in 2080. Increased pollution from runoff and untreated sewage will contribute further to water quality degradation, harming wildlife and river users.



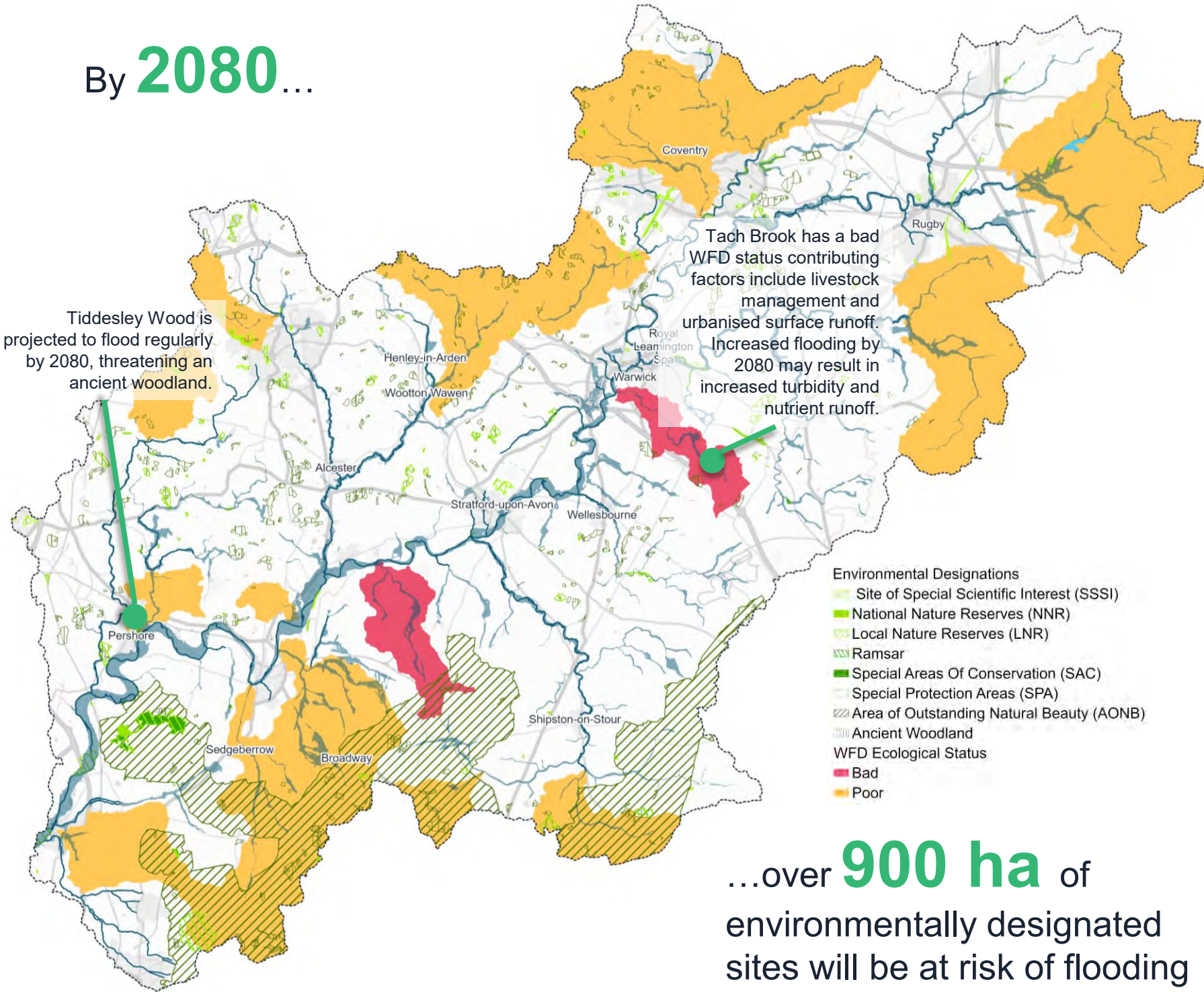
Ha of environmental designations at risk

2030	2050	2080
820	900	950

Opportunities

There are environmental enhancement opportunities through river re-naturalisation, as existing in-river assets are decommissioned. NFM interventions could enhance nature recovery, while improving flood resilience and sequestering carbon (contributing to the UK's net zero goals). Wetter winters could increase aquifer recharge, improving the water resource balance between supply and demand, and associated higher river flows could support with establishing a biodiverse wetland corridor.

By **2080**...



...over **900 ha** of environmentally designated sites will be at risk of flooding



People

Warwickshire Avon

Risks

By 2080, projected flood risk for a 1-in-100 year event will impact people catchment-wide, but particularly in places with high ethnic diversity and higher median ages (e.g. Coventry and Broadway, respectively). This could disproportionately worsen health outcomes, especially in more deprived local authority areas. Targeted interventions are needed to enable communities' resilience and mitigate adverse effects on their well-being.



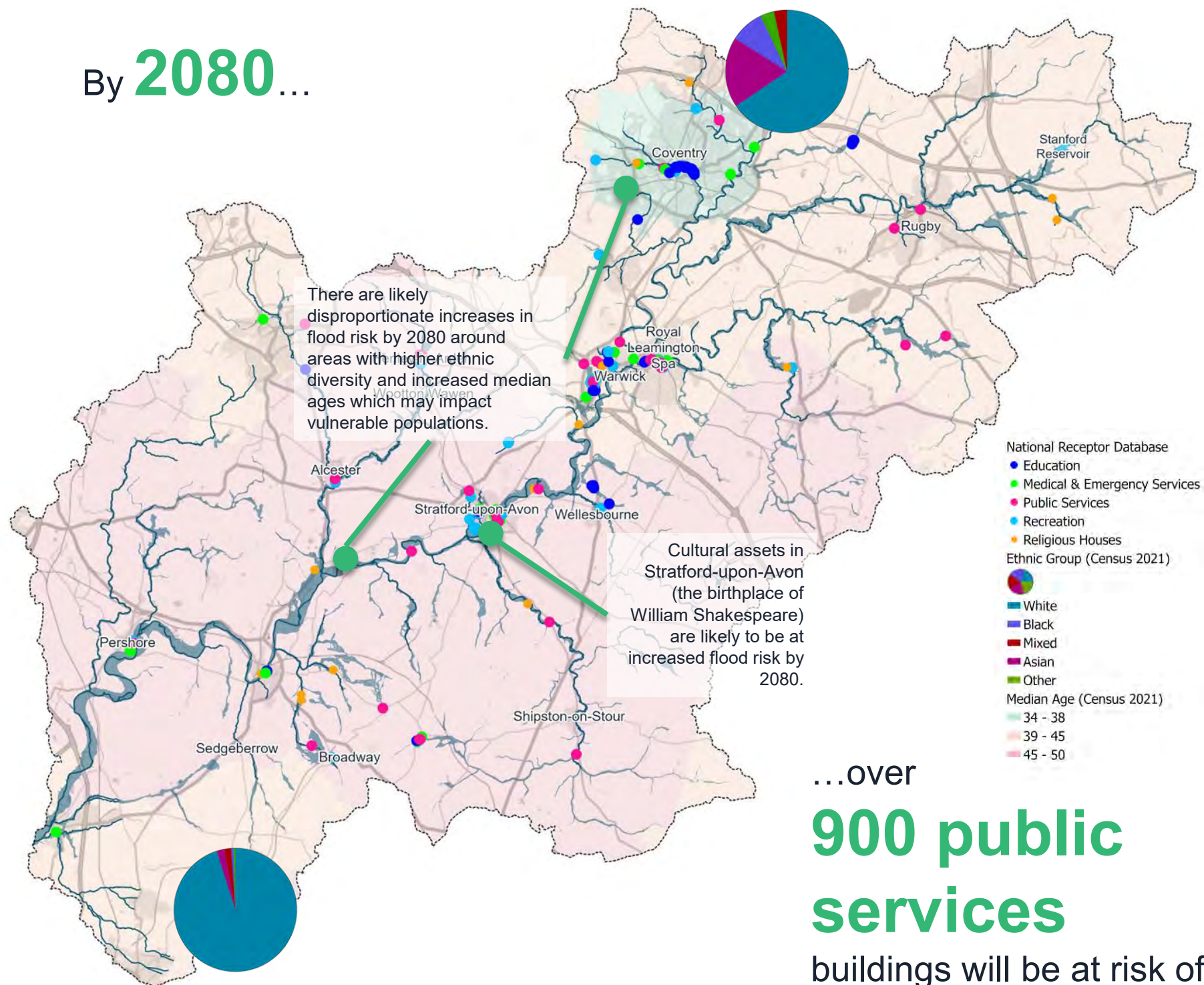
Number of public buildings and services at risk

	2030	2050	2080
	140	500	900

Opportunities

There are opportunities to daylight watercourses to enhance amenity value. Collaboration with key tourism / cultural landowners (e.g. Shakespeare Birthplace Trust) enable co-funding of local flood risk management schemes. Rising climate impacts may spur investment in carbon reduction and adaptation, driving green skills and jobs.

By **2080**...





Housing

Warwickshire Avon

Risks

In the Warwickshire Avon, a projected 157% increase in properties at risk of flooding is expected from 2030 to 2080, i.e. an increase from 7,000 to nearly 18,000. Spatially planning will need to considering increasing flood risk to avoid further development increasing that further. Flood risk management interventions are urgently needed to protect these communities from increasing risks.



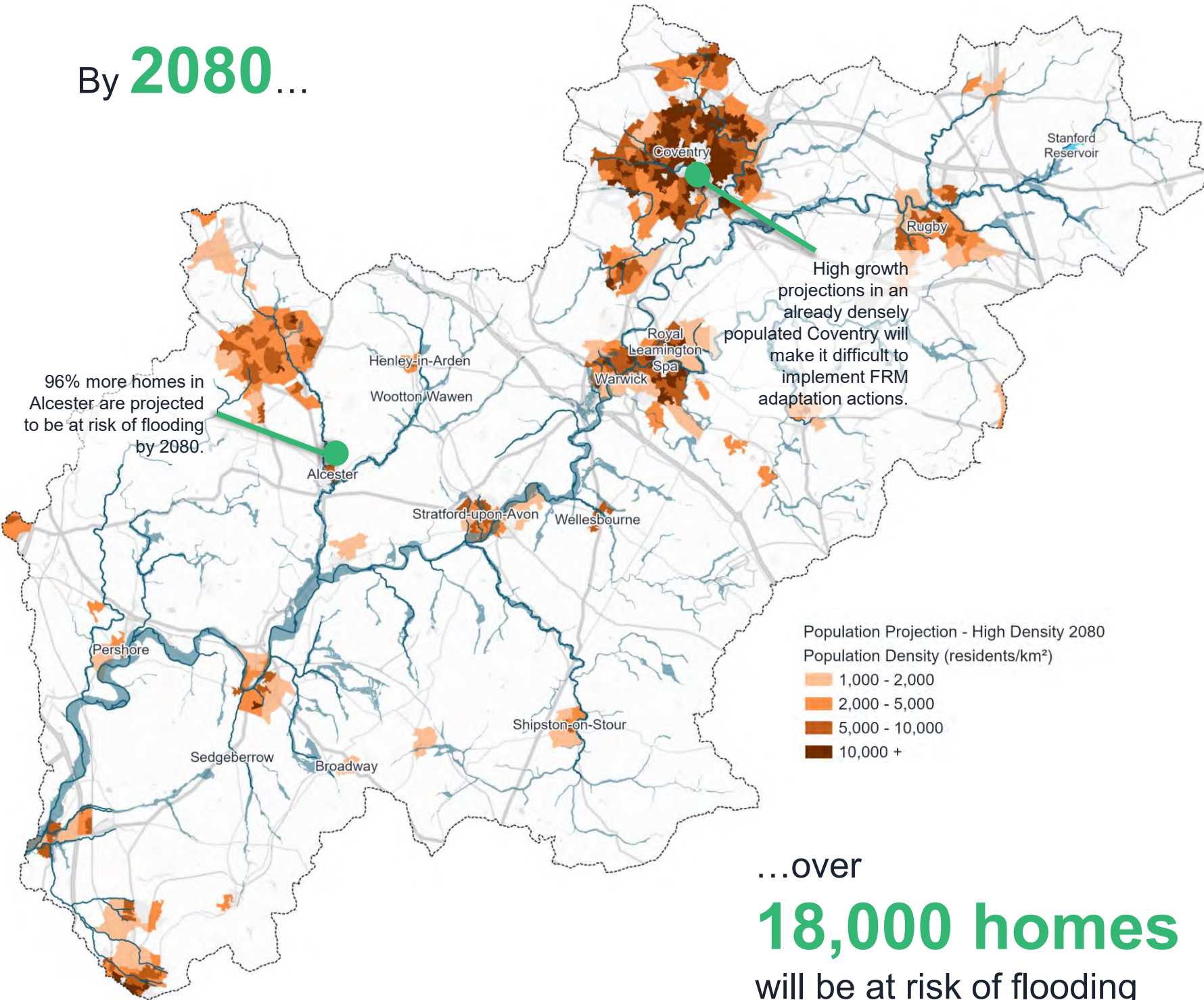
Number of residential properties at risk

2030	2050	2080
7,000	14,000	18,000

Opportunities

The urbanised nature of this focus area presents opportunities to co-deliver SuDS retrofitting schemes (e.g. alongside LLFAs) to intercept surface water before it enters capacity-constrained channels or the combined sewer system. With increasing growth, there are opportunities for sustainable housing development and water-resilient homes. Future planning reforms could ensure spatial planning complements flood risk management needs, whilst supporting improved regional connectivity.

By **2080**...





Agriculture

By **2080**...

Warwickshire Avon

Risks

For agriculture, there are significant changes in risk expected over time, with a projected 20% increase in ha of good to excellent quality agricultural land at risk of flooding by 2080. This high-quality land is essential to UK dairy and poultry production and supports international exports. Flooding of vital agricultural areas could disrupt food production and the transport of goods both regionally and nationally..

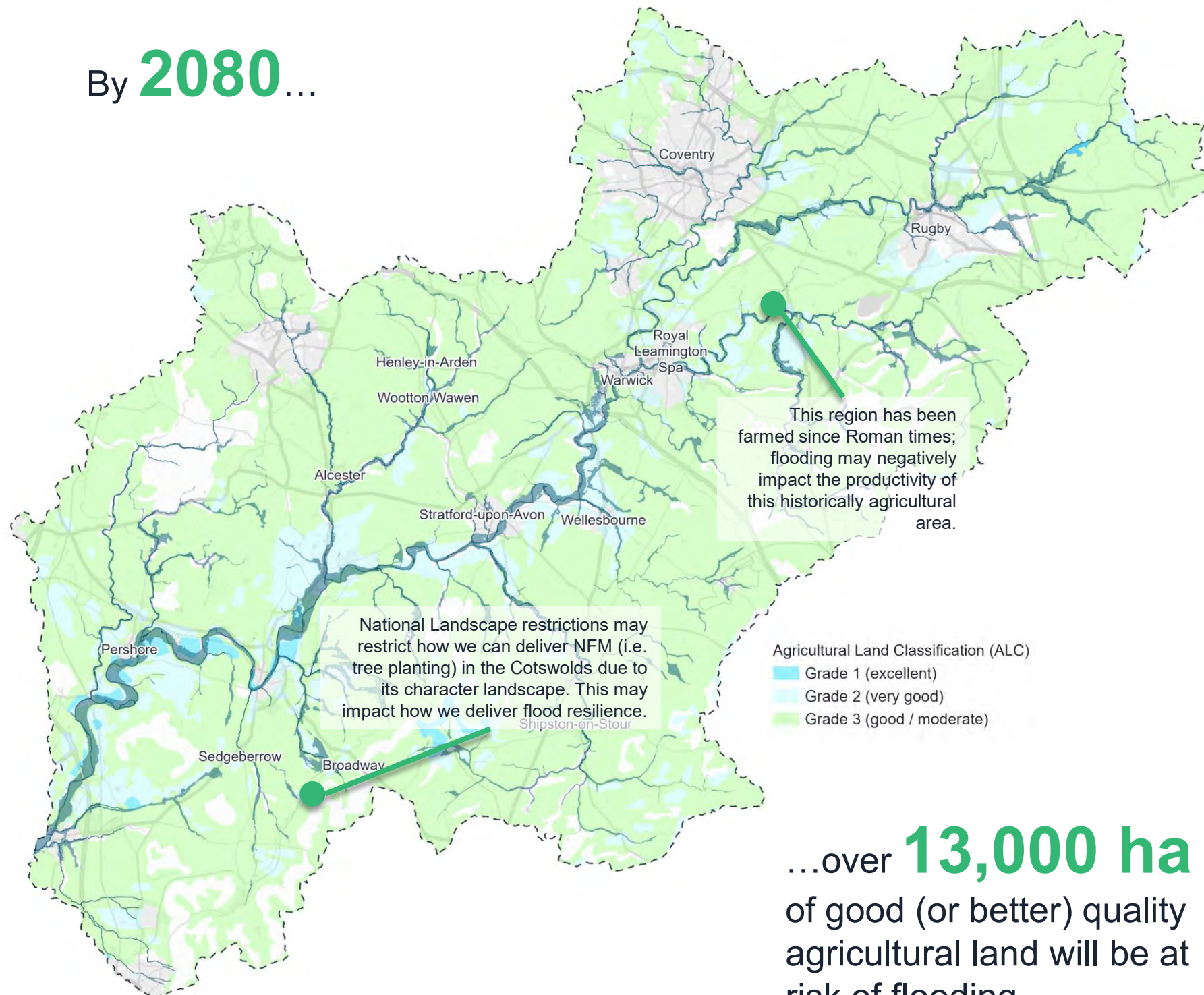


Ha of quality farmland at risk

	2030	2050	2080
	11,000	13,300	13,800

Opportunities

Future growth and climate pressures present opportunities to boost the agri-tech sector, e.g. the region could foster the development of pest and climate-resilient crops and farming techniques, supported by research from institutions like the University of Warwick. Adopting regenerative farming approaches and reinforcing historical agricultural traditions, such as refurbishing stone walls and re-establishing small farming parcels, can aid flood risk management and enhance agricultural sustainability.



...over **13,000 ha**
of good (or better) quality
agricultural land will be at
risk of flooding

Our insights from applying our approach are outlined below:



Trends & scenarios

- The use of scenarios was critical to enabling us to explore future uncertainties and identify 'low regrets' actions.
- A two-by-two scenario approach, as opposed to a more complex scenario development approach (e.g. morphological analysis involving multiple uncertainties, see Appendix B2), simplifies the development of future scenarios and keeps the level of decision-making around the adaptation pathways manageable.

Risks & opportunities

- The RSP key themes supported us to identify detailed changes in flood risk across the catchment. From this we could identify key risk hotspots, understand local impacts and opportunities under different futures, and form our actions in response.
- A dedicated data collection phase is essential to developing a comprehensive, robust evidence base. Due to the absence of strategic-scale models, local models were combined to create an overall view of flood risk. This was time-consuming and the varying spatial coverage, quality, and climate change projections led to several assumptions. We were only able to reliably predict a high climate change scenario through to 2080 (rather than 2100).

Hotspots

- The draft catchment statements within the environmental requirements aided in drawing out specific environmental risks and opportunities.
- Flood risk across the focus areas is complex. The identification of hotspots enabled us to determine key locations with higher current and future risks, around which we could target responses. Our approach involved using local models alongside local expert input, reinforcing the need for local knowledge in spatial planning.



Step 3

Adaptation Actions

Overview

Developing adaptation actions is a vital step in the adaptation pathways process. They represent the actions that respond to the current and future risks, and opportunities, and form the building blocks of the adaptation pathways.

This chapter sets out our approach to identify and appraise portfolios of adaptation actions through the following sections:

- Introduction & methodology.
- The Benefits Toolkit – developed to support strategic option appraisal.
- Portfolio summaries.
- Portfolio feasibility.
- Action development.
- Portfolio appraisal.

How should sustainability be considered at this step?

- Develop a long list of adaptation actions considering sustainability objectives, issues and opportunities.
- Incorporate sustainability objectives into your assessment of the adaptation actions to inform your shortlist of actions.



For the adaptation actions step of the adaptation pathways process, we have applied the following approach:



What are adaptation actions?

Adaptation actions are our responses to key risks and opportunities. In the context of the Severn 2100+, they are strategic, flexible, and structured measures designed to mitigate fluvial flood risk, whilst leveraging opportunities to enhance landscape and environmental resilience (e.g. habitat creation, carbon sequestration, etc.). Adaptation actions are the building blocks of adaptation pathways.



Figure 21: Adaptation actions workshop with the RSP.

We drew on good practice, including CCRA3 [27], IPCC [28] and wider flood risk management adaptation projects (e.g. Fens2100 [29]), to develop a longlist of adaptation actions that could respond to fluvial flood risk management related risks and opportunities. We trialled, expanded, and subsequently refined this list with the RSP in a workshop setting (Figure 21), see Appendix C1 for details.

We categorised the longlisted actions into broad portfolios to enable development and appraisal of actions at a catchment-scale. We used a source, hazard pathway and receptor model to frame the adaptation action portfolios. Considering our system mapping, we looked beyond physical interventions to consider actions across broader systems that could impact our ability to achieve our ambitions (e.g. land-use, growth etc).



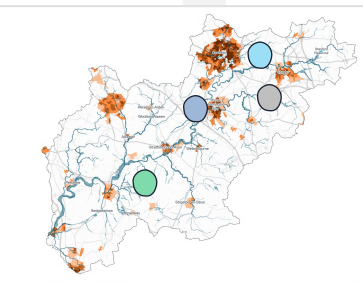
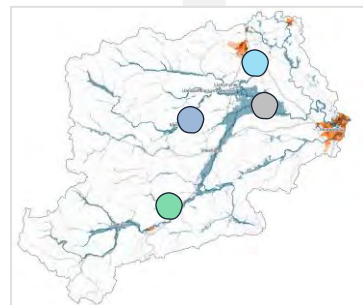
Methodology



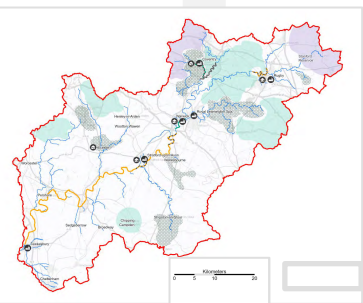
Environment
Agency



ARUP Jacobs
supported by



Feasibility
assessment



Option
development

We developed and assessed the feasibility of the portfolios of adaptation actions trialling two approaches across the focus areas, as outlined below, in Appendix C2:

Data-driven: Upper Severn

The Upper Severn currently has a robust, data-based water management scheme ongoing (the Severn Valley Water Management Scheme*, SVWMS). We used the initial project phase's outputs to inform our portfolio feasibility and performance assessment. Key steps we undertook included:

- Feasibility mapping: Using outputs of SVWMS's option feasibility assessment tool, we analysed the feasibility of delivering Working with Natural Processes (WwNP) and traditional flood storage areas (FSAs) using a range of criteria (including land use and topography).
- Option development: We identified actions' abilities to support peak flow mitigation, where applicable – based on hydrographs from an aggregate storage model.
- Option development: For localised, non-storage related actions, we manually identified flooding trigger points at hotspot locations and compared these to existing assets and local topography to inform action feasibility and performance.

Expert-driven: Warwickshire Avon

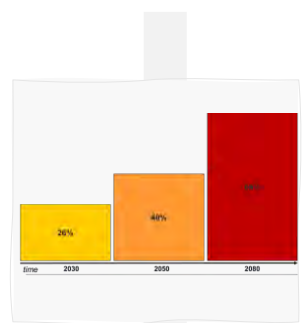
The Warwickshire Avon does not currently have an ongoing catchment-wide scheme. We therefore took a more qualitative approach to inform portfolio feasibility and performance, with the input of local experts. Key steps we undertook included:

- Feasibility mapping: EA Place Managers inputted into the identification of ongoing schemes (e.g. Arrow & Alne NFM [\[30\]](#) feasibility study, Nature 4 Water [\[31\]](#), etc.) and considered opportunities for further actions. This informed high-level adaptation action feasibility maps.
- Option development: The feasibility mapping informed indicative scales of deployment of actions. Land-use types were classified and an indicative storage potential was assumed (based on existing schemes) to inform potential downstream peak flow mitigation.
- Option development: For localised, non-storage related actions, analysis was undertaken as per the Upper Severn.

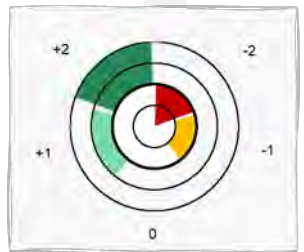
**Note: Analysis undertaken for the Upper Severn is based on the 2023 SVWMS Strategic Study. The outputs presented do not form part of the emergent SVWMS Strategy.*



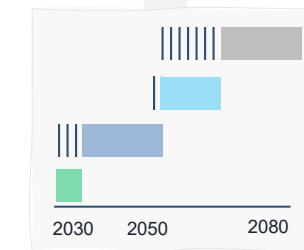
Methodology



Performance assessment



Portfolio appraisal



Adaptation pathways

To appraise the performance, cost and benefits of the portfolios of actions, we developed a decision-making framework that considered the following criteria:

Performance

- Peak flow mitigation: We considered the maximum peak flow mitigation potential anticipated during a 1-in-100 year event, at the focus area's outlet, from widespread implementation of applicable portfolios.

Cost

We identified the relative scale of capital costs required to deliver and maintain a portfolio. These ranged from £ (e.g. land use change) to £££ (e.g. flood storage area implementation).

Benefits

We applied a Benefits Toolkit, described overleaf to assess the benefits of each portfolio.

Adaptation considerations

- Lead time: the lead time required to deliver a portfolio (ranging from low to high (i.e. 5 to 20 years)).
- Lifespan: the overall lifespan of a portfolio once implemented (ranging from short to long (i.e. 30 to 100 years)).
- Adaptability: considers how adaptable a portfolio can be over time to ensure no / low regrets spending.

Environmental considerations and Sustainability Appraisal

Sustainability objectives were identified as part of the development of 'catchment statements' based on an initial, high-level environmental review. This identified key issues in each catchment. We identified the ability of the portfolios of actions to mitigate these, see Figure 22. Note that if we were doing a full SA, the SA framework would be used to help guide the development of the adaptation actions and test their suitability.

We developed a series of scorecards for each portfolio in both focus areas outlining their place-based performance in an accessible form, see Appendix C4. These were used in the pathway building workshops.

The portfolios form the building blocks for the adaptation pathways, enabling us to respond to risks and unlock place-based opportunities to promote holistic, catchment-wide resilience.

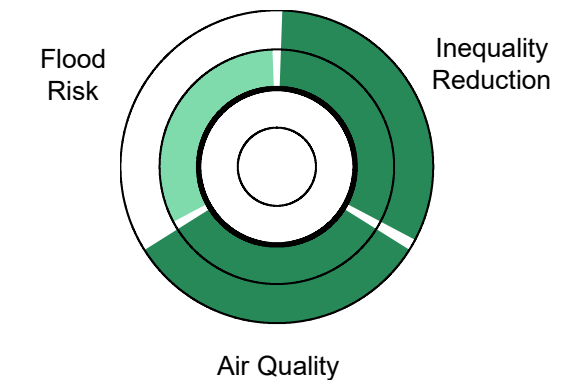
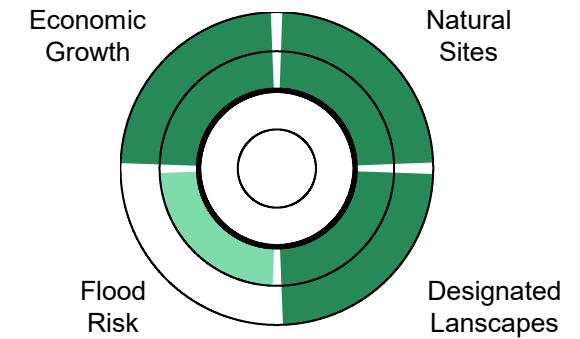


Figure 22: A graphic example outlining sustainability appraisal criteria for the Upper Severn (top) and Warwickshire Avon (bottom).



Benefits Toolkit

Benefits

We developed a Benefits Toolkit to assist the strategic appraisal of the adaptation portfolios and pathways. The Benefits Toolkit employs a framework that considers impacts across the Six-Capitals and the RSP themes. A Six-Capitals approach considers wider forms of capital beyond just financial capital, to identify and capture the total impacts and benefits of actions. By aligning these to the RSP's key themes, actions can be appraised against their ability to support achieving the regional vision.

The toolkit also:

- Adopts the sustainability objectives identified as part of the development of 'catchment statements'. This allows pathways that had a greater contribution to the sustainability objectives to be prioritised.
- Identifies where benefits are supporting the goals of the Well-being of Future Generations (Wales) Act 2015 [\[32\]](#) and the EA2025 [\[33\]](#) goals.

For this high-level portfolio appraisal, a subset of the benefits from the Toolkit were qualitatively assessed drawing on RSP input.

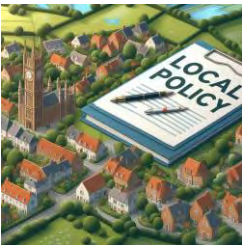
Table 3: Benefit Toolkit framework.

Capital	Benefits Toolkit assessment & related icon representing the RSP theme	
 Financial and manufactured capital Funds, physical infrastructure, assets owned by an organisation	Flood damages	
	Land use available	
 Natural capital Natural resources, energy, renewable and non-renewable materials, processes and ecosystem services	Biodiversity	
	GHG emissions	
	Water quality	
	Water for use	
	Agricultural land	
 Human and intellectual capital People's health & wellbeing, engagement, organisational data, innovation, productivity	Health and wellbeing	
	Critical infrastructure	
 Social capital Relationships with people, equality, trust, opportunity	Economic growth	

Portfolio summaries

Portfolios of actions

Portfolios of actions are groups of aggregated adaptation actions. Those we considered as described below, more information around these portfolios can be found in Appendix C.

Enablers		Source	
	Policy Actions that enable a joined-up approach to FRM. These interventions include the consideration of FRM in national and regional planning, reform of long-term FRM funding and financing mechanisms, and FRM governance to enable a joined-up approach.		Upstream Storage: NFM NFM helps to manage flood risk by protecting, restoring and emulating natural processes. This portfolio includes NFM land use changes and the restoration of rivers' natural hydrological regime through restoration, asset removal and floodplain reconnection.
	Behaviour Actions that enable a community and organisational resilience. These interventions include improved personal resilience and response to flooding and information sharing across borders.		Upstream Storage: Artificial Artificial upstream storage provided through man-made flood storage areas (FSAs), reservoirs, and managed agricultural washlands delivered across sub-catchments. These interventions can vary widely in scale and storage provision.
More information on the enabling portfolios can be found in the Planning for Implementation chapter.			Urban Source Control: Urban SuDS / BGI Widespread incorporation of Sustainable Urban Drainage Systems (SuDS) (or Blue Green Infrastructure (BGI)) in urban environments to manage surface water runoff and water quality.
			Urban Source Control: Property Level SuDS / BGI This portfolio includes Sustainable Urban Drainage Systems (SuDS) (or Blue Green Infrastructure (BGI)) undertake at a property level.
Key			
Policy Enablers Behaviour Enablers		Working with Natural Processes Grey Solutions Asset Management	



Portfolio summaries

Portfolios of actions (continued)

Hazard Pathway



In-Channel Measures: NFM

Natural Flood Management (NFM) helps to manage flood risk by protecting, restoring and emulating natural processes. This portfolio includes in-channel NFM measures that interrupt flow pathways resulting in temporary water storage to flatten and elongate peak river flows.



In-Channel Measures: Artificial

In addition to measures upstream, storage can be implemented at key points further downstream across the catchment. Alongside flood storage areas (as captured in the Upstream Storage portfolio), interventions can include bypass channels and offline storage areas.



Hard Defences: Permanent Linear

Permanent linear defences are typically constructed alongside watercourses in urban areas to protect people, property and infrastructure from the risk of flooding.



Hard Defences: Temporary Linear

Temporary flood defences are designed to be quickly deployed in pre-planned locations which do not have permanent defences.

Receptor



Property-Level: Property Flood Resilience

Property Flood Resilience is a set of modifications added to a building to lower its flood risk. It can reduce flood damage and speed up recovery after a flood.



Managed Realignment: Removal & Relocation

Managed realignment is a long-term strategy for managing land adjacent to watercourses and may result in the need for relocation of communities, properties, cultural sites, critical infrastructure and businesses.



Asset Management: Hydraulic Management

This portfolio includes hydraulic management of watercourses through assets such as sluice gates, pumping stations, barriers and barrages. These manage flood risk through providing temporary storage and managed release of water.



Asset Management: Review & Enhance

This portfolio includes the review and enhancement of existing assets across the catchment area to increase the existing resilience of FRM responses. This can inform whether new assets are required.

Portfolio feasibility

Upper Severn

This page sets out an overview of the different opportunities available in the Upper Severn. Detailed feasibility maps are being produced by the SVWMS and thus, are not presented here [\[34\]](#).

Upstream storage (NFM): There are widespread opportunities to deliver upstream storage via NFM including substantial areas of peat restoration and woodland planting.

In-channel measures (NFM): There is significant potential to deliver widespread in-channel measures throughout the Upper Severn focus area.

Asset management: There are opportunities for asset removal upstream of both Caersws and Meifod and asset management considerations at the confluence upstream of Shrewsbury.

Upstream storage (Artificial): There are pockets of opportunities across the catchment to deliver a combination of engineered flood storage areas of varying scale.

In-channel measures (Artificial): There are multiple opportunities to deliver online storage and are incorporated as part of the Upstream Storage (Artificial) portfolio. Other measures such as offline storage may need to be considered under a severe climate change future (note: these measures have not been identified as part of this review).

Hard defences (Linear): Flood mitigation at the flood risk hotspots of Caersws and Meifod is becoming increasingly difficult over time. In Shrewsbury it's likely that through a combination of upstream storage and spatial planning, flood risk could be largely mitigated, and hard defences (linear) may be suitable in very localised areas in the long-term.

Urban Source Control: Opportunities around larger urban areas in the catchment (Shrewsbury) to deliver blue-green infrastructure such as SuDS to slow the flow of surface water into the watercourse.

Property Flood Resilience: Prioritising modifications added to a building to increase its flood resilience across flood risk hotspots (Shrewsbury, Caersws, Meifod, Welshpool, Meverley, Llanymyneck and Llansantffraid-ym-Mechain) should be considered.

Enabling actions (including behavioural and policy enablers) are presented in the Planning for Implementation chapter.



Figure 23: Photo of a runoff attenuation feature (i.e. Upstream Storage: NFM) in the Upper Severn focus area.



Portfolio feasibility

Warwickshire Avon

This page sets out an overview of the different opportunities available in the Warwickshire Avon. The map indicates where adaptation action portfolios could be applicable:

-  **Upstream storage (NFM):** The focus area is quite urbanised so there are pockets of opportunities across the catchment to restore regional, farming cultural heritage, wetland restoration, floodplain reconnection and other land use / management changes
-  **In-channel measures (NFM):** Daylighting the river in Coventry and along the stretch between Royal Leamington Spa and Warwick; and NFM features such as large woody debris and runoff attenuation features
-  **Asset management:** Reviewing the existing asset management regime through Rugby, and as part of the Avon Weirs and Sluices project running from Warwick down to Tewksbury
-  **Upstream storage (Artificial):** Above Coventry and Rugby, there are low-flow / abstraction restricted areas with opportunities for engineered flood storage interventions. Otherwise, the catchment is lowlying and likely not suitable for many additional engineered storage interventions.
-  **In-channel measures (Artificial):** The most notable opportunity relating to the movement of water in this focus area is the Severn to Thames transfer scheme which is a strategic water resources solution to move water from the Severn catchment to the Thames in times of drought [35].
-  **Hard defences (Linear):** Linear defences could be delivered along the river in the flood risk hotspots (Alcester, Stratford Upon Avon, Warwick, Rugby and Coventry) subject to individual feasibility studies.
-  **Urban Source Control:** Opportunities around larger urban areas in the catchment (Tewksbury, Rugby, Coventry, Stratford Upon Avon, Royal Leamington Spa and Warwick) to deliver blue-green infrastructure such as to slow the flow of surface water into the watercourse.
-  **Property Flood resilience:** Prioritising modifications added to a building to lower its flood risk across flood risk hotspots (Alcester, Stratford Upon Avon, Warwick, Rugby and Coventry) should be considered.

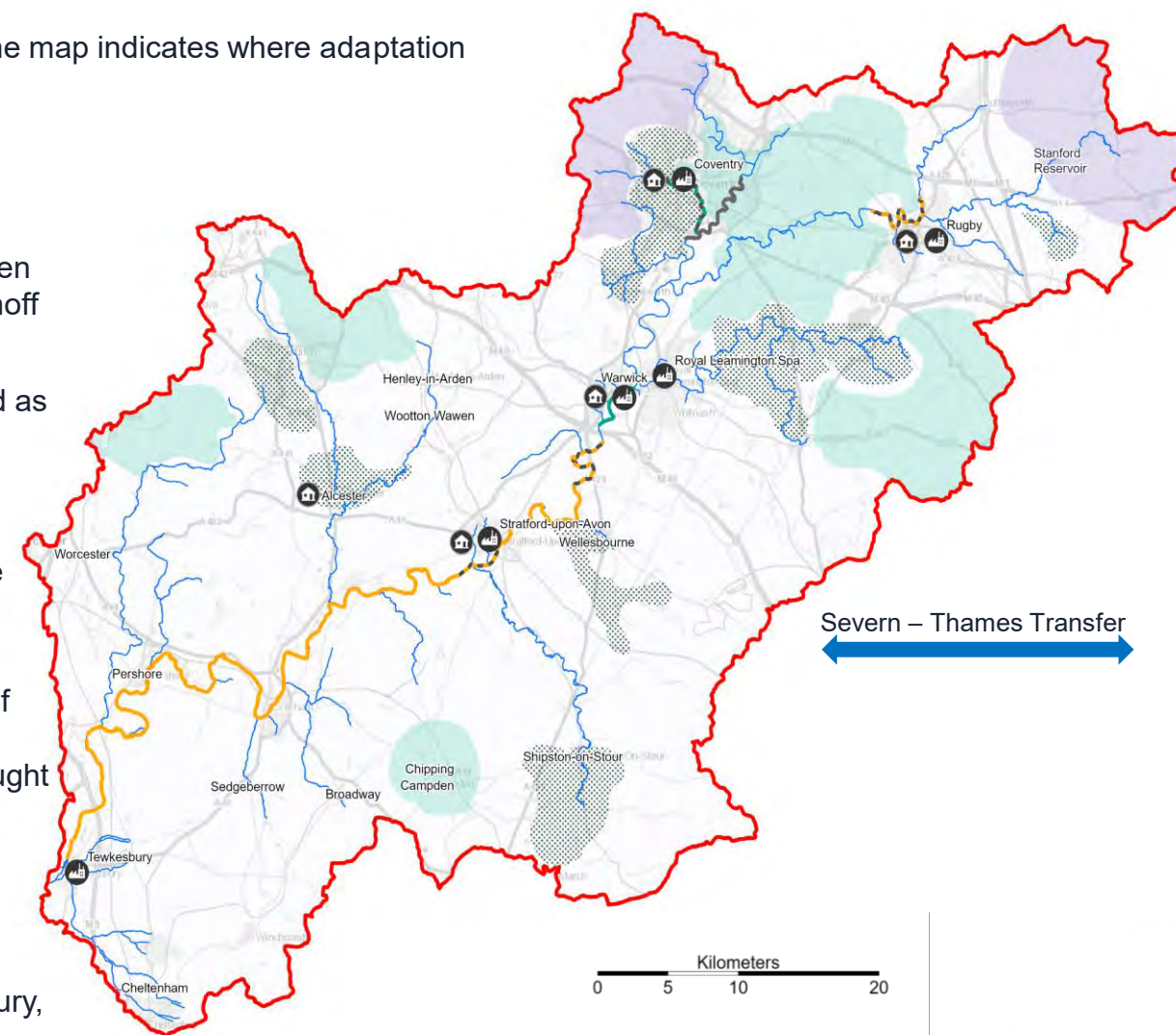


Figure 24: Map of the Warwickshire Avon focus area highlighting feasible portfolio distribution.

Enabling actions (including behavioural and policy enablers) are presented in the Planning for Implementation chapter.

Portfolio appraisal overview

Guide to the portfolio appraisals

A high-level summary of the portfolio appraisal is captured on the following pages, with full detail provided in Appendices C2 - C4.

Figure 25, illustrates the layout of the portfolio summary, which includes:

- Suitability and performance of portfolios across the focus areas – the performance has been indicatively RAG-scored to indicate the scale of performance in mitigating flood risk alongside the peak flow mitigation potential (where applicable). Please note that these values are indicative to demonstrate thinking and the adaptation pathways approach. Future work would be needed to refine these through localised feasibility studies and hydraulic analysis.
- Sustainability appraisal objectives & the wider benefits (i.e. Benefits Toolkit). Figure 26, illustrates how the outputs have been presented, with each block indicating the relative impact of each portfolio across the benefits.
- Costs – RAG-scored to indicate the relative scale of cost.

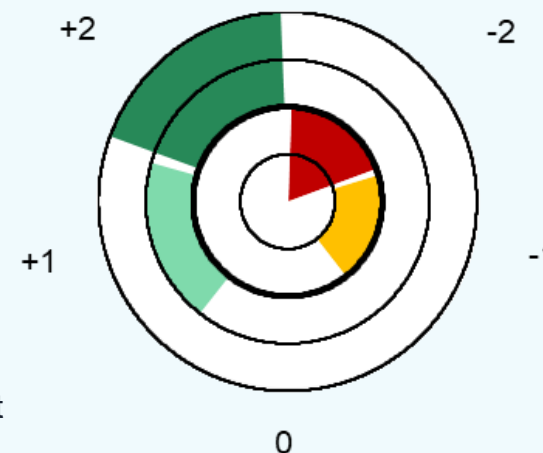


Figure 26: This diagram acts as a key to interpreting the benefits associated with the Benefits Toolkit and the SA objectives that are presented throughout this chapter.

Impacts range from -2 (very negative) to +2 (very positive) with 0 being the "base state" / neutral impact.

Portfolio	Performance & Suitability Upper Severn		Performance & Suitability Warwickshire Avon		Benefits Toolkit	Cost
Upstream Storage: NFM	 9% peak flow mitigation	Predominantly rural, especially in its headwaters. Significant potential to deliver widespread upstream storage opportunities through NFM.	 4% peak flow mitigation	Urbanised catchment. NFM is likely only feasible in smaller areas south and west of Rugby and upstream of Redditch.		£

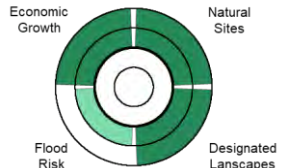
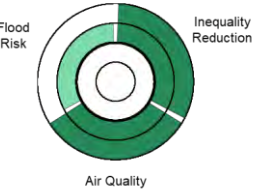
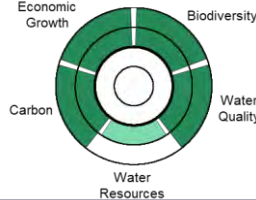
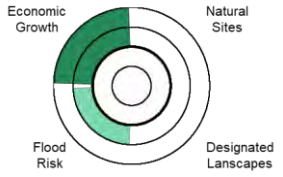
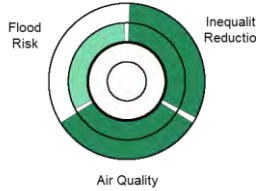
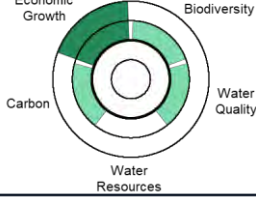
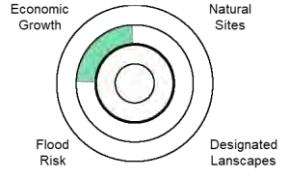
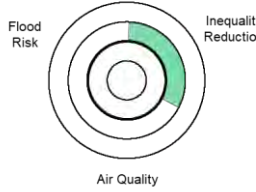
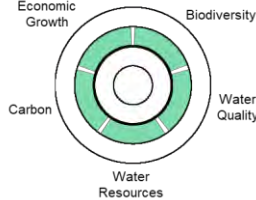
Figure 25: This figure represents the layout of the following Portfolio Summary slides, and a key to the RAG scoring has been outlined to the right. RAG scoring system is a universally recognised colour scheme, however when presenting to wider audiences, users should consider EDI.

Key		
Criteria	RAG Score	Symbol
Performance	High	
	Moderate	
	Minimal	
	Consider at discrete locations	
	Unfeasible	
Cost	Low	
	Medium	
	High	
Not Applicable / Not Assessed		

Portfolio Appraisals

This table presents a summary of the appraised Source portfolios. Detailed appraisal sheets for each focus area can be found in Appendix C4.

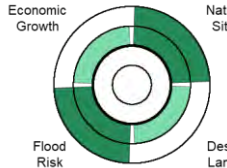
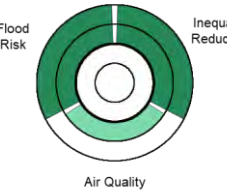
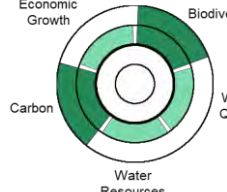
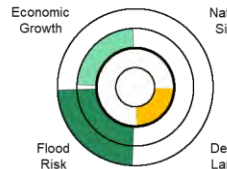
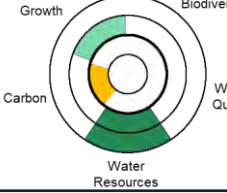
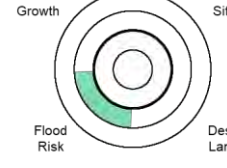
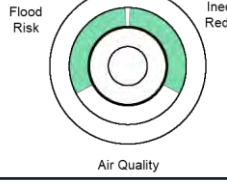
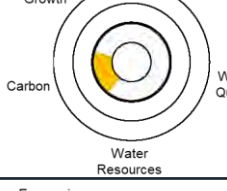
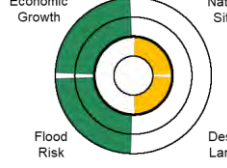
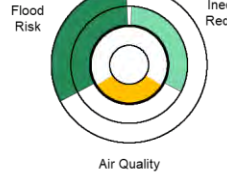
Table 4: Source portfolio appraisal including performance and sustainability scores from benefit toolkit and indicative cost.

Portfolio	Performance & Suitability Upper Severn			Performance & Suitability Warwickshire Avon			Benefits Toolkit	Cost
Upstream Storage: NFM	 9% peak flow mitigation	Predominantly rural, especially in its headwaters. Significant potential to deliver widespread upstream storage opportunities through NFM.		 4% peak flow mitigation	Urbanised catchment. NFM is likely only feasible in smaller areas south and west of Rugby and upstream of Redditch.			£
Upstream Storage: Artificial	 49% peak flow mitigation	Predominantly rural, especially in its headwaters. Significant potential to deliver engineered storage opportunities.			There are a few opportunities upstream of Coventry and Rugby for engineered flood storage interventions; the rest of the focus area is urbanised and low-lying and likely not suitable for engineered storage opportunities.			£
Urban Source Control: Urban SuDS	 1% peak flow mitigation	Predominantly rural catchment; meaning there is limited applicability outside of large urbanised centres, such as Shrewsbury. Supports mitigation of local surface water flooding.		 3% peak flow mitigation	Ample opportunity to incorporate Urban SuDS across the area as it's an urbanised catchment.			£
Urban Source Control: Property-level SuDS	 1% peak flow mitigation	Property-level SuDS are applicable across both focus areas, wherever there are residences or buildings that can incorporate measures such as green roofs, rainwater storage, and permeable paving.		 1% peak flow mitigation	Property-level SuDS are applicable across both focus areas, wherever there are residences or buildings that can incorporate measures such as green roofs, rainwater storage, and permeable paving.			£

Portfolio Appraisals

This table presents a summary of the appraised Hazard Pathway portfolios. Detailed appraisal sheets for each focus area can be found in Appendix C4.

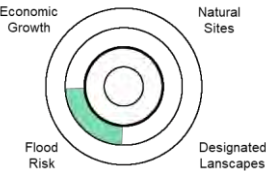
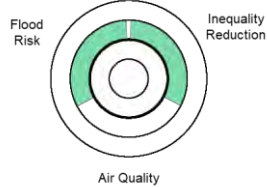
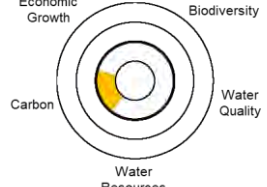
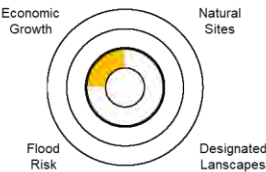
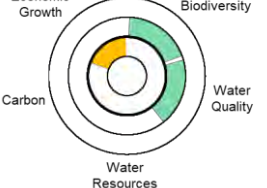
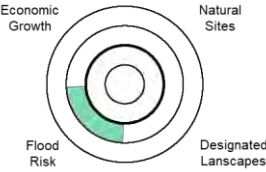
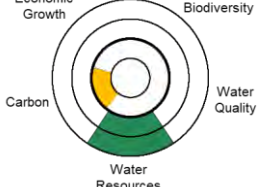
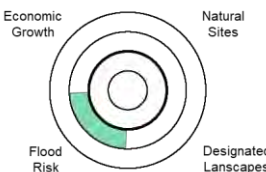
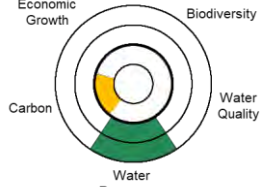
Table 5: Hazard pathway portfolio appraisal including performance and sustainability scores from benefit toolkit and indicative cost.

Portfolio	Performance & Suitability Upper Severn			Performance & Suitability Warwickshire Avon			Benefits Toolkit	Cost
In-Channel Measures: NFM	 15% peak flow mitigation	Predominantly rural, especially in its headwaters. Significant potential to deliver widespread in-channel opportunities through NFM.		 6% peak flow mitigation	Urbanised catchment. NFM is likely only feasible at a smaller scale.			£
In-Channel Measures: Artificial	 peak flow mitigation	There are ample opportunities to deliver offline storage opportunities, and these have been encompassed within the Upstream Storage: Artificial Portfolio.			Bypass channels or other innovative infrastructure may need to be carefully considered as to their applicability. Many culverts present opportunities for daylighting to increase conveyance.			£
Hard Defences: Temporary Linear	 feasibility	It becomes increasingly difficult in hotspot areas outside of Shrewsbury to defend from 2050.		 feasibility	It becomes increasingly difficult in hotspot areas to defend using linear defences from 2050 due to capacity constraints.			£
Hard Defences: Permanent Linear	 feasibility	It becomes increasingly difficult in hotspot areas outside of Shrewsbury to defend from 2050.		 feasibility	It becomes increasingly difficult in hotspot areas to defend via linear defences from 2050 due to capacity constraints.			£

Portfolio Appraisals

This table presents a summary of the appraised Receptor portfolios. Detailed appraisal sheets for each focus area can be found in Appendix C4.

Table 6: Receptor portfolio appraisal in performance & sustainability, scores from benefit toolkit and indicative cost.

Portfolio	Performance & Suitability Upper Severn			Performance & Suitability Warwickshire Avon			Benefits Toolkit	Cost
Property-Level: Property Flood Resilience		Property flood resilience measures can be applied across both focus areas, to residences or buildings that are at high risk of flooding.			Property flood resilience measures can be applied across both focus areas, to residences or buildings that are at high risk of flooding.			£
Managed Realignment: Removal & Relocation		Managed realignment may need to be considered across both focus areas at varying scales, in the long-term.			Managed realignment may need to be considered across both focus areas at varying scales, in the long-term.			£
Asset Management: Hydraulic Management	 feasibility	There are opportunities for asset removal upstream of both Caersws and Meifod to enable river restoration and increase conveyance. There are also asset management considerations at the confluence upstream of Shrewsbury.		 feasibility	Ample opportunity to examine the asset management regime of various weirs and sluices, to be explored through the Avon Weirs & Sluices FBC.			£
Asset management: Review & Enhance	 feasibility	There is a need to review existing assets to determine if enhancement would enable FRM resilience.		 feasibility	There is a need to review existing assets to determine if enhancement would enable FRM resilience.			£

Our insights from applying our approach are outlined below:



Longlist

Portfolio assembly

Portfolio appraisal

- Stakeholder input, through the RSP was invaluable to refining an appropriate list of actions. Their inputs informed which adaptation actions were relevant to the local context and offered best value for local communities and the environment.
- Physical portfolios cannot enable holistic, catchment-wide resilience alone. We need broader enabling actions (e.g. policy, behaviour) to unlock portfolio delivery and enable catchment-wide resilience.
- An expert-driven approach can support in making preliminary decisions in locations where data and/or modelling information is scarce. These provide a good starting point for further refinement. However, a data-driven approach provides a greater level of detail and robustness in the scale, location and performance of actions. The lead-in time for the adaptation actions needs to account for catchment-wide studies being undertaken.
- Our broad appraisal criteria allowed us to identify key considerations to enable the formation of the adaptation pathways and understand the total impact (including environmental and social impacts) of our interventions. This supports identifying opportunities for co-funding.
- Aligning the assessment of option benefits to the regional vision's themes, through the Benefits Toolkit, enabled us to consider how actions would support the regional vision, providing a line-of-sight from ambition to delivery.
- The Benefits Toolkit allowed us to systematically and strategic quantify the scale of benefits for adaptation portfolios.



Step 4

Adaptation Pathways

Overview

This step involves the development and appraisal pathways of adaptation portfolios, including exploring how actions are influenced by different future scenarios (i.e. 'stress-testing' pathways). From this, an emerging adaptation pathway is formed. This is a fundamental part of the adaptation pathways approach, which brings together insights from the previous steps to inform flexible route-maps for enabling regional resilience and adaptation.

This section contains the following:

- Our methodology for the development of the pathways, including a collaborative workshop approach.
- An overview of the candidate pathways and the development of an emerging pathway for each focus area which outlines the preferred way forwards.
- Stress-testing of the adaptation pathways to different future trends.
- Insights.

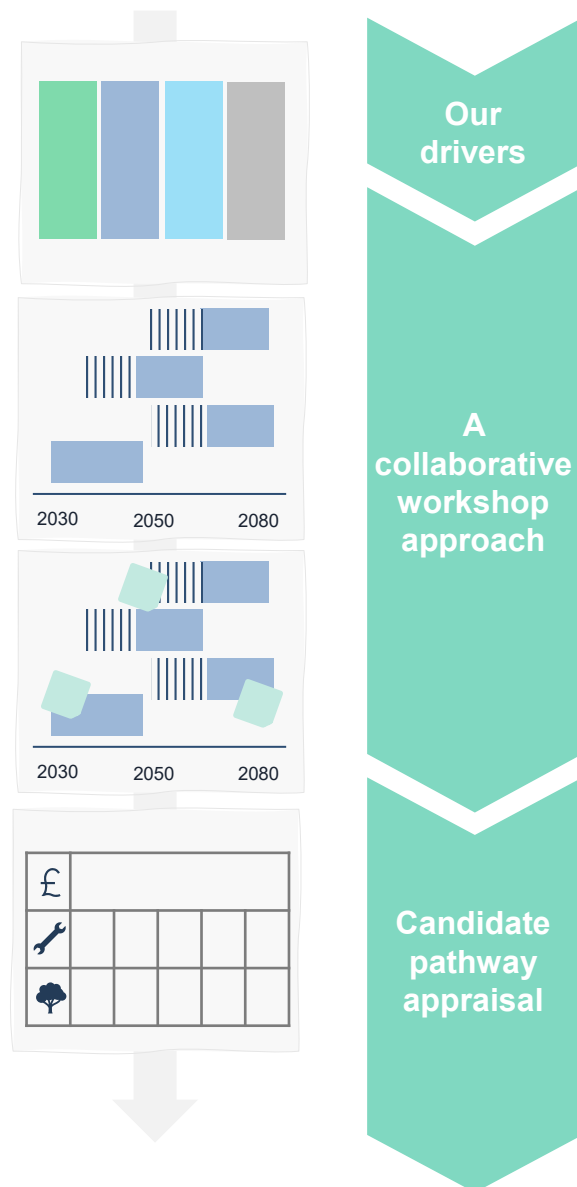
How should sustainability be considered at this step?

- Appraise adaptation actions and assess reasonable alternatives to form adaptation pathways.
- Produce and consult on an Environmental Report and a Statement of Environment Particulars outlining how feedback provided during consultation has been considered.



Methodology

For the adaptation pathways step, we have applied the approach outlined below. Further information is available in Appendix D.



Our key driver was to develop pathways that achieve our ambitions to maintain or improve on current levels of flood risk in the face of future change, whilst supporting the regional vision of the Severn becoming Britain’s “most vibrant, resilient, and sustainable river network”.

We used a collaborative, workshop approach to inform pathway development. These workshops brought together catchment experts to consider how portfolios of adaptation actions could be sequenced to achieve our ambitions (see Appendix D1 for further detail). We looked at this through three lenses to develop three ‘candidate pathways’, each offering different outcomes for the region:

- Pathways which maximised **wider benefits** such as sustainability, whilst meeting objectives around managing flood risk.
- Pathways which enabled a **precautionary approach** by seeking to mitigate risks pro-actively.
- Pathways which were **cost constrained** whilst managing flood risks where possible.

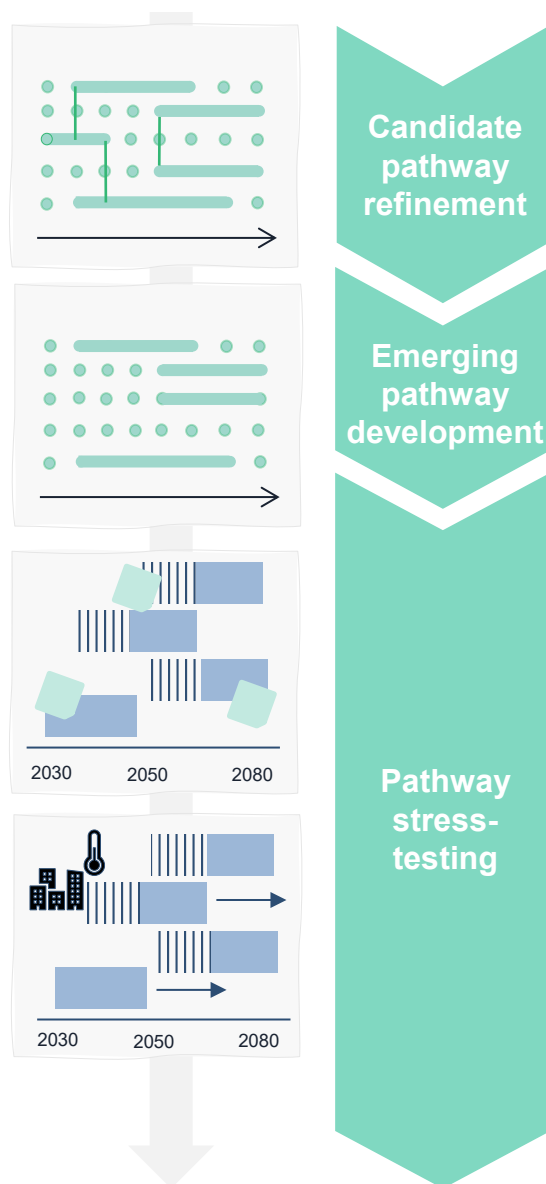
Participants were provided with portfolio cards (as presented in the Adaptation Actions chapter), which included quantitative and qualitative estimations of the portfolio’s impacts. Participants assembled the portfolio cards with the aim of mitigating peak flow uplifts across three epochs for a high-climate change scenario, aligning to DEFRA’s peak river flow climate change allowances [36]. They explored the interdependencies between actions, what would be needed to enable them and their potential lead-in times. They then stress-tested the pathways against future scenarios of low climate change and high and low growth.

We considered a range of appraisal techniques for the candidate pathways, including Real Options Analysis (ROA), Multi-Criteria Analysis (MCA), Robust Decision Making, etc. We determined MCA was most appropriate as it allows for the consideration of both quantitative and qualitative criteria, enabling a more holistic evaluation of adaptation options. This is particularly useful when dealing with complex issues like climate change, where multiple factors need to be considered. Whereas a ROA approach is more appropriate when assessing sequential decisions with associated probabilities - requiring much more robust data than currently available.

Using the workshop outputs, we applied an MCA, which incorporated our draft SA objectives, to determine which candidate pathway most closely aligns to the desired outcomes of the region (see Appendix D2). This pathway formed the backbone of the core pathway.



Methodology



Alongside the MCA, we explored the commonalities and differences between the candidate pathways – considering portfolio types, sequencing, and interdependencies. We used this analysis to draw out ‘low regret’ activities and key interdependencies between portfolios.

We compared the outputs of the Upper Severn and Warwickshire Avon, to understand how pathways are shaped by catchment risks, constraints and ambitions.

We refined our preferred candidate pathway, by considering our analysis above, e.g. low regret activities, portfolio interdependencies, and enabling activities. We trialled the emerging pathways with local EA place managers and the RSP, to further refine them - incorporating feedback and place-based considerations. A detailed supporting delivery framework is available in Appendix D3.

To consider changing influences and external pressures, we stress-tested the emerging adaptation pathways against our key trends and scenarios. We considered how sequencing, timings, delivery, and performance of portfolios may change.



Climate Change

In the pathway building workshop, the initial exercise focused around developing responses to a high climate change future (RCP 8.5) and associated peak river flow uplifts [\[37\]](#).

We ‘stress-tested’ this to draw out what changes may be required under a low climate change future (RCP 4.5). Within this scenario the pace of increasing flood risk is slower.

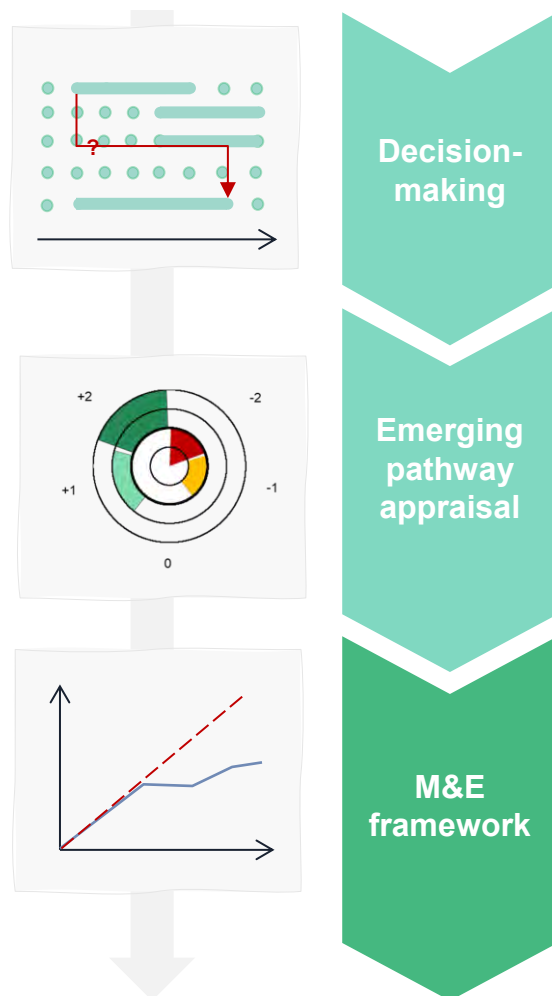


Growth

Growth projections across the Severn region are not uniform there is significant uncertainty in future growth patterns. Using our scenarios, we considered:

- A low growth future – with a slow (or negative) population growth and a more dispersed population across the catchment.
- A high growth future – with increased urbanisation and housing demand leading to more pressure on land for development and food security.

Methodology



The underlying decision-making framework (as layered onto the annotated pathways) draws out the key questions required for portfolio delivery and informs what feasibility studies would be required. We then layered on the growth and climate change scenarios to stress test the emerging pathways under a range of plausible futures. Note as part of making decisions, future studies should incorporate a Sustainability Appraisal and associated consultation of options.

We deployed the Benefits Toolkit and undertook a high-level economic appraisal of the emerging pathways. This allowed us to indicatively consider the economic viability of the proposed pathways. Due to the availability of information, we focused the appraisal around the high-climate change emerging pathway.

Developing the emerging pathways has identified interdependencies between actions and questions to be answered ahead portfolio delivery. These questions have informed the indicators, triggers, and thresholds along the pathways within the M&E framework.

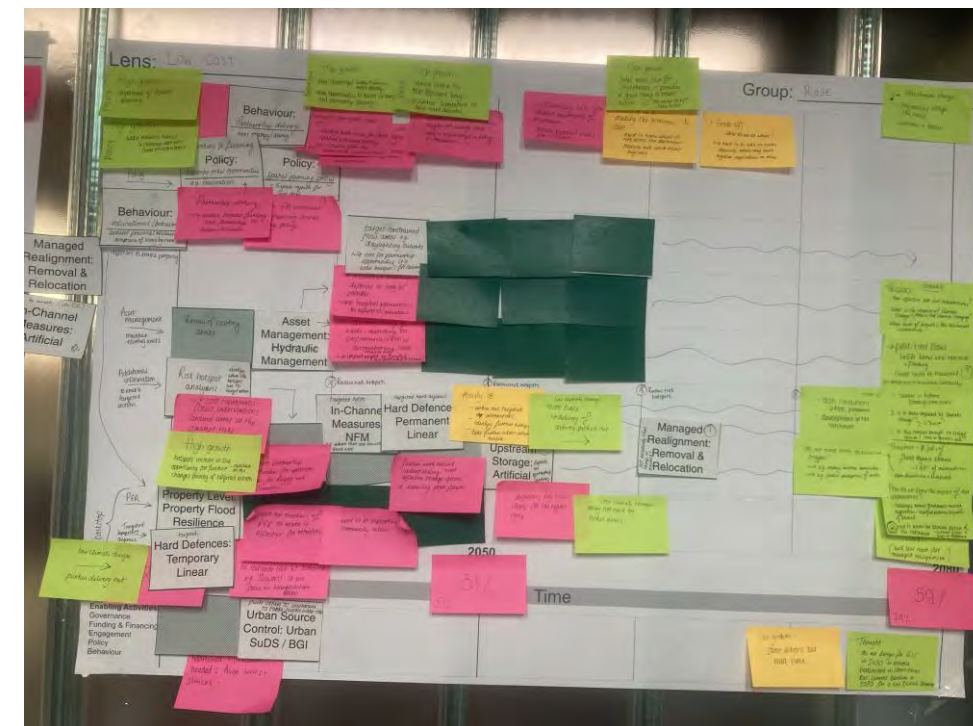


Figure 27: Workshop outputs of a stress-tested candidate pathway annotated with anticipated changes against growth (post its) and climate change (arrows).



Candidate pathway appraisal

Multi-Criteria Analysis

This page presents the workshop candidate pathway outputs assessed using a qualitative MCA aligned to the RSP themes, see Tables 7 and 8.

We determined the **wider benefits* candidate pathways** align most closely to the vision for the Severn catchment and the draft SA objectives for the focus areas. This candidate pathway formed the foundation of the emerging pathway for each focus area, which was refined further as described in the methodology. Notably, practitioners should consider their own regional ambitions and contexts to determine the preferred candidate pathway.

Criteria	RAG Score	Symbology
Appraisal	Very positive	
	Likely positive	
	Neutral	
	Likely negative	
	Very negative	

Table 7: Appraisal of the Upper Severn candidate pathways – refer to Appendix D2 for further details.

Lens	Cost	Pathway outcomes aligned to the RSP Themes						
Wider Benefits	£ monetary cost	economy	using the river	people	agriculture	flooding & drought	environment	housing
Precautionary	£ monetary cost	economy	using the river	people	agriculture	flooding & drought	environment	housing
Cost Constrained	£ monetary cost	economy	using the river	people	agriculture	flooding & drought	environment	housing

Table 8: Appraisal of the Warwickshire Avon candidate pathways – refer to Appendix D2 for further details.

Lens	Cost	Pathway outcomes aligned to the RSP Themes						
Wider Benefits	£ monetary cost	economy	using the river	people	agriculture	flooding & drought	environment	housing
Precautionary	£ monetary cost	economy	using the river	people	agriculture	flooding & drought	environment	housing
Cost Constrained	£ monetary cost	economy	using the river	people	agriculture	flooding & drought	environment	housing



Emerging pathways

The following sections describe the emerging core pathways developed for the Upper Severn and Warwickshire Avon focus areas, including:

- A supporting narrative;
- ‘Stress-testing’ of the pathways for climate change and growth scenarios; and
- A high-level economic appraisal.

How to read the adaptation pathway diagrams

The diagram (Figure 28) opposite identifies the symbology used across the pathways. They are presented as a waterfall timeline – meaning they should be read from:

- **Top to bottom** - informing portfolio sequencing; and
- **Left to right** - informing portfolio delivery timelines.

Each lightly shaded node represents an approximate **5-year period**. Each solid node indicates a change (e.g. the start of delivery) in the portfolio’s state

Each portfolio has been characterised by its overarching **intervention type**, which is indicated by the colour of each portfolio:



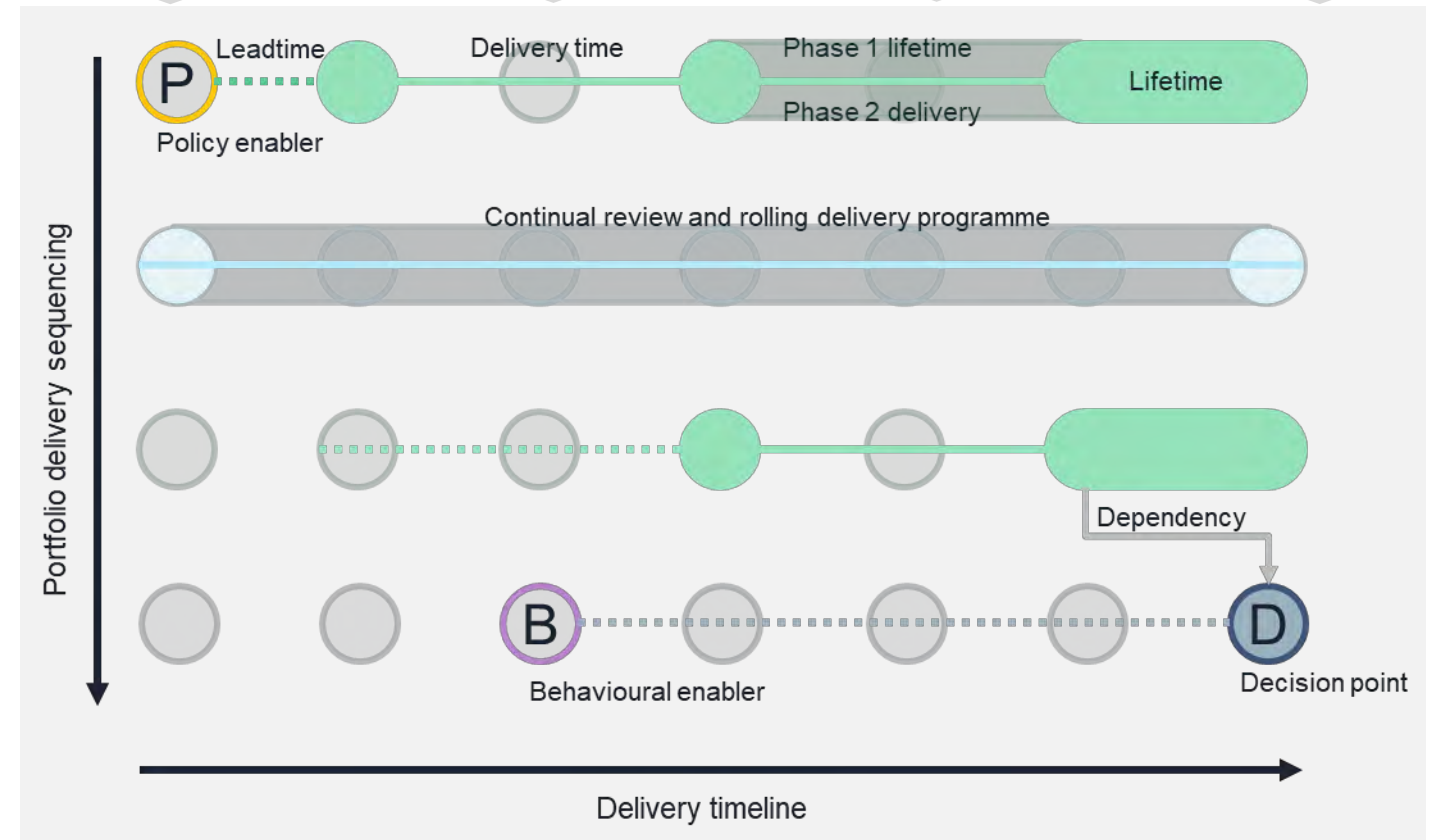
Commentary, wider considerations, and dependencies are identified for each portfolio.

Leadtime: Time required ahead of portfolio delivery, including feasibility assessments, public consultations, permitting, planning, and design.

Delivery time: Period required to construct and deliver the intervention. The delivery start time is denoted by a solid node.

Phased delivery: Some portfolios will be delivered in a phased manner, over time so benefits will be realised incrementally, represented by the transparent bar.

Lifetime: This solid bar represents the time from which the entirety of the portfolio is delivered and is effective (i.e., providing its full benefits and flood risk mitigation potential).



Enabling activities: Yellow nodes indicate policy enablers, and purple nodes indicate behavioural enablers that are required to deliver a portfolio under the presented timeframes.

Dependency: Arrow showing how one portfolio will influence the delivery of another portfolio, drawing out the decision-making process and considerations required.

Continual review and rolling delivery programme: A solid delivery line over time indicates that the implementation of these adaptation actions are continually re-assessed and delivered, aligning to the monitoring & evaluation framework.

Figure 28: Symbology used across the pathways presented throughout this chapter.



Emerging pathway

Upper Severn

The emerging pathway for the Upper Severn builds on the foundations of the ongoing **Severn Valley Water Management Scheme** (up to 2050) to enable flood resilience to 2100. The pathway involves:

- Initial actions focus around understanding the **existing condition of assets** and their performance over time. This informs a rolling asset management and enhancement programme influencing where actions are required (i.e. enhancing permanent linear defences to complement broader actions).
- The Upper Severn's agricultural landscape offers opportunities for **upstream storage** to mitigate downstream risks through **Working with Natural Processes (WwNP)** and **artificial storage** (i.e. Flood Storage Areas (FSAs)). These are prioritised in the short-term as no / low regrets activities:
 - Due to the wider benefits that WwNP portfolios provide, these were prioritised for delivery.
 - FSAs are planned in a two-phased approach to optimise upstream storage, whilst enabling flexibility to future external changes and the performance of WwNP measures.
- **Policy enablers** are essential for fast-tracking WwNP delivery, enabling widespread adoption, and streamlining planning and permitting.
- **Behavioural enablers** are essential for building community and personal resilience through education and engagement, improved communication of flood risk and warnings, and enabling regional, co-ordinated action.
- **Permanent linear defences** have limited applicability across the Upper Severn in the short-term. However, in the long-term, these portfolios may be able to “top up” flood resilience across the focus area by complementing the upstream storage provided through WwNP and FSAs portfolios.
- Finally, **managed realignment** is considered as a last resort in limited locations if flood risk management fails under future climate scenarios.

Further modelling and analysis is needed to refine the emerging pathway. This is recommended for future iterations. More information is available on the approach in Appendix D3.





Stress-testing

Upper Severn



Climate change

Low climate change (RCP4.5) considerations

Due to the substantial flood risk still projected in a low climate change future, many of the portfolios are still likely to be required. However, in the Upper Severn, our dependence on engineered solutions in the long-term is likely to be much lower. Under a low climate change future, it is likely that flood risk could be largely managed through WwNP, land-use management, and flood resilient planning. Permanent linear defences, Phase 2 of FSA delivery, and managed realignment may not be necessary.



Growth

High growth considerations

- Growth across the region may put increasing pressure on existing tensions around land-use and emphasises the need for a joined-up, catchment-scale land-use management approach.
- Flood resilient growth is reliant on decisions around long-term land use (i.e. earmarking land for flood risk management in the long-term), spatial planning and building standards. These decisions should influence future development to avoid increasing future risks. Enabling activities (e.g. local planning reforms) to support these long-term decisions are vital to mitigating risks.

Low growth considerations

- Opportunities are presented around land-use change and having the space to deliver flood risk management, environmental benefits and support UK food security.
- Reduced development may provide challenges around achieving positive BCR schemes.
- Managed realignment may not be required, or may be undertaken at a reduced scale.



Upper Severn: Low Growth



Please click on the buttons below to reveal each layer of the pathways.

- High Climate Change Scenario
- High Growth Scenario
- Low Climate Change Scenario
- Low Growth Scenario



Economic appraisal

Upper Severn

A high-level economic appraisal using the Benefits Toolkit has been undertaken for the Upper Severn emerging core pathway, relative to indicative Do-Nothing and Do-Minimum baselines (informed by SVWMS Economic Appraisal (2023)). We considered a 100-year appraisal period and that benefits are realised when portfolios are delivered across the indicated epochs (i.e. 2030, 2050, and 2080). The findings are described below.

Table 9: High-level appraisal assessment summary for the Upper Severn focus area.

Scenario	Damages (£k)	Benefits (£k)	Costs (£k)
Do Nothing	1,137,000	-	-
Do Minimum	461,000	675,300	-
Do Something (i.e. Emerging pathway for a high-climate change scenario)	279,000	857,800 Wider environmental benefits could range £350,000k+, which if included would result in benefits of £1,200,000k+. This value should be refined further based on ongoing work by Shropshire Council.	468,600 Costs are based on the SVWMS only. This is conservative, but indicates a BCR of 1.8.

Limitations:

- The SVWMS and the RS APP have utilised different approaches (i.e. WAAD and MCM Depth-Damage Curves), thus, comparative values are highly indicative.
- The SVWMS considered benefits and damages associated with downstream reaches of the Upper Severn focus area, whereas this analysis has only identified damages and benefits resulting from inside the catchment boundaries.
- Highly indicative assumptions have been made around portfolio performance, as compared to the SVWMS initial outputs (no modelling of the pathway has been done to confirm performance). As such, this analysis presented is a high-level assessment.

Benefits

For the emerging pathway



Risk to 130 commercial & industrial properties mitigated



Risk to 50 public buildings and services mitigated



Risk to 1,700 ha of farmland mitigated



Risk to 70 ha of environmental designated sites mitigated



Risk to 1,600 residential properties mitigated

£ 858m



Emerging pathway



Environment
Agency



River
Severn
Partnership

ARUP supported by
Jacobs

Warwickshire Avon

The Warwickshire Avon presents a diverse, partially-urbanised focus area with low-lying topography. The catchment's characteristics and constraints (e.g. land use, topography, hydrology, etc.) lead to a complex picture of flood risk. As a result, a **combination of measures is needed**, but they may not wholly solve the problem. Difficult decisions may lie ahead around where risk can and cannot be mitigated, and what land is used for what purpose.

Actions are explored across the upper, more rural reaches and in the more urbanised middle / lower reaches of the catchment:

Upper Reaches

Opportunities for **upstream storage are limited**. However, **initial actions look to maximise these opportunities where possible** and provide benefits to upper catchment locations (e.g. Coventry, Rugby and Alcester):

- Initial, short-term activities build upon ongoing schemes to widen their performance and impact (e.g. Arrow & Alne NFM feasibility assessment, Nature 4 Water, etc.).
- There are likely to be additional WwNP portfolios that are deliverable across the catchment (e.g. river re-naturalisation, washlands) along the River Stour and Badsey Brook.
- There are few locations across the focus area (due to land use, locations of population centres, and topography) to deliver formal flood storage areas. However areas in the northeast of the catchment may be suitable and improve flood resilience at Coventry and Rugby. Existing infrastructure (e.g. Draycote Reservoir) can likely be enhanced and optimised to maximise flood risk benefits.

Middle / Lower Reaches

Within the middle and lower reaches, an urbanised “belt” divides the focus area, hugging the watercourse from Rugby through down to Tewkesbury. This **restricts** what can be delivered. We have identified the following actions:

- Many of the flood risk hotspots are impacted by channel capacity constraints. As a result, localised **improvements to channel capacity** (including de-culverting opportunities) and **SuDS** (both property and urban) are prioritised in the short-term to manage contributing urban run-off into existing assets.
- Wider portfolios require significant lead times due to the complex nature of their delivery. Thus, they can only likely be delivered in the medium- to long-term. These could include a **combination of permanent linear defences, localised storage or bypass opportunities**, such as channel re-naturalisation and **washland delivery** (i.e. managed, temporary flooding of historic floodplains).

Due to the urbanisation along the majority of the length of the watercourse, it is **challenging to mitigate increasing flood risk**. If solving capacity constraint issues across focus area or delivering linear defences do not sufficiently mitigate flood risk in the area, we will need to consider whether our long-term ambitions align to moving the river, moving homes, or living with water.

The actions presented are emerging and will require further refinement through modelling and analysis. More information around the delivery framework of actions can be found on the following pages and in Appendix D3.



Stress-testing

Warwickshire Avon: Emerging Pathway



Climate Change

Low Climate Change (RCP4.5) Considerations

In a low climate change future, flood risk mitigation in the Warwickshire Avon can be more effectively managed as peak flow increases are slower. Notably:

- There is additional time to plan and deliver co-ordinated responses for positive regional outcomes whilst avoiding maladaptation.
- The sequencing of portfolios in the emerging pathway does not alter. However, the scale and urgency of the delivery of portfolios, that require more difficult decisions around land use change and managed realignment (e.g. washlands, managed realignment, bypass channels), may be reduced if sufficient flood risk can be mitigated through upstream and in-channel storage opportunities.

However, the risks remain complex, even under a low climate change future.



Growth

High Growth Considerations

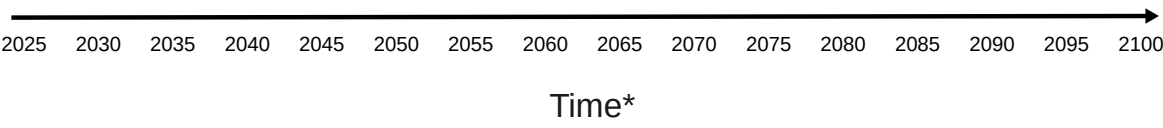
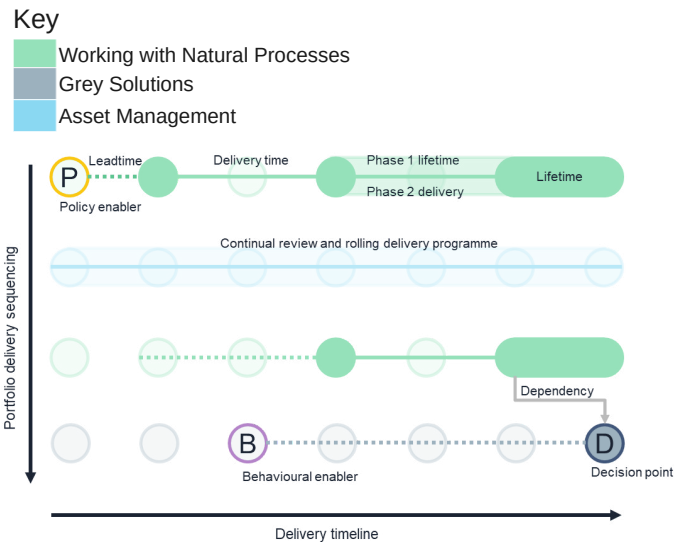
- Rural development may mean competing pressures on land-use for the delivery of NFM, washlands, and river re-naturalisation vs. growth and food security,
- Flood resilient growth is reliant on decisions informing long-term land use, spatial planning and building standards to influence future development and avoid increasing future risks. Enabling activities which support this are vital to mitigating risks,
- Development and long-term land use must be strategically planned to accommodate high growth; and,
- Increased urbanisation may further complicate the hydrology in the catchment, increasing surface runoff and the 'flashy' nature of the catchment.

Low Growth Considerations

- Opportunities are presented around land-use change and having the space for to deliver FRM / environmental benefits; and,
- NFM and river restoration can be prioritised to deliver maximum effectiveness and nature recovery.



Warwickshire Avon: Low Growth



Low growth considerations

*The pathway was developed to respond to a high climate change future and projected peak flow uplifts under RCP 8.5, climate change projections.

Please click on the buttons below to reveal each layer of the pathways.

- High Climate Change Scenario
- High Growth Scenario
- Low Climate Change Scenario
- Low Growth Scenario



Economic appraisal

Warwickshire Avon

A high-level economic appraisal using the Benefits Toolkit has been undertaken for the Warwickshire Avon emerging core pathway, relative to an indicative Do-Minimum baseline (under a high climate change (RCP8.5) future). We considered a 100-year appraisal period and that benefits are realised when portfolios are delivered across the indicated epochs (i.e. 2030, 2050, and 2080). The findings are described below.

The findings are described below.

Table 10: High-level appraisal assessment summary for the Warwickshire Avon focus area.

Scenario	Damages (£k)	Benefits (£k)
Do Minimum	606,049	-
Do Something (i.e. Emerging pathway)	463,075	120,000

Limitations:

- A Do Nothing scenario was not assessed due to baseline data unavailability.
- The benefits from Do-Something do not include wider benefits from biodiversity increases or GHG emission reductions by implementing more NFM, water quality improvements, protection to critical infrastructure or economic growth. It is likely that the benefits presented in this assessment are under-valued.

Benefits

For the emerging pathway



Risk to 652 commercial & industrial properties mitigated



Risk to 438 public buildings and services mitigated



Risk to 1614 ha of farmland mitigated



Risk to 44 ha of environmental designated sites mitigated



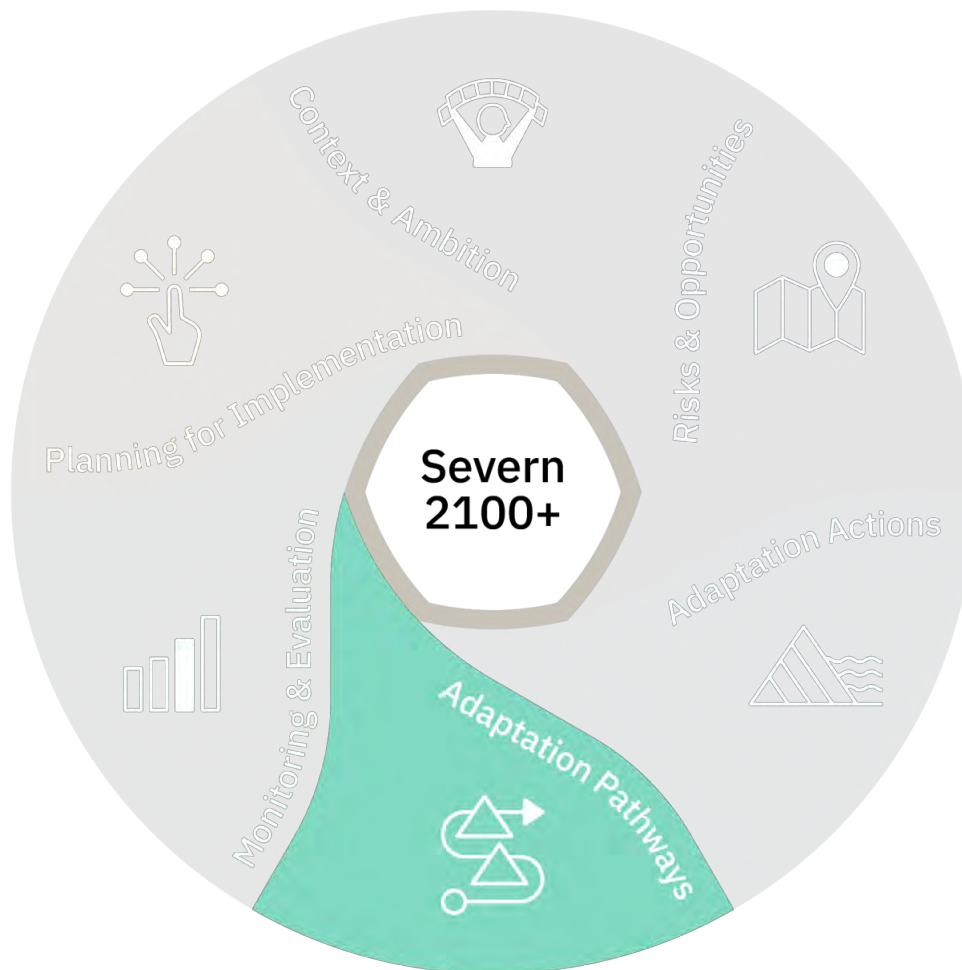
Risk to 6339 residential properties mitigated

£ 120m*



Insights

Our insights from applying our approach are outlined below:



Collaborative
workshop
approach

Candidate
pathway

Pathway
appraisal

Stress-
testing

Decision-
making

- Through a collaborative, workshop approach, we were able to simplify and respond to a complex problem, with varying levels of information. As a result, we successfully developed emerging pathways, which can be refined as additional information is made available.
- The use of three candidate pathways demonstrated varying approaches to respond to flood risk. They highlighted action interdependencies, actions that may be least regrets and options for sequencing. These insights can collectively inform emerging pathway development.
- The extensive feasibility studies for the SVWMS enabled the development of more robust, pathways for the Upper Severn. Whilst the Warwickshire Avon is more reliant on extrapolation of the performance of current projects in the catchment and local EA expertise.
- We developed strategic-scale adaptation pathways in two focus areas. Developing pathways at this scale enabled us to appropriately reflect the different characteristics of each area, whilst looking strategically at what actions can be taken. This enabled a holistic, integrated approach to achieving flood resilience.
- By utilising quantitative trends across epochs (i.e. peak flow uplifts) and qualitative scenarios, we were able to stress-test the pathways against a range of uncertainties.
- A high-level economic appraisal indicatively informed the economic feasibility of the proposed pathways. Future pathway iterations needs to explore this and refine the pathways further.



Step 5

Monitoring & Evaluation

Overview

M&E underpins an adaptation pathways approach. It provides the framework to monitor both the performance of the pathways and the external changes that may impact the proposed approach. The framework informs decisions on when to accelerate, decelerate, or change pathways. The key objectives of this stage involved developing a framework of indicators of change and identifying a governance structure to determine how to make future decisions. This chapter sets out:

- Methodology used to develop the monitoring and evaluation framework and indicators.
- The monitoring and evaluation framework, including the core indicators.
- Application of indicators to the pathways.

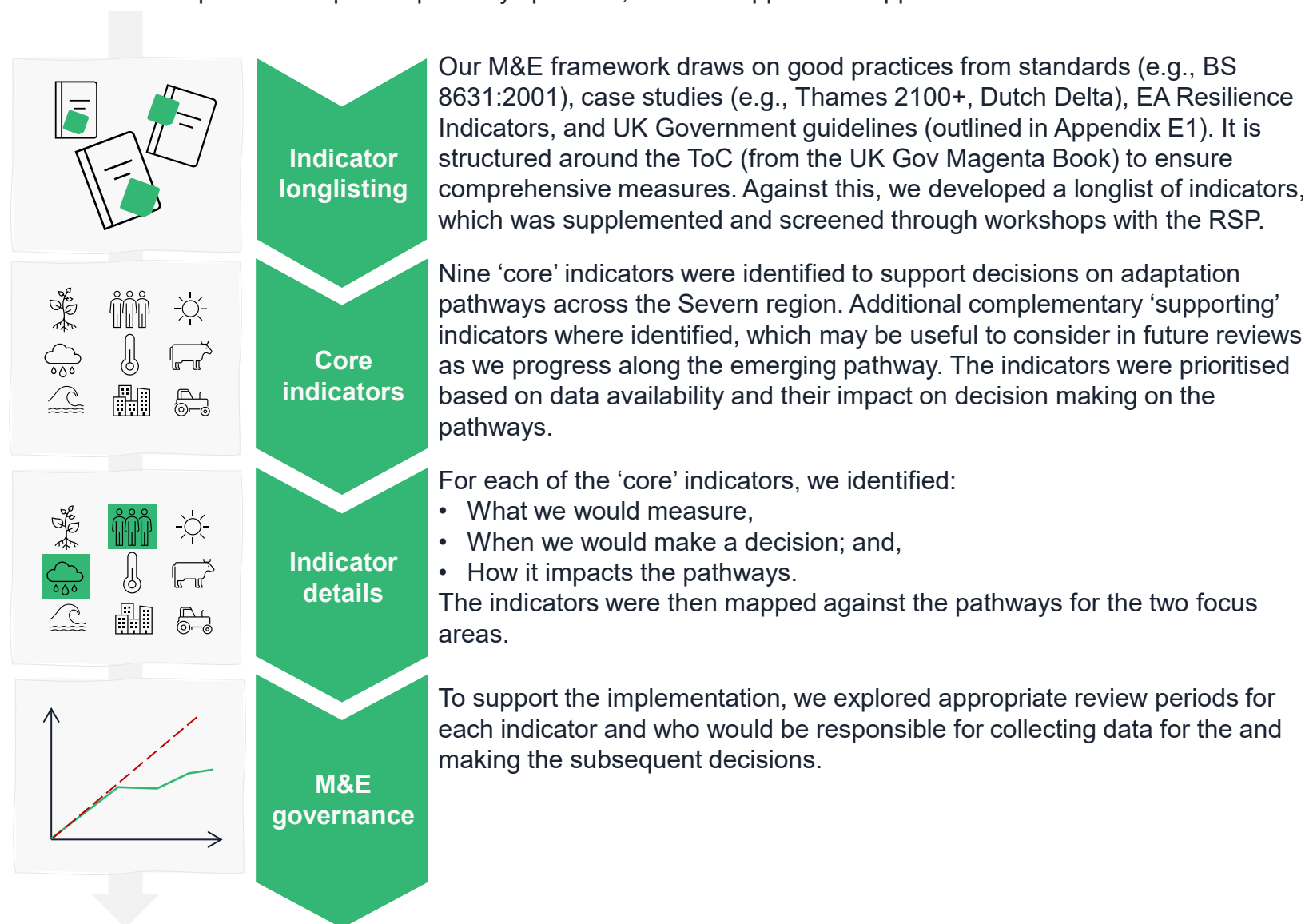
How should sustainability be considered at this step?

- Define sustainability indicators based on sustainability objectives.
- Capture sustainability indicators in a monitoring framework as part of the Environmental Report.
- Monitor indicators to understand the potential significant effects resulting from implementation of the pathways.



Methodology

For the M&E step of the adaptation pathways process, we have applied the approach outlined below. Further information is available in Appendix E.



What is a monitoring and evaluation framework?

The future is uncertain. We expect our understanding of climate change and other factors to improve over time as new data and scientific evidence become available. To help us understand how the Severn catchment is changing, how we are performing and ensure we adapt appropriately, we need a M&E framework. A M&E framework should establish:

- What will be monitored and evaluated (i.e. the key **indicators**) and the associated triggers and thresholds which inform when decisions need to be made,
- Who is responsible across each aspect of the M&E framework,
- The programme for M&E, including frequency of reviews,
- A feedback framework for learning and development; and,
- Information and data needs.

What are triggers and thresholds?

- ▲ **Triggers** are when an indicator shows conditions are approaching a significant point that may require a change in pathways or approach.
- **Thresholds** are when an indicator shows that consequences are not acceptable because they could cause significant disruption or the system to change in a way wherein it not return to its initial state.

Regular reporting

Regular monitoring and evaluation is needed to inform pathway decisions. We recommend the EA conducting a partial review every 5 years and a full review every 10, aligning to frequency of the EA planning cycles.

5-year review: Review of the **core indicators**, with targeted data collection (e.g. focusing on risk hotspots). The outcomes inform: flood risk management planning for the next 5-year period, identifying key adaptation actions / portfolios that need to be progressed / funded and feasibility studies required.

10-year review: Review of the **core** and **supplementary indicators** (where needed) to evaluate how the pathways have performed over the past 10 years, how risks have changed, and whether a change/alteration to pathways and adaptation actions is needed. This may lead to revised pathways of adaptation actions to inform flood risk management planning for the medium term.

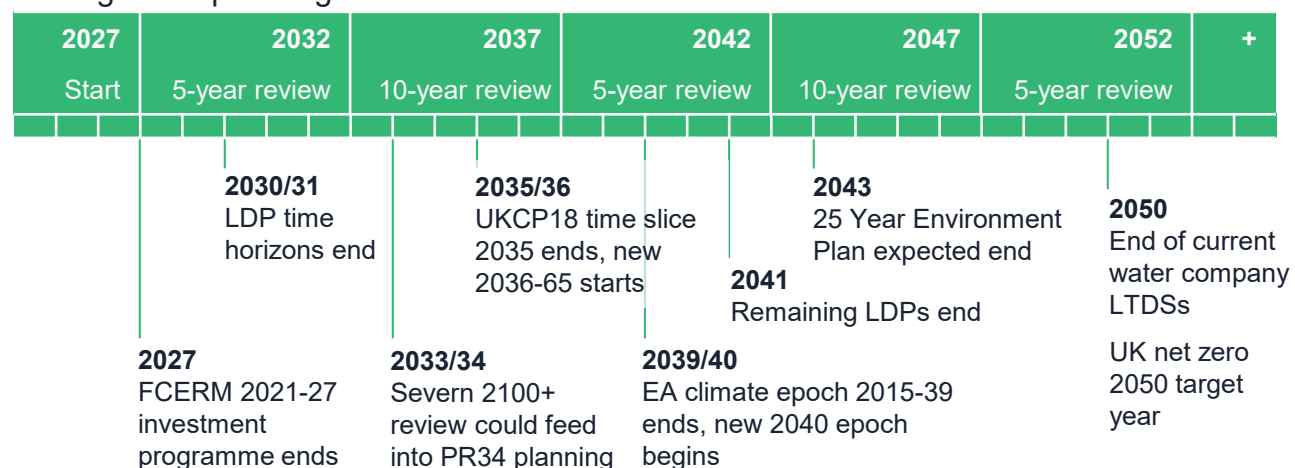
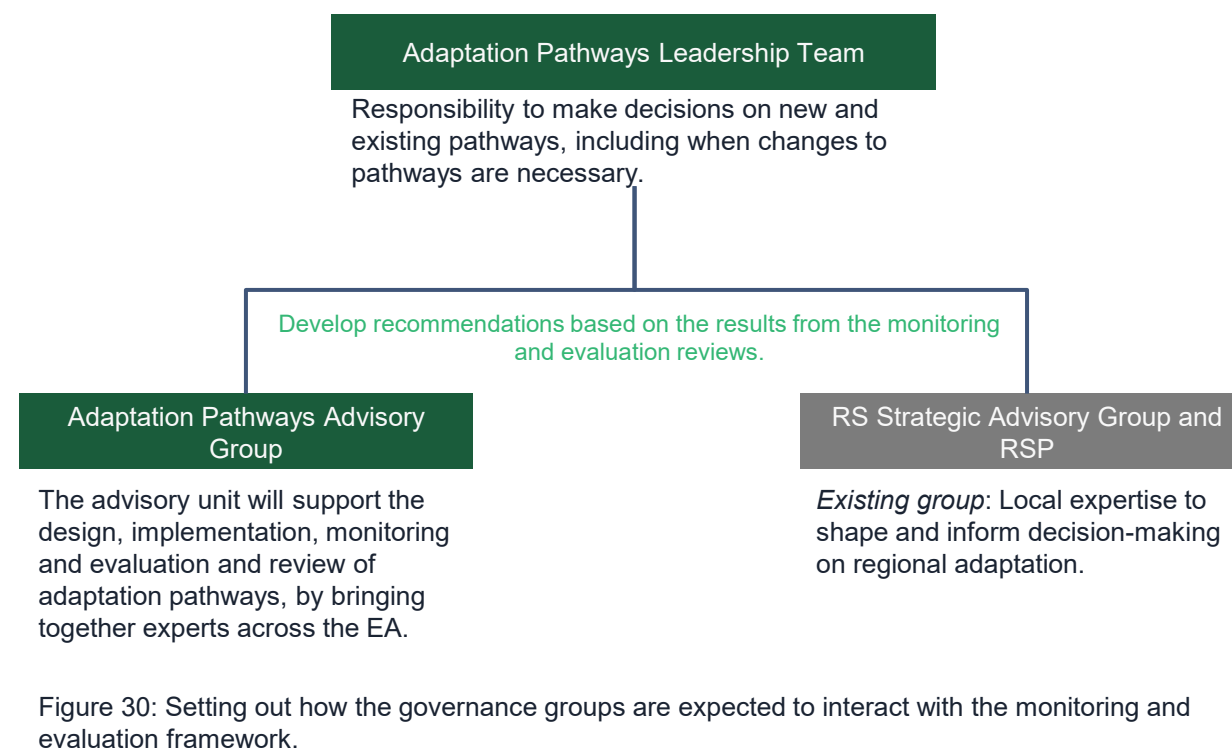


Figure 29: Timeline of project reviews.

The EA should lead the periodic reviews. If there is an opportunity (e.g. through partnership funding) or eNGO delivery, that should not impede additional portfolios / adaptation actions from being implemented.

Roles and responsibilities

In the Planning for Implementation chapter, we have recommended that the EA establish the following groups to support the monitoring & evaluation of adaptation pathways:



Draft sustainability objectives developed through the catchment statements informed the development of the monitoring and evaluation framework. When a full SA is conducted, any additional sustainability indicators which monitor the potential significant effects on the environment resulting from implementation of the pathways should be included within the M&E framework.

Indicators

We have used the Theory of Change (ToC) as the foundation for our catchment-wide M&E framework, aligning to the UK government good practice set out in the Magenta Book [37].

The longlist of indicators (Figure 31) captures the proposed inputs (data, skills and investment), expected outputs and outcomes and desired impacts on the catchment. This structure acknowledges the external and supporting factors at play.

The 'core' indicators for the two focus areas are highlighted in white, bold text.

On the subsequent pages we have set out, for each core indicator:

- What we will measure,
- When we will make a decision; and,
- How the indicator impacts the pathways.

Future iterations of this work will include a Sustainability Appraisal which may identify additional sustainability indicators that should be incorporated into the M&E framework.

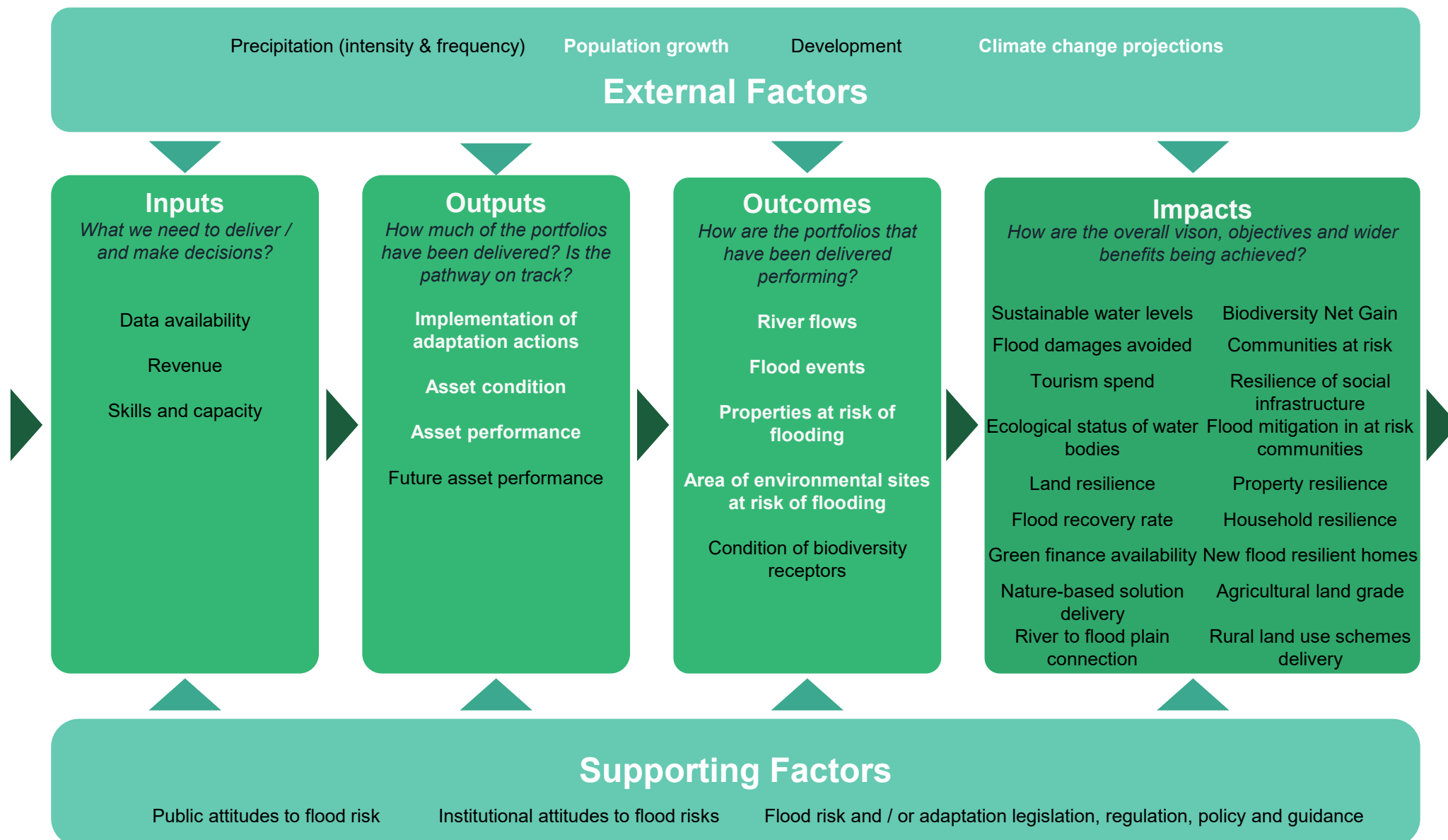
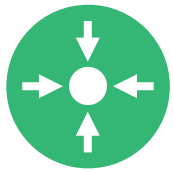


Figure 31: Longlist of indicators for each aspect of the Theory of Change model, with core indicators in white.



External factors

Growth

What we will measure:

- **Growth Projections:** Measure development associated with growth in the catchment.
- **Observed Major Development:** Monitor updates to Local (Development) Plans, Strategic Development Plans and planning applications for areas earmarked for future development, evaluating how the development it impacts flood risk.

When we will make a decision: When there are any changes in observed growth versus projected growth in the catchment, for example:

- ▲ **Trigger:** observed growth is starting to deviate from projections in Local Authority Plans or development is occurring where it wasn't outlined in the local plans; and,
- **Threshold:** more growth than anticipated, resulting in trade-offs between land earmarked for development versus FRM.

How it impacts the pathways: More growth and associated development may impact who is at risk, where we can act, and the scale of the interventions we can deliver. Increased development can impact the hydraulics within a catchment and increased surface runoff can impact modelled flood dynamics.

Figure 32 presents the population projections obtained from the Local Authority Plans for the entire River Severn Catchment as an indication of growth. We have set the threshold at the population projections (a).

The purple line is hypothetical data to represent growth diverging from current projections to demonstrate an example of the threshold being exceeded (b).

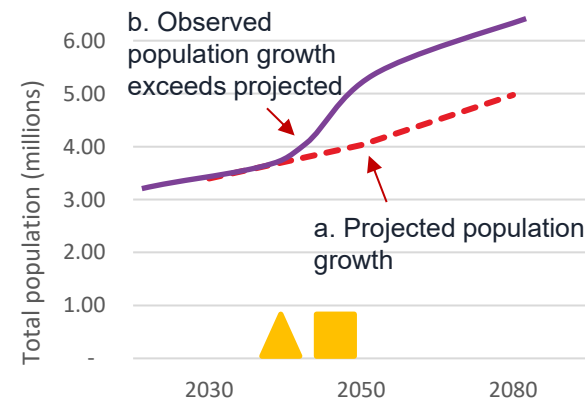


Figure 32: Population projections for the River Severn Catchment

Climate Change

What we will measure:

- **Climate change projections:** Monitor updates or developments to climate change projections from the Met Office or the IPCC, looking for cases of new data or additional detail on precipitation projections.
- **Global surface warming temperatures:** Monitor information released by the IPCC on global surface warming temperatures, to inform which climate trajectory.

We will make a decision: When new climate projections or updates to latest global surface warming temperatures are released:

- ▲ **Trigger:** Actual global surface warming temperatures start to deviate from the central trajectories for RCP8.5 or RCP4.5; and,
- **Threshold:** Actual global surface warming temperatures exceeding the upper RCP8.5 and the lower RCP4.5 limits.

How it impacts the pathways: The adaptation pathways have been developed to respond to two UKCP18 climate change projections: high (RCP8.5) and low (RCP4.5). If the climate trajectory exceeds RCP8.5, additional action may be needed to mitigate more severe climate change. If it falls below RCP4.5 then the programme of adaptation actions in the pathways could be delayed or reduced.

Figure 33 shows the global surface warming trajectories for RCP 8.5 and 4.5. The red lines and turquoise lines are based on data extracted from the CMIP5 model referenced by the IPCC. The turquoise area has been created for the purposes of this project to represent the global surface warming allowance range for our pathways. The purple line is hypothetical data to represent two different trajectories which exceed the RCP8.5 upper limit threshold (a) or fall below the RCP4.5 lower limit threshold (b).

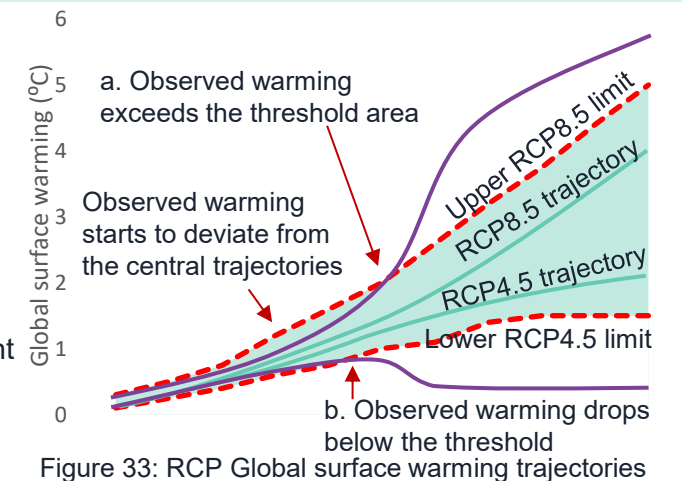


Figure 33: RCP Global surface warming trajectories

Implementation of adaptation actions

What we will measure:

- **Implementation:** Monitor the roll-out and delivery of adaptation actions (as a proportion of those planned) see Table 11 below.

When we will make a decision: When there is a divergence between the planned versus actual implementation indicator for each adaptation action over a specified time period.

How it impacts the pathways: Rate of implementation can indicate whether the delivery of the pathway is on track or slower than anticipated. Further work may be needed to unlock delivery or identify / bring forward additional actions to mitigate increasing flood risk.

Table 11: How to measure the implementation of each adaptation action portfolio.

Adaptation action portfolio	Implementation indicator
Upstream storage: NFM	Volume of flood storage (m ³)
Upstream storage: artificial	Volume of flood storage (m ³)
Urban source control: Urban SuDS / BGI	Volume of flood storage (m ³)
Urban source control: Property Level SuDS / BGI	Volume of flood storage (m ³)
In-Channel Measures: NFM	Length of restored river (m)
In-Channel Measures: Artificial	Volume of flood storage (m ³)
Hard Defences: Permanent Linear	Length and height of linear defences (m)
Property-Level: Property Flood Resilience	Number of properties with PFR (no.)
Asset Management: Hydraulic Management	See asset condition and performance indicators
Asset Management: Review & Enhance	

Performance of adaptation actions

What we will measure:

- **Actual asset performance:** Monitor the performance of assets in managing fluvial flood risk, see Table 12 below.
- **Asset performance projections:** Monitor how assets / portfolios are projected to perform across a range of return periods based on feasibility assessments.

When we will make a decision: When the action is not mitigating peak flows and flood events as anticipated during pathway development.

How it impacts the pathways: Lower performance is a signal that either further or different adaptation is required, i.e. portfolios may need to be delivered ahead of the programmed date. Lead time of adaptation actions needs to be accounted for.

Table 12: How performance across portfolios should be assessed over time.

Adaptation action portfolio	Performance indicator
Upstream storage: NFM	Mitigated peak flow (m ³ /s) achieved across a range of return periods through portfolio delivery based on gauged river data.
Upstream storage: artificial	
Urban source control: Urban SuDS / BGI	
Urban source control: Property Level SuDS / BGI	
In-Channel Measures: NFM	
In-Channel Measures: Artificial	Number of properties (no.) resilient to flooding aligning to the return period the assets are designed for.
Hard Defences: Permanent Linear	
Property-Level: Property Flood Resilience	Number of properties (no.) utilising PFR measures during flood events.
Asset Management: Hydraulic Management	See asset condition and performance indicators
Asset Management: Review & Enhance	

Condition

What we will measure:

- **Actual asset condition:** Monitor and record overarching asset condition grades across portfolios. Focus should be placed on those that would result in catastrophic impacts if they failed (i.e. critical assets).
- **Asset condition projections:** Project how the conditions of assets are likely to change over time to identify when investment is required.

Assets may degrade more quickly due to climate change and associated morphological changes. However, their degradation may be slower than anticipated due to the delivery of other adaptation actions.

When we will make a decision: If asset conditions are declining (i.e. approaching a specified risk threshold), a decision needs to be made as to whether an asset (or its maintenance regime) can be improved, enhanced, refurbished, or replaced.

How it impacts the pathways: The emerging pathways identified the need for a 10-year, rolling asset management programme (see the Adaptation Pathways chapter for more information).

Asset degradation will drive asset maintenance and refurbishment programmes.

The asset management programme may need to be adjusted if assets degrade faster than anticipated.

Table 13 represents an example from Thames 2100 of indicative proportions of portfolios across condition grades. This highlights the need to monitor all of the assets in a portfolio to determine when an intervention may be required as you approach a threshold (a.). The table demonstrates that interventions are done in 2030/40 to bring the majority of assets back up to grade 2 and the same again in 2090.

Table 13: Asset portfolio condition grade projections.

Asset condition	2030	a. 2040	2050	2060	2070	2080	2090	a. 2100
Grade 1 – very good	4.6%	2.8%	2.4%	1.4%	2.2%	1.4%	3.1%	2.4%
Grade 2 – good	32.9%	81.5%	85.5%	81.2%	70.5%	53.2%	28.6%	82.9%
Grade 3 – fair	53.6%	13.9%	11.3%	17.0%	25.5%	41.9%	50.5%	13.4%
Grade 4 – poor	6.6%	1.4%	0.7%	0.3%	1.4%	3.4%	15.7%	0.8%
Grade 5 – very poor	2.3%	0.1%	0.1%	0.1%	0.4%	0.2%	2.1%	0.5%

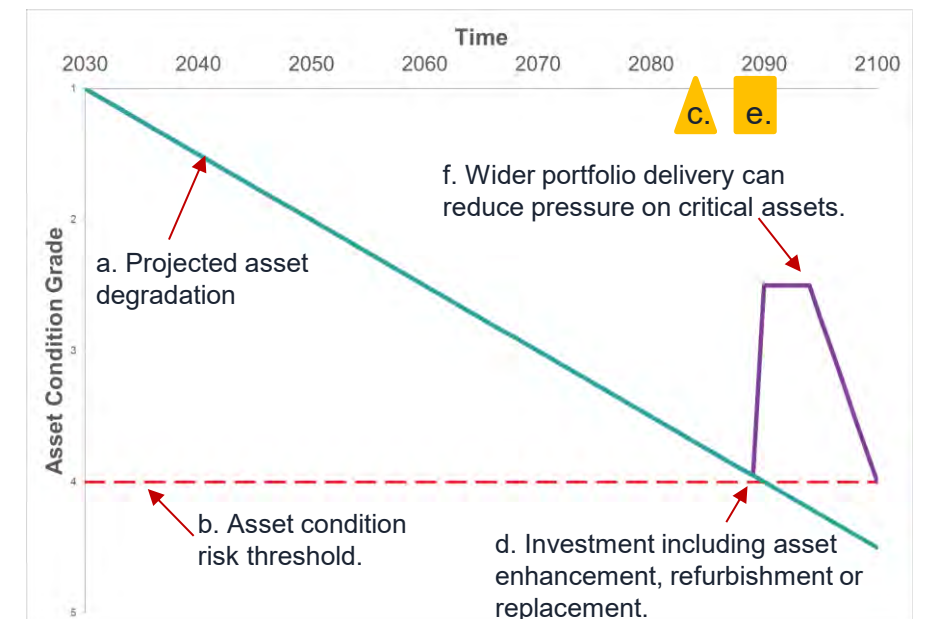


Figure 34: Single asset condition grade projections.

Figure 34 shows an indicative asset condition grade degradation trajectory (a) of a single, critical asset that is approaching a risk threshold (b); the trigger point (c) results in investment (d) to improve the asset condition ahead of crossing a threshold (e).

River Flows

What we will measure:

- **River flow and water levels:** Measure daily flows that exceed 5%, 50%, and 95%, annual maximum flows, annual mean flows, and seasonal mean flows. As average flows increase over time, frequency of out of bank flow is also likely to increase; and,
- **Future peak flow projections:** Assess how future peak flow projections are likely to be impacted based on updated climate change projections / hydraulic modes.

When we will make a decision: The emerging pathways were developed based on peak flow uplifts anticipated under RCP 8.5 climate change projections, with aims to mitigate flood risk to 2030 projections:

▲ **Trigger:** If the observed trends in peak flows (e.g. frequency and duration of peak flow water levels resulting in out of bank flow or a defence threshold) increases

■ **Threshold:** The 2030 frequency of exceedance projections.

How it impacts the pathways: If the triggers or thresholds are met there may be a need for further adaptation, i.e. portfolios may need to be delivered ahead of the programmed date, or additional portfolios need to be added to the pathways to mitigate flow levels. Pathways have been designed to allow for action lead-in time.

Figure 35 presents the number of days with out of bank river flows at Shrewsbury - based on historical gauge data (from 1963 through 2024 [38]). If this trend increases over time (a), approaching the 2030 risk threshold (b), the trigger point (c) results in investment / portfolio delivery (d) ahead of crossing the threshold (e). Flood resilience would then improve (f) until climate change peak flow uplifts surpass the mitigation of delivered portfolios causing risk to increase again (g) and approach additional thresholds.

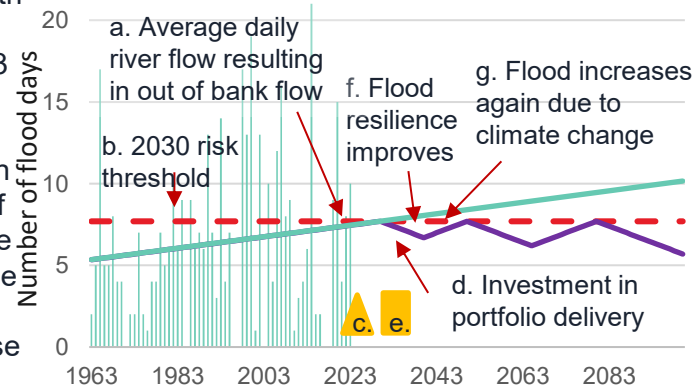


Figure 35: Shrewsbury number of flooded days per year

Flood Events

What we will measure:

- **Intensity and frequency of flood events:** Monitor the frequency, duration, and extent of flood events at key locations in the catchment (e.g. risk hotspots, urbanised areas, public services, productive agriculture land, critical infrastructure and environmentally designated areas); and,
- **Future flood events:** Monitor how future flood events are likely to impact the region based on updated climate change projections.

When we will make a decision: If flood events are becoming more intense (more frequently exhibiting high flows and out of bank flooding than previously anticipated), this signals a need for further adaptation.

How it impacts the pathways: If flooding intensity (frequency, duration, extent) in certain areas is occurring more than anticipated, this may indicate the need for additional adaptation actions or a change in pathways, i.e. portfolios may need to be delivered ahead of the programmed date.

Figure 36 presents the flood duration and observed annual peak flows at Shrewsbury, based on historical gauge data (1963 to 2024 [39]). The frequency of events resulting in significant damages and impacts are becoming more frequent (stars).

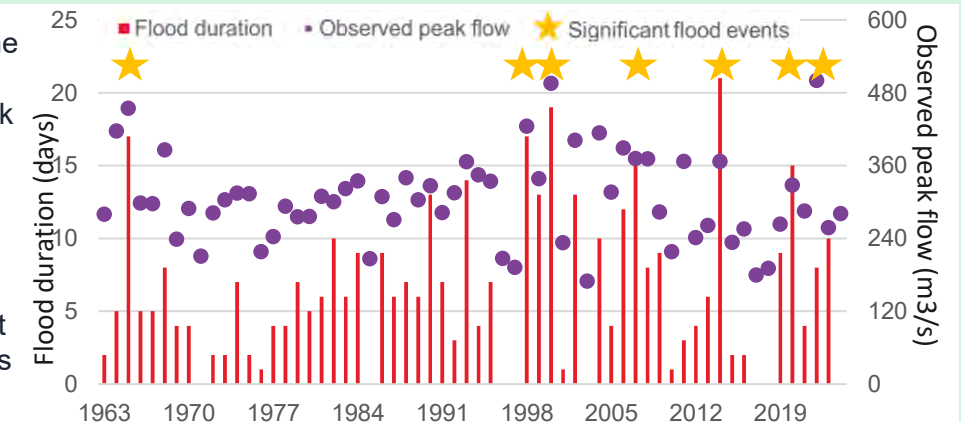


Figure 36: Historical flood events in Shrewsbury.

Impacted Environmental Sites

What we will measure:

- **Area of environmental designated sites:** Monitor the area of environmental designated sites at risk of flooding; and,
- **Condition of environmental designated sites:** Monitor the condition of designated and protected sites in the focus areas currently at risk of flooding.

When we will make a decision:

- ▲ **Trigger:** A decline in the condition of these sites, or loss of area, between Natural England reporting periods (5 to 10 years)
- **Threshold:** Increase in the area (ha) of environmental designated sites at risk of flooding against 2024 levels. (assuming that no new sites will be designated.)

How it impacts the pathways: Actions may not be performing as intended or we need to do more to deliver nature-positive outcomes with our pathways; directing adaptation actions towards protecting specific vulnerable areas, and prioritising NFM to protect these sites.

Figure 37 shows the areas (ha) of environmental designations at risk of flooding in two focus areas. Turquoise lines (a) represent projections for area of environmental designations at risk of flooding, extracted from the risk mapping. Red line (b) represents the threshold. The trigger point (c) prompts investment / portfolio delivery, to respond to these increasing risks ahead of crossing a threshold (d).

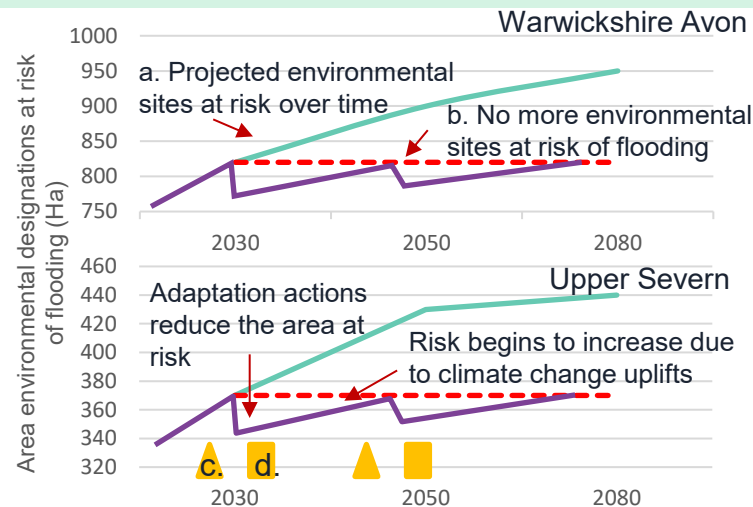


Figure 37: Area of environmental designations at risk of flooding for the two focus areas

Impacted Properties

What we will measure:

- **Observed properties impacted:** Monitor the number of impacted properties by observed flood events. Monitor flood depth properties are exposed to; and,
- **Projected properties impacted:** Monitor how many properties are likely to be impacted due to peak flow uplifts over time based on updated climate change projections, local flood models, and scale and performance of delivered adaptation actions.

When we will make a decision: When more properties are at risk (either observed or projected).

How it impacts the pathways: Either the performance of interventions isn't as expected or the risk is increasing. Therefore, the pathway adaptation actions (e.g. upstream storage, linear defences, etc.) may be required earlier to manage this risk in specific risk locations. Existing properties that are located within high-risk areas and regularly impacted by flood events should be prioritised for PFR.

Figure 38 shows the quantity of residential properties (a) impacted over time under RCP 8.5 projections in the two focus areas. When number of impacted properties approaches a flood risk threshold (b); the trigger point (c) prompts investment / portfolio delivery (d) to respond to these increasing risks ahead of crossing a threshold (e). Flood would then improve in the short-term (f) until climate change causes risk to increase again (g)

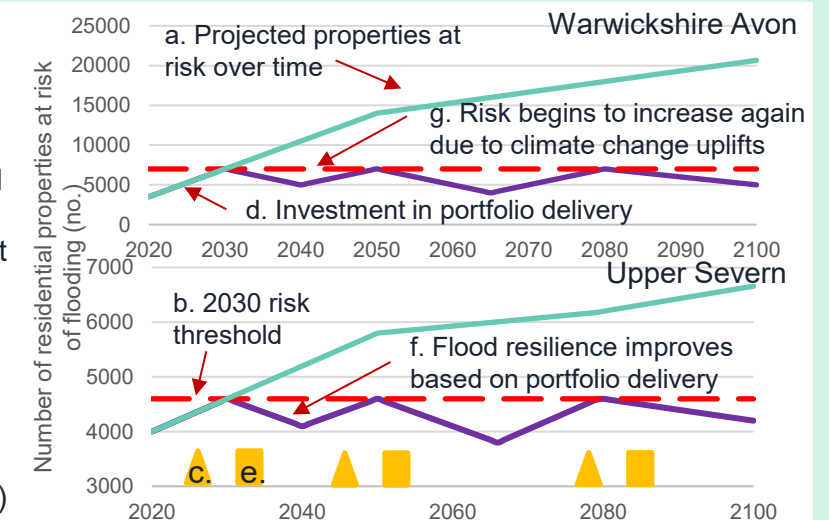


Figure 38: Residential properties at risk of flooding



Indicator review process

Figure 39 recommends organisations with overarching ownership of monitoring core indicators, and how they contribute to the 10-year review cycle. Note that this is a simplification of the products and interdependencies and is centred around the core indicators.

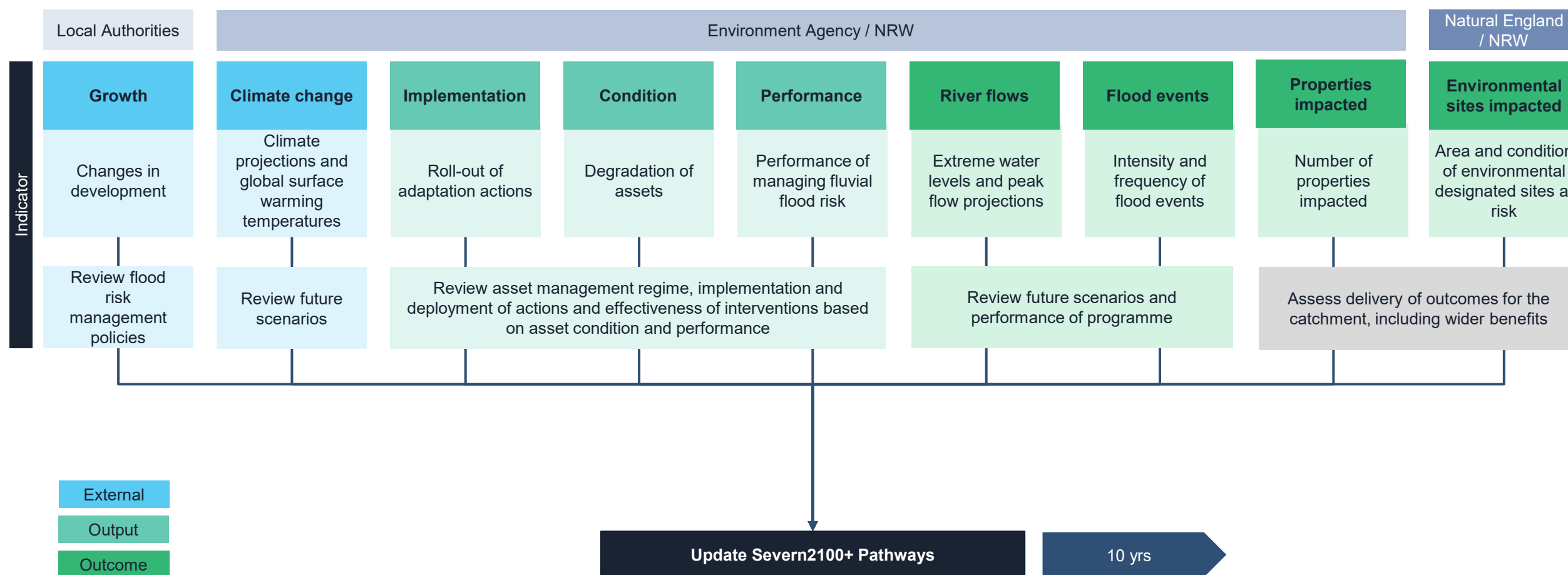
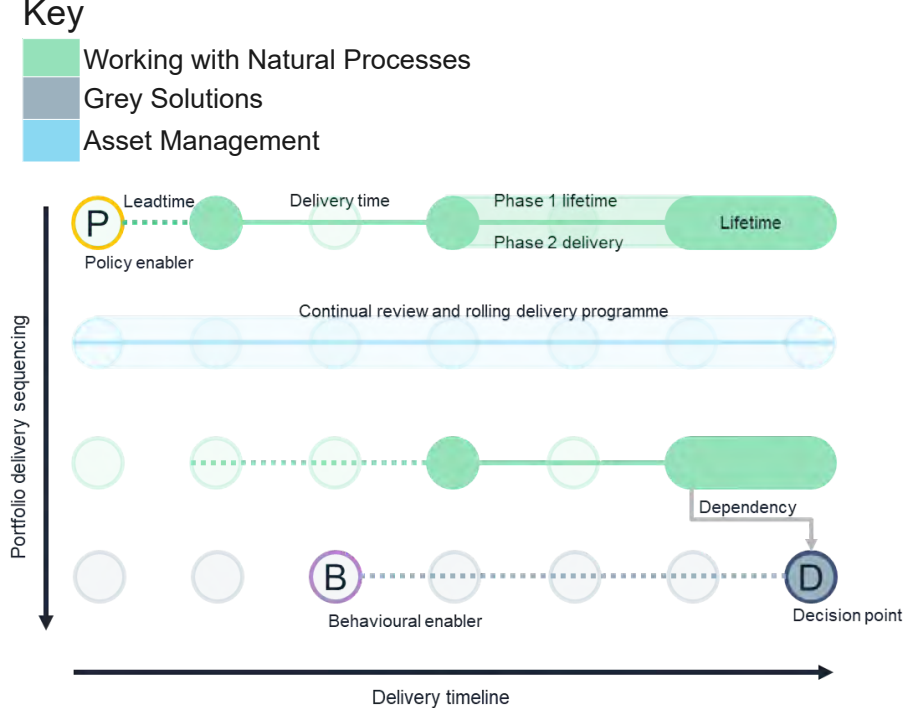
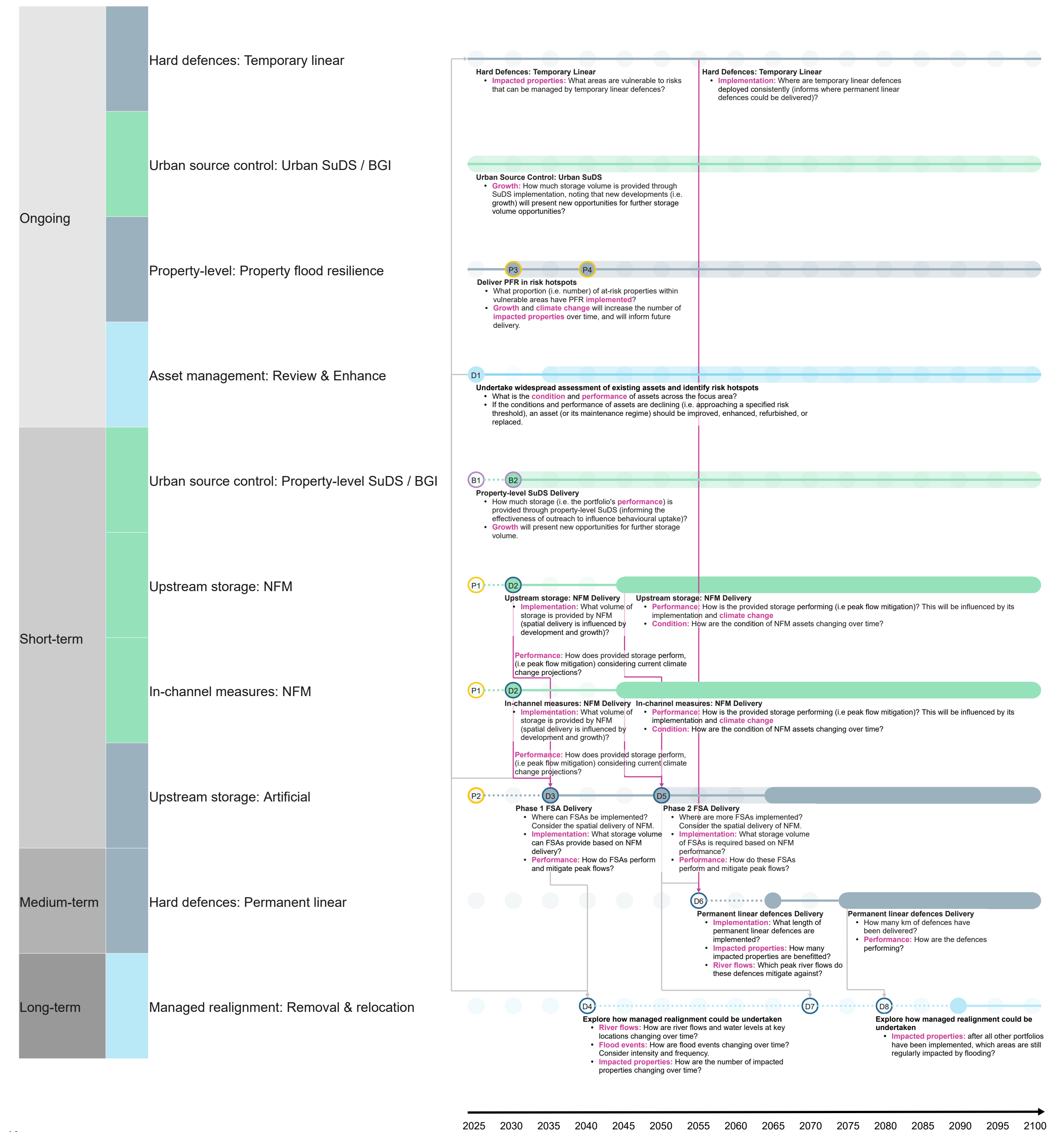


Figure 39: 10-year review process for the core indicators, highlighting responsible organisations along the top.

Upper Severn: Monitoring & Evaluation Framework

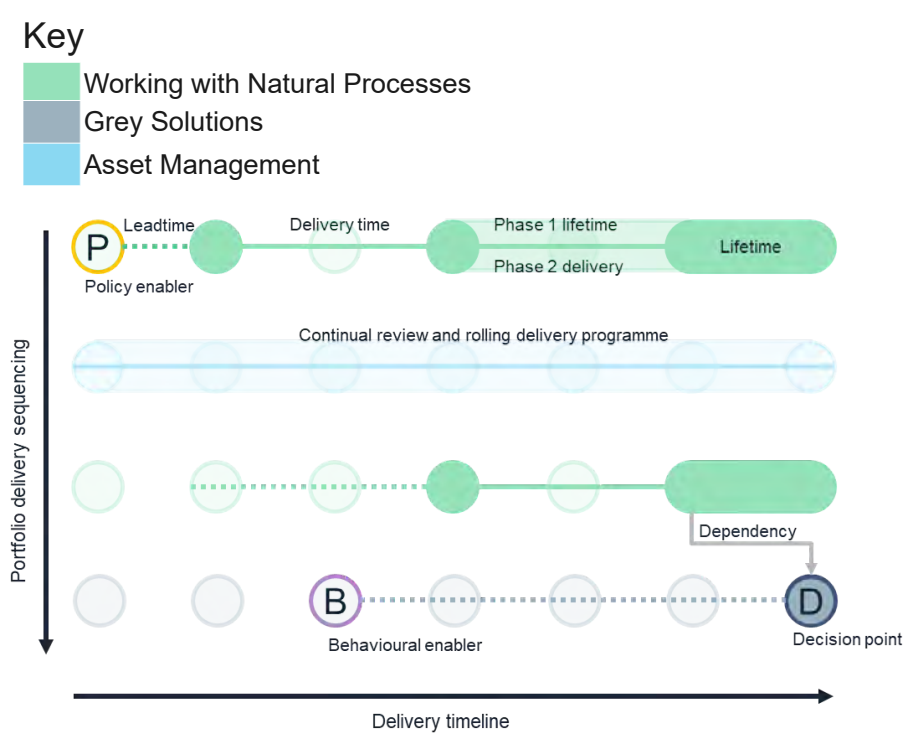
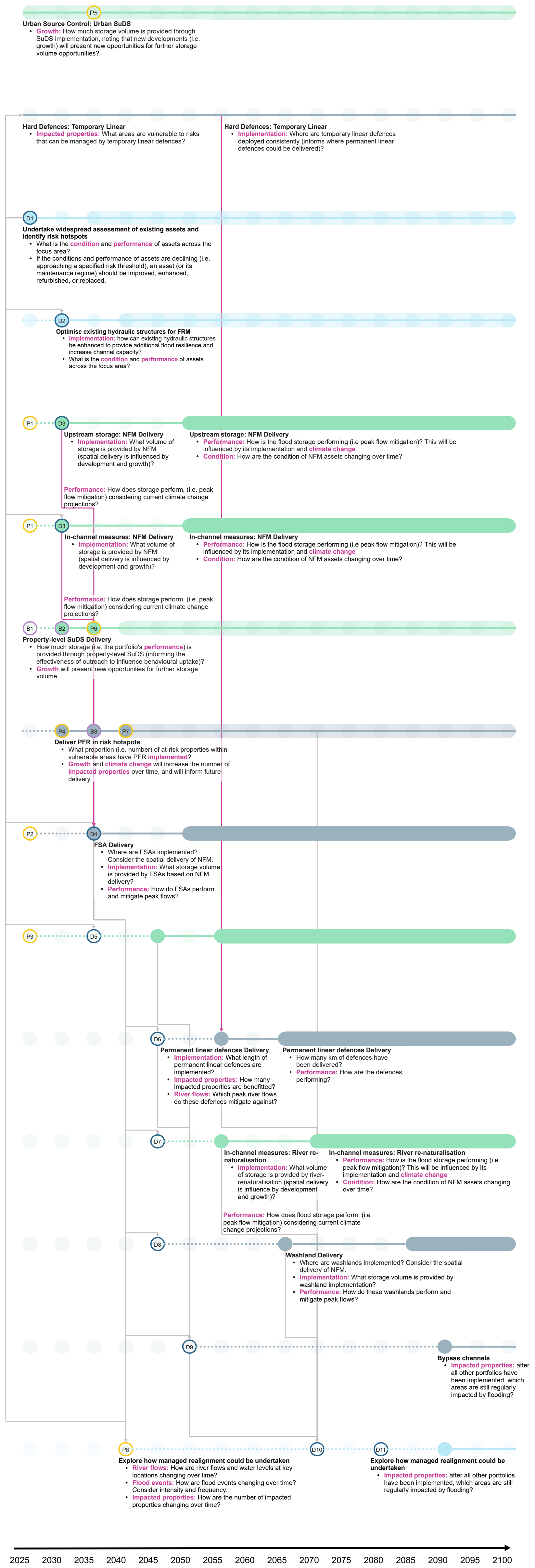
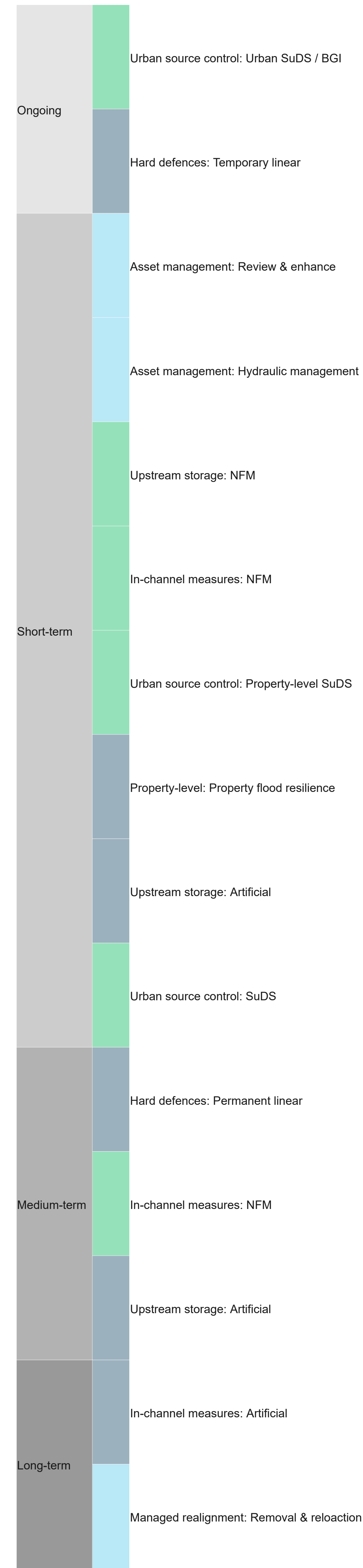


Some indicators influence specific activities (as outlined in the text below for portfolio), whereas some indicators influence entire programmes and deliverability (as outlined in the pink dependency arrows). Indicators and dependencies aligning to the monitoring and evaluation framework are identified in **pink**.

Climate change and **growth** will impact how adaptation pathways are delivered and underpin the entirety of the adaptation pathways and monitoring and evaluation framework. We have drawn out specific portfolios that are highly dependent on climate change and growth. However, these two trends will impact the implementation, performance, condition, and timing of every portfolio.

Peak river flow is an indicator that is influenced both by external (e.g. climate change) factors and portfolio delivery; both sources of influence should be considered when evaluating changes in peak river flows over time.

*The pathway was developed to respond to a high climate change future and projected peak flow uplifts under RCP 8.5, climate change projections.



Some indicators influence specific activities (as outlined in the text below for portfolio), whereas some indicators influence entire programmes and deliverability (as outlined in the pink dependency arrows). Indicators and dependencies aligning to the monitoring and evaluation framework are identified in **pink**.

Climate change and **growth** will impact how adaptation pathways are delivered and underpin the entirety of the adaptation pathways and monitoring and evaluation framework. We have drawn out specific portfolios that are highly dependent on climate change and growth. However, these two trends will impact the implementation, performance, condition, and timing of every portfolio.

Peak river flow is an indicator that is influenced both by external (e.g. climate change) factors and portfolio delivery; both sources of influence should be considered when evaluating changes in peak river flows over time.

*The pathway was developed to respond to a high climate change future and projected peak flow uplifts under RCP 8.5, climate change projections.

Our insights from applying our approach are outlined below:



Indicator longlisting

- Monitoring and evaluation is a fundamental aspect of an iterative, adaptive approach. It ensures the adaptation pathways remain adaptive to future change.
- RSP and EA Place Manager input was invaluable in developing the longlist of indicators. They informed available data and responsible parties for each indicator.

Core indicators

- The ToC provided a comprehensive framework indicators could be defined against.
- The M&E framework is applicable to both focus areas, and therefore regionally. But triggers and thresholds are dependent on the characteristics of each catchment. Therefore, M&E need to be carried out at a focus area (i.e. sub-catchment) scale to align with the adaptation pathways developed.
- It is important core indicators monitor changes in the assumptions that underpin the pathways.

Indicator details

- By developing example or indicative projections for the indicators, we were able to explore what we would monitor locally and when we would make decisions.
- It is important to set out who is responsible for monitoring indicators and evaluating how their trends change over time. A range of organisations will have distinct roles to play in the delivery of an adaptation pathways plan.
- When a SA is conducted the indicators and monitoring requirements need to be captured within this framework.

M&E governance



Step 6

Planning for Implementation

Overview

To achieve climate resilience and adaptation, it is fundamental to develop an enabling environment that allows for an adaptive approach and catalyses the delivery of the desired outcomes. These enabling conditions encompass a range of factors, including access to relevant data & information, effective governance structures, meaningful stakeholder engagement, adequate financial resources, and overarching policy and behavioural change.

This chapter presents an overview of each 'enabler,' with more detail available with detailed actions against each is provided in Appendix F:



Governance



Policy



Stakeholder engagement



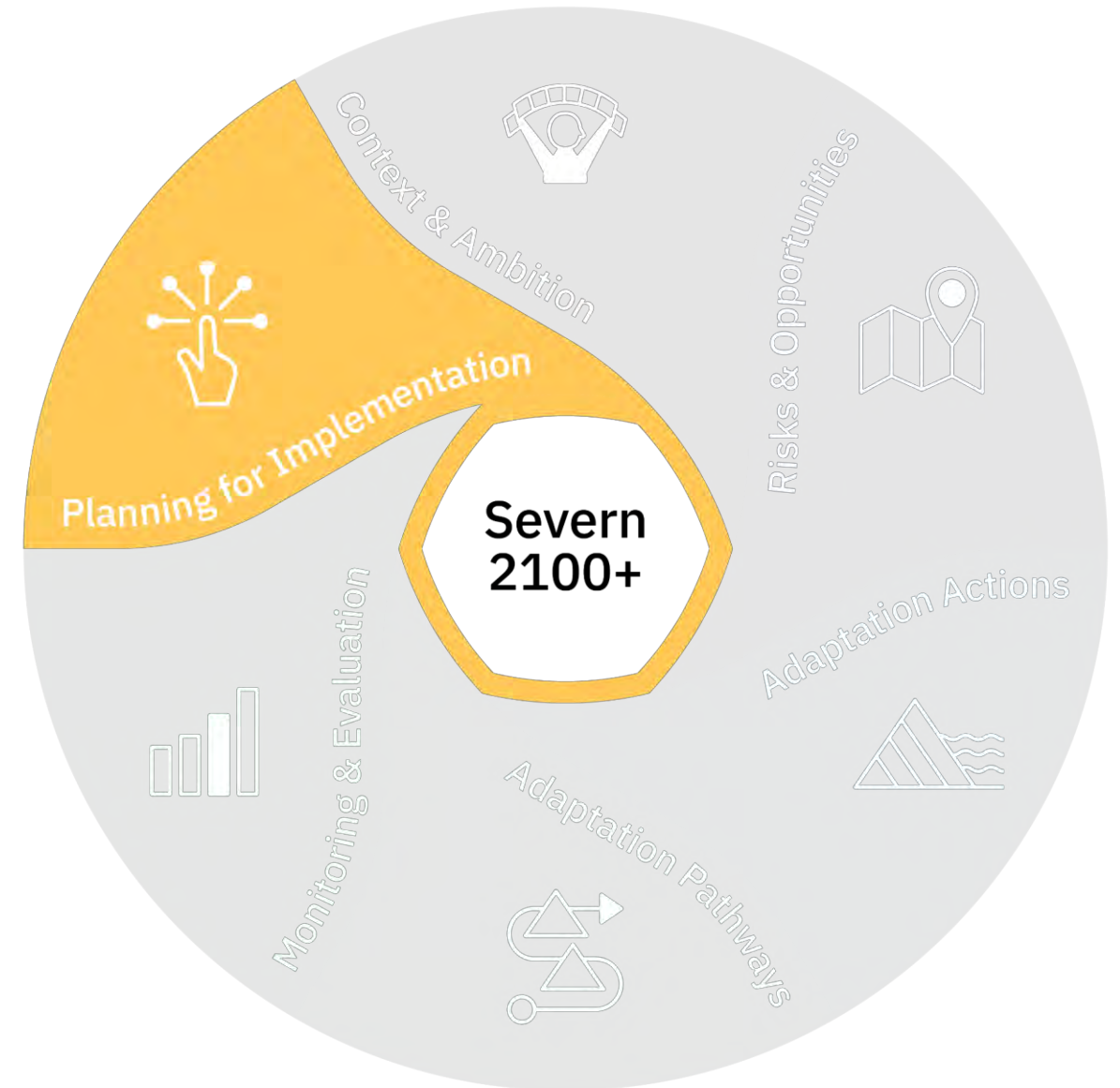
Funding & finance



Behaviour



Data & information



Governance

Current challenges and opportunities

Developing, implementing, monitoring and reviewing adaptation pathways are complex activities. It requires decision-making within dynamic, iterative processes and across multiple organisations throughout the Severn catchment operating across varying spatial and temporal scales.

A strong governance framework is needed to enable the development of adaptation pathways and manage regional challenges around:

- Driving adaptive EA capital and revenue programme decision-making, from opportunity identification to business case development,
- Engaging the RSP and regional stakeholders in decision-making, providing coherence to the delivery of wide-reaching interventions,
- Managing trade-offs across competing objectives (e.g. flood risk management, growth, environment and food security); and,
- Enabling the region to capitalise on opportunities to deliver responses that address multiple catchment issues and access diverse sources of funding.

Future needs for adaptation pathways

Adaptation pathways require adaptive governance structures that determine who is responsible for decision-making, delivering the actions, on-going monitoring and evaluation, and key triggers for determining a change in approach.

This type of governance structure represent a considerable departure from current processes and governance for the EA. A significant organisational change process is required to enable a shift from a localised 'predict and act' to a strategic, catchment-wide 'monitor and adapt' approach. Key to this, will be establishing the groups that can support the development, implementation and monitoring of adaptation pathways. We have identified a preferred future state below:

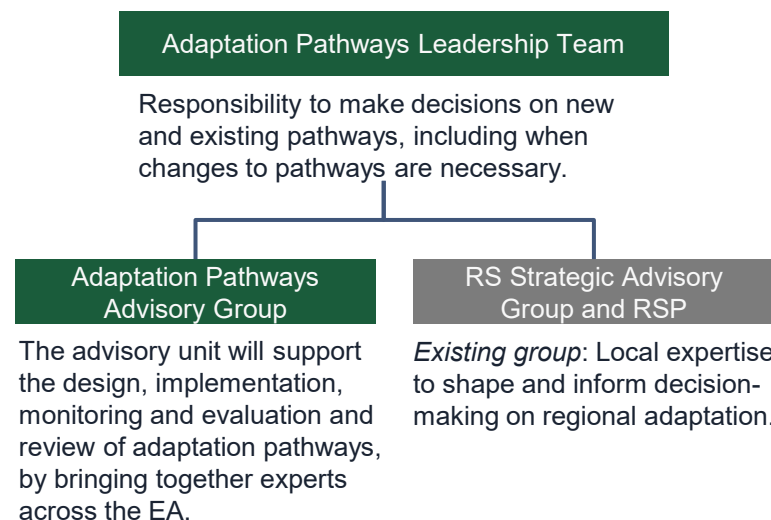


Figure 40: Suggested governance structure for the Severn catchment.



An in-depth review of governance needs to enable the region's adaptation pathways is located in Appendix F1.

Key recommendations

To enable the successful design and implementation of adaptation pathways, we have developed ambitious yet pragmatic, sensible recommendations with achievable 'next steps' that are within the EA's ability and remit to implement now. In the first instance, we recommend:

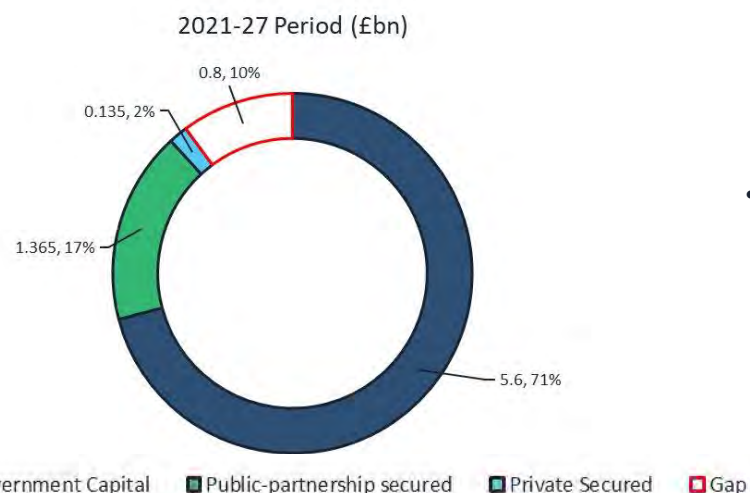
1. The EA use adaptation pathways that have been developed for the **catchment scale to help evaluate and prioritise individual interventions at the local level.**
2. **Establish an adaptation pathways advisory group:** Taking the first steps to establishing an adaptation pathways advisory group within the EA, as described opposite. In the long term, this group will support/lead the development, implementation, monitoring and review of adaptation pathways.
3. **Integrate adaptive thinking into FCERM business cases:** The EA should require capital scheme delivery leads to consider how their intervention will respond to the uncertainties of climate change in FCERM business cases. This will promote the uptake of an adaptation pathways mindset for FCERM projects across England.
4. **Clarify and articulate the roles and responsibilities of the RSP:** and other stakeholder groups in the Severn region. This work should include how they interact with EA and the level of influence they have in regional FRM decision-making.
5. **Build on collaborative working efforts:** to deliver adaptation across the NRW and EA. This may include learning from officials and leadership at the Dutch Delta Programme and Great Lakes Commission.

Funding & Finance

Current challenges and opportunities

Due to the rural nature of the catchment, sourcing GiA funding on the basis of flood damages avoided is much harder compared to urban areas. As a result, there is a significant shortfall in funding to cover the costs of the proposed capital delivery programme (FCERM1). Although there is some level of partnership funding supplementing central-government GiA, there needs to be a significant increase to meet the costs to deliver responses. To address the current funding gap and unlock future private sector resources, new approaches that attract sustainable, private sector funding are required.

The future landscape of funding and financing will likely look very different from BAU today. The EA is well-positioned to play a significant role in overcoming existing barriers. If executed correctly, the EA can help unlock funding and financing to help deliver the outcomes of the Severn catchment.



Future needs for adaptation pathways

Delivering catchment-wide adaptation pathways will require:

- Continuity and stability of funds to allow for multi-year programming and the realisation of long-term goals.
- New, long-term funding streams to cover the revenue aspects related to long-term M&E and funding for action when triggers are met.
- A shift in funding mechanisms to deliver adaptation actions at scale.

A long-term flood risk strategy (i.e. Adaptation Pathways) enables a prescribed workstream of actions that can attract wider investment. It is therefore essential that funding and financing strategies and plans are established that mobilise greater public, private and voluntary sector investment in a just and equitable way. These will need to consider:

- The strengths of the River Severn catchment. Its rurality and agricultural nature is a key differentiator. This means less opportunity to raise finance directly through business or innovation zones, but the catchment is well-placed to leverage private investment through large scale landscape restoration, trading of WwNP solutions and philanthropic donations.
- Barriers preventing the rapid upscaling and deployment of investment include:
 - o Widespread land-owner co-ordination,
 - o Supporting policy, legislation and guidance to encourage private investment; and,
 - o Standards to support investor confidence, including verification of impact.



An in-depth review of funding & financing opportunities to enable the region's adaptation pathways is located in Appendix F2.

Key recommendations

Fundamentally, the EA (both in the West Midlands and Nationally) needs to rapidly determine its role and scale of ambition in the quickly evolving landscape of funding and financing for climate resilience, landscape and nature schemes. Recognising this, we have identified the following recommendations:

- 1. Develop a funding & finance working group:** Develop the governance model of a working group, to sit within the AP Advisory Group (as described in Governance). This could range from in/formally joining an existing organisation/partnership e.g. Marches Forward, or developing its own approach in isolation.
- 2. Establish scale of ambition:** The working group should determine its approach and ambition to attracting new funding and finance. This may evolve over time.
- 3. Identify required process changes:** Understand the requirements to develop value mechanisms and an investable vehicle for private sector investment to be channelled into the catchment.
- 4. Assess current and required capability** for unlocking funding & financing, e.g. stakeholder and investor engagement, procurement etc.
- 5. Map opportunities** for developing and implementing green finance mechanisms.
- 6. Build a portfolio of projects and develop an investment prospectus.**
- 7. Develop and grow investor relationships** and routes to market for investors and stakeholders.

Figure 41: Current available funding and financial gap breakdown.



Policy

Current challenges and opportunities

The current policy and legislative landscape:

- Presents a complex picture of how risks are managed. This can often impede co-ordinated action at scale.
- Can mean slow progress on flood infrastructure projects influence due to:
 - Strict planning regulations which limit the flexibility needed for adaptive measures, such as creating flood storage.
 - A focus on maintaining existing infrastructure on a like-for-like basis rather than upgrading it to respond to future climate conditions, leading to maladaptation.
- Is often siloed and creates competing objectives across systems (e.g. EA are a statutory consultee on planning but not the decision-maker).
- Enables the prioritisation of certain land uses over others, which can restrict the ability to implement WwNP or other adaptive strategies.
- Provides limited funding for climate adaptation projects which can hinder the planning and implementation of necessary measures.

It is important that legislation and policy provides clarity in approach and is integrated across multiple systems to enable and drive resilience and adaptation.

Future needs for adaptation pathways

Flood risk management in the Severn region is interlinked with broader regional challenges and opportunities around growth and spatial planning, agriculture and food security, and the environment. As a result, the adaptation pathways for the River Severn encompass a range of adaptation actions that facilitate flood resilience and maximise wider value. A series of policy enablers are needed to support:

- Managing multiple pressures and competition between objectives (e.g. agriculture, population growth, nature recovery, etc.) on our land and trade-offs between these.
- Accelerating the delivery of key actions or interventions that are critical to managing changing catchment risks.
- Incentivising the delivery of actions that achieve desired catchment outcomes, for example the deployment of natural flood management to realise environmental and flood risk benefits.
- Transformational adaptation with negative implications, e.g. where it may not be possible to adequately manage risks, policy needs to determine mechanisms for managed realignment.

With changes to policy taking time, action needs to be taken in the short-term to achieve long-term ambitions.



Through the development of the adaptation pathways, we have identified supporting policy enablers. These are outlined in Appendix F3.

Key recommendations

Through the development of the adaptation pathways, we determined policy enablers were needed that supported:

1. **Align FRM and the spatial planning process:** This has significant influence over our ability to manage water at source and impacts the proportion of receptors at risk. The UK government has introduced structural changes to the planning system, enabling regional co-operation. The EA are well-placed to feed into both regional plans and local plans (including new planning system requirements) to manage future risks.
2. **Facilitate English-Welsh border collaboration:** (e.g. funding may be required for upstream interventions that protect properties within another administrative boundary). Effective cross-border working requires the alignment of strategies and regular sharing of information to coherently deliver.
3. **Explore what agricultural and land-use policy change is needed:** To deliver landscape scale interventions in a timely manner, we need policy to enable rapid deployment across multiple land-owners.



Behaviour

Current challenges and opportunities

Managing increasing flood risk requires multiple actors to act. While it is critical to continue to take action to reduce the future risk of climate-related flooding, it is also critical that we help communities and households to adapt and prepare for increasing risks.

Actions to support behavioural change need to consider the regional context of the Severn, notably:

- Engagement and communications in a diverse, cross-border catchment will require language (including Welsh) and EDI / accessibility considerations for underrepresented groups,
- Different social (e.g. ageing populations, language barriers) and economic (e.g. poverty) vulnerabilities will influence the risk hotspots and how community resilience can be developed; and,
- Recognising the need to engage with those living and working across both urban and rural landscapes. Engagement, emergency response needs and types of personal action are likely to differ as a result.

Future needs for adaptation pathways

An integrated, strategic approach is required. Organisations, communities and businesses each have a role to play. To achieve this, behavioural change will be needed. This means:

- Increasing awareness and improving preparedness around climate risks to enable individuals and communities to be prepared for, respond to, and recover from floods. Building personal and community flood resilience requires an understanding of the barriers faced by people in at-risk areas, alongside strong and inclusive engagement.
- Enabling behavioural change that supports widespread adoption of sustainable practices and action to support others in managing flood risk.
- Adopting practices that promote collaboration and integration across parties and actors involved in managing flood risk. This may include sharing of relevant data and information to enable co-ordinated responses.



Through the development of the adaptation pathways, we have identified supporting behavioural enablers. These are outlined in Appendix F4.

Key recommendations

Through the development of the adaptation pathways, we determined behavioural enablers were needed that supported:

1. **Diverse and inclusive engagement** that improves awareness of catchment risks and supports the co-development of adaptation pathways to integrate place-based needs.
2. **Sharing and communicating information** around flood risk management and flood risk warnings to both communities and regional stakeholders/decision-makers.
3. **Behavioural change and community empowerment** to support taking action to manage flood risk. This should include:
 - Explore how to shift public perceptions and behaviours to be able to ‘live with water’,
 - ‘Deliberative governance’ and participatory approaches to support community buy-in to how flood risk is managed; and,
 - Development of community and personal resilience action plans to support personal resilience.

Stakeholder Engagement



A detailed stakeholder engagement plan is located in Appendix F5.

Current challenges and opportunities

The Severn catchment is home to over 5 million people, 100,000 businesses and thirteen different organisations have responsibilities for the management of flood risk – with many more across wider systems. The development of adaptation pathways needs to consider how best to engage with these groups in a proportionate way – balancing resources with building broad consensus around the way forwards.

Any engagement needs to be tailored to the regional landscape and local challenges and opportunities, including:

- Agricultural stakeholders and land-owners to manage sensitive trade-offs on land-use between flood storage and food security; and,
- The demographics of the catchment, considering accessibility needs and rural communities.

To date, engagement has involved series of workshops with the RSP (focused around testing the adaptation planning approach), and a Community Panel (focused on discussing how the catchment should manage flood risk). Future strategic planning activities will need to broaden beyond this to build buy-in and tailor regional adaptation pathways to meet local needs.

Future needs for adaptation pathways

Meaningful stakeholder and citizen engagement, are essential cornerstones for accelerating adaptation and resilience. It builds trust, a sense of ownership and enables collaborative action.

Stakeholder engagement delivers the best results when it’s considered right at the start of adaptation planning. Therefore, a stakeholder engagement strategy and plan has been developed to support any future adaptation planning across the region. This includes stakeholder mapping to identify the relevant groups and their level of interest/influence to place them into a stakeholder classification. An extract of the stakeholder mapping and their classification is provided below.

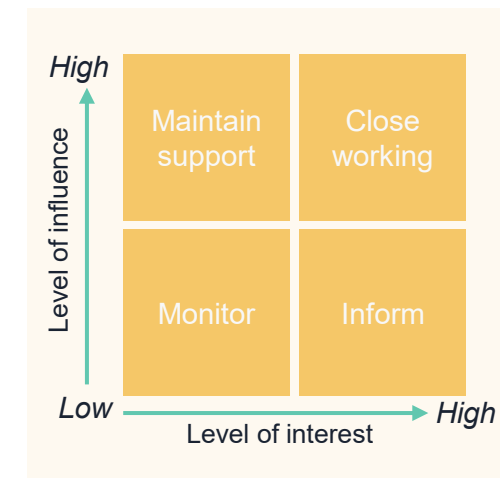


Figure 42: EA engagement classification matrix.

Table 14: Stakeholder mapping.

Group	Organisations	Activities	
RSP	RSP partners, Senior Leadership Group	Close working	Sub-catchment focused workshops, 1-2-1s: to seek agreement on key matters in the catchment.
NRW	Natural Resource Wales and Welsh Government (if interested)	Close working	
Wider EA	Senior Leadership in the EA and local area managers	Close working	Workshops: to seek agreement on key matters and progress APP development.
Political advocates	MPs and councilors in the River Severn Region	Maintain support	MP caucus, councillor meetings: to update stakeholders and provide feedback.
Interest groups	Organisations and groups across agriculture, infrastructure & development, environment & heritage, community and resilience, and business	Inform & Monitor	Focus groups with organisational representatives: to discuss the APP and provide feedback.
Communities	Local communities across the River Severn region	Inform & Monitor	Citizens panel: to provide feedback and recommendations.
Sustainability Appraisal Groups	Natural England, Historic England, EA, NRW, Cadw	Inform & Monitor	Specific consultation process: to provide feedback on the sustainability appraisal.

Data & Information

Current challenges and opportunities

Due to the scale of the catchment, information and data that supports adaptation planning sits across multiple organisations, geographics and scales.

The APP has drawn from best available information, however key challenges include:

- **Risks & opportunities:** Our understanding of flood risk and the impacts of climate change is largely through the EA's area expertise and a patchwork of local hydraulic modelling (with varying climate scenarios and model runs available). Significant efforts were required to develop a strategic, catchment-wide picture of flood risk, in lieu of NAFRA2. Trends around growth were estimated from local (development) plans and ONS population trends, but challenges remain in accessing consistent local data-sets.
- **Adaptation actions and pathways:** Despite the modelling available, it can be challenging to determine the performance of adaptation actions at a strategic scale. A data vs. expert driven approach was trailed to support option development in catchments with varying levels of information.
- **Monitoring and evaluation:** Key indicators were identified based on numerous data sources. However, this data sits across varying organisations and platforms, and significant effort is required to evaluate key trends.

Future needs for adaptation pathways

Effective decision-making relies on robust, accurate, and relevant data and information sources. A number of key success factors underpin a robust evidence base for the adaptation pathways. These include:

- A consistent, 'reliable' evidence base will support robust decision-making and help to achieve desired outcomes. For adaptation pathways in particular, information for monitoring indicators is needed to be able to reliably understand when and how to act, e.g. like how climate change is progressing,
- Facilitating 'access' to knowledge and data are critical for better understanding and managing risks. The democratisation of climate-related knowledge and a common evidence base can enable parties and communities to strategise effectively, mobilise resources efficiently, and respond resiliently to challenges; and,
- 'Transparency' of data and evidence underpinning decision-making is important for building trust amongst parties and communities.



An overview of data and information used to inform the adaptation pathways is located in Appendix F6.

Key recommendations

For future iterations of the adaptation pathways, it is recommended:

1. **Explore the recently released NAFRA2 dataset** to determine how this information can inform an understanding of catchment current and future risks and support decision-making.
2. **Collate and map risks, opportunities and projects** to promote catchment-wide cooperation and data-sharing. This could form the basis of a common-evidence base to support consistent decision-making across catchment actors.
3. **Further explore local trends around growth** are to develop a consistent data-set that identifies spatial areas ear-marked for developed and implications on flood risk management.
4. **Conduct detailed option development and opportunity mapping**, similar to the SVWMS, to determine the scale and performance of adaptation actions. This should consider targeted modelling, or appropriate strategic analysis, to inform the impact of actions both in isolation and sequenced within a pathway. This would support a more robust appraisal, including economic analysis.
5. **Trial the monitoring and evaluation framework** to determine the form and level of information available to support the evaluation of the indicators. As part of this, identify recommendations for further improvement of datasets and whether a platform is needed to support long-term monitoring.

Conclusion

- Success Factors
- Recommendations
- Our Impact



Success factors

The River Severn is at the forefront of innovation in flood risk management, being one of four national pilot projects funded by Defra Innovation to pioneer adaptation pathways for the region. Being the first of its kind in the region, our project has sparked learning and innovation, uncovering valuable insights that will benefit both the region and nationally. Figure 43 sets out our headline success factors across each step in the adaptation pathways process.

Overarching: The British Standard (BS 8631:2021) for Adaptation to Climate Change provides a robust framework for the Severn2100+ AP approach. This supported engagement by providing credibility to the process undertaken. Using two sub-catchments to focus our efforts meant we were able to conceptualise the creation of pathways, moving from theoretical to practical application. Taking an agile, sprint approach to delivery also meant we were able to make progress quickly in a complex environment. The principles of the SA process has helped integrate environmental, economic and social needs and requirements into the development of our draft adaptation pathways.



How do we implement our plan?

Implementation is an iterative process, delivered across a long period. Early consideration of enabling conditions were fundamental to the success of the project. Governance, engagement, funding and finance and data are all needed to ensure effective delivery.



How do we know it's working?

The Theory of Change provided a comprehensive structure to the monitoring and evaluation framework and indicators. Using the focus areas to apply the indicators moved this out of the theoretical space, and helped recognise the importance of monitoring changes in the assumptions that underpin the pathways.



When do we need to act and in what sequence?

Through pathway-building workshops with local experts we were able to sequence the portfolios of adaptation actions into strategic-scale adaptation pathways in two focus areas. Using the three lenses of 'wider benefits, precautionary approach, and cost constrained' encouraged a 'low-regrets' approach when developing the pathways.



Where do we want to be in the future?

Engagement with the RSP was essential to establishing the context and ambition, by defining a strong regional vision for flood resilience. Aligning goals and objectives across partner organisations provided a strong sense of collaboration and mutual understanding.



What is happening that could impact us?

Scenarios were critical to enabling an adaptive approach - they provided different future projections of risks and allowed us to develop plans for these different scenarios.



What can we do about it?

Our framework of actions looked beyond typical physical FRM interventions to include behavioural and policy enablers. We trialled a data-driven versus expert-driven approach to assess the feasibility and performance of adaptation actions. We created high-level scorecards as an engagement tool to communicate the different actions to stakeholders. Our Benefits Toolkit enabled a systematic, strategic appraisal of actions.

Figure 43: Our success factors.

Recommendations

Adaptation planning is iterative by nature. Our work presents the first iteration of adaptation pathways for two areas of the catchment. We recommend next steps refine these and apply our approach across the wider catchments to inform a regional strategy for climate resilience. Our headline recommendations to guide future work are outlined in Figure 44. As Severn 2100+ is a pilot project, a full SA has not been developed, however, at the start of each chapter we have set out what should be undertaken at each stage to conduct a full SA for future adaptation pathway development, .



How do we implement our plan?

- Action the enabling recommendations.
- Build a detailed cross-organisational implementation plan, supported by a long-term funding & financing strategy/plan.
- Explore how the pathways can direct capital investment programme.



How do we know it's working?

- Trial the monitoring and evaluation framework.
- Model performance and impact of pathways on managing the risk, to understand the limits of the different actions in more detail to support with setting triggers and thresholds.
- Strengthen the indicator baselines by feeding in actual events when they occur.



When do we need to act and in what sequence?

- Expand the development of pathways across the wider catchment and beyond a fluvial FRM focus (i.e. incorporating the wider water system).
- Explore how progress along a pathway (and its appraisal) can be supported by digital tools.
- Further refine the economic appraisal of the adaptation pathways.



Where do we want to be in the future?

- Engage with stakeholders and the public to consider the scale of the ambition and set targets at sub-catchment level for each objective, supported by quantitative metrics (where possible).



What is happening that could impact us?

- Develop our understanding of catchment risks through the use of NAFRA2 and a more detailed assessment of how and where growth and development will impact the catchment.



What can we do about it?

- Conduct a detailed review of the existing pipeline of activities to identify how they align with the emerging pathways.
- Conduct portfolio feasibility mapping and performance assessment catchment-wide to support a data-driven approach being applied consistently across the region (e.g. similar to the SVWMS).

Figure 44: Our recommendations.

Our impact

Our project represents the collective efforts of the EA and Arup, supported by Jacobs and the RSP. We have brought together local experts and regional stakeholders to co-create a strategic, adaptive approach to managing long-term flood risk, which delivers wider benefits for a region of over 5 million people.

Our approach is:

- Is replicable across the catchment and nationally.
- Is applicable across the broader water system, i.e. water resources and quality.
- Helps to save costs and avoid mal-adaptation, by ensuring the catchment takes a low-regrets approach and adaptation actions can be deployed when needed.
- Informs a pipeline of schemes and drives efficiencies in early stages of business case development.
- Enables decisions that maximise wider benefits and partnership funding of FRM actions.
- Moves the concept of adaptation pathways from theoretical to practical application.

The insights generated from our pilot may support adaptation efforts by others. By trialling our proof-of-concept approach nationally across different scales, systems, and contexts, it can be further refined and developed to enable wide-spread adaptation.



“Taking a strategic, catchment-scale approach in the Severn, will help the EA, and partners, to drive efficiencies by enabling targeted action and accelerating the development of businesses cases for capital schemes.”

Dan Trewin (Environment Agency)

“The Severn Pilot is leading the way. The insights, tools, and guidance developed will better equip the Environment Agency and risk management authorities to embed adaptive approaches nationally across FCERM activities.”

Harry Chalk (Environment Agency)

“Responding to these challenges and opportunities requires a strategic, catchment-scale approach with collaboration beyond a single organisation. Our collaborative approach has helped build regional capacity for adaptation - better equipping practitioners and policymakers to make the best decisions, at the right time, for the benefit of the River Severn’s communities, environment and economy.”

Members of the RSP

“This project was an exciting opportunity to move the concept of adaptation pathways from theoretical to practical application in flood risk management.”

Louise Ellis (Arup)



Environment
Agency



River
Severn
Partnership

ARUP

supported by
Jacobs

If you have any questions relating to the content in this report, please email:
enquiries@environment-agency.gov.uk

This pilot has been delivered by the Environment Agency and Arup
(supported by Jacobs)

With special thanks to our collaborators, the River Severn Partnership



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Jacobs

Daniel Trewin

EA Place Manager for Shropshire and Worcestershire

Harry Chalk

EA FCERM Senior Advisor for Adaptation

Will Shaw

EA Severn 2100+ Project Executive

John Morgan

EA Severn 2100+ Project Manager

Lesley Tims-Cooper

EA Severn 2100+ Partnership Manager

Stephen Lawrence

EA Severn Adaptive Pathways Pilot Senior User

Josh Ystenes

EA National Environmental Assessment Service

Louise Ellis

Arup Project Director

Eloise Orrey

Arup Project Manager

Rose Jenkinson

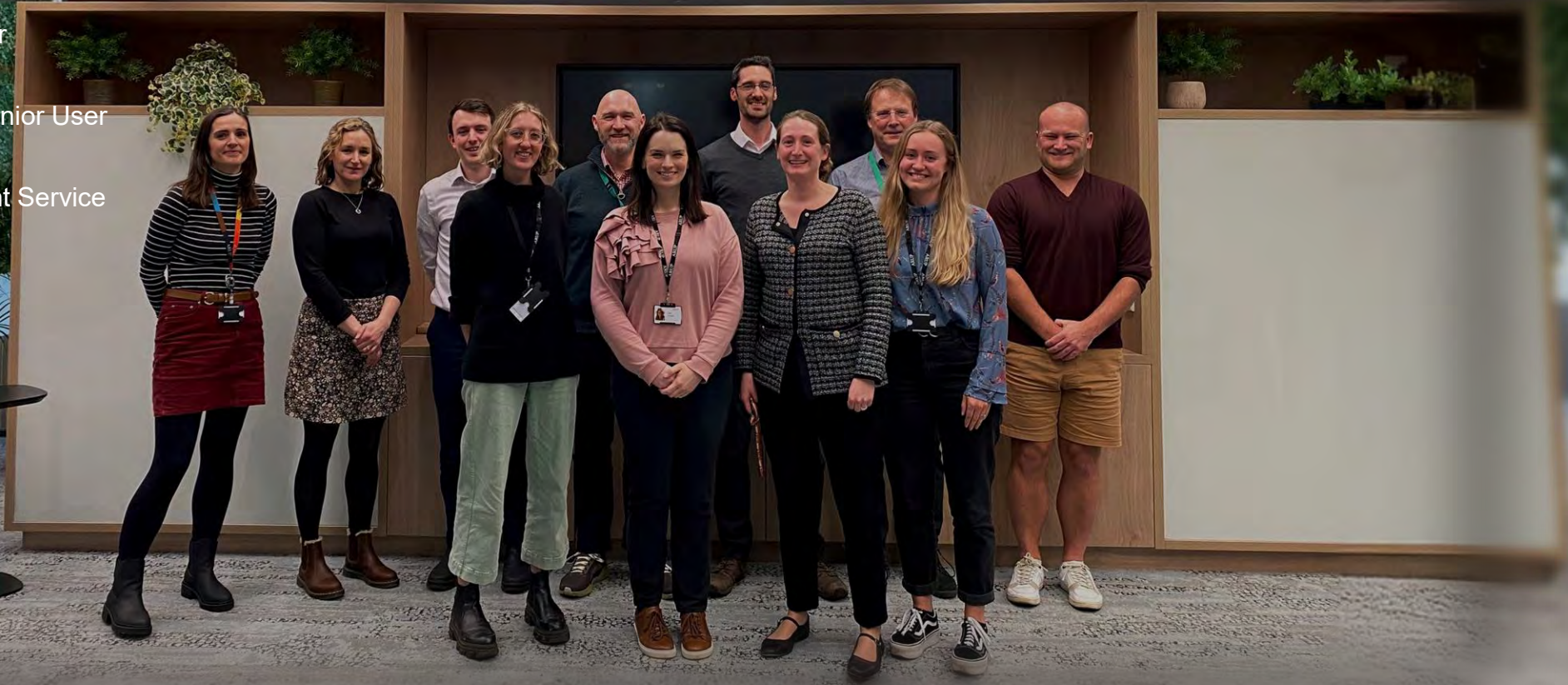
Arup Technical Expert

Nina Noreika

Arup Technical Lead

Peter von Lany

Jacobs Technical Lead



Discovery & Design Report Appendices

Severn 2100+

River Severn (Afon Hafren) Adaptation Pathways Pilot

P02

May 2025

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Appendix A

Context & Ambition

Contents

This appendix contains:

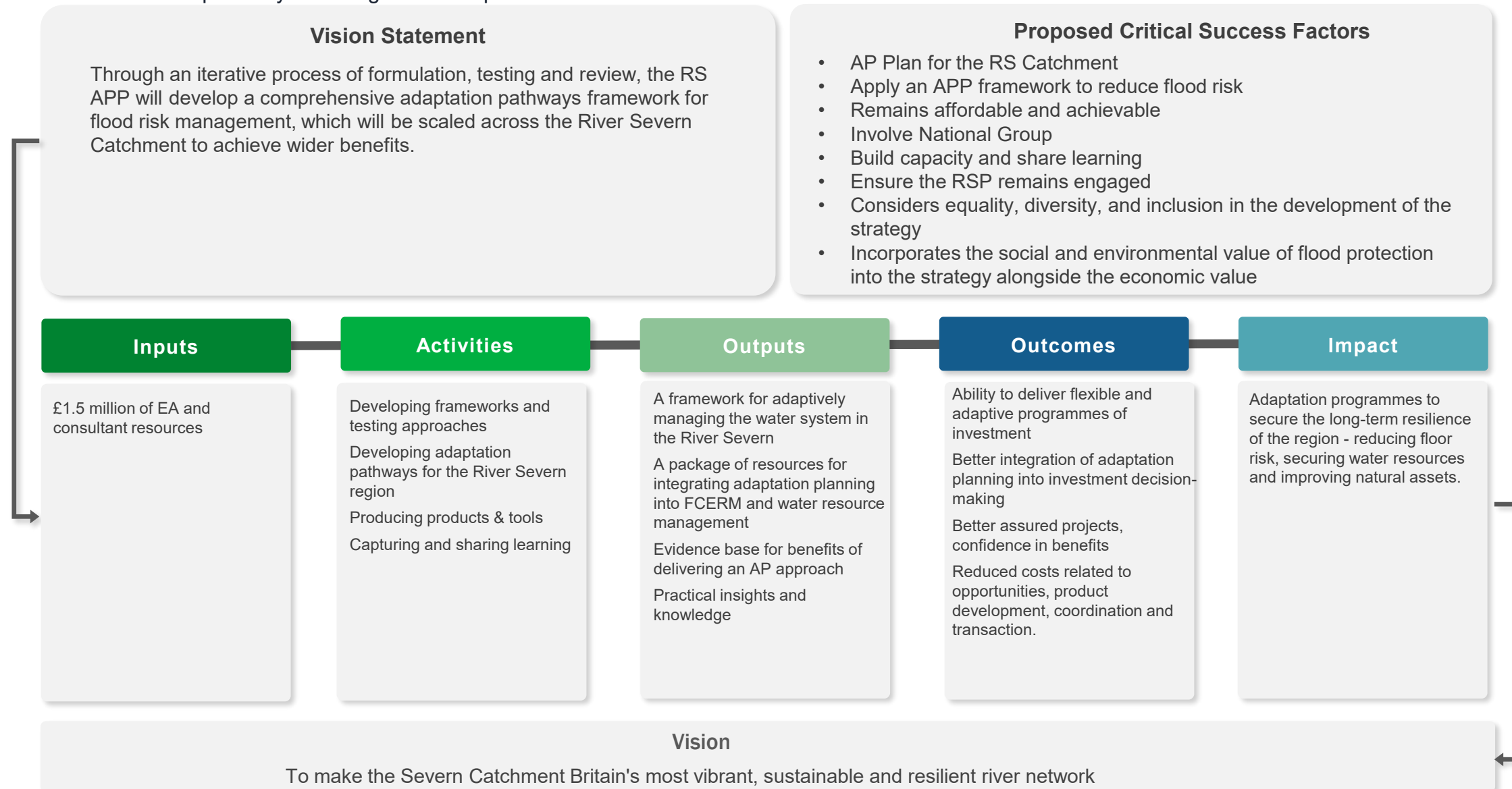
- A1: The River Severn Partnership Theory of Change; and,
- A2: Measures of success across the River Severn Partnership Themes.



Appendix A1

River Severn Partnership Theory of Change

The River Severn Partnership Theory of Change Model is presented below.



Appendix A2

Measures of success across the River Severn Partnership Themes

Appendix A3 presents measures of success aligning to the RSP vision.

Table A2.1: List of measure of success aligning to the RSP vision.

Objective	Existing targets/ Metric	Source	Data collection
Housing: Enable climate resilient places and resilient communities where everyone can adapt to flood risk under current and future climates to an economically affordable level.	Reduced proportion (%) of new development for which planning applications were granted against Environment Agency and lead local flood authority (LLFA) flooding advice.	Defra FCRM metrics	Environment Agency Section 18 reports; Gov.uk data
	Reduced proportion (%) of properties at risk.	Defra FCRM metrics	Environment Agency FCERM capital investment programme
	Increased proportion of household level flood resilience (i.e., flood insurance, PFR, etc.)	Defra FCRM metrics	Defra PFR recovery grant claims
	Increased percentage of new houses delivered outside of flood risk areas annually.	Defra FCRM metrics	Local authority housing development metrics
	Increased number of properties with PFR installed as part of Environment Agency FCERM capital investment programme.	Defra FCRM metrics	Environment Agency FCERM capital investment programme
	Increased proportion (%) of 'at risk' properties where flood warnings are available and residents are automatically signed up.	Defra FCRM metrics	Environment Agency Flood Warning Service
	Increased proportion (%) of 'at risk' residents proactively signed up to flood warnings (excluding opt-out).	Defra FCRM metrics	Environment Agency Flood Warning Service
	Increased proportion (%) of people in areas at risk of flooding who have taken the time to understand how they would respond as a community to flooding in their neighbourhood.	Defra FCRM metrics	Environment Agency Public Flood Survey
	Increased proportion (%) of properties recovered with additional physical PFR resilience measures post event.	Defra FCRM metrics	Defra PFR recovery grant claims
	Increased availability of flood insurance – increased proportion (%) of householders with prior flood claims who can receive quotes from 5 or more insurers.	Defra FCRM metrics	Flood Re data
	Increased proportion (%) of local design guides and/or codes which specify building standards for flood resilience.	Defra FCRM metrics	No current data available
	Increased proportion (%) of property flood resilience (PFR) measures installed which are installed and maintained in alignment with current industry standards.	Defra FCRM metrics	There is limited data on PFR installation and maintenance. Data on the effectiveness of PFR in improving resilience is also lacking.
	Increased proportion (%) of properties which trust and act on (when appropriate) flood warnings received.	Defra FCRM metrics	Data collection – potential to use post-event surveys or Environment Agency Public Flood Survey
	Reduced risk of flooding for more households - 300,000 homes better protected by March 2021.	EA2025 Creating a better place (publishing.service.gov.uk)	
	Increased proportion of planning decisions by local planning authorities in line with EA advice (goal of 97%).	EA2025 Creating a better place (publishing.service.gov.uk)	

Appendix A2

Measures of success across the River Severn Partnership Themes

Table A2.2: List of measure of success aligning to the RSP vision.

Objective	Existing targets/ Metric	Source	Data collection
People: Support our services, infrastructure and built assets to be resilient to current climate extremes and be able to adapt to future flood events.	Increased proportion (%) of 'at risk' areas with flooding adaptation plans adopted by public bodies.	Defra FCRM metrics	Consistent understanding of what is meant by 'adaptation plans' and data collection still needed
	Increased proportion (%) of 'at risk' areas covered by non-mandatory emergency plans which include a response to flooding.	Defra FCRM metrics	Data collection and collation from multiple sources would be needed including from LRFs and LLFAs
	Increased proportion (%) of 'at risk' community where effective and exercised multi-agency flood emergency plans are in place.	Defra FCRM metrics	Data collection – potential to use Section 19 reporting. Need to define and get consensus on what is meant by 'effective' plans.
	Increased proportion (%) of 'at risk' areas where community members participate in incident response activities.	Defra FCRM metrics	Data collection – potential to use Environment Agency Public Flood Survey
	Increased number of public services, education, medical service, recreation, religious houses other social infrastructure, and culturally-significant sites resilient to flooding.	Defra FCRM metrics	NaFRA2; NRD
	Increased proportion of schools within areas at risk of flooding with curriculums that include teaching on local impacts and resilience.	Defra FCRM metrics	Further research; data collection with Department for Education support
	Increased proportion (%) of people actively participating in FCERM decision-making.	Defra FCRM metrics	Data collection – potential to use Environment Agency Public Flood Survey. Difficult to define, quantify and measure community participation
	Increased proportion (%) of people within 'at risk' areas who know where they will live and work if or when their current home or workplace becomes uninhabitable due to flooding or erosion.	Defra FCRM metrics	Data collection – potential to use Environment Agency Public Flood Survey
	Increased community confidence in future actions for increasing resilience to flooding.	Defra FCRM metrics	Data collection – potential to use Environment Agency Public Flood Survey. Need to define and get consensus on what community 'confidence' means.
	Increased maintainance of an up-to-date project list for the catchment allowing greater sharing of knowledge and evidence.	Severn Vale Catchment Plan	
	Increased proportion (%) of flood management assets at or above the target condition.	EA2025 Creating a better place (publishing.service.gov.uk)	
	Increased proportion (%) of adaptation actions delivered and on track in our FCERM Strategy and Adaptation Report (minimum 90%).	EA2025 Creating a better place (publishing.service.gov.uk)	
	Increased high quality, trained incident response capability (goal of 6,000 staff).	EA2025 Creating a better place (publishing.service.gov.uk)	
	Increased proportion (%) of 'at risk' areas with flooding adaptation plans adopted by public bodies.	Defra FCRM metrics	Consistent understanding of what is meant by 'adaptation plans' and data collection still needed

Appendix A2

Measures of success across the River Severn Partnership Themes

Table A2.3: List of measure of success aligning to the RSP vision.

Objective	Existing targets/ Metric	Source	Data collection
Agriculture: Support the agricultural industry to adapt to current and future flood risk, promoting sustainable, high-quality agriculture and food security.	Reduced proportion of existing land use at risk of flooding (all sources) – now (current year) and with climate change.	Defra FCRM metrics	NaFRA; NCERM; National Receptor Database
	Reduced proportion (%) of Excellent, Very Good, and Good to Moderate (ALC grades 1-3) agricultural land at risk of flooding.	Defra FCRM metrics	NaFRA
	Increased proportion (%) of rural land area covered by rural land use schemes or new farming techniques which reduce flood impact.	Defra FCRM metrics	Definition, measurement and data collection for schemes. Data from future ELMs schemes may help with this measure.
	Increased proportion (%) of land use resilient to flooding.	Defra FCRM metrics	NaFRA
Economy: Support sustainable growth under today and tomorrow's climate, enabling businesses and critical infrastructure to be resilient to flooding.	Increased proportion (%) of flood and coastal assets managed and maintained within and above a specific condition level.	Defra FCRM metrics	Environment Agency FCERM capital investment programme
	Reduced proportion (%) of 'at risk' essential infrastructure which do not maintain minimum levels of service during a flood/coastal erosion event.	Defra FCRM metrics	No agreed definition for minimum levels of service. No current way of collecting data and reporting information from utility and infrastructure providers.
	Reduced annual average residual damage (£) of properties (non-residential and residential) and critical infrastructure due to flooding.	Defra FCRM metrics	NaFRA
	Increase in annual £s spent through tourism in the region.	ONS, Visit Britain, Local Council data	Domestic and overseas tourism data, including income from tourism
	Reduced total economic damages (£) from flooding annually.	Defra FCRM metrics	Proactive data collection and quality control needed. No agreed way of assessing actual economic damages.
	Reduced average time taken to recover following a flooding or coastal erosion event.	Defra FCRM metrics	Method for measurement needs development; data collection on different aspects of recovery needed.
	Increased annual £s in the region sustainably invested through green finance.		

Appendix A2

Measures of success across the River Severn Partnership Themes

Table A2.4: List of measure of success aligning to the RSP vision.

Objective	Existing targets/ Metric	Source	Data collection
Environment: Protect and enhance the unique system of natural landscapes, and areas of outstanding natural beauty to allow habitats to thrive and support current and future generations.	Increased number of schemes with NFM/NBS in FCERM programme.	Defra FCRM metrics	Environment Agency FCERM capital investment programme
	Reduced (%) national flood risk (modelled).	Defra FCRM metrics	Environment Agency FCERM capital investment programme
	Increased proportion (%) of SuDS in new development that are designed and implemented meeting government or industry technical standards.	Defra FCRM metrics	Standardised data from LLFAs or LPAs currently not available. Reporting framework needed.
	Reduced number of flood events breaching defences annually.	Defra FCRM metrics	
	Increased area / length of river connected to its natural floodplain.	Defra FCRM metrics	
	Increased proportion (%) of flood or coastal defence schemes that include nature-based solutions (NBS) that offer quantitative evidence it is providing flood benefits.	Defra FCRM metrics	Consistently quantifying the benefits of nature-based solutions that slow the flow, store flood waters or offer erosion benefits is not currently possible
	Increased proportion (%) of land use for which sustainable drainage systems (SuDS) were retrofitted in the past year meeting government or industry standards.	Defra FCRM metrics	There is limited data on SuDs retrofit. A standardised data collection and reporting framework is needed.
	Increased number of water bodies with high ecological status.	Teme Catchment Management Plan	
	Increased healthy and recruiting population of Freshwater pearl mussels.	Teme Catchment Management Plan	
	Increased wildlife returning to the river and the catchment, including rare fish, such as shad and formerly common birds such as the cuckoo.	Teme Catchment Management Plan	
	Increased km ² of healthy and connected woodland.s	Teme Catchment Management Plan	
	River sediment reduced to natural levels through improved practices, such as sustainable urban and rural drainage and good buffer strips along riverbanks on cultivated land and fewer livestock accessing the river.	Teme Catchment Management Plan	
	Increased annual average days with sustainable levels of water in the streams and rivers.	Teme Catchment Management Plan	
	Reduced need for pesticide removal from drinking water.	Teme Catchment Management Plan	
	Increased use of innovative Natural Flood Management techniques throughout the catchment, taking a holistic approach to addressing flood risk in key areas.	Severn Vale Catchment Plan	
	Increase in actively sought after opportunities for wildlife and biodiversity gains and implement changes to benefit habitats and species.	Severn Vale Catchment Plan	

Appendix A2

Measures of success across the River Severn Partnership Themes

Table A2.5: List of measure of success aligning to the RSP vision.

Objective	Existing targets/ Metric	Source	Data collection
Environment: Protect and enhance the unique system of natural landscapes, and areas of outstanding natural beauty to allow habitats to thrive and support current and future generations.	Increased working with communities in the area to increase awareness and enjoyment of the water environment. Increased community participation in the monitoring and maintaining of a healthy river catchment.	Severn Vale Catchment Plan	
	Increased identification and remediation of issues with water quality.	Worcestershire Middle Severn Catchment Management Plan	
	Increased collation of flood impact information, taking a catchment-wide, holistic approach to alleviating problems in specific areas.	Worcestershire Middle Severn Catchment Management Plan	
	Increase in actively sought-after opportunities for wildlife and biodiversity gains and implement changes to benefit habitats and species.	Worcestershire Middle Severn Catchment Management Plan	
	Increased engagement with communities in the area to increase awareness and enjoyment of the water environment.	Worcestershire Middle Severn Catchment Management Plan	
	Improved access for all and encouragement of participation in maintaining a healthy river catchment.	Worcestershire Middle Severn Catchment Management Plan	
	Reduced pollution across 5 priority pollutants: NOX, SOX, NMVOC, NH3 and Particulates in the refineries sector.	EA2025 Creating a better place (publishing.service.gov.uk)	
	Reduced oxides of sulphur emissions, towards meeting target: 90% of 2017 baseline (479 g/t) = 431 grams/tonne.	EA2025 Creating a better place (publishing.service.gov.uk)	
	Reduced oxides of nitrogen emissions, towards meeting target: 90% of 2017 baseline (225 g/t) = 203 grams/ tonne of oil processed.	EA2025 Creating a better place (publishing.service.gov.uk)	
	Increased (km) of water environment enhanced, ensuring our rivers and coasts have better water quality and are better places for wildlife.	EA2025 Creating a better place (publishing.service.gov.uk)	
	Increased use of innovative Natural Flood Management techniques throughout the catchment, taking a holistic approach to addressing flood risk in key areas.	Severn Vale Catchment Plan	
	Increase in actively sought after opportunities for wildlife and biodiversity gains and implement changes to benefit habitats and species.	Severn Vale Catchment Plan	



Appendix B

Risks & Opportunities

Contents

This appendix contains:

- B1: Longlisted trends,
- B2: Scenario analysis,
- B3: Hydraulic model collation,
- B4: Local (development) plans; and,
- B5: GIS spatial layers.



Appendix B1

Longlisted trends

This section presents our trend analysis and how individual trends may impact the River Severn catchment in the future posing both risks and opportunities.

Methodology

We developed a longlist of trends associated with each of the PESTLE categories and linked those to the RSP key themes. We then collaboratively categorised trends based on their relative impact and uncertainty to the River Severn catchment.

The following tables summarise supporting narratives of each trend, first and second order impacts (i.e. risks) and implications (i.e. opportunities). These trends have been categorised across the RSP key themes: Environment, Economy, People, Agriculture, and Housing.

Table B1.1: High-impact trends from PESTLE analysis.

Identified High-impact Trends	
Economy	Ageing infrastructure
	Flood damage
	Improved regional connectivity
	Economic growth
	Complex governance and funding structures
	Change in supply chains
	Increased energy demand
Environment	Climate change: temperatures and precipitation changes
	GHG emissions
	Growing competition for natural resources
	Governance of global commons
People	Changing face of public services
	Regeneration and placemaking
	Digital Skills
	Healthy life expectancy
	Ageing population
Housing	Urbanisation
	Housing shortage
	Increased migration
Agriculture	Changes in agricultural land management
	Changes in water resource management
	Food demand
	Crop yield variance

Appendix B1

Economy: High Impact Future Trends

Table B1.2: Economy High-impact trends.

Trend	Supporting Narrative	First order impacts	Second order impacts	Implications (opportunity areas)
Ageing flood infrastructure	Much of the flooding infrastructure in the UK is ageing and outdated. A significant amount was built following flood events in the 80s/90s and will need replacing by 2050. In addition, future climate change may put additional pressure on these assets such as more frequent intensive rain events resulting in flooding and an alteration in the wet / dry cycling of the soil.	Ageing assets with condition exacerbated by climate change leading to an increasing risk of failure and cascading impacts via asset networks. Failure of both FRM assets and non-FRM assets can lead to loss of life, economic/financial losses, and disruption.	Failing FRM assets can result in increased flood risk to local communities and transportation networks. Assets may need to be replaced to defend against higher return periods, incurring extra cost.	Investing in adaptive capacity and robustness (flexible resilience) in asset systems.
Improved regional connectivity	Regional connectivity is likely to increase in urbanised areas to support sustainable growth and regeneration. Many city centres have adopted ultra-low emission zones to encourage the uptake of public transport and active travel. New infrastructure is likely needed to support these efforts such as more pedestrian / cycle paths, bus lanes, etc. However, in future climate change scenarios these alternate modes of transport will need to be resilient to flooding and overheating associated with increasing number of hot days.	FRM implications: Critical components of transport networks (especially road and rail) may be directly affected by flooding (fluvial or pluvial) leading to loss of capacity and disruption. In extreme events, hazardous conditions could lead to loss of life or serious injury of those using the transport systems. CC implications: more frequent/extreme/variable weather events could exacerbate (a) asset deterioration resulting in loss of performance (e.g. speed restrictions on trains during hot weather); and (b) hazardous conditions near transport assets (e.g. landslips and ground movement).	FRM implications: Components of transport networks (especially road and rail) may be indirectly affected by the cascade effects of flooding (fluvial or pluvial) on systems on which they depend (e.g. power, communications) leading to loss of capacity and disruption. CC implications: cascade impacts on system capacity and performance as a consequence of weather events.	Investing in adaptive capacity and robustness (flexible resilience) in transport and 'connectivity' systems.
Flood damages	Climate change projections indicate more severe and frequent floods in the future.	More frequent flood events cause increased damages and put extra pressure on (a) maintaining the condition and resilience of existing assets, infrastructure and buildings; and (b) investing in new/improved flood risk management systems.	More frequent severe flooding can have impacts on financial security of communities, their public health and mental health, through loss and damage as well as the distribution of contaminants.	Investing in adaptive capacity and robustness (flexible resilience) in flood defence systems, whilst looking for 'low-regret' early adaptation actions (e.g. nature-based solutions).
Complex governance and funding structures	There is a growing complexity in the structure of governance and policy-making in the UK and specifically between Wales and England. The centralised UK government is a large source for FRM funding and that funding is not always distributed proportionally which may lead to a discrepancy in the flood response across the cross-border River Severn catchment.	Determines how flood risk is managed and how flood risk management is funded (especially urgent and time-critical flood risk-management interventions); and how the costs and benefits of flood management are distributed within society.	Weak or poor governance could result in 'lock-in' to expensive or inappropriate forms of flood risk management.	FRM may become more focused around the CaBA, enabling catchment units to distribute FRM funding where necessary.

Appendix B1

Environment: High Impact Future Trends

Table B1.3: Environment High-impact trends.

Trend	Supporting Narrative	First order impacts	Second order impacts	Implications (opportunity areas)
Climate change: temperatures and precipitation	The UKCP18 projections show an increased chance of milder, wetter winters and hotter, drier summers, rising sea levels and an increase in the frequency and intensity of extreme weather events. The severity of these changes is dependent on the different representative concentration pathways. Warming means the air can hold more moisture (for every 1°C of warming, the atmosphere can hold 7% more moisture).	Wetter winters can lead to waterlogged ground and overall increased river levels. Hotter drier summers with combined with extreme rainfall events can lead to flash flooding .	Changes in weather patterns could potentially reduce the resilience of certain types of flood defence (e.g. cracking and/or settlement of earth embankments).	
Greenhouse gas emissions	In line with the Paris Agreement the UK is signed up to seek to limit global warming to 1.5°C, however global greenhouse gas (GHG) emissions still on the rise meaning it is likely we will exceed this level of warming. Despite this rise, carbon dioxide (CO2) emissions in the UK decreased by 3.4% from 2021 to 2022, or by 14 million tonnes of carbon dioxide equivalent.	GHG targets are not being reached to achieve net-zero goals which will exacerbate flood risk and events in line with climate change projections.	Rainfall associated with storms is already more intense and more likely than pre-industrial times, and further global warming could see storm rainfall becoming even more intense and more likely.	
Pace of government climate mitigation	The various governmental entities across Wales and England have different commitments to reach net-zero at different times and in different ways; some commitments have also changed since Brexit. Emissions reductions can slow the pace of climate change which will have knock-on implications for flooding.	The rate at which the climate changes (and is then arrested) has a strong influence of the rate at which flood events change in magnitude and variability. These changes are dynamic, non-linear, and unpredictable, delivering various challenges in adapting to them.	Bringing climate change under control will make it easier to protect landscapes (e.g. from erosion and soil loss) and manage land uses in ways that are sustainable.	Implementing strong adaptation pathways that are designed with potential future scenarios in mind can help absorb dynamic and unpredictable changes.
Emerging and persistent contaminants	The growing scarcity of natural resources such as water and land has the potential to undermine current industrial practices and even to lead to conflict. Concerns over access to a range of vital resources have heightened in recent years.	Deterioration in water quality is likely to be a first order impact, increasing pressures on and vulnerability of natural ecological systems.	Distribution of contaminants by flood water is likely to be a second order impact, increasing pressures on and vulnerability of natural floodplain ecological systems as well as human and agricultural receptors.	

Appendix B1

Environment: High Impact Future Trends

Table B1.4: Environment High-impact trends.

Trend	Supporting Narrative	First order impacts	Second order impacts	Implications (opportunity areas)
Green recovery	There is a growing focus on green recovery (including BNG, BBN, NbS, NFM, etc. policies and drivers) to contribute to the mitigation of climate change. The Severn Rivers Trust was recently awarded funding from Defra's NFM Programme, however the long-term funding of these measures can be intermittent.	Uncertainty surrounding long-term funding can lead to stranded green assets or incomplete projects. Incomplete projects risk not providing adequate ecosystem services and hindering regional or national targets.	Widespread failure of green recovery projects due to a lack of funding certainty could increase the perceived risk of these projects, driving out private finance altogether.	Long-term funding commitments or secondary funding sources can reduce the risk of long-term funding not materialising. Capacity building and knowledge sharing can reduce the ongoing costs of projects, reducing the reliance on long-term funding.
Growing competition for natural resources	The growing scarcity of natural resources such as water and land has the potential to undermine current industrial practices and even to lead to conflict. Concerns over access to a range of vital resources have heightened in recent years.	May lead to increased cost of natural resources or conflict.		
Renewable energy	To meet net-zero goals and increasing societal pressures for access to renewable energy, there is likely significant investment requirements into new infrastructure that is resilient to climate change and flooding.	Reduced carbon emissions, but some renewable energy stations are very vulnerable to flooding. Solar farms developed on floodplains are at heightened risk of flooding. Hydroelectric schemes are at risk of being overwhelmed. These systems are designed to withstand current climate conditions (e.g. wind turbines designed shut off in storm-force winds), but future severe weather may overcome current or past design limits.	Increased design limits to withstand changing severe weather may drive up prices of renewable energy installations or delay their deployment.	Investing in research and design to improve the resilience of renewable energy systems and developing policies to ensure resilience will help deliver a net-zero grid that is prepared for the future.
Biodiversity loss and ecosystem degradation	Species and biodiversity loss across the UK has accelerated in the modern era due to the introduction of non-native, invasive species and habitat loss and fragmentation from anthropogenic influences. Climate change puts further pressure on native ecosystems through changing precipitation patterns and warmer temperatures. Additionally, there are political influences to rectify the trajectory of biodiversity loss such as biodiversity net gain (BNG) and net benefit for biodiversity (NBB) which are rolling out this year.	Biodiversity loss and ecosystem degradation can reduce the amount of water stored in the landscape and reduce local resilience	Biodiversity loss and ecosystem degradation can reduce the climate resilience and amenity value of a region.	

Appendix B1

People: High Impact Future Trends

Table B1.5: People High-impact trends.

Trend	Supporting Narrative	First order impacts	Second order impacts	Implications (opportunity areas)
Digital skills	Digital skills are increasingly sought after by employers of jobs across all skill levels, even 'low skill' positions.			
Digitalisation to improve flood predictions	Recent technological improvements can improve the government's ability to collect information to enable situational awareness on near-real flow rates in watercourses. This can improve the provision of flood alerts and emergency response times in a flood event, especially if the ideas of a digital twin and agent-based modelling are applied. Although the use of artificial intelligence is increasingly part of everyday life in the UK, the future trajectory of AI presence and usage in the UK is uncertain and is highly dependent on how prepared or willing society is to further adopt AI technologies.			Ability to use digital monitoring for floods (e.g., digital twins), alerting people to flood risk
Healthy life expectancies	While estimates vary significantly, prior to the COVID-19 pandemic, life expectancy across the UK was increasing, although the rate of increase has slowed over the past decade. However, this increase in life expectancy has not translated to a higher 'healthy life expectancy' (i.e., the years someone spends in good health), which has decreased slightly in the past decade.	There is a low likelihood of loss of life during flood events, especially flash-flooding. Although loss of life whilst in the home is rare, incidents can happen to motorists encountering swollen rivers and damaged roads/bridges	There may be second order impacts on general health due to damp and mould growth as a longer-term consequence of living in a home that has been flooded.	
Ageing population	An ageing population means that an increased number of vulnerable people will be at risk of flooding.	Reduced mobility - less likely to respond to flood warnings, inability to prepare for/cope with flood events, digital exclusion		
Changing face of public services	The current pressures on public services is expected to only increase in the years to come. When combined with new technologies and competition between different organisational models, this has the potential to fundamentally change the relationships between citizen, state and society.	Impact of support during / after a flood		
Regeneration and placemaking	Currently, across the River Severn catchment there is a discrepancy in access to public parks and gardens between England and Wales. The presence of accessible green space and connection to cultural assets can not only improve mental health and the amenity value of an area. These spaces may also help to build climate resilience especially within urbanised areas.	Disrupted access to recreational areas as a consequence of long duration flooding.	Cancellation of outdoor sports events due to flooding an/or poor weather	

Appendix B1

Housing: High Impact Future Trends

Table B1.6: Housing High-impact trends.

Trend	Supporting Narrative	First order impacts	Second order impacts	Implications (opportunity areas)
Urbanisation	Urbanisation involves the shift from rural to urban areas. The River Severn catchment is primarily a rural area, so urbanisation could either lead to people moving out of the catchment into nearby cities or increased population densities in the towns within the catchment. Growing urban populations may be exposed not only to fluvial flooding (if near a river) but also pluvial flooding, as well as other hazards exacerbated by climate change such as the creation of 'heat-islands' and reduced air quality.	More people living in urban areas exposed to current and potential future flooding within the catchment may increase the need for more or better flood defence systems in those areas. Larger urban areas lead to more severe urban runoff, increasing flood risk and water pollution.	This increase in urbanisation (unless accompanied by the implementation of SuDS) could, in turn, increase the risks associated with pluvial flooding	Applying SuDS to developments such as retention ponds and swales can support with flood storage in developed areas and benefit biodiversity
Housing shortages	To meet the housing need associated with population growth, local authorities in the catchment have earmarked land for future development in their local development plans	Pressure on building houses, perhaps in inappropriate areas. Increased migration Increased impervious cover can significantly increase surface runoff and reduced the infiltration capacity leading to increased flood risk.		Opportunity to deliver flood resilient and well-insulated housing in new developments.
Increased migration	The population in the River Severn region has been steadily growing over the last decade with an influx after COVID-19 when many people relocated from more urbanised areas to take advantage of new work-from-home policies. However, there is uncertainty around whether this trend will continue in the coming years which will affect how local authorities will approach their development plans. Additionally, because of some political influences (such as Brexit and increased visa salary requirements), international immigration into the UK may slow.	Increased pressure on land, increased need for housing and resources		

Appendix B1

Agriculture: High Impact Future Trends

Table B1.7: Agriculture High-impact trends.

Trend	Supporting Narrative	First order impacts	Second order impacts	Implications (opportunity areas)
Crop yield variance	The impacts of climate change are projected to reduce global crop yields. Additionally, various policies or flood defence schemes may increase the flood risk to agricultural fields which may further impact crop yields.	Regional crop yields may decrease in the face of climate change due to hotter weather, changing precipitation patterns and more frequent and/or severe weather events	Invasive species of crop pests and new pathogens could influence agricultural output	Opportunity for different crop types/varieties more resilient to future climate conditions and extreme weather events.
Changes in water resource management	Projected climate change and changes in water demand is likely to cause strains on water resources, this may lead to irrigation restrictions which can influence which crops can be effectively cultivated across the catchment.	Water resource strains can lead to irrigation / extraction restrictions which may influence crop suitability in the region.	Drier agricultural fields can be more resistant to water infiltration, increasing surface runoff proportions.	Opportunity for different crop types more resilient to future climate conditions
Food demand	A growing population results in intensified pressure on food production systems. Economic growth and globalisation have fuelled a shift to diets which contain more meat and dairy, both of which are more water-intensive than historic grain and vegetable diets. However, a trend is emerging in highly developed countries with more health-conscious populations – there is less meat being eaten and an observable trend towards more plant-based proteins like soybeans and other legumes. These changes in habits may be further impacted by changes in agricultural practices in the UK, as regulation such as the future Environmental Land Management scheme comes into force.	Agricultural emissions, food waste, obesity, poverty.	This could change the agricultural mix in the river Severn which is currently very focused around meat and dairy production	Opportunity for farmers to diversify or re-specialise in more resilient crops with lower water demand.
Changes in agricultural land management	Changes to agricultural and soil management can affect infiltration and surface runoff proportions and influence groundwater recharge and flood risk, this can be influenced by policies such as NFM and environmental land management scheme which incentivise farmers to provide occasional flood storage which can improve the level of nutrients in the soil.	Increased surface run-off from land compaction can increase local flood risk, this can also be mitigated if farmers are incentivised to provide flood storage	Water quality can be affected through agricultural management practices.	Opportunity for improved land-use practices to encourage infiltration and retention of soil moisture thus building capacity to withstand periods of drought.

Appendix B2

Scenario analysis

Scenarios can be interpreted and developed in different ways depending upon the drivers of change of interest as represented to the right, additional detail can be found in the Inception Report. When determining the most appropriate approach to take, consideration needs to be given on what the scenarios will be used for.

To explore current and future risks and opportunities, we have applied a two-by-two scenario development approach. We identified two key trends of highest impact and uncertainty to the Severn. We developed four scenarios to frame how these trends could change over time.

Based upon a longlist of applicable trends, as described in Appendix B1, we collaboratively identified the top two high impact and high uncertainty trends for the Severn 2100+ catchment. These were identified as climate change and growth. To inform the development of scenarios, applying a two-by-two scenario approach, we explored high and low impact projections across each.

Narratives to support each of these four, plausible future scenarios are explored over the following four pages.

Table B2.1: Different types of scenario analysis and associated benefits and disbenefits.

Single trend	Two by two analysis	Morphological analysis
Scenarios are sometimes referred to in the sense of changing levels of a specific trend such as climate change. Scenarios can be developed which explore how this one trend may change in the future.	Deductive scenario planning uses a structured framework to explore two highly impactful, highly uncertain drivers. The two axes form a two-by-two matrix with four quadrants. Each quadrant represents a contrasting but credible future scenario.	This is a sophisticated approach to scenario planning that allows exploration of multiple critical uncertainties to form an appropriate number of scenarios by a narrative.
+ A lot of existing data and scenarios are available on specific climate issues. - To get a comprehensive picture, climate issues can't be viewed in isolation from other trends.	+ Focuses on the critical uncertainties. - Only explores two highly impactful and uncertain factors.	+ Opportunity to manage systems or catchments holistically and maximise wider benefits. + The narrative make the scenarios more relatable to communities - Can become overcomplicated very quickly.

←

Single climate issues

Multiple vulnerabilities

→

Appendix B2

Rapid Action: High Climate Change x High Growth

Trends:

- **High climate change (RCP 8.5):** Hot and dry summers with severe heatwaves, droughts and flash flooding. Mild, wet winters with high river levels.
- **High growth (local (development) plan projections):** High population growth and denser population across the catchment.



Figure B2.1: Created via Microsoft CoPilot with the following prompt: “A British new build estate with flooding and people evacuating their homes with submerged street signs or lampposts and a rescue boat navigating through the flooded streets.”

In 2100, the Severn catchment experiences extreme climate change and significant urbanisation, leading to frequent flooding of the crowded flood plains. Growing economies drive investment but increase flood risk, with development competing for space with nature and native species. The UK government is forced to act quickly to protect communities, even relocating some to more flood resilient areas. Agriculture suffers from severe floods and extreme summers, and urban communities lose their connection to nature.

Economy

There has been significant economic growth due to increased local investment in businesses and housing due to population growth across the catchment. Increased economic investment may lead to more financial resources and enhanced capacity for disaster response.

Environment

There has been increased investment in renewable energy. However, due to extreme climate impacts and increased development the natural capital value across the catchment has significantly decreased over time.

People

Due to the overall growth across the catchment, the average age has decreased over time resulting in a reduced proportion of vulnerable populations. People across the River Severn have become used to rapidly responding to severe flooding events as a part of their daily life.

Housing

Development in the floodplains has continued to keep up with housing needs. Houses are delivered with PFR integrated, accompanied by a series of grants to low-income households. Significant land use change due to housing being delivered in high-demand commuter towns (e.g. Coventry) has disrupted hydraulic processes in the catchment and put extra pressure on existing infrastructure. Flood insurance is compulsory for all homeowners limited to 1% of the total annual household take-home salary.

Agriculture

Wetter winters and hotter summers have resulted in major crop losses stemming from delayed sowing. Animal welfare has also been greatly impacted by increases in heat stress and waterborne illness resulting in major dairy and poultry losses. The agricultural landscape is now primarily located in the catchment's headwaters and has pivoted to pest-resistant perennial crop varieties such as grapevine, blueberries, olives, and traditional mediterranean herbs which have fuelled new industries in the catchment such as wine and olive oil production and agrotourism.

Appendix B2

Space for Adaptation: High Climate Change x Low Growth

Trends:

- **High climate change (RCP 8.5):** Hot and dry summers with severe heatwaves, droughts and flash flooding. Mild, wet winters with high river levels.
- **Low growth (ONS projections):** Slow (or negative) population growth and a more dispersed population across the catchment.



Figure B2.2: Created via Microsoft CoPilot with the following prompt: “Flooded streets in a British village.”

In 2100, the Severn catchment faces frequent, extreme flooding due to worsening climate change. Floods regularly impact agriculture, businesses and homes, and communities are now more dispersed due to low growth rates, making flood defence investment difficult to obtain but allowing space for habitat creation and nature-based adaptation actions, though invasive species outcompete native ones. Economic growth stagnates, reducing private investment, and an aging population is left vulnerable to climate risks.

Economy

Economic growth in the region has been largely stagnant due to migration out of the catchment causing reduced development and investment when compared to the rest of the UK. Low population and growth has resulted in lower damages associated with flooding events. Relatively low damages makes flood schemes difficult to fund, resulting in a more individualistic approach to FRM.

Environment

There has been increased investment in renewable energy, however due to extreme climate impacts some rare habitats have been irreversibly damaged. Low growth and increased flood risk has meant there is more space to restore some historic floodplains and wetlands, supporting habitat creation.

People

Due to net migration out of the catchment, the average age has increased over time resulting in a higher proportion of vulnerable populations susceptible to climate change. With FRM schemes being more difficult to justify economically, communities are taking action – with local flood resilient plans are widespread in areas at risk.

Housing

Regional connectivity has improved, allowing for better-connected yet more dispersed development, allowing more space for floodplain storage and housing. The government requires all at-risk homes to be fitted with PFR, and this regulation is accompanied by a series of grants to low-income households. Due to low growth across the catchment, PFR is typically delivered by retrofitting historic buildings as new developments have not been delivered in the floodplains. Flood insurance is compulsory for all homeowners limited to 1% of the total annual household take-home salary.

Agriculture

Wetter winters and hotter summers have resulted in major crop losses stemming from delayed sowing. Animal welfare was greatly impacted by increases in heat stress and waterborne illness resulting in major dairy and poultry losses requiring adaptation to alternative agricultural practices and produce. More resilient cattle and poultry breeds have been incorporated, and the agricultural coverage of the catchment increases to 95% and is earmarked to support Britain’s food self-sufficiency goals. The Rivers Trust and the NFU have worked closely together to lobby for legislation enabling the space to restore agricultural floodplains, providing fertile soils for farmers and reducing the need for fertiliser application whilst providing flood mitigation and improving infiltration and groundwater recharge.

Appendix B2

Green Growth: Low Climate Change x High Growth

Trends:

- **Low climate change (RCP 4.5):** Warmer temperature averages and steady changes in precipitation across summer and winter.
- **High growth (local (development) plan projections):** High population growth and denser population across the catchment.



Figure B2.3: Created via Microsoft CoPilot with the following prompt: “A British new build with sustainable drainage systems.”

In 2100, the Severn catchment faces regular flooding, but a growing economy has enabled green investment for large-scale nature-based solutions and water resilient housing. Adaptation and sustainability are at the core of development, with technological advancements improving operational flood resilience. Green-centric businesses fuel the economy, and communities are reconnected to nature. The agricultural industry takes advantage of agri-technological improvements and supports the transformation of the catchment through diversification and adaptation.

Economy

There has been significant economic growth due to increased local investment in green-centric businesses and housing due to population growth across the catchment. Significant green growth and green investment has resulted in a network of 15-minute cities distributed across the River Severn region with convenient connections to economic centres such as Birmingham, Cardiff, Bristol, and London.

Environment

There has been increased investment in renewable energy and the natural capital value has increased catchment-wide. The vast green investment has resulted in improved WFD statuses of waterbodies, protected critical habitats, recovering biodiversity and reconnecting people to nature.

People

Technological advances including improved Met Office meteorological predictions, near real-time NaFRA hydraulic modelling, and improved flood alert systems through 5G and improved internet connectivity allow for early, targeted flood alerts to affected areas giving residents more time to prepare and evacuate. People across are resilient to flooding and recover faster. Due to the green growth across the catchment, the average age has decreased over time resulting in a reduced proportion of vulnerable populations. People are more connected to nature and mental health has improved.

Housing

Development in the floodplains has discontinued, and any new development tends to be more dispersed to align with a regional planning strategy. PFR is typically delivered by retrofitting historic buildings as all newer builds are as green as possible and accompanied by SuDS which are required to provide an appropriate level of storage aligning to updated climate change projections, and development has ceased on flood plains. New developments are well connected to economic centres due to the expanded rail network.

Agriculture

The Rivers Trust and the NFU have worked closely together to lobby for legislation enabling the restoration of agricultural floodplains, providing fertile soils for farmers and reducing the need for fertiliser application whilst providing flood mitigation and improving infiltration and groundwater recharge. Farmers are reimbursed for crop losses on washlands caused by flooding. The agricultural composition across the catchment has diversified significantly with a mix of dairy, poultry, and a wide variety of crops. Agrotechnological advances in crop testing have resulted in bespoke fertiliser and nutrient application depending on the specific needs of the plant, enabling regenerative farming across the River Severn catchment, fuelling agrotourism

Appendix B2

Time for Adaptation: Low Climate Change x Low Growth

Trends:

- **Low climate change (RCP 4.5):** Warmer temperature averages and steady changes in precipitation across summer and winter.
- **Low growth (ONS projections):** Slow (or negative) population growth and a more dispersed population across the catchment.



Figure B2.4: Created via Microsoft CoPilot with the following prompt: “Natural flood management in an agricultural landscape with contour ploughing and grass buffer strips.”

In 2100, the Severn catchment sees dispersed growth has allowed time and space for climate adaptation measures, but the catchment still faces regular flooding. Flood risk management focuses on sustainable practices and policies rather than physical grey interventions. Communities are gradually more connected to nature and more flood resilient; the economy is stimulated by new agricultural and environmental jobs. Agriculture has the space to be more resilient; high-risk to flood resilient areas, restoring floodplains and supporting catchment-wide resilience.

Economy

Economic growth in the region has been fairly stagnant due to migration out of the catchment causing reduced development and investment when compared to the rest of the UK. However, local investment is prioritised for green-centric businesses and regenerative farming.

Environment

There has been increased investment in renewable energy and the natural capital value has increased catchment-wide. Time has been taken to restore historic floodplains and widespread green investment has resulted in improved WFD statuses of waterbodies, protected critical habitats, and recovering biodiversity.

People

Due to net migration out of the catchment, the average age has increased over time resulting in a higher proportion of vulnerable populations susceptible to climate change. People are more connected to nature and individual resilience to flooding has increased.

Housing

Regional connectivity has improved, allowing for better-connected yet more dispersed development, reducing pressures on existing housing markets and floodplain storage. The UK government requires all at-risk homes to be fitted with PFR, and this regulation is accompanied by a series of grants to low-income households. Due to reduced development in the floodplains, PFR is typically delivered by retrofitting historic buildings.

Agriculture

The catchment is now over 95% agricultural and is earmarked to support Britain’s food self-sufficiency goals; the Rivers Trust and the NFU have worked closely together to lobby for legislation enabling the restoration of agricultural floodplains, providing fertile soils for farmers and reducing the need for fertiliser application whilst providing flood mitigation and improving infiltration and groundwater recharge. Farmers are reimbursed for crop losses on washlands caused by flooding. Agrotechnological advances in crop testing have resulted in bespoke fertiliser and nutrient application depending on the specific needs of the plant, enabling regenerative farming across the River Severn catchment. Although summers tend to be hotter and drier whilst the winters tend to be wetter, the River Severn catchment still leads the UK in dairy and poultry production, however, there are measurable losses due to heat stress and waterborne illness. Some farmers have diversified and shifted to more perennial crops that do not require annual sowing.

Appendix B3

Hydraulic model collation

Appendix B3 presents the approach undertaken and hydraulic models utilised to represent how flood risk in the focus areas may change over time due to climate change impacts.

Since there was not a regional (or national) hydraulic model available at the time of this project, we undertook the workflow presented to the right to represent how a high climate future is likely to influence flood risk over time.

The following two slides present the model runs utilised across the two focus areas to represent flood risk in 2030 and 2080.

Please note, we have presented only a high climate change future as there are typically not enough model runs to represent both high and low climate change over time.

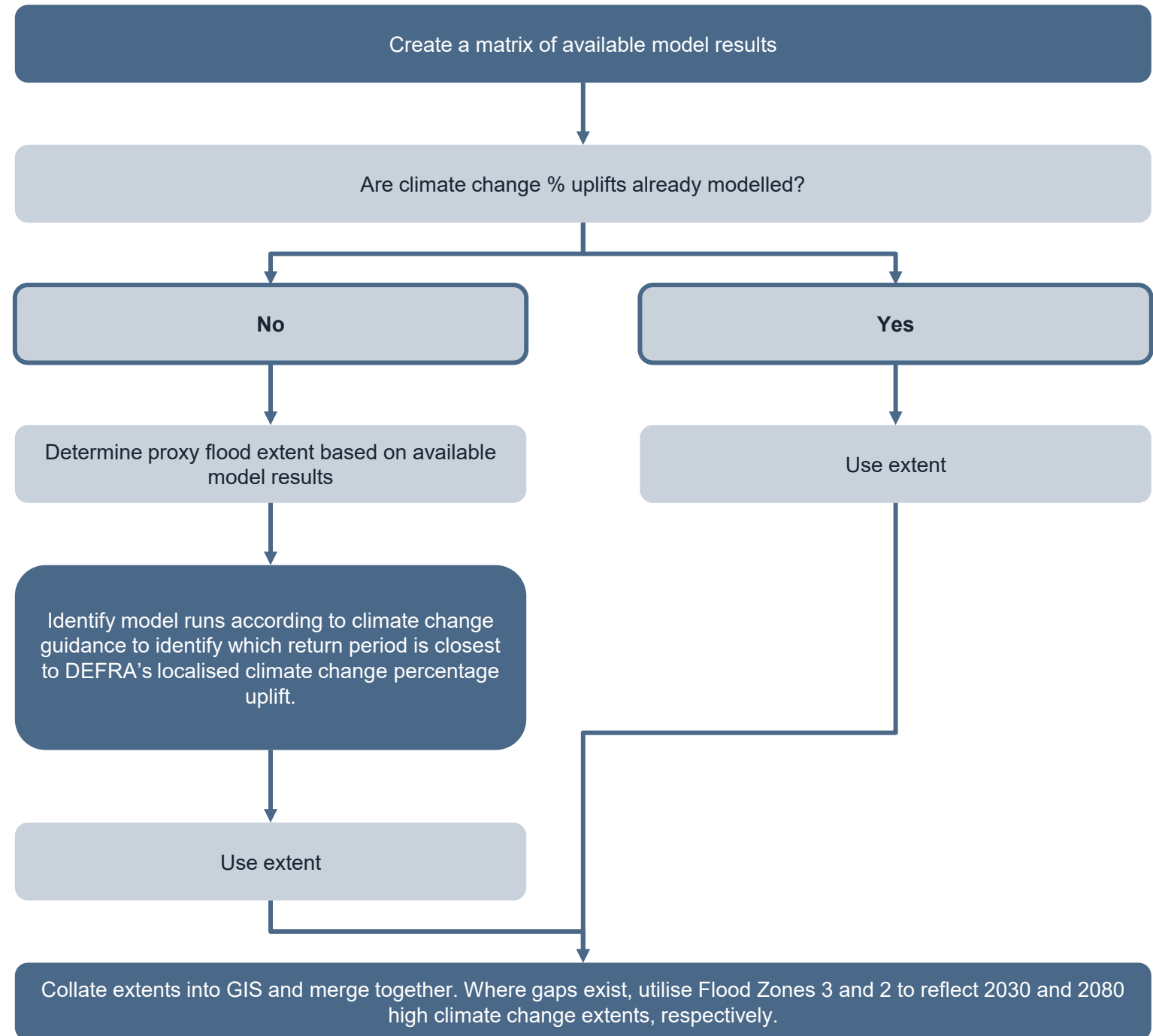


Figure B3.1: Workflow to inform future flood risk over time utilising available local hydraulic models.

Appendix B3

Hydraulic model collation

This slide presents a list of model runs that were utilised to represent high climate change flood risk extents in 2030 and 2080.

Table B3.1: Lists of model used for flood risk extent.

Model name	Flood extents	
	2030s	2080s
Wellesbourne FAS Update 2010	FZ3	FZ2
Kenilworth Hazard Mapping 2010	FZ3	FZ2
Middle Avon Tributaries (Racecourse and Shottery Brook) 2016	FZ3	FZ2
River Sowe (Baginton Weirs) 2011	FZ3	FZ2
River Leam Hazard Mapping (Pingle Brook) 2010	0.5%	0.10%
Badsley Brook Flood Mapping 2010	1% 21CC	1% 59CC
Bow Brook, Elcock Brook, Shell Brook FRMS 2003	1%	0.50%
Rad Brook FRMS 2002	150yr	FZ2
Rea Brook Hazard Mapping 2011	0.50%	0.10%
River Leam Hazard Mapping (River Leam) 2010	FZ3	FZ2
River Leam Hazard Mapping (River Itchen and River Stowe) 2010	1% 22CC	FZ2
Rugby Hazard Mapping - Clay Coton Brook 2015	0.50%	0.10%
River Avon Flood Risk Mapping Study 2010	0.50%	0.10%
Cov 2011- CovUp	0.50%	0.10%
Cov 2011- CovDown	0.50%	0.10%
Cov 2011 Canley Brook 2011	FZ3	FZ2
Warwick Tributaries Flood Risk & Hazard Mapping 2012	0.50%	0.10%
River Arrow and Alne 2009	1% 22CC	FZ2
Rugby Hazard Mapping - River Swift 2015	0.50%	0.10%
Rugby Hazard Mapping - Sow Brook 2015	0.50%	0.10%

Appendix B3

Hydraulic model collation

Model runs, continued.

Table B3.2: Lists of model used for flood risk extent.

Model name	Flood extents	
	2030s	2080s
Rugby Hazard Mapping - Wolston Brook 2015	FZ3	FZ2
Rugby Hazard Mapping -Clifton Brook 2015	0.50%	0.10%
River Sherbourne Modelling Study 2019	1%+25CC	1%+70CC
2019 Bell Brook	1%+20CC	FZ2
Racehorse brook 2019 (contains Shottery BR)	1%+20CC	0.10%
Abermule worcester 2003	FZ3	FZ2
Brookstray 2024	FZ3	FZ2
Noleham Brook 2023	1%	FZ2
St Johns Brook 2023	1% 21CC	0.10%
Finham and Canley 2022	1% 21CC	1% 59CC
Alcester 2024	1% 21CC	1% 59CC
Yelvertoft (Jackson Hyder 2019)	FZ3	FZ2
Severn in Powys NRW 2007 (Supplied by NRW)	0.50%	0.1% UD
River Vyrnwy National Grid 2016 (Supplied by NRW)	0.50%	0.10%
River Vyrnwy Meifod 2020 re-run (Supplied by NRW)	1%	0.10%
Newtown 2021 (Supplied by NRW)	1.00%	0.10%
Severn-Vyrnwy at Shrewsbury JBA 2020	1%	FZ2
Shipston Stour model 24	1% 21CC	1% 59CC
Wark Alcester FAS TufLOW	1% 21CC	1% 59CC

Appendix B4

Local (development) plans

Appendix B4 presents a list of the reviewed local (development) plans from across the catchment to inform a high growth future. These plans are presented, here and on the following slide.

Table B4.1: Lists of local (development) plans across the Severn Catchment.

Local Plan	Region / Area Applicability	Timescales	Housing Projections	Link
Shropshire		2011-2026	29,500	https://www.shropshire.gov.uk/planning-policy/local-planning/core-strategy-2006-2026/
Joint Core Strategy	Cheltenham, Gloucester City & Tewkesbury	2011-2031	28,400	https://www.jointcorestrategy.org/adopted-joint-core-strategy
Telford & Wrekin		2011-2031	17,280	https://www.telford.gov.uk/info/20452/research_and_information/1229/telford_and_wrekin_local_plan_2011-2031
Powys	Powys (except those parts of Powys covered by the Brecon Beacons National Park which are covered by the adopted Brecon Beacons National Park Authority LDP)	2011-2026	Not specified; average 194 per year	https://en.powys.gov.uk/article/4898/Adopted-LDP-2011---2026
Monmouthshire		2011-2021	Not specified; average 310 per year	https://www.monmouthshire.gov.uk/planning-policy/monmouthshire-local-development-plan/
South Worcestershire	Malvern Hills District, Worcester City and Wychavon District	2006-2030	28,400	https://www.swdevelopmentplan.org/
Forest of Dean		2006-2026	6,200	https://www.fdean.gov.uk/planning-and-building/planning-policy/our-current-local-plan/
Herefordshire		2021-2041	16,100	https://www.herefordshire.gov.uk/local-plan-1
Stroud		2015-2031	11,400	https://www.stroud.gov.uk/environment/planning-and-building-control/planning-strategy/stroud-district-local-plan
Wyre Forest		2016-2036	5,520	https://www.wyreforestdc.gov.uk/planning-and-buildings/planning-policy/wyre-forest-district-local-plan-2016-2036/
Cotswold	Cotswolds	2011-2031	8,400	https://www.cotswold.gov.uk/planning-and-building/planning-policy/local-plan-2011-to-2031/

Appendix B4

Local (development) plans

Table B4.2: Lists of local (development) plans across the Severn Catchment.

Local Plan	Region / Area Applicability	Timescales	Housing Projections	Link
Bromsgrove		2011-2031	6,980	https://www.bromsgrove.gov.uk/council/policy-and-strategy/planning-policies-and-other-planning-information/local-development-plan/the-bromsgrove-district-plan-2011-30/adopted-bdp.aspx
Redditch		2011-2030	6,400	https://www.redditchbc.gov.uk/council/policy-and-strategy/planning-policies/borough-of-redditch-local-plan/borough-of-redditch-local-plan-no-4/adopted-borlp4.aspx
South Gloucestershire		2006-2027	28,355	https://beta.southglos.gov.uk/core-strategy-2006-2027/
South Staffordshire		2023-2041	4,086	https://www.sstaffs.gov.uk/planning/planning-policy/local-plan-review
Stratford-upon-Avon	To be absorbed into a South Warwickshire Local Plan	2011-2031	14,600	https://www.stratford.gov.uk/planning-building/core-strategy.cfm
Warwick		2011-2029	16,776	https://www.warwickdc.gov.uk/info/20410/local_plan
Wolverhampton		2015-2026	2,963	https://wolverhampton.moderngov.co.uk/mgConvert2PDF.aspx?ID=232438
Dudley		2023-2041	Not specified	https://www.dudley.gov.uk/residents/planning/planning-policy/dudley-local-plan/ https://www.dudley.gov.uk/residents/planning/planning-policy/
Sandwell		2025-2041	11,166	https://www.sandwell.gov.uk/planning/sandwell-local-plan
Coventry		2011-2031	42,400	https://www.coventry.gov.uk/downloads/download/4881/adoption_statements
Stafford		2020-2040	500 / year	https://www.staffordbc.gov.uk/local-plan
Newcastle-under-Lyme		2006-2026	5,700	https://www.newcastle-staffs.gov.uk/downloads/download/131/newcastle-under-lyme-and-stoke-on-trent-core-spatial-strategy
West Northamptonshire		2023-2041	39,114	https://www.westnorthants.gov.uk/planning-policy/new-local-plan-west-northamptonshire
Harborough		2011-2031	3,975	https://www.harborough.gov.uk/downloads/file/5714/harborough_local_plan_2011-2031_-_adopted_april_2019
Cherwell		2011-2031	22,840	https://www.cherwell.gov.uk/info/83/local-plans/376/adopted-cherwell-local-plan-2011-2031-part-1
Rugby		2011-2031	14,567	https://www.rugby.gov.uk/w/local-plan-2011-31-adoption

Appendix B5

GIS Spatial Layers

Appendix B5 presents a list of relevant spatial GIS layers that were collated and presented in the mapping throughout the Discovery & Design Report to help inform the picture of risks and opportunities aligning to the RSP key themes across the catchment over time.

Table B5.1: List of GIS spatial layers used for Discovery & Design Report

Theme	Data Layer & Description	Data Source / Link	Permissions / Restrictions
Base Map	OS Greyscale	https://www.esriuk.com/en-gb/map-gallery/open-basemaps	OS Open basemaps available on ESRI Licence
	Catchment Boundary	River Severn Partnership	
	Sub-catchment Boundaries	River Severn Partnership - https://environment.data.gov.uk/catchment-planning/RiverBasinDistrict/9	
	Watercourses – Main rivers	https://environment.data.gov.uk/dataset/25dde009-ba7d-40de-8380-c5c3bb32ccdc https://datamap.gov.wales/layers/inspire-nrw:NRW_MAIN_RIVERS	Open Data
	Local Authority Boundaries	Ordnance Survey	Contains OS data © Crown copyright and database right 2021

Appendix B5

GIS Spatial Layers

Table B5.2: List of GIS spatial layers used for Discovery & Design Report

Theme	Data Layer & Description	Data Source / Link	Permissions / Restrictions
Base Map	Flood Zones	Environment Agency Natural Resources Wales	© Environment Agency copyright and/or database right 2023. All rights reserved. Some features of this map are based on digital spatial data from the Centre for Ecology & Hydrology, © NERC (CEH). Contains Natural Resources Wales information © Natural Resources Wales and database right. All rights reserved. Some features of this information are based on digital spatial data licensed from the UK Centre for Ecology & Hydrology © UKCEH. Defra, Met Office and DARD Rivers Agency © Crown copyright. © Cranfield University. © James Hutton Institute. Contains OS data © Crown copyright and database right.
	Major Towns & Cities	Office for National Statistics	Office for National Statistics licensed under the Open Government Licence v.3.0. Contains OS data © Crown copyright and database right 2024.
	English / Welsh Border		Contains OS data © Crown copyright and database right 2021
	Landscape Character Areas	Natural England Natural Resources Wales	© Natural England copyright. Contains Ordnance Survey data © Crown copyright and database right 2024. Contains Natural Resources Wales information © Natural Resources Wales and Database Right. All rights Reserved.
	WFD Reservoirs	Environment Agency Natural Resources Wales	Contains public sector information licensed under the Open Government Licence v3.0.
	WFD Rivers	Environment Agency Natural Resources Wales	Contains Natural Resources Wales information © Natural Resources Wales and Database Right. All rights Reserved. Contains Ordnance Survey Data. Ordnance Survey Licence number AC0000849444. Crown Copyright and Database Right. Derived in part from 1:50,000 and 1:250,000 scale digital data under permission from British Geological Survey. ©NERC.

Appendix B5

GIS Spatial Layers

Table B5.3: List of GIS spatial layers used for Discovery & Design Report

Theme	Data Layer & Description	Data Source / Link	Permissions / Restrictions
Economy	Employment	https://explore-local-statistics.beta.ons.gov.uk/ https://www.ons.gov.uk/surveys/informationforbusinesses/businesssurveys/businessregisterandemploymentsurvey	Open Data
	Major Roads	https://osdatahub.os.uk/downloads/open/OpenMapLocal	Contains OS data © Crown copyright and database right 2024
	Railway Stations	https://osdatahub.os.uk/downloads/open/OpenMapLocal	
	Railway Tunnels	https://osdatahub.os.uk/downloads/open/OpenMapLocal	
	Railway Tracks	https://osdatahub.os.uk/downloads/open/OpenMapLocal	
	Flood Defences	https://datamap.gov.wales/layergroups/geonode:nrw_flood_defence_structures https://environment.data.gov.uk/dataset/8e5be50f-d465-11e4-ba9a-f0def148f590	© Environment Agency copyright and/or database right 2020. All rights reserved. Contains Natural Resources Wales information © Natural Resources Wales and Database Right. All rights Reserved.
	Substations	https://www.nationalgrid.com/electricity-transmission/network-and-infrastructure/network-route-maps	© National Grid UK
	Towers	https://www.nationalgrid.com/electricity-transmission/network-and-infrastructure/network-route-maps	
	Cable Fire Lines	https://www.nationalgrid.com/electricity-transmission/network-and-infrastructure/network-route-maps	
	Overhead Line Routes	https://www.nationalgrid.com/electricity-transmission/network-and-infrastructure/network-route-maps	

Appendix B5

GIS Spatial Layers

Table B5.4: List of GIS spatial layers used for Discovery & Design Report

Theme	Data Layer & Description	Data Source / Link	Permissions / Restrictions
Environment	SSSIs	https://environment.data.gov.uk/catchment-planning/RiverBasinDistrict/9 https://environment.data.gov.uk/dataset/ba8dc201-66ef-4983-9d46-7378af21027e	© Natural England copyright. Contains Ordnance Survey data © Crown copyright and database right 2024.
	Ramsar	https://datamap.gov.wales/layers/inspire-nrw:NRW_RAMSAR https://environment.data.gov.uk/dataset/c626e031-e561-4861-8219-b04cd1002806	Contains Natural Resources Wales information © Natural Resources Wales and Database Right. All rights Reserved.
	Special Areas of Conservation (SAC)	https://environment.data.gov.uk/dataset/6ecea2a1-5d2e-4f53-ba1f-690f4046ed1c https://datamap.gov.wales/layers/inspire-nrw:NRW_SAC	© Natural England copyright. Contains Ordnance Survey data © Crown copyright and database right 2024.
	Special Protection Area	https://datamap.gov.wales/layers/inspire-nrw:NRW_SPA https://environment.data.gov.uk/dataset/4c660eee-887e-4c8b-91e5-d84b4c1078ac	Contains Natural Resources Wales information © Natural Resources Wales and Database Right. All rights Reserved. Contains Ordnance Survey Data. Ordnance Survey Licence number AC0000849444. Crown Copyright and Database Right.
	Local Nature reserve	https://datamap.gov.wales/layers/inspire-nrw:NRW_LNR https://environment.data.gov.uk/dataset/9364d6af-927e-4349-b4c3-dba77ac842d	
	National nature Reserve	https://environment.data.gov.uk/dataset/ff213e4c-423a-4d7e-9e6f-b220600a8db3 https://datamap.gov.wales/layers/inspire-nrw:NRW_NNR	© Natural England copyright. Contains Ordnance Survey data © Crown copyright and database right 2024.
	Area of Outstanding Natural beauty (AONB)	https://environment.data.gov.uk/dataset/0c1ea47f-3c79-47f0-b0ed-094e0a136971 https://datamap.gov.wales/layers/inspire-nrw:NRW_AONB	Contains Natural Resources Wales information © Natural Resources Wales and Database Right. All rights Reserved. Contains Ordnance Survey Data. Ordnance Survey Licence number AC0000849444. Crown Copyright and Database Right.
	Ancient Woodland	https://datamap.gov.wales/layers/inspire-nrw:NRW_ANCIENT_WOODLAND_INVENTORY_2021 https://environment.data.gov.uk/dataset/f425f1e1-fc18-4b5a-88d8-76934125627c	

Appendix B5

GIS Spatial Layers

Table B5.5: List of GIS spatial layers used for Discovery & Design Report

Theme	Data Layer & Description	Data Source / Link	Permissions / Restrictions
People	Registered Battlefields (England)	https://www.data.gov.uk/dataset/3b327613-faa1-4d0b-8fb8-75436fed80cc/registered-battlefields-gis-data	
	World Heritage Sites	https://opendata-historicengland.hub.arcgis.com/datasets/historicengland::national-heritage-list-for-england-nhle/explore?layer=10 https://datamap.gov.wales/layergroups/inspire-wg:WorldHeritageSites	© Historic England 2024 and for spatial data only add Contains Ordnance Survey data © Crown copyright and database right 2024.
	Scheduled Monuments	https://datamap.gov.wales/layers/inspire-wg:Cadw_SAM https://opendata-historicengland.hub.arcgis.com/datasets/historicengland::national-heritage-list-for-england-nhle/explore?layer=6	© Historic England 2024 and for spatial data only add Contains Ordnance Survey data © Crown copyright and database right 2024.
	Historic parks and gardens	https://opendata-historicengland.hub.arcgis.com/datasets/historicengland::national-heritage-list-for-england-nhle/explore?layer=7 https://datamap.gov.wales/layergroups/geonode:registered_historic_parks_and_gardens	Designated Historic Asset GIS Data, The Welsh Historic Environment Service (Cadw) 2024 , licensed under the Open Government
	Median Age	Census 2021	Office for National Statistics licensed under the Open Government Licence v.3.0. Contains OS data © Crown copyright and database right 2024.
	Ethnic Group	Census 2021	
	National Receptor Database (England)	Environment Agency	Permission Required.
	National Receptor Database (Wales)	Natural Resources Wales	Permission Required.
	Population Density	Office for National Statistics	Office for National Statistics licensed under the Open Government Licence v.3.0. Contains OS data © Crown copyright and database right 2024.

Appendix B5

GIS Spatial Layers

Table B5.6: List of GIS spatial layers used for Discovery & Design Report

Theme	Data Layer & Description	Data Source / Link	Permissions / Restrictions
Agriculture	Agricultural land Classification (ALC)	https://datamap.gov.wales/layers/inspire-wg:predictive_alc_partitioned https://environment.data.gov.uk/dataset/af1b847b-037b-4772-9c31-7edf584522aa	© Natural England copyright. Contains Ordnance Survey data © Crown copyright and database right 2024. Contains public sector information licensed under the Open Government Licence v3.0.
	Indices of Deprivation (IMD) 2019	https://www.arcgis.com/home/item.html?id=5e1c399d787e48c0902e5fe4fc1ccfe3	Contains OS data © Crown copyright and database right 2024.
Housing	Local Development Plan Boundaries	Various. See Appendix C.	Contains OS data © Crown copyright and database right 2024.
	Communities at Risk	https://datamap.gov.wales/layergroups/geonode:nrw_communities_at_risk_register https://environment.data.gov.uk/dataset/1065db5a-6665-49a3-b454-9e996993f0fe	Open data
Land Use	CORINE Land Cover (2018)	https://land.copernicus.eu/en/products/corine-land-cover/clc2018#download	© European Environment Agency (EEA) under the framework of the Copernicus programme - copernicus@eea.europa.eu
Water quality	Ecological status	Environment Agency	© Environment Agency copyright and/or database right 2015. All rights reserved. Contains Natural Resources Wales information © Natural Resources Wales and Database Right. All rights Reserved. Contains Ordnance Survey Data. Ordnance Survey Licence number AC0000849444. Crown Copyright and Database Right.
		Natural Resources Wales	

Appendix B5

GIS Spatial Layers

Table B5.7: List of GIS spatial layers used for Discovery & Design Report

Theme	Data Layer & Description	Data Source / Link	Permissions / Restrictions
Water resources	Source Protection Zones	https://environment.data.gov.uk/dataset/6fd0120f-d465-11e4-abee-f0def148f590 https://datamap.gov.wales/layers/inspire-nrw:NRW_Source_Protection_Zones	© Environment Agency copyright and/or database right 2016. All rights reserved. Contains Natural Resources Wales information © Natural Resources Wales and Database Right. All rights Reserved.
	Drinking Water Safeguard Zones	https://environment.data.gov.uk/dataset/1e0002f8-a322-4158-8165-3d688d634a3c	© Environment Agency copyright and/or database right 2022. All rights reserved.
	Nitrate Vulnerable Zones	https://environment.data.gov.uk/dataset/60be356d-6475-4d51-9572-9f8c09f1a764 https://datamap.gov.wales/layers/inspire-nrw:NRW_Nitrate_Vulnerable_Zones_2013	Open Government Licence. © Environment Agency copyright and/or database right. Derived in part from geological mapping data provided by the British Geological Survey © NERC. Derived in part from data provided by the National Soils Research Institute © Cranfield University. Contains Ordnance Survey data © Crown copyright and database rights 2016. Derived in part from data provided by the Department for the Environment, Farming and Rural Affairs © Crown 2016 copyright Defra. Derived in part from data provided by the Centre for Ecology and Hydrology © NERC. Derived in part from data provided by UK Water Companies. Contains Natural Resources Wales information © Natural Resources Wales and Database Right. All rights Reserved. Contains Ordnance Survey Data. Ordnance Survey Licence number AC0000849444. Crown Copyright and Database Right.



Appendix C

Adaptation Actions

Contents

This appendix contains:

- C1: Longlisted adaptation actions,
- C2: Portfolio appraisal and performance,
- C3: Hotspot trigger considerations; and,
- C4: Portfolio cards.



Appendix C1

Longlisted adaptation actions

This slide presents longlisted adaptation actions corresponding to grey, working with natural processes, and asset management interventions as well as policy and behavioural enabling actions. This longlist was explored in collaboration with the RSP to draw out place-based considerations which informed further portfolio development.

Please note: other catchments would need to consider specific challenges pertinent to that catchment as this list is not exhaustive.

Table C1.1: Longlist of adaptation actions

Grey	Working with natural processes		Asset Management
- Permanent linear defences - Property flood resilience (PFR) - Temporary defences - Hydraulic management - Reservoir - Managed Aquifer Recharge - Smart Infrastructure - Channel dredging - Flood relief channel	- Runoff attenuation features - Large woody debris - Gully stuffing - Soil management - River restoration - Floodplain reconnection - Tree planting - Buffer strips - Peat management - Wetlands	- Flood storage areas - Permeable pavement / surfaces - Property level interventions - Swales - Channels / rills - Filtration strips - Green roofs, screens and walls - Bioretention areas	- Review & optimise monitoring and maintenance regime - Refurbish and enhance existing assets - Remove existing FRM infrastructure and managed retreat
	Policy		Behavioural
	- Influence and contribute to National Development Management Policies (NDMPs) and Policies for England and Wales - Influence and contribute to the spatial development strategies across England and Wales - Monitoring and inputting into of Local Plans across England and Wales - FRM governance to enable integrated responses	- Integration of FRM and the broader water sector - Explore alternative financial investment opportunities	- Support community-led interventions - Information sharing - Public communication - Living with Flooding - Personal Resilience

Appendix C2

Portfolio appraisal and performance

Having developed the portfolios of actions, we then looked to understand their catchment suitability and performance. This involved identifying where and to what scale actions could be implemented and their anticipated contributions toward FRM resilience across the focus areas.

We took two approaches to consider this, as outlined below:

1. A **data-driven** approach (underpinned by place manager input and expertise) in the Upper Severn (drawing on the Severn Valley Water Management Scheme (SVWMS)). This supports the consideration of how data-driven, catchment-wide schemes can support adaptation pathway development.
2. An **expert-driven** approach in the Warwickshire Avon (relying upon place manager expertise). This looks at how pathway building can be undertaken in more people-based catchments with less data availability.

These distinct approaches were trialled to demonstrate how portfolio feasibility assessments can be undertaken to inform pathway building across catchments with different levels of data availability.

The workflows that underpin the expert-driven and data-driven approaches taken across the focus areas to inform portfolio feasibility, option development and subsequent pathway assembly is represented in the graphic to the right.

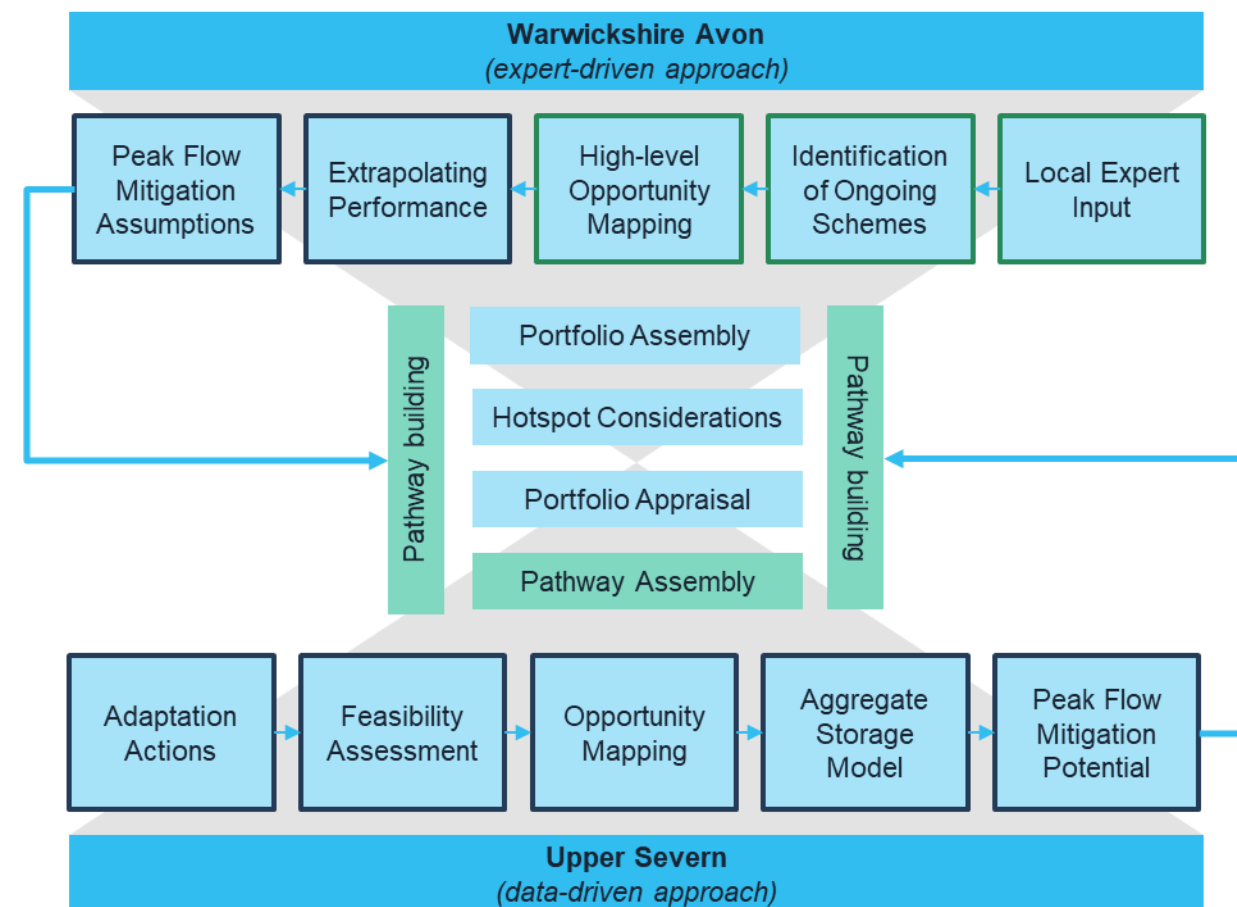


Figure C2.1: Portfolio appraisal and performance approach for Warwickshire Avon and Upper Severn catchment.

Appendix C2

Upper Severn: Portfolio Performance – Methodology & Assumptions

This page presents the methodology and assumptions that underpin our portfolio performance assessments as outlined on the portfolio cards. The following pages present performance estimations associated with flood storage area (i.e., Upstream Storage: Artificial) and linear defence deliverability.

1. Understanding the catchment	We collated relevant schemes (i.e., the SVWMS) to inform wider portfolio feasibility and engaged with place managers to: • Understand the catchment context and constraints; and, • Understand on-going schemes and their performance.			
2. Identifying where portfolios are feasible across the catchment	Upstream Storage & In-Channel Measures: NFM	Upstream Storage: Artificial	Urban Source Control (Urban & Property-Level SuDS)	Hard Defences (Temporary & Permanent Linear)
	NFM feasibility was outlined through the use of a feasibility assessment tool under the SVWMS which incorporates factors such as: • Topography, • Land cover & classification, • Geology; and, • Flood zones.	Artificial storage feasibility was informed through the development of a bespoke data science model that included a topographical analysis to identify widespread Upstream Storage: Artificial delivery opportunities.	SuDS feasibility was informed by: • Land-use – SuDS are typically delivered in urban centres; and, • Population centres – property-level SuDS, when delivered widespread across population centres, can have significant impacts on localised flood risk.	For each of the hotspots we determined the location of existing defences and the flooding mechanisms. The ability to deliver further linear defences was considered based on the defence's technical (considers height requirements) and economic (considers properties impacted) viability, influenced by modelled flood extents, depths, and properties at risk. See Appendix C3 for technical methodology.
3. Estimating the performance of the portfolios of interventions	To estimate the performance of NFM and artificial storage measures, the SVWMS utilised the Aggregate Storage Model (ASM) to estimate peak flow mitigation potential. The ASM is a catchment routing model that accounts for storage provided across sub-catchments and calculates the peak flow mitigation achievable at the catchment's outlet. The peak flow mitigation potential of FSAs throughout the SVWMS were presented as a proportion of the peak flow mitigation potential provided by the North West Relief Road (NWRR) reservoir scheme. We made some assumptions resulting in an estimated peak flow mitigation potential catchment-wide, as presented in the following page. A detailed methodology can be found under the SVWMS Opportunity Appraisal and Technical Methodology documents (2022).		To estimate the performance of SuDS, we: • Identified extents of urban coverage; and, • Identified potential storage densities based on literature values and translated this into a peak flow mitigation potential based on these schemes, extent of urban areas in the focus area, and expert opinion.	Based on Step 2, we considered if a defence (e.g., up to 2m high) would be effective at mitigating flood risk and provided RAG scoring for each hotspot.

Figure C2.2: Upper Severn portfolio performance estimation methodology and assumptions.

Appendix C2

Warwickshire Avon: Portfolio Performance – Methodology & Assumptions

This page presents the methodology and assumptions that underpin our portfolio performance assessments as outlined on the portfolio cards. The following pages present performance estimations associated with flood storage area (i.e., Upstream Storage: Artificial) and linear defence deliverability.

1. Understanding the catchment	We collated relevant schemes to inform wider portfolio feasibility. We engaged with place managers and CBG leads to: - Understand the catchment context and constraints ;and, - Understand on-going schemes and their performance.			
2. Identifying where portfolios are feasible across the catchment	Upstream Storage & In-Channel Measures: NFM We identified locations where NFM measures would be feasible by considering the following catchment characteristics: - Land-use – NFM measures are typically delivered in rural / agricultural landscapes, - Topography – NFM is typically most effective on moderately sloped terrain; and, - Ongoing successful engagement with farmers indicating appetite for NFM delivery based on place manager input.	Upstream Storage: Artificial We identified where artificial storage areas could be situated across the catchment by considering: - Land-use – artificial storage areas are typically delivered outside of urbanised areas (i.e., rural land use), - Topography – artificial storage measures are typically most effective in moderate to steep sloped terrain to direct water to an aggregated point; and, - Catchment location – artificial storage measures are typically delivered upstream of urbanised centres to maximise FRM benefits.	Urban Source Control (Urban & Property-Level SuDS) SuDS feasibility was informed by: - Land-use – SuDS are typically delivered in urban centres; and, - Population centres – property-level SuDS, when delivered widespread across population centres, can have significant impacts on localised flood risk.	Hard Defences (Temporary & Permanent Linear) For each of the hotspots we determined the location of existing defences and the flooding mechanisms. The ability to deliver further linear defences was considered based on the defence's technical (considers height requirements) and economic (considers properties impacted) viability, influenced by modelled flood extents, depths, and properties at risk. See Appendix C3 for technical methodology.
3. Estimating the performance of the portfolios of interventions	To estimate the performance of NFM measures: - We determined the storage volume NFM could provide upstream through estimated storage densities (m^3 per ha) from the ongoing Arrow & Aine NFM scheme and NFM coverage potential (ha) (from Step 2); and, - We translated the upstream storage density ($2,000 m^3$ / ha) into a peak flow mitigation potential by extrapolating NFM performance to areas which have capacity, suitability, and appetite for NFM delivery based on the ongoing Nature 4 Water scheme, place manager input, and NFM specialist professional opinion.	To estimate the performance of artificial storage measures we: - Defined the storage potential of available land (as defined in Step 1, considering assumed storage / ha as indicated by the SVWMS); and, - Translated the upstream storage potential to peak flow mitigation based on the excess storage calculations done as part of the trigger assessment (Appendix C).	To estimate the performance of SuDS, we: - Identified extents of urban coverage; and, - Identified potential storage densities based on other schemes (e.g., Coventry and Leamington Spa BGI studies) and translated this into a peak flow mitigation potential based on these schemes, extent of urban areas in the focus area, and expert opinion.	Based on Step 2, we considered if a defence (e.g., up to 2m high) would be effective at mitigating flood risk and provided RAG scoring for each hotspot.

Appendix C3

Hotspot out of bank flooding considerations

This page presents the workflow (including inputs and assumptions) underpinning the trigger assessment at each of the risk hotspots. A high-level, worked example of this process is outlined on the following page.

Workflow	Goal	Methodology / Limitations	Assumptions / Implications
1. Hydraulic Model Extraction	Identification of flooding mechanisms and properties impacted	The hydraulic models for each of the hotspots were extracted and animations were examined to identify the flooding mechanisms at each hotspot. Flooding mechanisms influence the applicability of linear defences in the focus area.	Note that not all models could be used, mainly the newer models with animation data available. Older models did not have this function at the time. However, all hotspot areas were covered.
2. Identify Out of Bank Flooding	Identification of discharge resulting in home / asset flooding	The hydraulic model animations indicated the point at which assets / homes become flooded. The discharge at this time slot was recorded.	The difference between the out of bank flooding discharge and peak flows feed into the excess storage calculation.
3. Excess Storage Calculation	Upstream storage required to mitigate flooding	Hydrographs were extracted at suitable locations in relation to the out of bank flooding locations- mainly downstream faces of structures where triggers were close to the upper extents of a model; the respective hydraulic inflow hydrograph was used. Out of bank flooding hydrograph volumes were calculated for each respective epoch.	Excess storage calculations (i.e. the upstream storage required to mitigate flood risk) can inform the long-term defend-ability of a hotspot. E.g., if a hotspot is located in the headwaters of the catchment, delivering 10,000,000 m ³ of storage upstream is likely not feasible.
4. Linear Defence Feasibility	Feasibility assessment	A high-level assessment of linear defence feasibility was undertaken for each trigger location. This involved evaluating the flood risk mechanism to understand if a linear defence would support the reduction in flood risk. In cases where flood risk was due to limited channel capacity alone, linear defences could be appropriate. Where flooding was caused by insufficient culvert capacity for example, a linear defence would reduce flood risk but would not solve the root cause of the issue so culvert capacity should be considered in the first instance. The assessment also considered the number of properties impacted, displacement of flood water if a linear defence were to be added to consider wider flood risk and buildability.	This linear defence feasibility assessment considers modelled flood extents, depths, and properties at risk over time which can inform the long-term defend-ability of a location.

Figure C2.4: Workflow to identify risk hotspots and their out of bank flooding.

Appendix C3

Hotspot Considerations – Worked Example: Linear defences

This presents a worked example of how an analysis of out of bank flooding mechanisms at hotspot locations informs portfolio feasibility.

- Out of bank flooding occurs first at the upstream face of a culvert passing under a road. The receptors at this location include the commercial buildings on the industrial estate. Peak flood waters extend across this area up to a depth of 2m.
- The flooding mechanism in this location appears to be due to the culvert surcharging and the resulting overland flow passing through the estate back into channel further downstream which then also has insufficient capacity and floods out over an A road.
- Whilst putting linear defences around receptors in this location would improve their flood resilience, it would not solve the initial source of flooding that could be potentially resolved by increasing culvert capacity or reducing flows (through upstream interventions) to this location.
- Resolving the initial flood risk mechanism could reduce the overall flood risk in this out of bank flooding location and potentially add other benefits depending on the solution.
- Linear defences to protect this many commercial properties would likely be economically unfeasible and would likely divert flows wider than the immediate channel corridor including over the main road and further downstream and exasperate flooding where there is already flood depths of up to 2m.

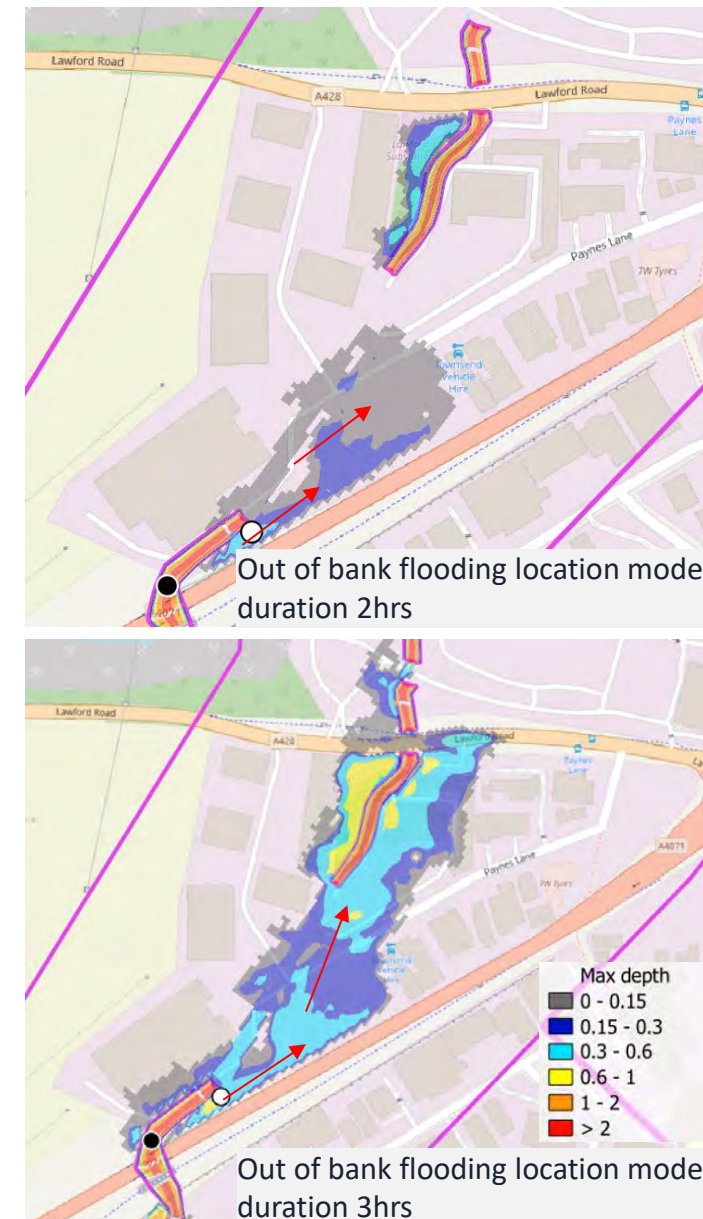


Figure C2.5: Hotspot considerations – a worked example.

Appendix C4

Portfolio cards

Appendix C4 presents portfolio cards which contain the portfolio name, description, performance (indicative peak flow mitigation potential, cost, lead time, life-span, adaptability), benefits toolkit qualitative outputs, alignment to the Sustainability Appraisal objectives, and any additional considerations across each focus area.

Some cards (including linear defences and managed realignment) have been RAG scored based on the hotspot considerations (see Appendix C3).

The two graphics to the right are annotated portfolio cards, to be referenced throughout this appendix.

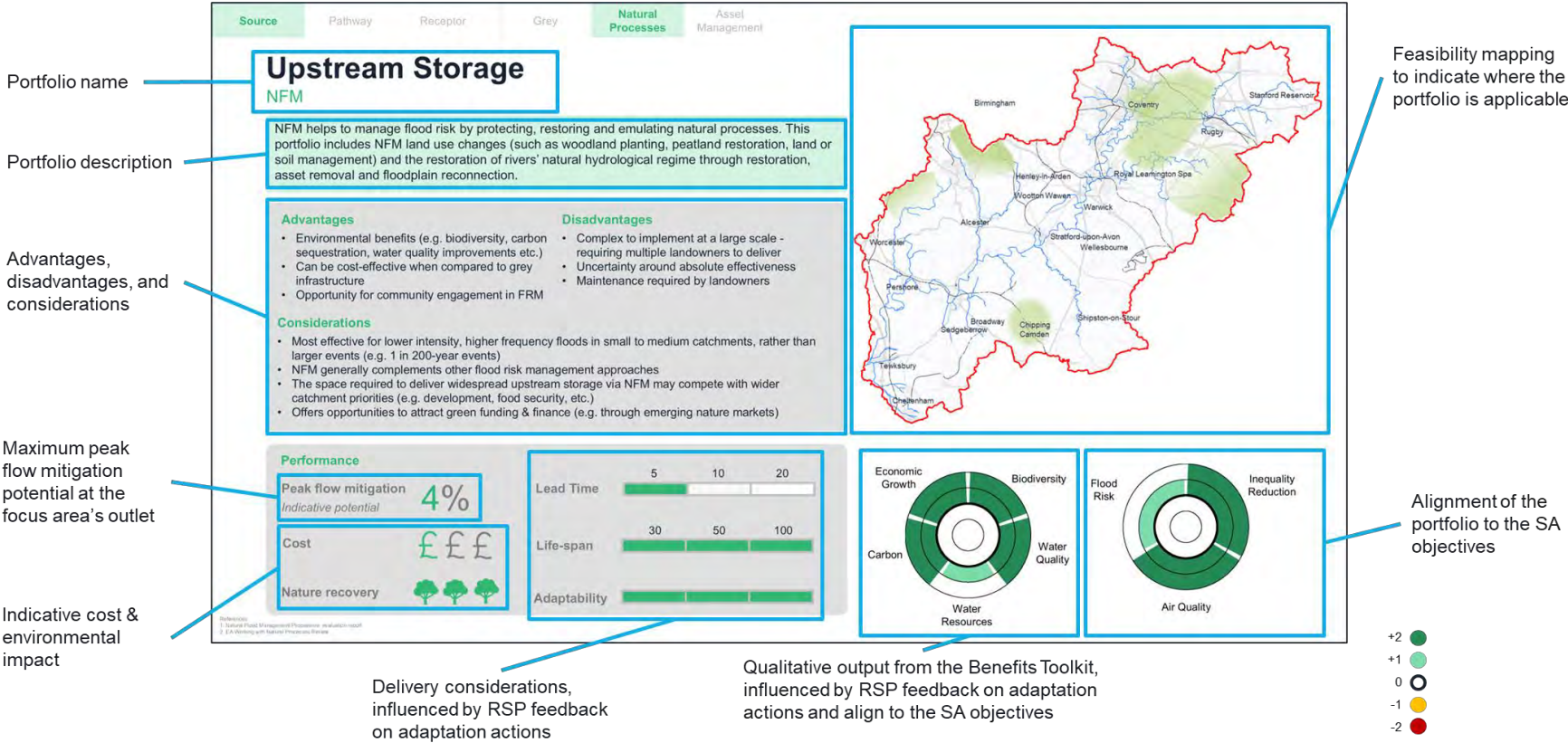


Figure C4.1: Portfolio cards outline and example.

Appendix C4

Upper Severn

The following slides present the developed portfolio cards for the Upper Severn focus area.



Figure C4.2: Upper Severn focus area Map

Upstream Storage

NFM

NFM helps to manage flood risk by protecting, restoring and emulating natural processes. This portfolio includes NFM land use changes (such as woodland planting, peatland restoration, land or soil management) and the restoration of rivers' natural hydrological regime through restoration, asset removal and floodplain reconnection.

Advantages

- Environmental benefits (e.g. biodiversity, carbon sequestration, water quality improvements etc.)
- Can be cost-effective when compared to grey infrastructure
- Opportunity for community engagement in FRM

Disadvantages

- Complex to implement at a large scale - requiring multiple landowners to deliver
- Uncertainty around absolute effectiveness
- Maintenance required by landowners

Considerations

- Most effective for lower intensity, higher frequency floods in small to medium catchments, rather than larger events (e.g., 1 in 200-year events)
- NFM generally complements other flood risk management approaches
- The space required to deliver widespread upstream storage via NFM may compete with wider catchment priorities (e.g. development, food security, etc.)
- Offers opportunities to attract green funding & finance (e.g., through emerging nature markets)

Performance

Peak flow mitigation

Indicative potential

9%

Cost

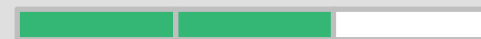
£ £ £

Nature recovery



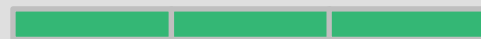
Lead Time

5 10 20

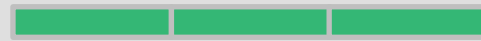


Life-span

30 50 100

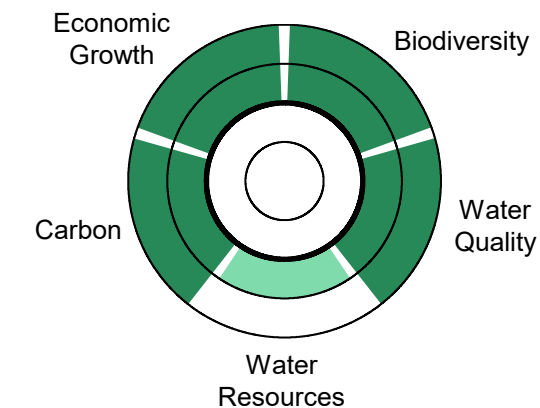


Adaptability

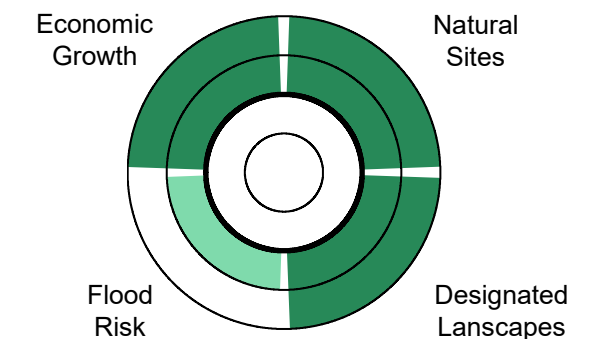


geograph-3821222-by-Jonathan-Billinger

Benefits Toolkit



SA Objectives



Upstream Storage

Artificial

Artificial upstream storage provided through man-made flood storage areas (FSAs), reservoirs, and managed agricultural washlands delivered across sub-catchments. These interventions can vary widely in scale and storage provision.

Advantages

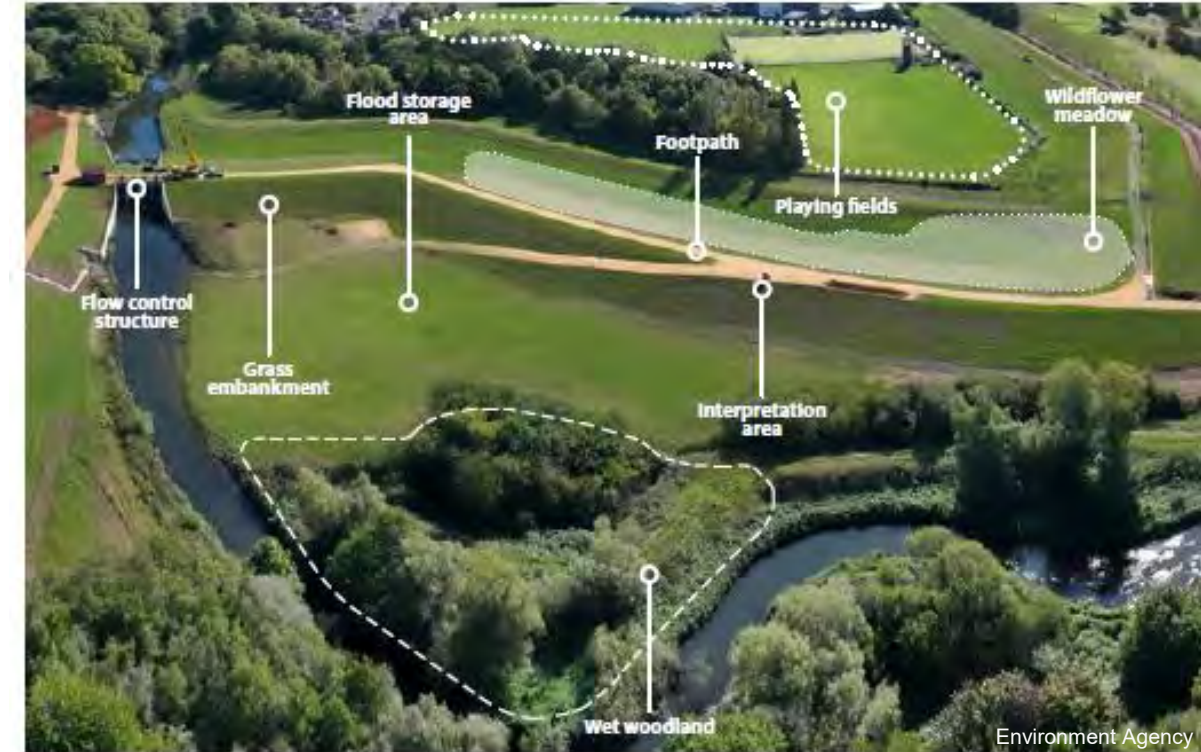
- Enables significant storage volumes upstream, offering reliable mitigation for a range of events
- Environmental & recreational opportunities associated with some assets, e.g. reservoirs
- Can support groundwater recharge and managing of river flows

Disadvantages

- Requires significant land uptake, which in-turn requires acquisition or landowner buy-in
- Environmental impacts due to change of land-use and potential alteration of natural river flows
- Adherence to the Reservoirs Act (1975).
- High embodied carbon & costs

Considerations

- New FSAs and reservoirs require detailed modelling and design, alongside frequent inspections and management to comply with the Reservoirs Act (1975) (applicable to storage areas over 10,000m³). The Reservoir Act (1975) restricts land use to flood storage only, including for temporary retention areas (e.g., these areas could not be used for grazing livestock in dry conditions)
- Artificial storage areas can be deployed at a range of scales across the catchment (i.e., small to large).
- Localised topography and geology will influence the applicability of FSA incorporation



Performance

Peak flow mitigation

**See leaflet for details*

Max
49*%

Cost

£££

Nature recovery



Lead Time

5 10 20

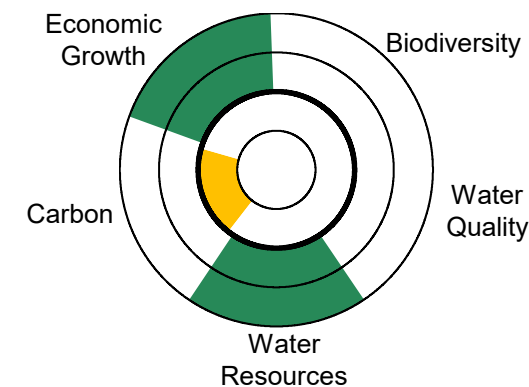
Life-span

30 50 100

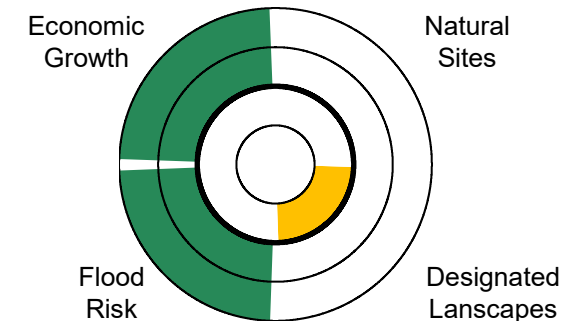
Adaptability



Benefits Toolkit



SA Objectives



Urban Source Control

Urban SuDS

Widespread incorporation of Sustainable Urban Drainage Systems (SuDS) (or Blue Green Infrastructure (BGI)) in urban environments to manage surface water runoff and water quality. Measures can support water retention, re-use, infiltration, filtration and conveyance. Measures typically include swales, infiltration basins, filtration strips, urban ponds and control structures.

Advantages

- Wider benefits related to water quality (urban pollution), urban biodiversity, urban heat, air pollution and recreation etc.
- Improves resilience to surface water flooding
- Opportunities to improve public realm & active travel

Disadvantages

- Requires ring-fenced maintenance funding & resource (especially if delivered at a large scale)
- Significant upfront costs if delivered at scale
- Retrofitting of SuDS can be costly, complicated and disruptive (e.g. traffic disruption)

Considerations

- Different bodies, responsible for the management and development of urban areas and surface water, need to work collaboratively to enable successful implementation, adoption and maintenance
- Retrofitting can be challenging in urban areas where space is limited – i.e. road systems can require re-landscaping to implement
- Ability to implement measures depends on groundwater infiltration and utilising existing topography

Performance

Peak flow mitigation

Indicative potential

2%

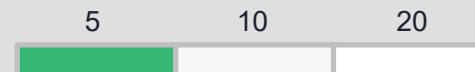
Cost

£ £ £

Nature recovery



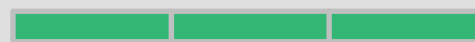
Lead Time



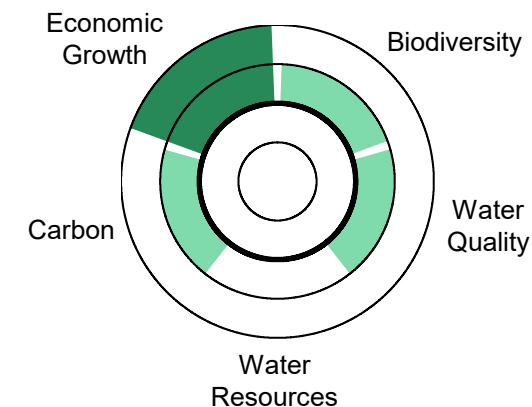
Life-span



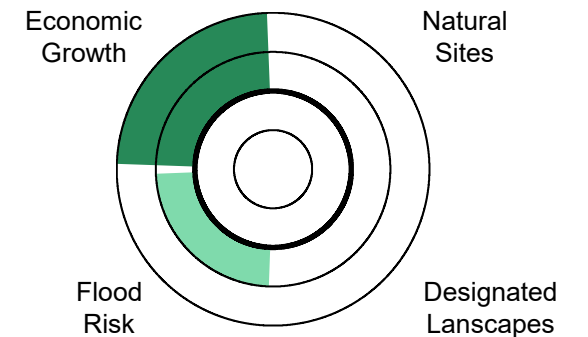
Adaptability



Benefits Toolkit



SA Objectives



Urban Source Control

Property-level SuDS

This portfolio includes Sustainable Urban Drainage Systems (SuDS) (or Blue Green Infrastructure (BGI)) undertake at a property level. Measures can include installation of green roofs, rainwater storage through water butts, rain-gardens and de-paving of gardens.

Advantages

- Wider benefits related to water quality (urban pollution), urban biodiversity, urban heat, air pollution and recreation etc
- Can improve understanding on individual responsibility to reducing flood risk

Disadvantages

- Effectiveness is dependent upon scale of uptake by properties
- Reliant on continued home-owner maintenance to realise benefits over the long-term
- Challenging to retrofit measures across different types of properties (e.g. rental properties)

Considerations

- Further measures may be required to enable up-take at scale across urban areas – e.g. educational campaigns or subsidies to support
- Implementation offers benefits to RMAs and water companies managing surface water and sewer flooding



AMP5 Rainscape Stebonheath School _© Arup

Performance

Peak flow mitigation

Indicative potential

1%

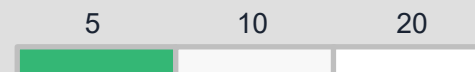
Cost

£ £ £

Nature recovery



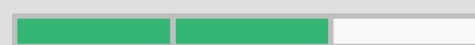
Lead Time



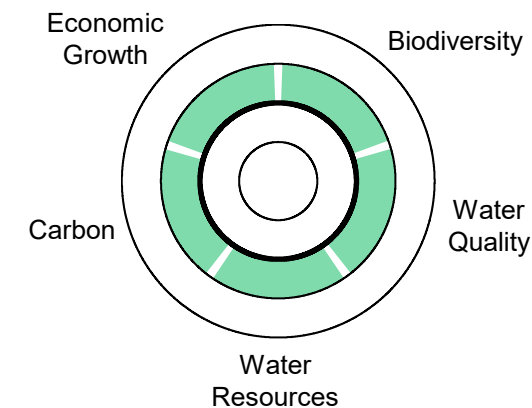
Life-span



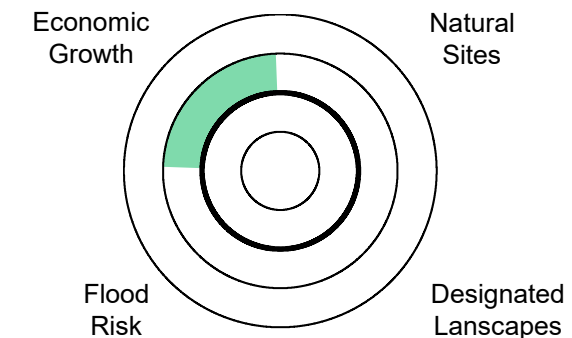
Adaptability



Benefits Toolkit



SA Objectives



In-Channel Measures

NFM

Natural Flood Management (NFM) helps to manage flood risk by protecting, restoring and emulating natural processes. This portfolio includes in-channel NFM measures that interrupt flow pathways resulting in temporary water storage to flatten and elongate peak river flows. This may include measures such large woody debris, floodplain storage, and attenuation features.

Advantages

- Environmental benefits (e.g. biodiversity, carbon sequestration, water quality improvements etc.)
- Can be cost-effective when compared to grey infrastructure
- Opportunity for community engagement in FRM

Disadvantages

- Complex to implement at a large scale - requiring multiple landowners to deliver
- Uncertainty around absolute effectiveness
- Maintenance required by landowners

Considerations

- Most effective for lower intensity, higher frequency floods in small to medium catchments, rather than larger events (e.g. 1 in 200-year events)
- NFM generally complements other flood risk management approaches
- The space required to deliver widespread upstream storage via NFM may compete with wider catchment priorities (e.g. development, food security, etc.)
- Offers opportunities to attract green funding & finance (e.g. through emerging nature markets)



Natural meander in canalised Highland Water, New Forest cc-by-sa/2.0 - © Jim Champion

Performance

Peak flow mitigation

Indicative potential

15%

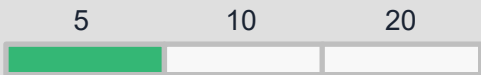
Cost

£ £ £

Nature recovery



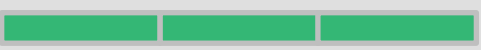
Lead Time



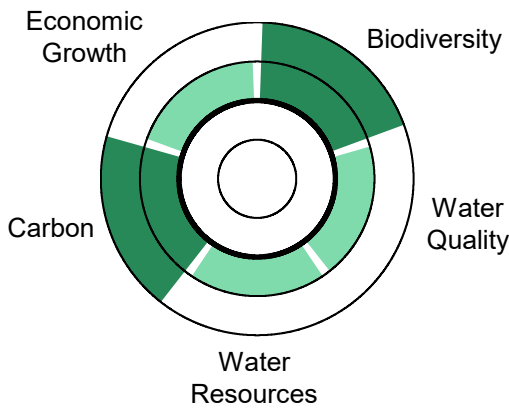
Life-span



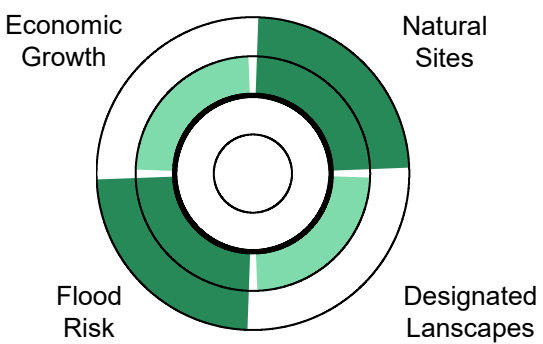
Adaptability



Benefits Toolkit



SA Objectives



In-Channel Measures

Artificial

In addition to measures upstream, storage can be implemented at key points further downstream across the catchment. Alongside flood storage areas (as captured in the Upstream Storage portfolio), interventions can include bypass channels and offline storage areas. *The advances and disadvantages of these wider measures are described below.*

Advantages

- Environmental benefits – e.g. potential for habitat creation, such as reedbeds
- Recreational opportunities – e.g. outdoor swimming
- Can provide additional flood risk mitigation to key areas of vulnerability (e.g. densely populated urban environments)

Disadvantages

- Requires complex engagement and land acquisition
- Environmental impacts due to change of land-use and potential alteration of natural river flows
- Significant monetary and carbon costs
- Requires on-going maintenance to maintain performance

Considerations

- Flood bypass channels can be used to route floodwaters around critical areas and rejoin the river downstream. They can act as flood relief ‘valves’ by increasing the cross-sectional area available to move floodwaters. However, this can increase flood risk downstream due to localised, increased conveyance.
- Ability to implement these interventions depends on topography constraints and land availability



Arup Rodley by pass channel whole

Performance

Peak flow mitigation

Indicative potential

The peak flow mitigation impacts of storage measures is captured as part of the Upstream Storage: Artificial Portfolio.

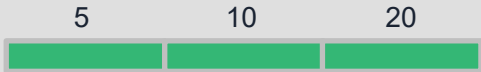
Cost



Nature recovery



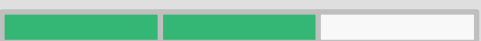
Lead Time



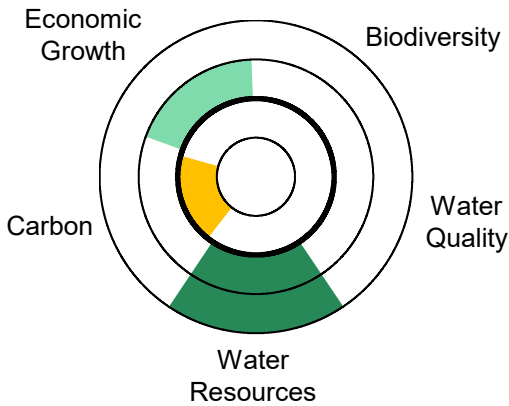
Life-span



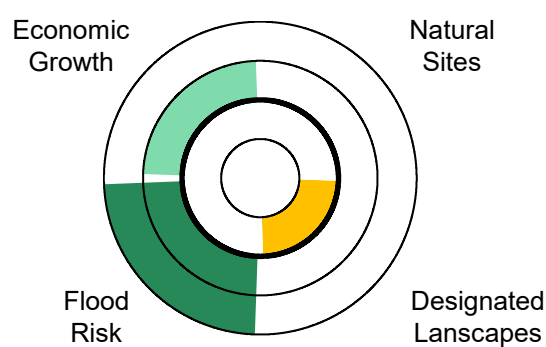
Adaptability



Benefits Toolkit



SA Objectives



Hard Defences

Temporary Linear

Temporary flood defences are designed to be quickly deployed in pre-planned locations which do not have permanent defences. When flooding is expected, the barriers are quickly put up. When the risk has passed, the barriers are taken down, checked over and put back into storage. They include temporary flood barriers (portable metal frames with covers) and demountable defences.

Advantages

- Relatively quick and easy deployment to protect assets for short periods
- Retains economic and amenity value of watercourses outside of flood events
- Designed to a specific, and reliable, standard of protection
- Minimal environmental impact

Disadvantages

- Limited durability and reduced lifespan when compared to permanent defences
- Storage and transportation implications of barriers
- Long-term funding is not typically available
- Catastrophic flooding if the asset fails whilst deployed
- Regular maintenance, inspections and replacement required

Considerations

- Temporary flood barriers are generally deployed in places where it isn't possible, practical or economical to build a permanent flood defence (or where one hasn't yet been built)
- Temporary barriers do not provide the same level of protection as permanent defences and typically have failure rates of 20-30%, although these can be reduced by good advanced planning
- Safe and robust deployment requires reliable flood forecasting and flood warning services

Performance

Peak flow mitigation

Indicative potential

N/A

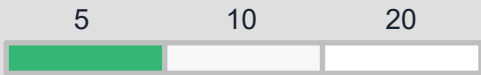
Cost

£ £ £

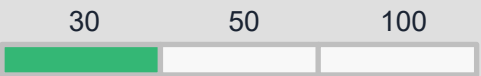
Nature recovery



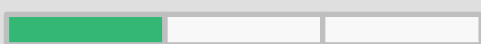
Lead Time



Life-span



Adaptability



Hotspot review

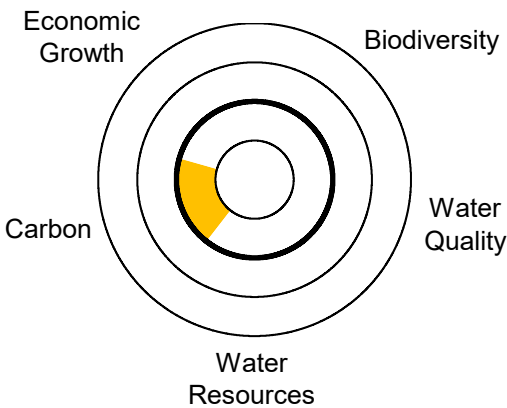
Three risk hotspots in the Upper Severn focus area have been identified for the River Severn through the Risk & Opportunities analysis. We have considered whether it's possible to mitigate flood risk at these locations through the use of temporary or hard flood walls for a **high climate change scenario** (UKCP 8.5). A summary is provided below with further information in the Hotspot Considerations leaflets

Epoch	2030	2050	2080
Caersws	Amber	Red	Red
Meifod	Amber	Red	Red
Shrewsbury	Amber	Amber	Amber

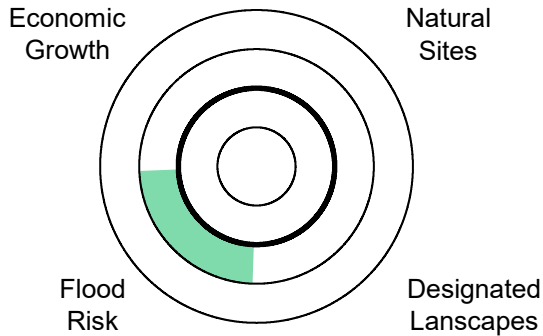
Key:

- Red: Increasingly unable to mitigate risks using hard defences
- Amber: Flood mitigation possible with hard defences
- Green: No further FRM measures required

Benefits Toolkit



SA Objectives



Hard Defences

Permanent Linear

Permanent linear defences are typically constructed alongside watercourses in urban areas to protect people, property and infrastructure from the risk of flooding. They can include concrete flood walls, glass barriers, embankments etc. Defences may be modular and built to enable an increase in height over time due to changing flood risk.

Advantages

- Offers flood mitigation in localised areas
- Designed to a specific, and reliable standard of protection

Disadvantages

- Significant financial costs and embodied carbon
- Long-term investment (incl. timely maintenance) is required by asset owners to maintain performance
- Potential to impact on aesthetic, amenity and habitats (incl. hydromorphology) along river frontages

Considerations

- There is a point at which it is not possible to raise defences further to mitigate flood risk due to amenity, recreational or performance constraints – as indicated opposite
- Using flood defences can increase flood risk downstream and this needs to be accounted for in design
- Maintaining both existing and new assets requires long-term funding. Inflation, alongside impacts by storm events (which are increasing in frequency due to climate change), can impact maintenance costs and requirements further.

Performance

Peak flow mitigation

Indicative potential

N/A

Cost

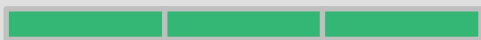
£££

Nature recovery



Lead Time

5 10 20

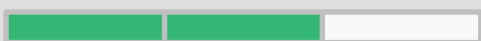


Life-span

30 50 100



Adaptability



Hotspot review

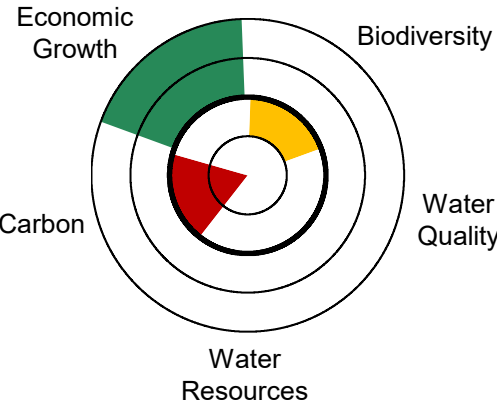
Three risk hotspots in the Upper Severn focus area have been identified for the River Severn through the Risk & Opportunities analysis. We have considered whether it's possible to mitigate flood risk at these locations through the use of temporary or hard flood walls for a **high climate change scenario** (UKCP 8.5). A summary is provided below with further information in the Hotspot Considerations leaflets

Epoch	2030	2050	2080
Caersws			
Meifod			
Shrewsbury			

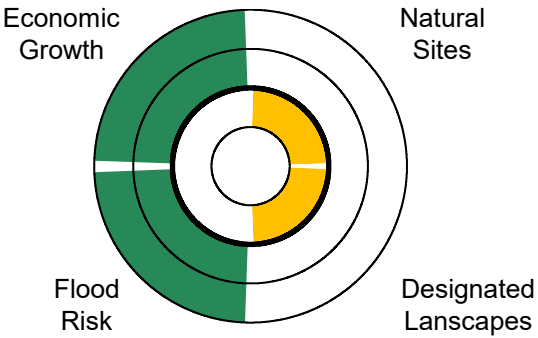
Key:

- Red: Increasingly unable to mitigate risks using hard defences
- Amber: Flood mitigation possible with hard defences
- Green: No further FRM measures required

Benefits Toolkit



SA Objectives



Asset Management

Hydraulic Management

This portfolio includes hydraulic management of watercourses though assets such as sluice gates and pumping stations. These manage flood risk through providing temporary storage and managed release of water. This portfolio also involves aquifer recharge schemes to artificially recharge, which may be accessed during times of drought.

Advantages

- Provides automated and active flood control opportunities
- Opportunities to recharge groundwater aquifers if designed appropriately

Considerations

- Hydraulic management assets can contribute to more artificial watercourses and hydromorphology alterations
- Maintaining both existing and new assets requires long-term funding.

Disadvantages

- Long-term investment (incl. timely maintenance) is required by asset owners to maintain performance
- May alter natural hydrological regimes
- Processes may be susceptible to hacking / power outages
- High construction, operational and carbon costs



NEECA2 - Newmans Sluice © Arup

Performance

Peak flow mitigation

Indicative potential

N/A

Cost

£££

Nature recovery



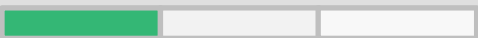
Lead Time

5 10 20

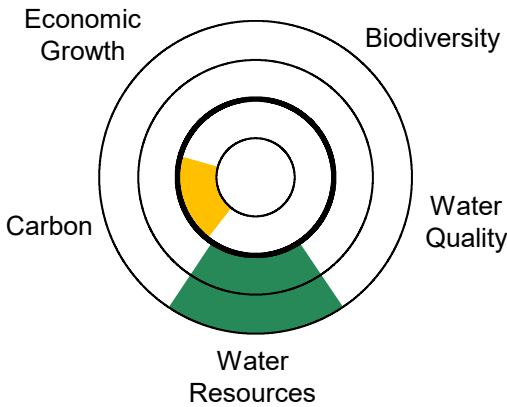
Life-span

30 50 100

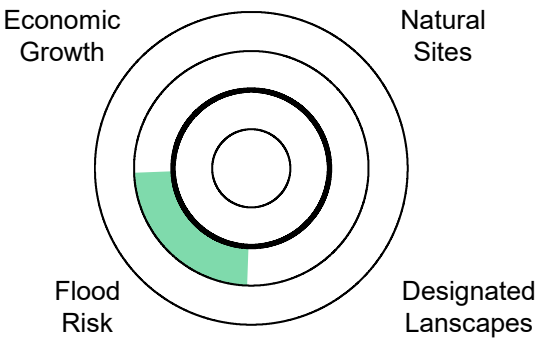
Adaptability



Benefits Toolkit



SA Objectives



Asset Management

Review & Enhance

This portfolio includes a robust review and assessment of all FRM assets across the catchment. These reviews should consider whether assets (especially those impacting flood risk hotspots) can be enhanced, resulting in improved FRM. This assessment may influence the delivery of hard defences such as FSAs and linear defences.

Advantages

- Opportunities to reduce overall FRM capital costs by maximising the effectiveness of existing assets
- Opportunities to increase localised flood resilience where an economic appraisal may not enable the delivery of a new scheme.

Considerations

- Hydraulic management assets can contribute to more artificial watercourses and hydromorphology alterations
- Enhancement (i.e., raising of defences) may impact river access and local amenity value
- Maintaining both existing and new assets requires long-term funding.

Disadvantages

- Long-term investment (incl. timely maintenance) is required by asset owners to maintain performance
- May alter natural hydrological regimes
- Existing assets may not have been designed with enhancement / adaptation in mind (e.g., the foundations may not support increased height / weight)



Dormay Street River Wall Replacement_© Arup

Performance

Peak flow mitigation

Indicative potential

N/A

Cost

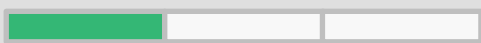
£ £ £

Nature recovery



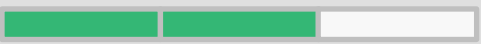
Lead Time

5 10 20

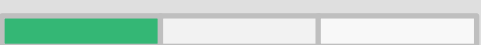


Life-span

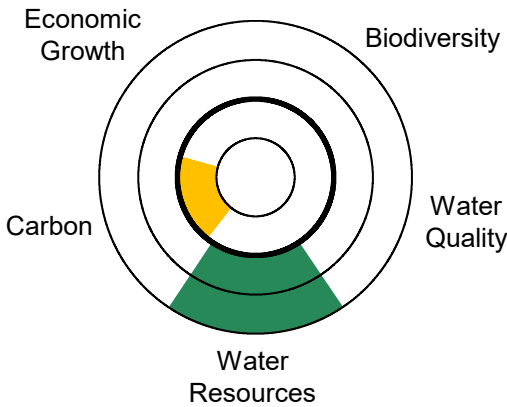
30 50 100



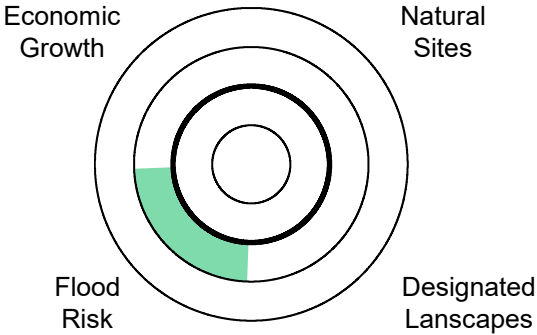
Adaptability



Benefits Toolkit



SA Objectives



Property Level

Property Flood Resilience

Property Flood Resilience is a set of modifications added to a building to lower its flood risk. It can reduce flood damage and speed up recovery after a flood. The risk of flooding cannot be mitigated entirely. However, PFR reduces the risk of water getting into properties and speeds up recovery if the worst happens.

Advantages

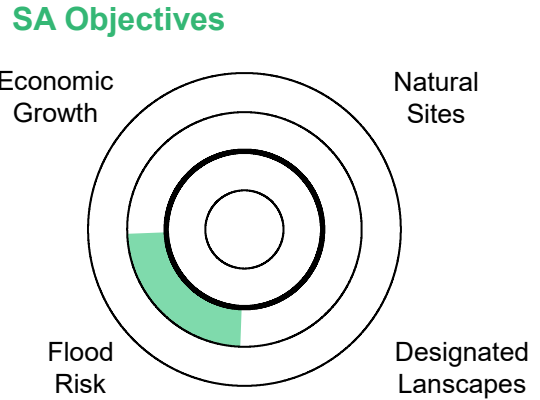
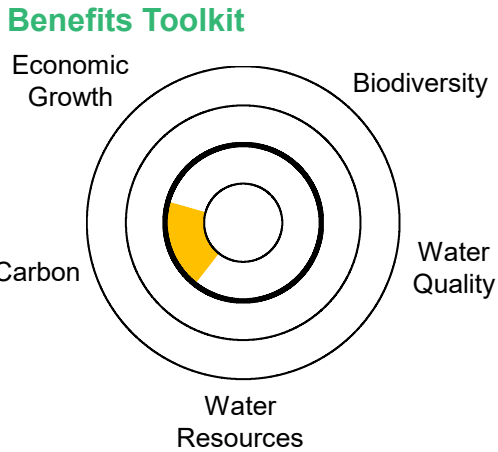
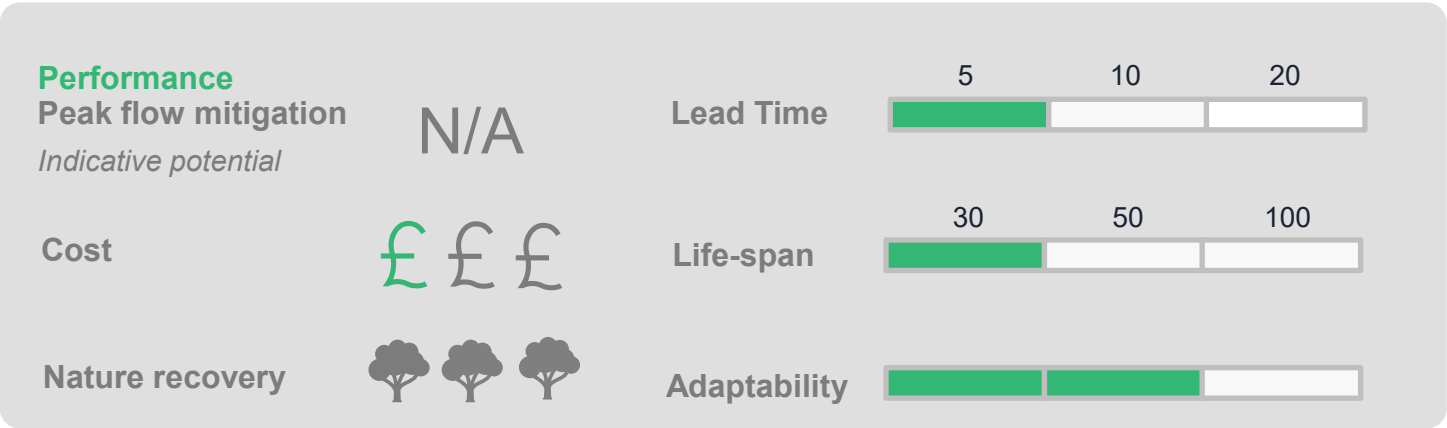
- Relatively low cost of installation in comparison to other measures
- Quick implementation
- Provides “peace of mind” to the residents
- Lower environmental impacts

Disadvantages

- Reliant on public and flood warning services to enable implementation effectively
- Effectiveness is dependent upon uptake and deployment by property owners
- There can be negative aesthetic implications to properties

Considerations

- Performance of measures is dependent on homeowner operation, maintenance and use of flood forecasting services. Typically, they require grants to at-risk homeowners to enable uptake.
- There can be health & safety risks associated with deployment
- They require reliable public flood forecasting and flood warning services to support deployment
- If measures are integrated into building standards, they offer an opportunity to develop water resilient buildings



Managed Realignment

Removal & Relocation

Managed realignment is a long-term strategy for managing land adjacent to watercourses that involves altering FRM approaches to allow previously protected land to flood. This can involve the removal or abandonment of FRM assets in areas of highest risk. This may result in the need for relocation of communities, properties, cultural sites, critical infrastructure and businesses.

Advantages

- Moves people, properties and infrastructure away from the risks of flooding
- Environmental restoration opportunities – e.g. habitat creation or replacement (supporting requirements of the Habitats Regulations)
- Reduces on-going defence costs

Disadvantages

- Irreversible loss of residences, communities, assets, and cultural heritage sites
- Highly disruptive and impactful to individuals, society and economies
- Subject to high political and social controversy
- Potential changes or loss of habitats

Considerations

- Managed retreat can be complex and often contentious. It requires extensive consultation and public participation to manage negative implications to people’s lives and the infrastructure they depend on.
- There is currently a lack of a financial compensation mechanism (incl. both land purchase and payment for the use of land). Under present legislation, landowners do not generally have any right to financial compensation where a decision is made to no longer defend their land.
- A complex planning process can delay implementation

Performance

Peak flow mitigation

Indicative potential

N/A

Cost

£££

Nature recovery

Lead Time

51020

Life-span

3050100

Adaptability

Hotspot review

Three risk hotspots in the Upper Severn focus area have been identified for the River Severn through the Risk & Opportunities analysis. We have considered whether it’s possible to mitigate flood risk in a **high climate change future scenario** (UKCP 8.5). at these locations through the use of hard defences and upstream storage. *A summary is provided below with further information in the Hotspot Considerations leaflets*

Epoch	2030	2050	2080
Caersws			
Meifod			
Shrewsbury			

Key:

- Red: Increasingly unable to mitigate risks - managed realignment is increasingly likely
- Amber: Additional measures are required (e.g., hard defences, upstream storage)
- Green: No further FRM measures required

Benefits Toolkit

Benefit	Progress
Economic Growth	10%
Biodiversity	75%
Water Quality	50%
Carbon	25%
Water Resources	100%

SA Objectives

Objective	Progress
Economic Growth	10%
Natural Sites	50%
Designated Landscapes	75%
Flood Risk	100%
Economic Growth	25%

Appendix C2

Warwickshire Avon

The following slides present the developed portfolio cards for the Warwickshire Avon focus area.



Figure C4.3: Warwickshire Avon focus area Map

Upstream Storage

NFM

NFM helps to manage flood risk by protecting, restoring and emulating natural processes. This portfolio includes NFM land use changes (such as woodland planting, peatland restoration, land or soil management) and the restoration of rivers' natural hydrological regime through restoration, asset removal and floodplain reconnection.

Advantages

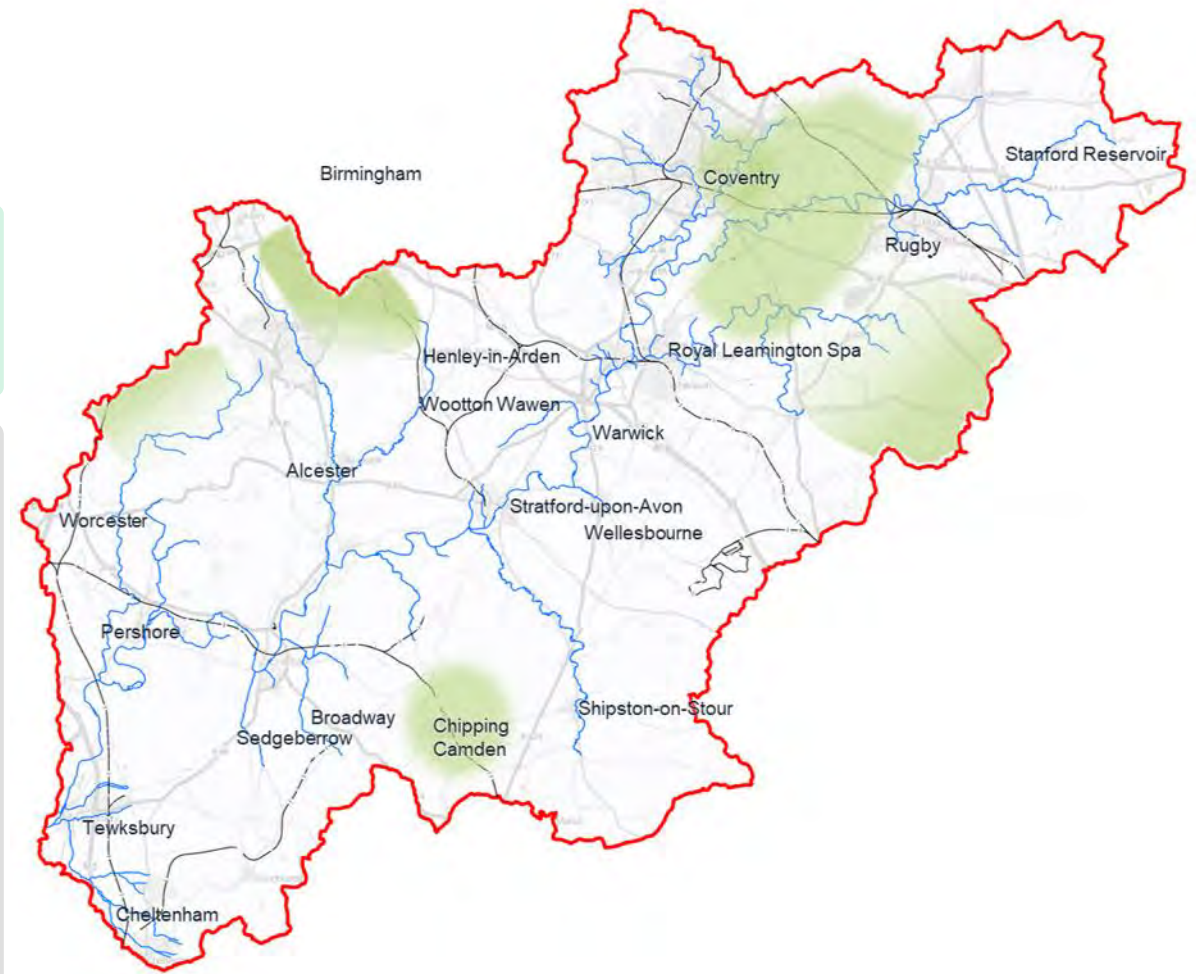
- Environmental benefits (e.g. biodiversity, carbon sequestration, water quality improvements etc.)
- Can be cost-effective when compared to grey infrastructure
- Opportunity for community engagement in FRM

Disadvantages

- Complex to implement at a large scale - requiring multiple landowners to deliver
- Uncertainty around absolute effectiveness
- Maintenance required by landowners

Considerations

- Most effective for lower intensity, higher frequency floods in small to medium catchments, rather than larger events (e.g. 1 in 200-year events)
- NFM generally complements other flood risk management approaches
- The space required to deliver widespread upstream storage via NFM may compete with wider catchment priorities (e.g. development, food security, etc.)
- Offers opportunities to attract green funding & finance (e.g. through emerging nature markets)



Performance

Peak flow mitigation

Indicative potential

4%

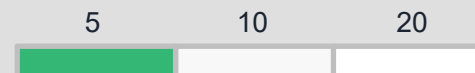
Cost

£ £ £

Nature recovery



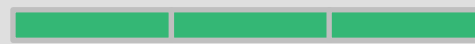
Lead Time



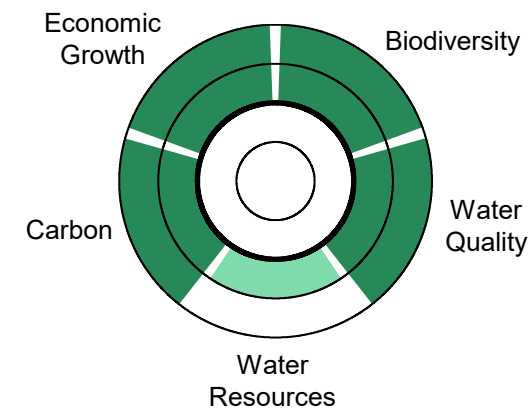
Life-span



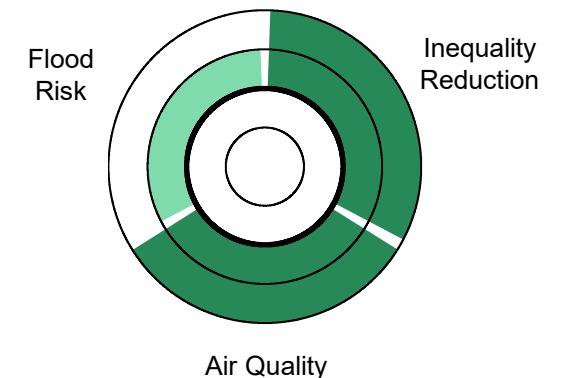
Adaptability



Benefits Toolkit



SA Objectives



Upstream Storage

Artificial

Artificial upstream storage provided through man-made flood storage areas (FSAs), reservoirs, and managed agricultural washlands delivered across sub-catchments. These interventions can vary widely in scale and storage provision.

Advantages

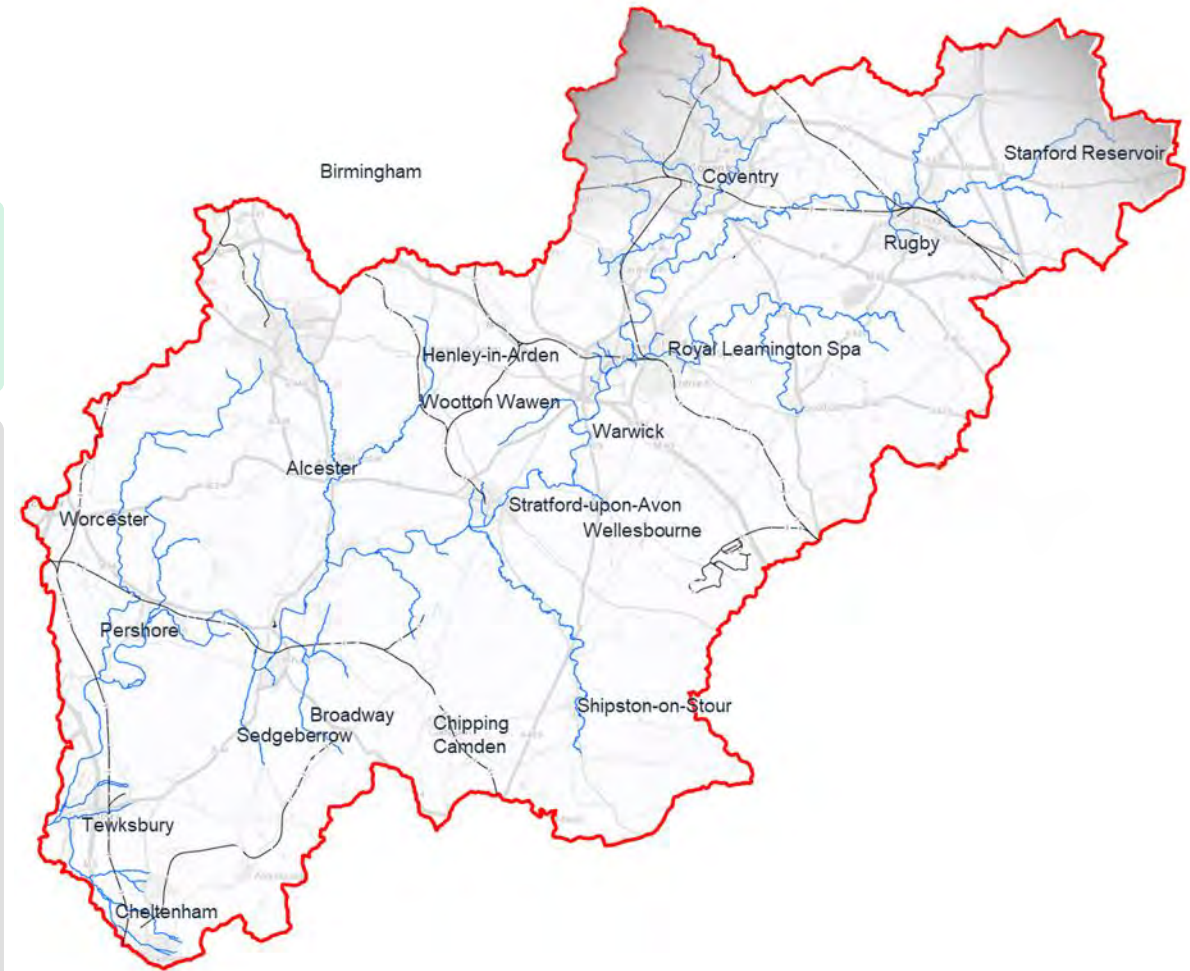
- Enables significant storage volumes upstream, offering reliable mitigation for a range of events
- Environmental & recreational opportunities associated with some assets, e.g. reservoirs
- Can support groundwater recharge and managing of river flows

Disadvantages

- Requires significant land uptake, which in-turn requires acquisition or landowner buy-in
- Environmental impacts due to change of land-use and potential alteration of natural river flows
- Adherence to the Reservoirs Act (1975).
- High embodied carbon & costs

Considerations

- New FSAs and reservoirs require detailed modelling and design, alongside frequent inspections and management to comply with the Reservoirs Act (1975) (applicable to storage areas over 10,000m³). The Reservoir Act (1975) restricts land use to flood storage only, including for temporary retention areas (e.g. these areas could not be used for grazing livestock in dry conditions)
- Artificial storage areas can be deployed at a range of scales across the catchment (i.e., small to large).
- Localised topography and geology will influence the applicability of FSA incorporation



Performance

Peak flow mitigation

*See leaflet for details

Max
11*%

Cost

£££

Nature recovery



Lead Time



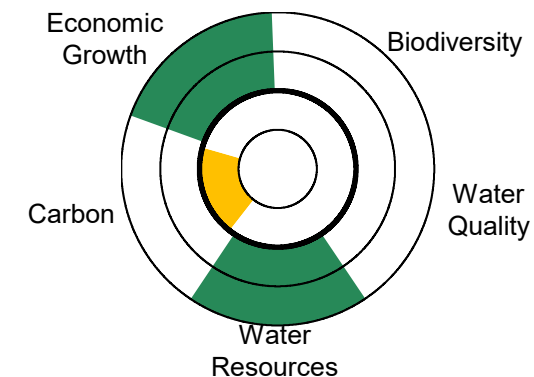
Life-span



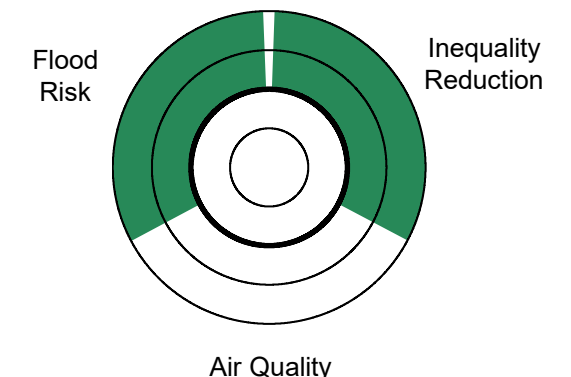
Adaptability



Benefits Toolkit



SA Objectives



Urban Source Control

Urban SuDS

Widespread incorporation of Sustainable Urban Drainage Systems (SuDS) (or Blue Green Infrastructure (BGI)) in urban environments to manage surface water runoff and water quality. Measures can support water retention, re-use, infiltration, filtration and conveyance. Measures typically include swales, infiltration basins, filtration strips, urban ponds and control structures.

Advantages

- Wider benefits related to water quality (urban pollution), urban biodiversity, urban heat, air pollution and recreation etc.
- Improves resilience to surface water flooding
- Opportunities to improve public realm & active travel

Disadvantages

- Requires ring-fenced maintenance funding & resource (especially if delivered at a large scale)
- Significant upfront costs if delivered at scale
- Retrofitting of SuDS can be costly, complicated and disruptive (e.g. traffic disruption)

Considerations

- Different bodies, responsible for the management and development of urban areas and surface water, need to work collaboratively to enable successful implementation, adoption and maintenance
- Retrofitting can be challenging in urban areas where space is limited – i.e. road systems can require re-landscaping to implement
- Ability to implement measures depends on groundwater infiltration and utilising existing topography

Performance

Peak flow mitigation

Indicative potential

3%

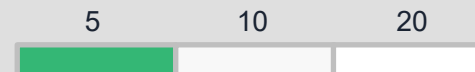
Cost

£ £ £

Nature recovery



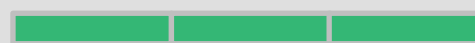
Lead Time



Life-span

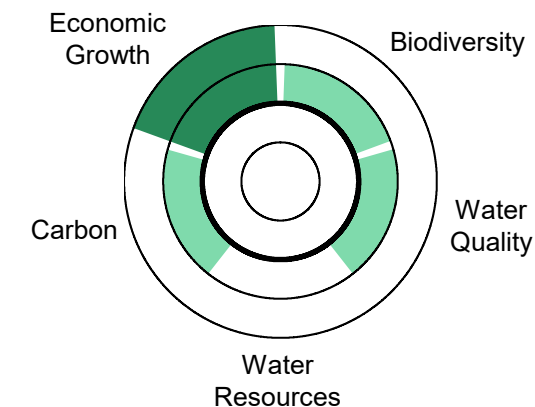


Adaptability

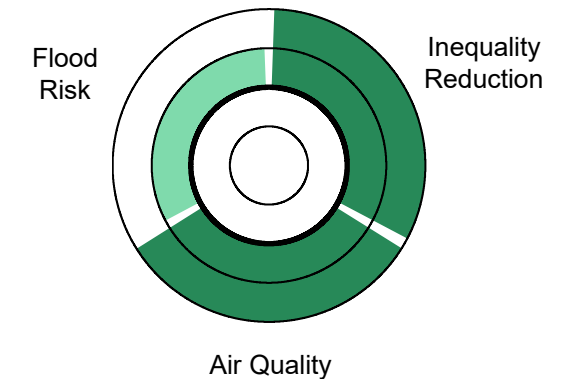


West Gorton Community Park, Manchester © Arup

Benefits Toolkit



SA Objectives



Urban Source Control

Property-level SuDS

This portfolio includes Sustainable Urban Drainage Systems (SuDS) (or Blue Green Infrastructure (BGI)) undertake at a property level. Measures can include installation of green roofs, rainwater storage through water butts, rain-gardens and de-paving of gardens.

Advantages

- Wider benefits related to water quality (urban pollution), urban biodiversity, urban heat, air pollution and recreation etc
- Can improve understanding on individual responsibility to reducing flood risk

Disadvantages

- Effectiveness is dependent upon scale of uptake by properties
- Reliant on continued home-owner maintenance to realise benefits over the long-term
- Challenging to retrofit measures across different types of properties (e.g. rental properties)

Considerations

- Further measures may be required to enable up-take at scale across urban areas – e.g. educational campaigns or subsidies to support
- Implementation offers benefits to RMAs and water companies managing surface water and sewer flooding



Performance

Peak flow mitigation

Indicative potential

1%

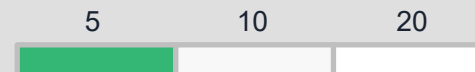
Cost

£ £ £

Nature recovery



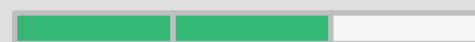
Lead Time



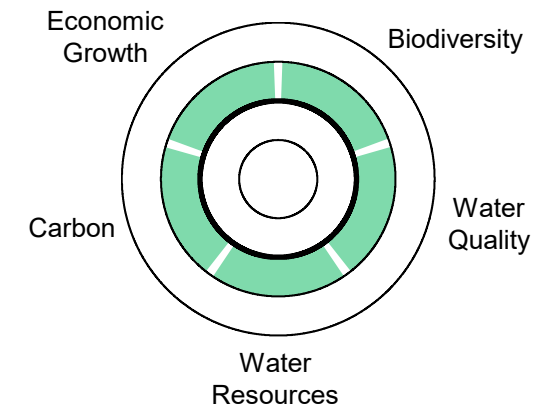
Life-span



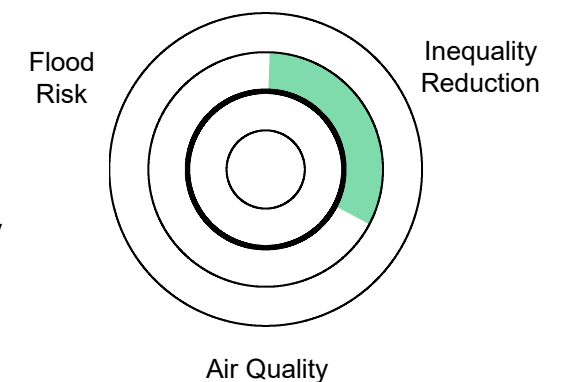
Adaptability



Benefits Toolkit



SA Objectives



In-Channel Measures

NFM

Natural Flood Management (NFM) helps to manage flood risk by protecting, restoring and emulating natural processes. This portfolio includes in-channel NFM measures that interrupt flow pathways resulting in temporary water storage to flatten and elongate peak river flows. This may include measures such large woody debris, floodplain storage, and attenuation features.

Advantages

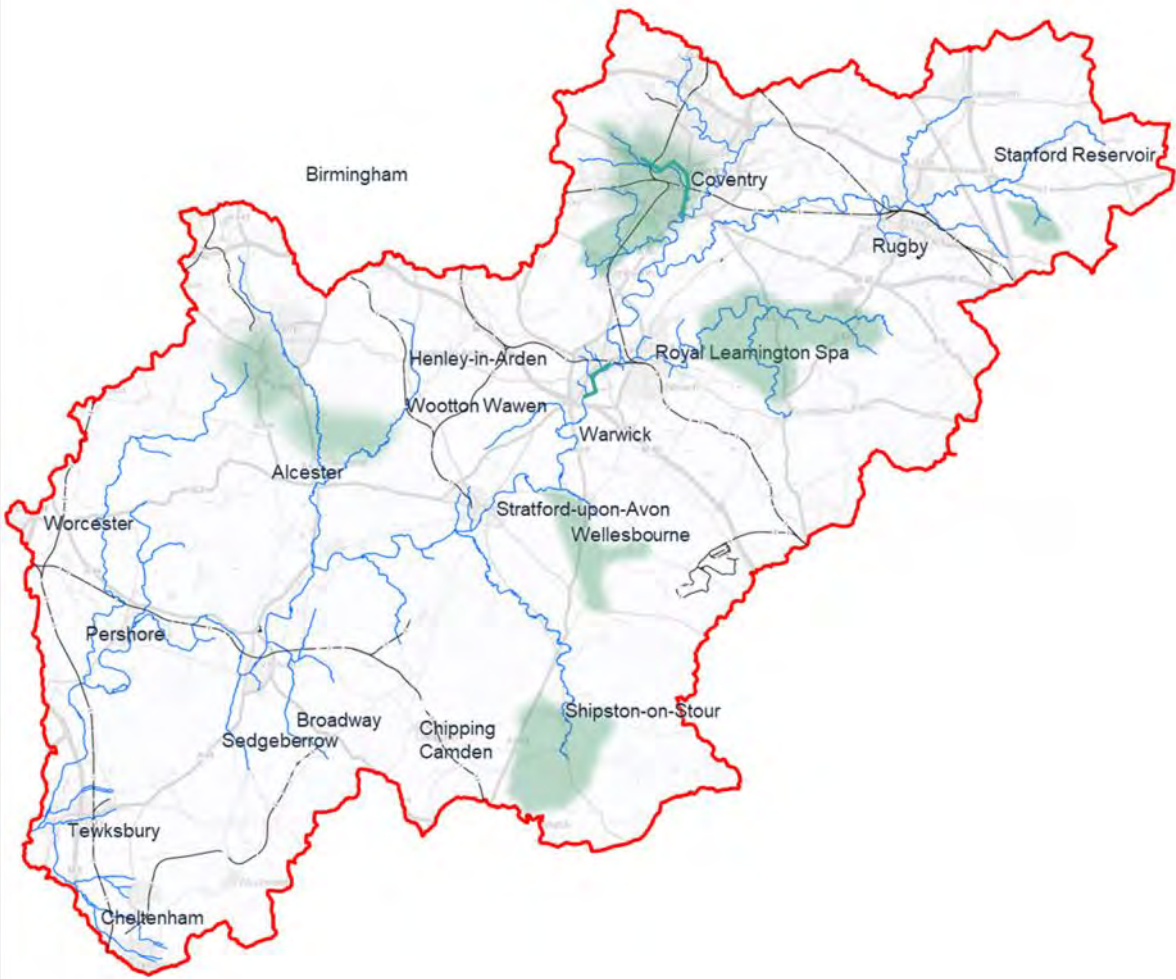
- Environmental benefits (e.g. biodiversity, carbon sequestration, water quality improvements etc.)
- Can be cost-effective when compared to grey infrastructure
- Opportunity for community engagement in FRM

Disadvantages

- Complex to implement at a large scale - requiring multiple landowners to deliver
- Uncertainty around absolute effectiveness
- Maintenance required by landowners

Considerations

- Most effective for lower intensity, higher frequency floods in small to medium catchments, rather than larger events (e.g. 1 in 200-year events)
- NFM generally complements other flood risk management approaches
- The space required to deliver widespread upstream storage via NFM may compete with wider catchment priorities (e.g. development, food security, etc.)
- Offers opportunities to attract green funding & finance (e.g. through emerging nature markets)



Performance

Peak flow mitigation
Indicative potential

6%

Cost

£££

Nature recovery



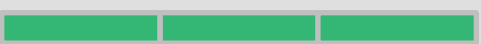
Lead Time



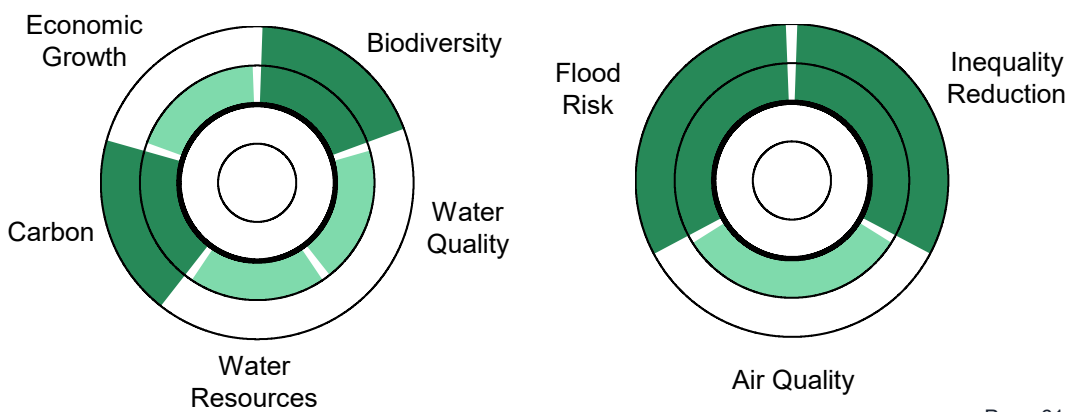
Life-span



Adaptability



Benefits Toolkit



In-Channel Measures

Artificial

In addition to measures upstream, storage can be implemented at key points further downstream across the catchment. Alongside flood storage areas (as captured in the Upstream Storage portfolio), interventions can include bypass channels, offline storage areas and increasing channel capacity. Please see the hotspot consideration leaflets.

Advantages

- Environmental benefits – e.g. potential for habitat creation, such as reedbeds
- Recreational opportunities – e.g. outdoor swimming
- Can provide additional flood risk mitigation to key areas of vulnerability (e.g. densely populated urban environments)

Disadvantages

- Requires complex engagement and land acquisition
- Environmental impacts due to change of land-use and potential alteration of natural river flows
- Significant monetary and carbon costs
- Requires on-going maintenance to maintain performance

Considerations

- Flood bypass channels can be used to route floodwaters around critical areas and rejoin the river downstream. They can act as flood relief ‘valves’ by increasing the cross-sectional area available to move floodwaters. However, this can increase flood risk downstream due to localised, increased conveyance.
- Ability to implement these interventions depends on topography constraints and land availability



Arup Rodley by pass channel whole

Performance

Peak flow mitigation

Indicative potential

The peak flow mitigation impacts of storage measures is captured as part of the Upstream Storage: Artificial Portfolio.

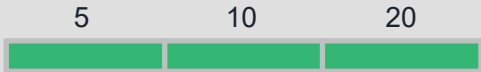
Cost



Nature recovery



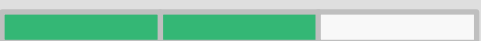
Lead Time



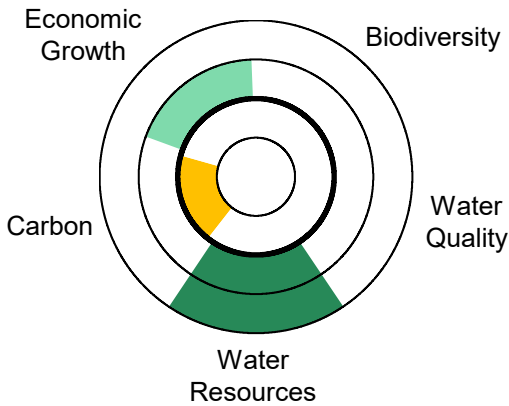
Life-span



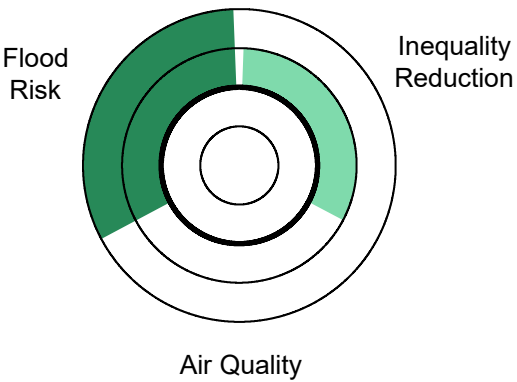
Adaptability



Benefits Toolkit



SA Objectives



Hard Defences

Temporary Linear

Temporary flood defences are designed to be quickly deployed in pre-planned locations which do not have permanent defences. When flooding is expected, the barriers are quickly put up. When the risk has passed, the barriers are taken down, checked over and put back into storage. They include temporary flood barriers (portable metal frames with covers) and demountable defences.

Advantages

- Relatively quick and easy deployment to protect assets for short periods
- Retains economic and amenity value of watercourses outside of flood events
- Designed to a specific, and reliable, standard of protection
- Minimal environmental impact

Disadvantages

- Limited durability and reduced lifespan when compared to permanent defences
- Storage and transportation implications of barriers
- Catastrophic flooding if the asset fails whilst deployed
- Regular maintenance, inspections and replacement required

Considerations

- Temporary flood barriers are generally deployed in places where it isn't possible, practical or economical to build a permanent flood defence (or where one hasn't yet been built)
- Temporary barriers do not provide the same level of protection as permanent defences and typically have failure rates of 20-30%, although these can be reduced by good advanced planning
- Safe and robust deployment requires reliable flood forecasting and flood warning services

Performance

Peak flow mitigation

Indicative potential

N/A

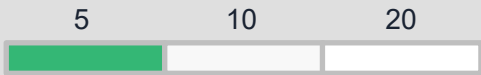
Cost



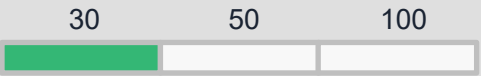
Nature recovery



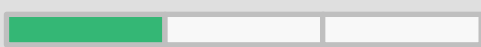
Lead Time



Life-span



Adaptability



Hotspot review

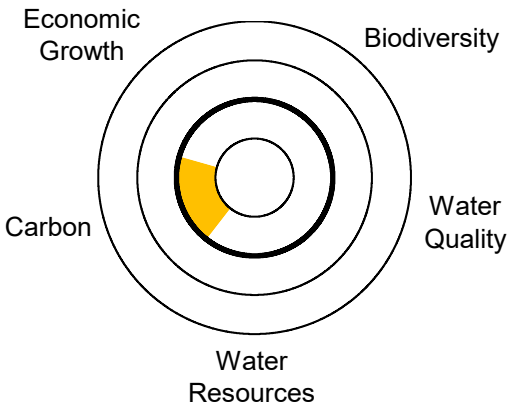
Three risk hotspots in the Warwickshire Avon focus area have been identified for the River Severn through the Risk & Opportunities analysis. We have considered whether it's possible to mitigate flood risk at these locations through the use of temporary or hard flood walls for a **high climate change scenario** (UKCP 8.5). A summary is provided below with further information in the Hotspot Considerations leaflets

Epoch	2030	2050	2080
Alcester			
Coventry			
Rugby			

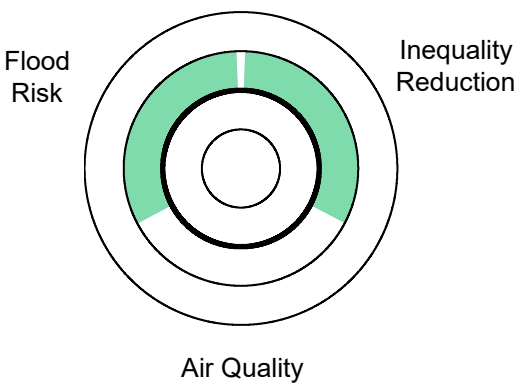
Key:

- Red: Increasingly unable to mitigate risks using hard defences
- Amber: Flood mitigation possible with hard defences
- Green: No further FRM measures required

Benefits Toolkit



SA Objectives



Hard Defences

Permanent Linear

Permanent linear defences are typically constructed alongside watercourses in urban areas to protect people, property and infrastructure from the risk of flooding. They can include concrete flood walls, glass barriers, embankments etc. Defences may be modular and built to enable an increase in height over time due to changing flood risk.

Advantages

- Offers flood mitigation in localised areas
- Designed to a specific, and reliable standard of protection

Disadvantages

- Significant financial costs and embodied carbon
- Long-term investment (incl. timely maintenance) is required by asset owners to maintain performance
- Potential to impact on aesthetic, amenity and habitats (incl. hydromorphology) along river frontages

Considerations

- There is a point at which it is not possible to raise defences further to mitigate flood risk due to amenity, recreational or performance constraints – as indicated opposite
- Using flood defences can increase flood risk downstream and this needs to be accounted for in design
- Maintaining both existing and new assets requires long-term funding. Inflation, alongside impacts by storm events (which are increasing in frequency due to climate change), can impact maintenance costs and requirements further.

Performance

Peak flow mitigation

Indicative potential

N/A

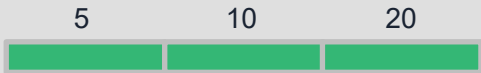
Cost

£££

Nature recovery



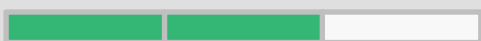
Lead Time



Life-span



Adaptability



Hotspot review

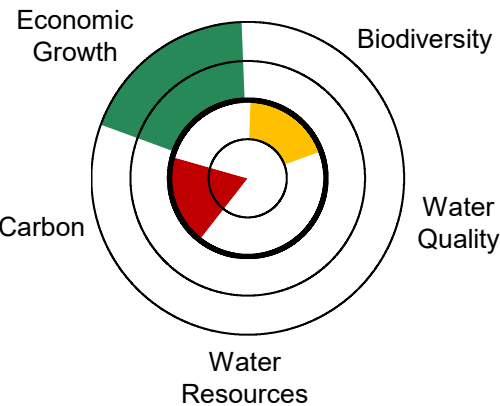
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Epoch	2030	2050	2080
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Coventry			
Rugby			

Key:

- Red: Increasingly unable to mitigate risks using hard defences
- Amber: Flood mitigation possible with hard defences
- Green: No further FRM measures required

Benefits Toolkit



SA Objectives



Asset Management

Hydraulic Management

This portfolio includes hydraulic management of watercourses though assets such as sluice gates and pumping stations. These manage flood risk through providing temporary storage and managed release of water. This portfolio also involves transfer (e.g., Severn – Thames) and aquifer recharge schemes to artificially recharge, which may be accessed during times of drought.

Advantages

- Provides automated and active flood control opportunities
- Opportunities to recharge groundwater aquifers if designed appropriately

Disadvantages

- Long-term investment (incl. timely maintenance) is required by asset owners to maintain performance
- May alter natural hydrological regimes
- Processes may be susceptible to hacking / power outages
- High construction, operational and carbon costs

Considerations

- Hydraulic management assets can contribute to more artificial watercourses and hydromorphology alterations
- Maintaining both existing and new assets requires long-term funding.



NEECA2 - Newmans Sluice_ © Arup

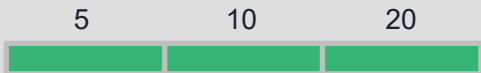
Performance

Peak flow mitigation

Indicative potential

N/A

Lead Time



Cost

£ £ £

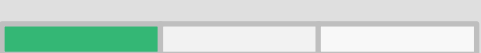
Life-span



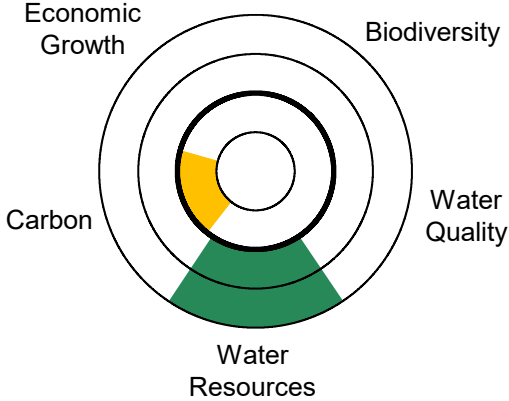
Nature recovery



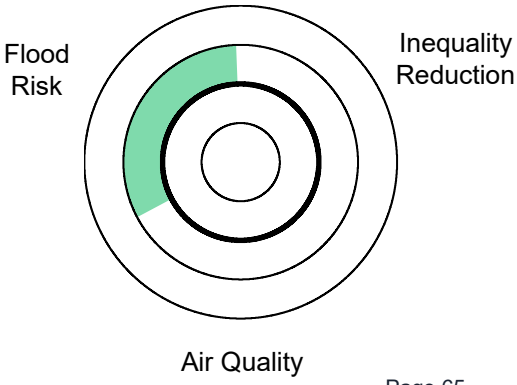
Adaptability



Benefits Toolkit



SA Objectives



Asset Management

Review & Enhance

This portfolio includes hydraulic management of watercourses through assets such as sluice gates and pumping stations. These manage flood risk through providing temporary storage and managed release of water. This portfolio also involves transfer (e.g., Severn – Thames) and aquifer recharge schemes to artificially recharge, which may be accessed during times of drought.

Advantages

- Provides automated and active flood control opportunities
- Opportunities to recharge groundwater aquifers if designed appropriately

Disadvantages

- Long-term investment (incl. timely maintenance) is required by asset owners to maintain performance
- May alter natural hydrological regimes
- Processes may be susceptible to hacking / power outages
- High construction, operational and carbon costs

Considerations

- Hydraulic management assets can contribute to more artificial watercourses and hydromorphology alterations
- Maintaining both existing and new assets requires long-term funding.



Dormay Street River Wall Replacement_© Arup

Performance

Peak flow mitigation

Indicative potential

N/A

Lead Time

5 10 20

Cost

£ £ £

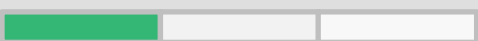
Life-span

30 50 100

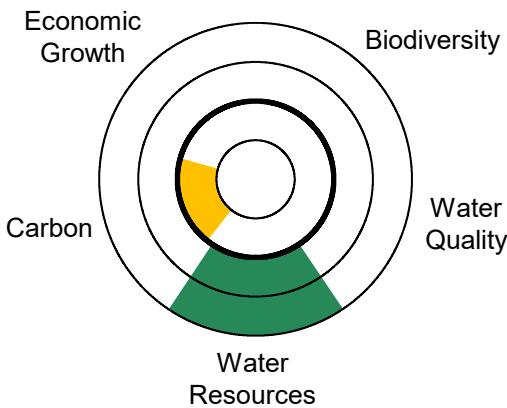
Nature recovery



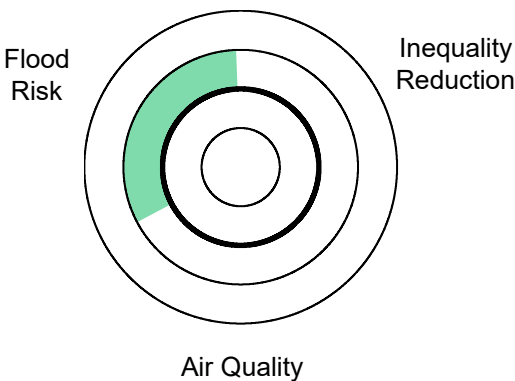
Adaptability



Benefits Toolkit



SA Objectives



Property Level

Property Flood Resilience

Property Flood Resilience is a set of modifications added to a building to lower its flood risk. It can reduce flood damage and speed up recovery after a flood. The risk of flooding cannot be mitigated entirely. However, PFR reduces the risk of water getting into properties and speeds up recovery if the worst happens.

Advantages

- Relatively low cost of installation in comparison to other measures
- Quick implementation
- Provides “peace of mind” to the residents
- Lower environmental impacts

Disadvantages

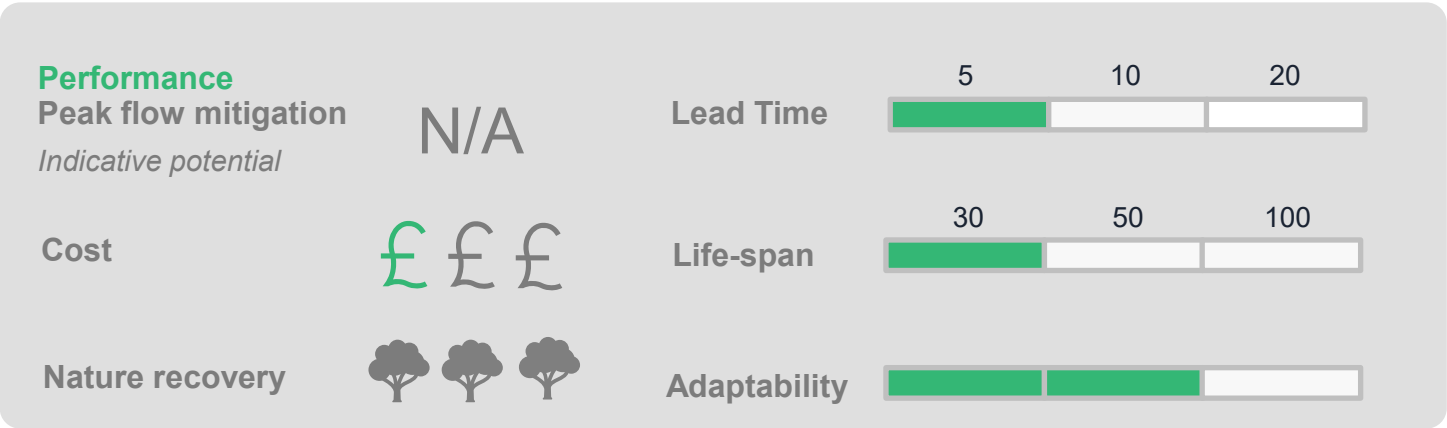
- Reliant on public and flood warning services to enable implementation effectively
- Effectiveness is dependent upon uptake and deployment by property owners
- There can be negative aesthetic implications to properties

Considerations

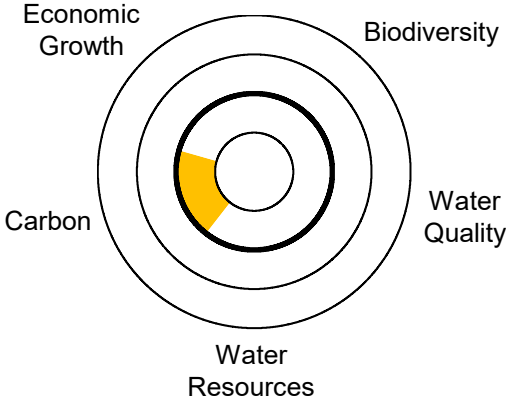
- Performance of measures is dependent on homeowner operation, maintenance and use of flood forecasting services. Typically, they require grants to at-risk homeowners to enable uptake.
- There can be health & safety risks associated with deployment
- They require reliable public flood forecasting and flood warning services to support deployment
- If measures are integrated into building standards, they offer an opportunity to develop water resilient buildings



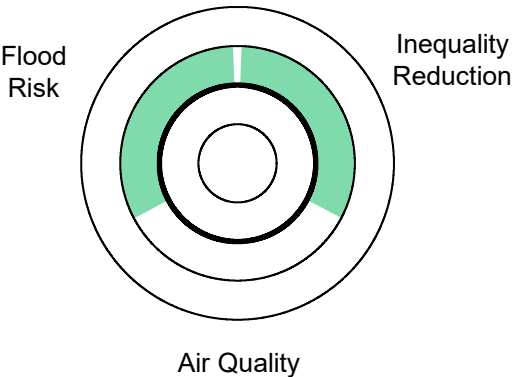
Houses with flood gates © Stephen Craven



Benefits Toolkit



SA Objectives



Managed Realignment

Removal & Relocation

Managed realignment is a long-term strategy for managing land adjacent to watercourses that involves altering FRM approaches to allow previously protected land to flood. This can involve the removal or abandonment of FRM assets in areas of highest risk. This may result in the need for relocation of communities, properties, cultural sites, critical infrastructure and businesses.

Advantages

- Moves people, properties and infrastructure away from the risks of flooding
- Environmental restoration opportunities – e.g. habitat creation or replacement (supporting requirements of the Habitats Regulations)
- Reduces on-going defence costs

Disadvantages

- Irreversible loss of residences, communities, assets, and cultural heritage sites
- Highly disruptive and impactful to individuals, society and economies
- Subject to high political and social controversy
- Potential changes or loss of habitats

Considerations

- Managed retreat can be complex and often contentious. It requires extensive consultation and public participation to manage negative implications to people’s lives and the infrastructure they depend on.
- There is currently a lack of a financial compensation mechanism (incl. both land purchase and payment for the use of land). Under present legislation, landowners do not generally have any right to financial compensation where a decision is made to no longer defend their land.
- A complex planning process can delay implementation

Performance

Peak flow mitigation

N/A

Indicative potential

Cost

£££

Nature recovery

Lead Time

51020

Life-span

3050100

Adaptability

Hotspot review

Three risk hotspots in the Warwickshire Avon focus area have been identified for the River Severn through the Risk & Opportunities analysis. We have considered whether it’s possible to mitigate flood risk at these locations through the use of hard defences and upstream storage. *A summary is provided below with further information in the Hotspot Considerations leaflets*

Epoch	2030	2050	2080
Alcester			
Coventry			
Rugby			

Key:

- Red: Increasingly unable to mitigate risks - managed realignment is increasingly likely
- Amber: Additional measures are required (e.g., increased storage and / or conveyance)
- Green: No further FRM measures required

Benefits Toolkit

SA Objectives



Appendix D

Adaptation Pathways

Contents

This appendix contains:

- D1: Pathway building workshop materials,
- D2: Candidate pathways; and,
- D3: Emerging pathway delivery framework.



Appendix D1

Pathway building workshop materials

Appendix D1 presents the collaborative pathway building workshop materials. They are presented in first person, as if the workshop was being undertaken. A group of approximately 12 people, split into three groups (one group aligning to each lens) of four is ideal.

An example agenda is provided to the right.

Table D1.1: Pathway building workshop agenda

Time	Item
09:30	Arrival
10:00	Introduction • Purpose of the day and overview of activities Set the scene • Vision and key assumptions and key terminology • Approach so far Introduce activity • Introduce the scenarios, portfolios and risk and opportunity maps
10:30	Activity 1a: Sequencing of portfolios into high-level pathways • Precautionary approach • Maximising wider benefits • Cost constrained
11:35	Break
11:45	Activity 1b: Adjusting the pathways to improve baseline flood risk
12:15	Discussion on Activity 1
12:45	Lunch
13:30	Activity 2a: Stress-testing the pathways against low climate
14:10	Activity 2b: Stress-testing the pathways against growth
14:50	Break
15:00	Discussion on activity 2 • Present back the pathways to the group • Reflections on the process
16:00	Next steps

Appendix D1

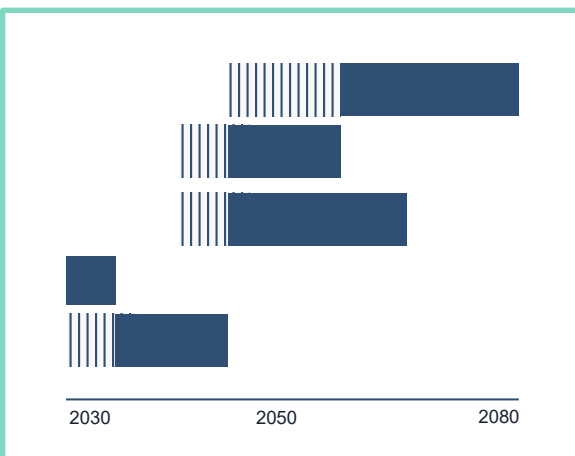
Overview of workshop activities

Activity 1

1a: Sequencing of portfolios into high-level pathways

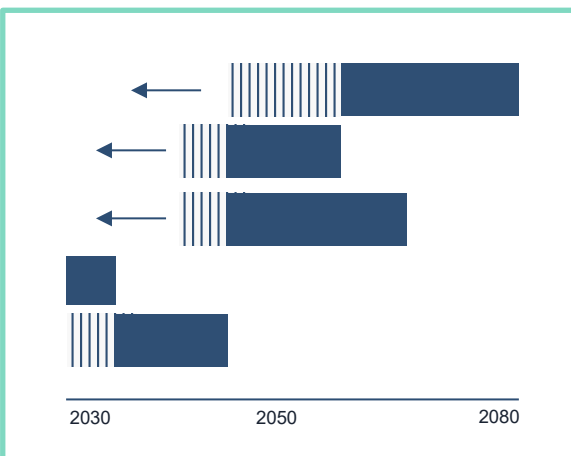
Identifying pathways of actions which maintain current levels of flood risk in the face of increasing peak river flows due to climate change. Applying three different lenses:

- Precautionary approach
- Maximising wider benefits
- Lowest cost



1b: Adjusting the pathways to improve the baseline flood risk

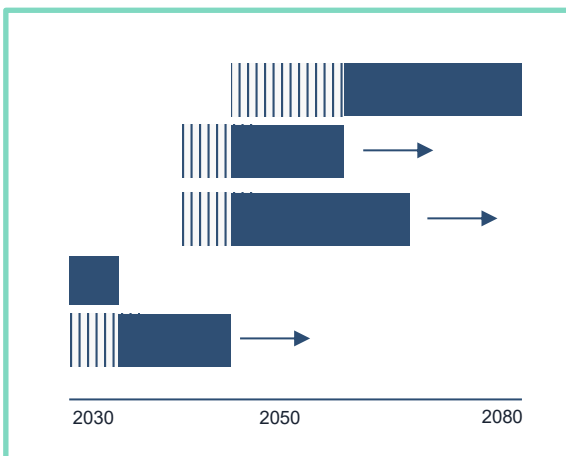
Exploring what further actions are required, and how pathways change, when seeking to improve the baseline flood risk beyond mitigating climate change impacts.



Activity 2

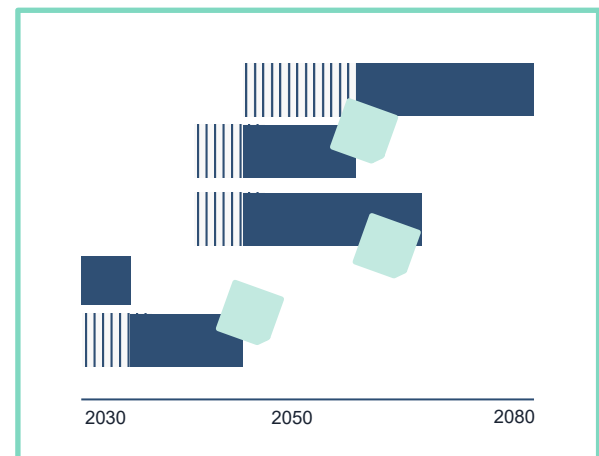
2a: Stress-testing the pathways against different future scenarios (climate)

Exploring how the pathways would change if climate change is less severe than anticipated in Activity 1 (i.e. a low climate change scenario).



2b: Stress-testing the pathways against different future scenarios (growth)

Exploring how the pathways would change if growth (e.g. housing and development) is lower and higher than anticipated.



Appendix D1

Activity 1a: Sequencing portfolios through different lenses

Map sequences of actions / portfolios which maintain current levels of flood risk in response to increasing peak flows for one of the following different lens:

1) Precautionary approach	A cautious approach, where the aim is to remain ahead of the curve by prioritising dealing with increasing peak flows and flood risk before it occurs at each epoch.
2) Maximising benefits	A modular approach where the aim is to achieve the most co-benefits whilst trying to meet objectives around managing flood risk
3) Lowest cost	Aim is to keep monetary costs as low as possible, minimising and delaying any capital expenditure for as long as possible

You should think about:

- The lead-in times of actions
- The scale of deployment of actions and the locations you would target first
- What would you need to monitor to inform when to act?
- What additional information would you need to make decisions about what you do and when?

Appendix D1

Activity 1a: Instructions

- 1 Capture existing projects that are on-going between **2025-2030**.
- 2 Review the different portfolios to identify those which align to the catchment and the lens you are focusing on.

- 3 Consider the % change in peak flows due to climate change for **2030**. Identify what actions you need to take to mitigate this and manage flood risk across the catchment. Map these across your timeline.

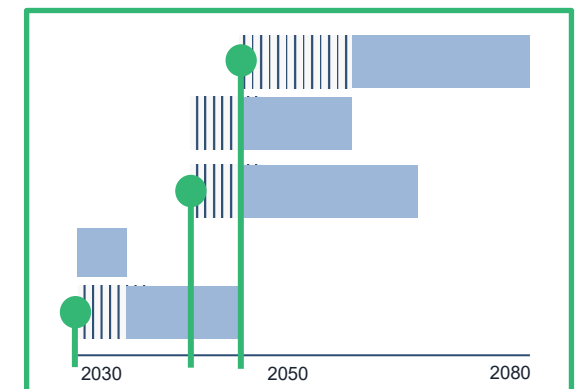
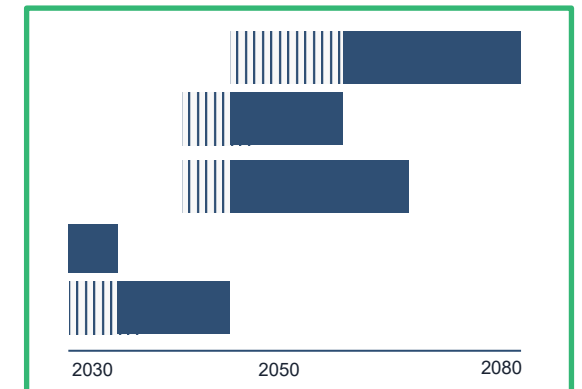
- 4 Now consider the % change in peak flows due to climate change for **2050**. Building on your previous actions, consider what further actions you would need to take to mitigate this and manage flood risk across the catchment.

- 5 Now consider the % change in peak flows due to climate change for **2080**. What further actions would you need to take to mitigate this and manage flood risk across the catchment.

You should consider:

- *Scale of deployment* of options (e.g. 20% of Upstream NFM now) and *where* you might implement them.
- What are the *lead-in times* for these actions? *How long* might it take before these actions realise flood risk mitigation and wider benefits?
- Are there any *interdependencies* or *trade-offs* between the actions?
- What *additional information* would you need to make decisions about what you do and when?
- Are there any *enabling activities* required to deliver the actions, e.g. funding and financing, governance, engagement?

- 6 Once your pathway has been developed, consider:
 - What are the key decision-points along the pathways that could inform trigger points for action?
 - What are the pros and cons of your pathway?



Appendix D1

High Climate Change scenario (RCP8.5 / 1in100 year) peak flow uplifts

The aim of Activity 1 is to mitigate peak flow uplifts over time, as projected below, across the two focus areas.

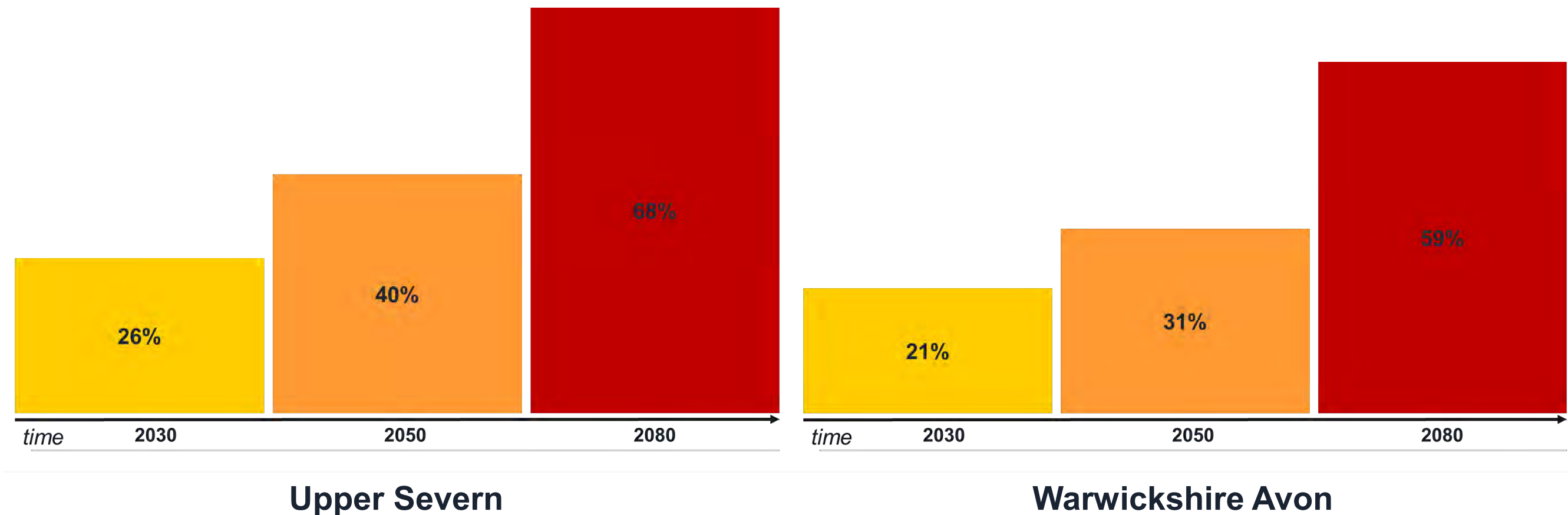


Figure D1.2: Peak flow uplift high climate change scenario projection (left: Upper Severn, right: Warwickshire Avon).

Appendix D1

Activity 2a: Stress-testing the pathways to a lower climate change scenario

Adjust your pathways from Activity 1 to consider what you would do differently if climate change is less severe, with updated peak flow uplifts, as outlined below.

Consider:

- What would you do differently?
- How is the overall sequence of your actions affected?
- Are the lead-times of any actions affected, i.e. is it easier or harder to implement any of them?
- Is the length of viability of the actions affected, i.e. are they now viable for more or less time?
- Is the impact on flood risk mitigation affected?

Low climate

- Peak flow uplifts are projected to be significantly lower (when compared to the high climate scenario). See below
- There are warmer temperature averages, but steady changes in precipitation across summer and winter

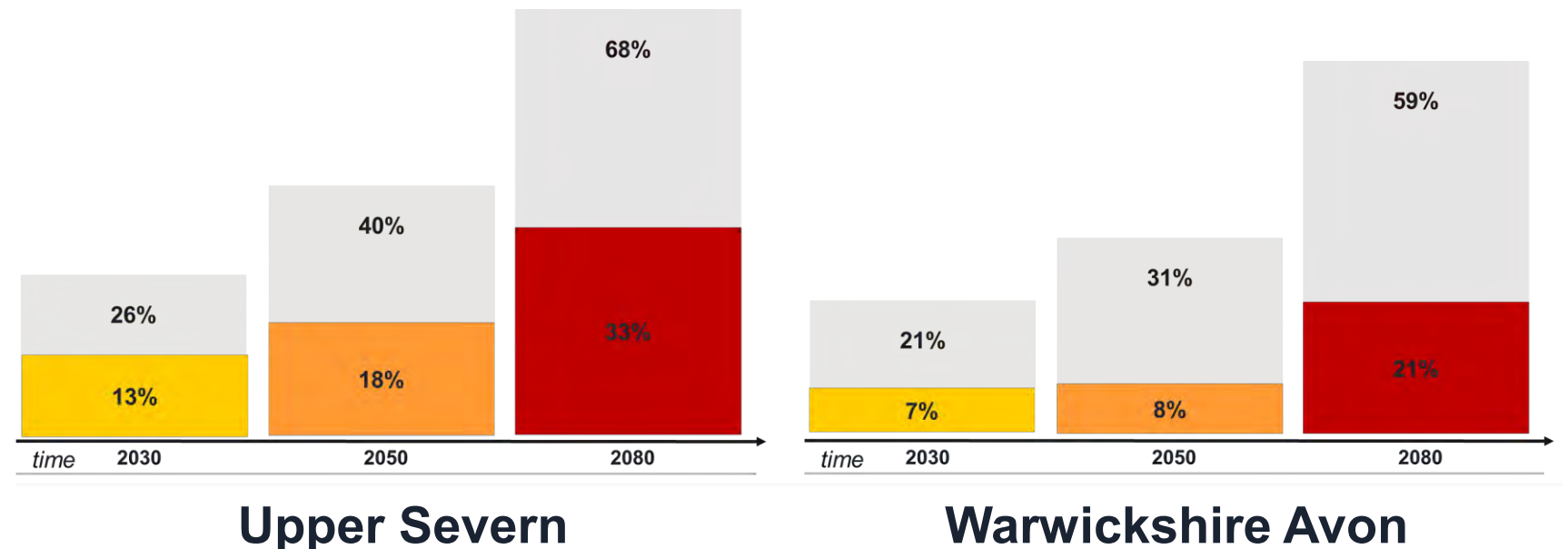


Figure D1.3: Peak flow uplift under low climate change projection (left: Upper Severn, right: Warwickshire Avon).

Appendix D1

Activity 2b: Stress-testing the pathways against low and high growth

Adjust your pathways from Activity 1 and 2a to consider what you would do differently if growth is higher or lower than anticipated

High growth

High population growth and development occurs across the catchment. This results in:

- Rapid development on floodplains and in urban cities/towns due to high housing demand
- Population growth fuels economic growth and activity across the catchment
- There are competing pressures on land-use; with competition for land and water resources used for development and people vs. food security vs. environment and flood mitigation
- Developed impermeable land increases surface runoff - resulting in increased flash flooding and pressures on the combined sewer systems, impacting river water quality

Low growth

Population growth and development is lower than anticipated. This results in:

- Development on the floodplains slowing due to low housing demand. Less pressure for development eases pressure on land-use, supporting its use for flood mitigation and environmental purposes
- Slow / low growth provides longer time to plan development in a holistic way at a catchment scale
- Low growth, when compared to the rest of the UK, influences the fundability of FRM schemes via GiA
- With less pressure on development, the catchment is earmarked to support Britain's food self-sufficiency goals and fuel the agrotourism sector – increasing agricultural investment.

Consider:

- What would you do differently?
- How is the overall sequence of your actions affected?
- Are the lead-times of any actions affected, i.e. is it easier or harder to implement any of them?
- Is the length of viability of the actions affected, i.e., are they now viable for more or less time?
- Is the impact on flood risk mitigation affected?

Appendix D2

Upper Severn: Candidate pathways

The following slides present the Upper Severn candidate pathways (developed as part of the workshop), their appraisal, and key differences and commonalities across them to inform the development of the emerging pathway for the focus area.



Figure D2.1: Upper Severn focus area

Upper Severn

Wider Benefits Candidate Pathway

Focus area strategy:

This lens focuses on delivering system-wide resilience through FRM whilst maximising co-benefits (e.g., economic, environmental, etc.). It initially focuses on reviewing asset conditions across the area to determine which assets need to be replaced and which can be enhanced (e.g. existing linear defences); whilst fast-tracking the delivery of widespread NFM through incentivising policy enablers.

Temporary defences and PFR are utilised in the short-term to mitigate flood risk whilst NFM / NbS and FSAs are being delivered. This pathway assumes that storage delivery upstream and spatial planning policies will negate the need for the delivery of additional permanent linear defences across the catchment.

Beyond these measures, two phases of FSA deliver incremental FRM actions that can be adapted depending on how climate change develops and the effectiveness of broader adaptation actions. Property-level SuDS are encouraged catchment-wide, building personal resilience and community action to mitigate flood risk whilst managed realignment is considered as a last resort, influenced by effectiveness of other adaptation actions and severity of climate change.

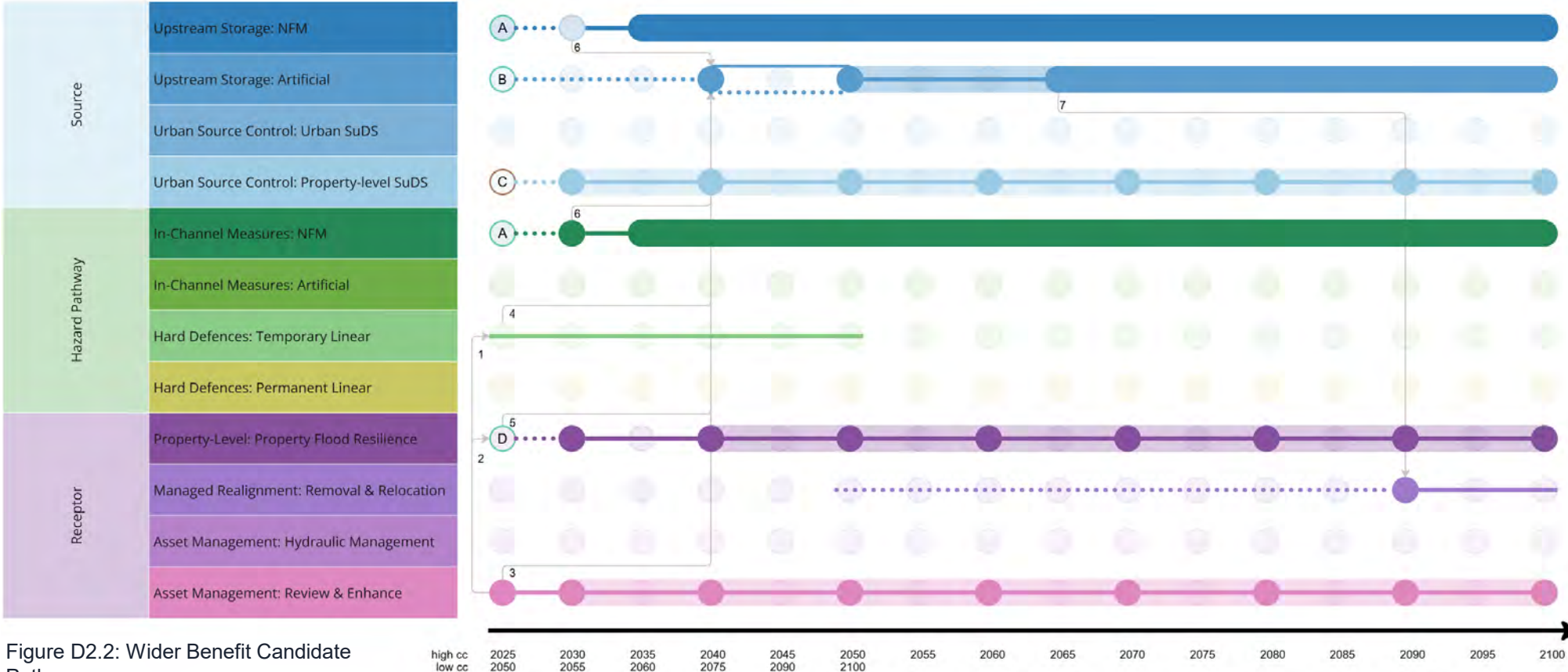


Figure D2.2: Wider Benefit Candidate Pathway.

Supporting information

Dependencies

- 1 - 3. Outputs of the asset review will inform the need for asset enhancement and delivery of temporary defences, PFR and FSAs.
4. Delivery of temporary linear defences informs FSA prioritisation (i.e., identifying risk hotspots)
5. Delivery of PFR informs FSA prioritisation (i.e., identifying risk hotspots)
6. Delivery of NFM informs where FSAs can be delivered
7. Performance of widespread FSAs informs the need for managed realignment.

Enablers

- A:** Agricultural and land-use policies to support the delivery of NFM and upstream storage. This could include incentivising farmers and rural landowners to adopt NFM adaptation actions.
- B:** Accelerate planning and permitting required for FSA delivery.
- C:** Funding and educational outreach to support uptake of property-level SuDS
- D:** Policy / funding and community outreach to support the rollout of PFR
- Overarching:** Spatial planning policy to integrate FRM considerations and mitigate flood risk to future development.
- Overarching:** Long-term, robust funding & financing is required to enable adaptation. Alternative funding and financing mechanisms are needed to enable scheme delivery and the widespread uptake of NFM and SuDS.

Upper Severn

Precautionary Candidate Pathway

Focus area strategy:

This lens aims to maximise flood resilience to across the region to mitigate increasing flood risks before they fully materialise.

This candidate pathway starts with a number of enabling actions looking to either mitigate trends that may increase future risks or start to build resilience amongst communities early on (e.g. spatial planning policy, behaviour change, etc.). An early programme of PFR and temporary defences are rolled-out regionally to mitigate risks whilst broader adaptation actions are delivered.

From a capital delivery perspective, existing assets are assessed to determine their capacity to be enhanced. Flood mitigation is focused on the phased delivery of artificial storage upstream. Due to uncertainties around their absolute effectiveness, nature-based solutions (like upstream NFM) and SuDS are undertaken to provide wider resilience.

Based on the activities above, further hard defences are delivered to mitigate increasing risks and depending on the scale and extent of climate change, managed realignment is considered for those at greatest risk.

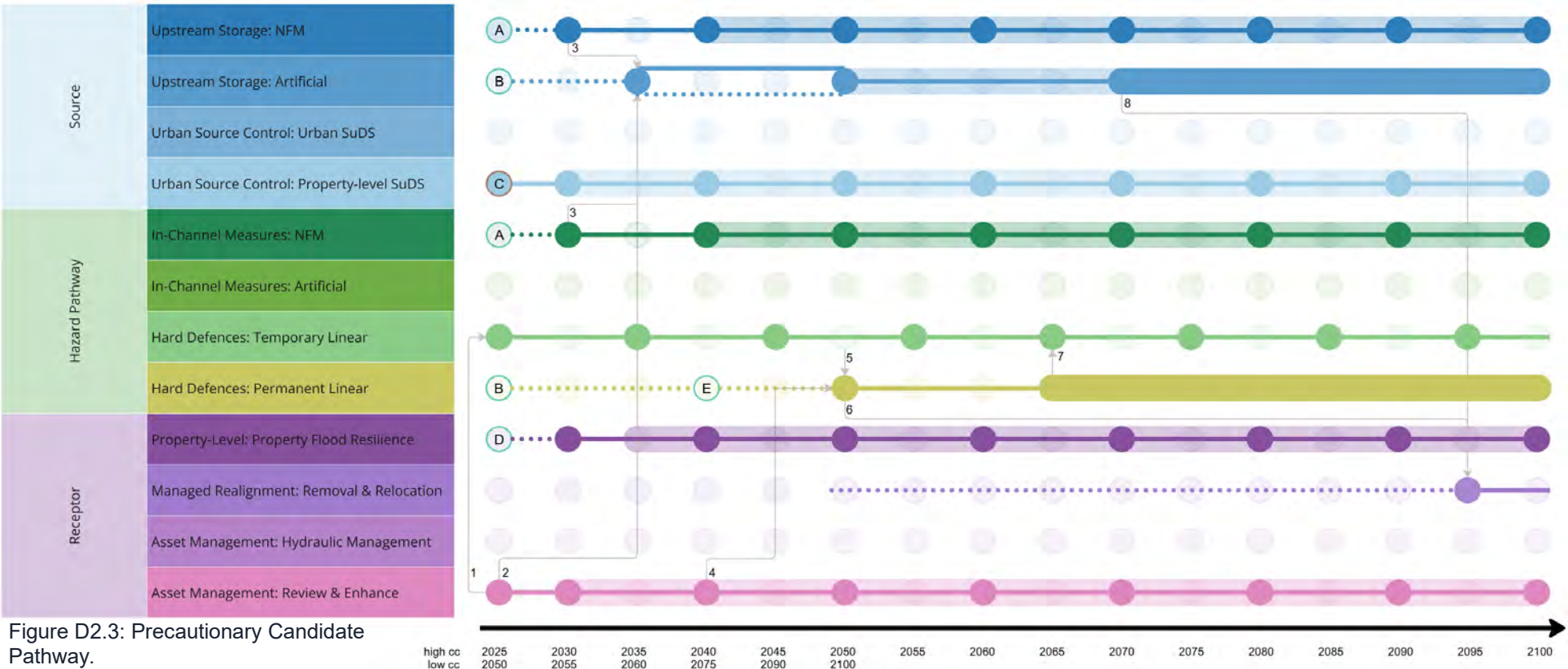


Figure D2.3: Precautionary Candidate Pathway.

Supporting information

Dependencies

- 1 - 2. Outputs of the asset review will inform the need for asset enhancement and delivery of temporary defences and FSAs.
3. Delivery of NFM informs where FSAs can be delivered
4. Outputs of the asset review will inform the need for and delivery of permanent linear defences
5. Continued delivery of temporary linear defences informs the need for permanent linear defences
- 6 - 7. Feasibility of permanent linear defences informs the need for managed realignment and the need for the continued delivery of temporary linear defences.
8. FSA performance informs the need for managed realignment.

Enablers

- A:** Agricultural and land-use policies to support the delivery of NFM and upstream storage. This could include incentivising farmers and rural landowners to adopt NFM adaptation actions.
- B:** Accelerate planning and permitting required for FSA delivery.
- C:** Funding and educational outreach to support uptake of property-level SuDS
- D:** Policy / funding and community outreach to support the rollout of PFR
- E:** Reviews to current policy around funding FRM infrastructure (e.g., changing payments for outcome measures)
- Overarching:** Spatial planning policy to integrate FRM considerations and mitigate flood risk to future development.
- Overarching:** Long-term, robust funding & financing is required to enable adaptation. Alternative funding and financing mechanisms are needed to enable scheme delivery and the widespread uptake of NFM and SuDS.
- Overarching:** Action to enable personal and community resilience in the face of increasing flood risk

Upper Severn

Cost Constrained Candidate Pathway

Focus area strategy:

This lens focuses on delivering flood resilience within a cost constrained future. This pathway depends on portfolios that can be easily implemented, require less resources, or can be delivered by partners / communities to enable flood resilience (e.g. NFM, property-level SuDS, PFR, etc.).

This candidate pathway initially focuses on reviewing asset conditions to maximise their performance whilst delivering cost-effective upstream NFM and the continued, medium-term delivery of temporary linear defences. A single phase of strategically placed FSAs are then delivered to maximise downstream peak flow mitigation, optimising BCR. To complement FSA delivery, in-channel measures are explored focussing on extreme risk hotspots.

Under this cost constrained lens, the long-term mitigation of flood risk becomes increasingly challenging, thus, managed realignment is explored earlier than other lenses – initially targeting failing assets and communities who are most vulnerable. As a result, the lead-in time for this activity is considered in the short-term epoch. Depending on the performance of wider measures, a second phase of managed realignment may be explored.

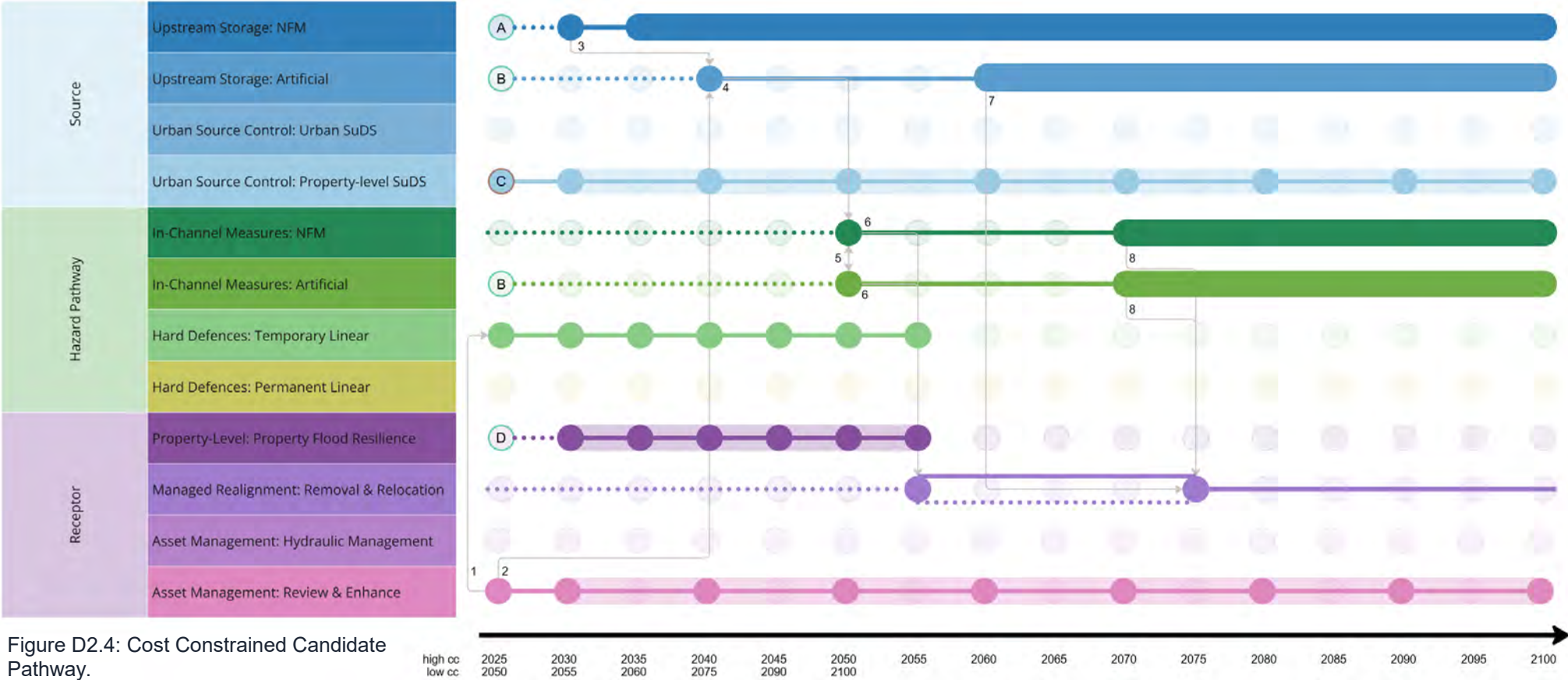


Figure D2.4: Cost Constrained Candidate Pathway.

Supporting information

Dependencies

- 1 - 2. Outputs of the asset review will inform the need for asset enhancement and delivery of temporary defences and FSAs.
3. Delivery of Upstream Storage: NFM informs where FSAs can be delivered
4. FSA delivery informs where In-Channel Measures: NFM can be delivered
5. In-Channel Measures should be considered in tandem as both NFM and Artificial measures cannot be delivered in the same location
6. In-Channel Measure feasibility informs an initial phase of managed realignment.
7. FSA performance informs the need for a second phase of managed realignment.
8. In-Channel Measure performance informs the need for managed realignment.

Portfolio enablers

- A:** Agricultural and land-use policies to support the delivery of NFM and upstream storage. This could include incentivising farmers and rural landowners to adopt NFM adaptation actions.
- B:** Accelerate planning and permitting required for FSA delivery.
- C:** Funding and educational outreach to support uptake of property-level SuDS
- D:** Policy / funding and community outreach to support the rollout of PFR
- Overarching:** Spatial planning policy to integrate FRM considerations and mitigate flood risk to future development.
- Overarching:** Long-term, robust funding & financing is required to enable adaptation. Alternative funding and financing mechanisms are needed to enable scheme delivery and the widespread uptake of NFM and SuDS.
- Overarching:** Improved accessibility and communication around flood warning systems to support emergency response and community resilience.

Appendix D2

Upper Severn: Candidate pathway appraisal



Key		
Criteria	RAG Score	Symbology
Appraisal	Very positive	
	Positive	
	Likely positive	
	Likely negative	
	Very negative	

The workshops allowed us to test and explore what pathways could look like for the Upper Severn. We assessed these outputs and, recognising the limitations of a workshop focused-approach, used them to draw out insights to develop an emerging core pathway. To form the foundations of this pathway, using a qualitative multi-criteria framework, we appraised the outcomes of the candidate pathways against the RSP key themes - indicating the relative performance and cost of the overarching pathways of actions. Based on this, we determined which candidate pathway aligned most closely to the vision for the Severn catchment to be *'Britain's most vibrant and resilient river network'*.

	Cost	Pathway outcomes aligned to the RSP Themes							Benefits	Trade-offs / limitations
Wider Benefits	£ monetary cost	 economy	 using the river	 people	 agriculture	 flooding & drought	 environment	 housing	- Focuses on nature recovery and building wider system resilience via widespread NFM delivery - Most closely aligns to the ambitions of the SVWMS - Delivers wider benefits including economic growth, tourism, and natural capital	- Unable to meet peak flow uplifts in the short-term - Farming incentives are key enablers - Assumes that planning and permitting for FRM infrastructure can be fast-tracked
Precautionary	£ monetary cost	 economy	 using the river	 people	 agriculture	 flooding & drought	 environment	 housing	- Provides the highest-level flood risk mitigation across the catchment - Delays the possibility of managed realignment - Implements policy and behaviour enablers early to mitigate future risks due to increasingly vulnerable receptors	- Requires high monetary / carbon cost to implement - Depends on expedited lead-times for NFM and substantial infrastructure delivery - Requires significant changes to current policies and permitting processes - Does not support building communal / personal resilience
Cost Constrained	£ monetary cost	 economy	 using the river	 people	 agriculture	 flooding & drought	 environment	 housing	- Focuses on building personal and communal flood resilience - Optimises the FRM impacts of existing assets - Enables no / low regrets spending by delaying adaptation actions / portfolios	- Considers managed realignment the earliest, likely having negative impacts on affected communities, the local economy, and housing - Limited nature recovery impacts



Preferred way forwards

Based on our high-level appraisal of the candidate pathways against the RSP key themes and an assessment of the benefits provided, we determined that the wider benefits candidate forms the foundation of the emerging pathway. We used insights from the broader lenses and further engagement to build upon this thinking, including:

- Consideration of permanent linear defences in the long-term depending on the performance of upstream storage
- Early consideration of how managed realignment could be undertaken (e.g. required engagement and planning processes), alongside consideration of the focus area's long-term priorities – i.e. managed realignment versus living with water

Figure D2.5: Benefits and Trade-offs/limitations of each candidate pathway in Upper Severn.

Appendix D2

Upper Severn: Insights from the candidate pathways

This table below explores the commonalities and differences across the candidate pathways for the Upper Severn considering types of actions, sequencing, and interdependencies. These insights helped to identify low / no regrets activities and key interdependencies which, alongside local expertise, informed the development of the emerging core pathways.

	Key commonalities	Key differences
Short-term	- All candidate pathways identified a series of key enablers which were required upfront for successful pathway delivery. These included the need for spatial planning reforms, NFM incentivisation, behavioural / societal shifts to enable community resilience, etc.) - All candidate pathways identified the need for a review of existing assets to determine asset risks and whether existing assets can be enhanced to mitigate future risks. The outputs of this assessment influenced the scale of required delivery of other portfolios - Due to its feasibility in the upper reaches of the Upper Severn, widespread NFM delivery was prioritised, to varying extents, across the candidate pathways. Each candidate pathway looked to support a holistic, catchment-scale approach to FRM which delivered wider benefits. - The need for widespread PFR, property-level SuDS and temporary linear defence deployment was identified across all candidate pathways whilst other adaptation actions are undertaken.	Whilst each of the pathways considered the need for FSAs, they approached their delivery in a number of different ways. The wider benefits and precautionary lenses identified the need to deliver a phased approach to FSAs, influenced by the scale of delivery of NFM; a first phase to target mitigation around flood risk hotspots and a second phase in the medium-term. Whilst the cost constrained lens focuses on building personal and communal flood resilience and delivering a single phase of FSAs to mitigate downstream peak flows.
Medium-term	- The candidate pathways all identified the need to prioritise upstream storage across the catchment in the first epoch. However, the wider benefits and precautionary pathways opted for a second phase of FSAs which built on an initial phases of FSA delivery to maximise downstream peak flow mitigation depending on how external trends (like climate change) materialise. - All three candidate pathways explored the emerging need and scale of managed realignment (however initial phases are undertaken by the cost constrained lens, as described to the right).	The cost constrained approach took a different approach in two main areas: - It explored a two-phased approach to managed realignment, informed by FSA delivery and discontinued delivery of PFR and temporary defences whilst the precautionary and maximising benefits lenses postpone managed realignment to the long-term. - It further considered the relocation of assets / homes (via managed realignment) to strategic economic epicentres to be protected in the long-term by in-channel measures (e.g., bypass channels, river re-naturalisation, etc.). Whilst the precautionary lens explored the feasibility, and subsequent delivery of permanent linear defences, requiring a policy enabler to re-define BCR thresholds for defence delivery.
Long-term	The precautionary and wider benefits candidate pathways explored the policy and cultural context required to undertake managed realignment and identify those areas which may be increasingly undefendable under future climate change projections. Each pathway identified targeted managed realignment in the long-term.	The cost constrained lens undertakes a second phase of managed realignment based on the performance of in-channel measures (as described above).

Figure D2.6: Identified commonalities and differences among three candidate pathways in Upper Severn.

Appendix D2

Warwickshire Avon: Candidate pathways

The following slides present the Warwickshire Avon candidate pathways (developed as part of the workshop), their appraisal, and key differences and commonalities across them to inform the development of the emerging pathway for the focus area.



Figure D2.7: Warwickshire Avon focus area

Warwickshire Avon

Wider Benefits Candidate Pathway

Focus area strategy:

This lens focuses on delivering system-wide resilience through FRM whilst maximising co-benefits (e.g. economic, environmental, etc.). It initially focuses on reviewing asset condition to determine replacement and enhancement needs (e.g. can existing reservoirs be enhanced to provide FRM benefits?). Alongside this, it includes a fast-tracked, phased delivery of NFM (based on on-going schemes) in the limited areas they are feasible, to maximise wider benefits. This includes the delivery of in-channel NFM measures which may involve the re-prioritisation of land use to make space for water.

PFR and urban SuDS are utilised throughout to reduce pressure on channel capacity restraints (i.e. culvert surcharging) that contribute to flood risk across urban areas of the catchment. Beyond these measures, FSAs are delivered in the limited locations available. They are likely to mitigate flood risk to upstream urbanised centres only. Property-level SuDS are encouraged to mitigate flood risk. Permanent linear defences are then considered, their feasibility will inform considerations as to whether we should move people away from water, or water away from people (i.e. in-channel measures: artificial or managed realignment).

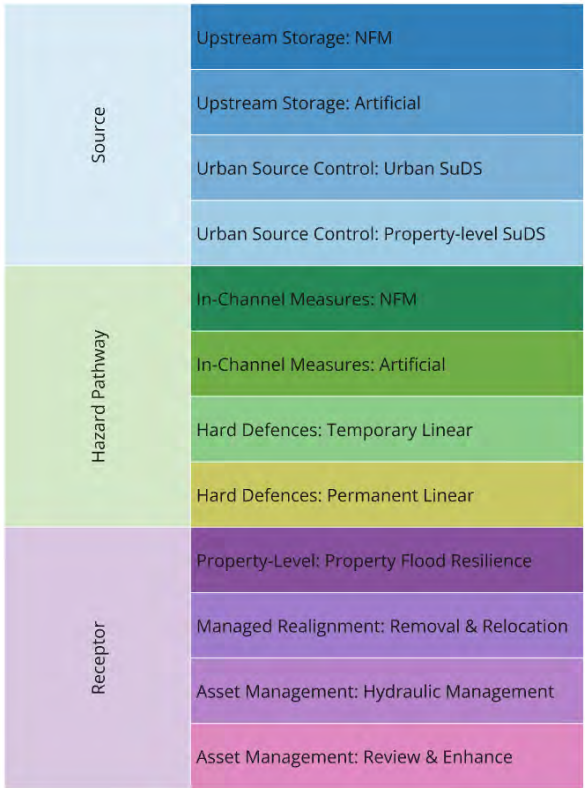
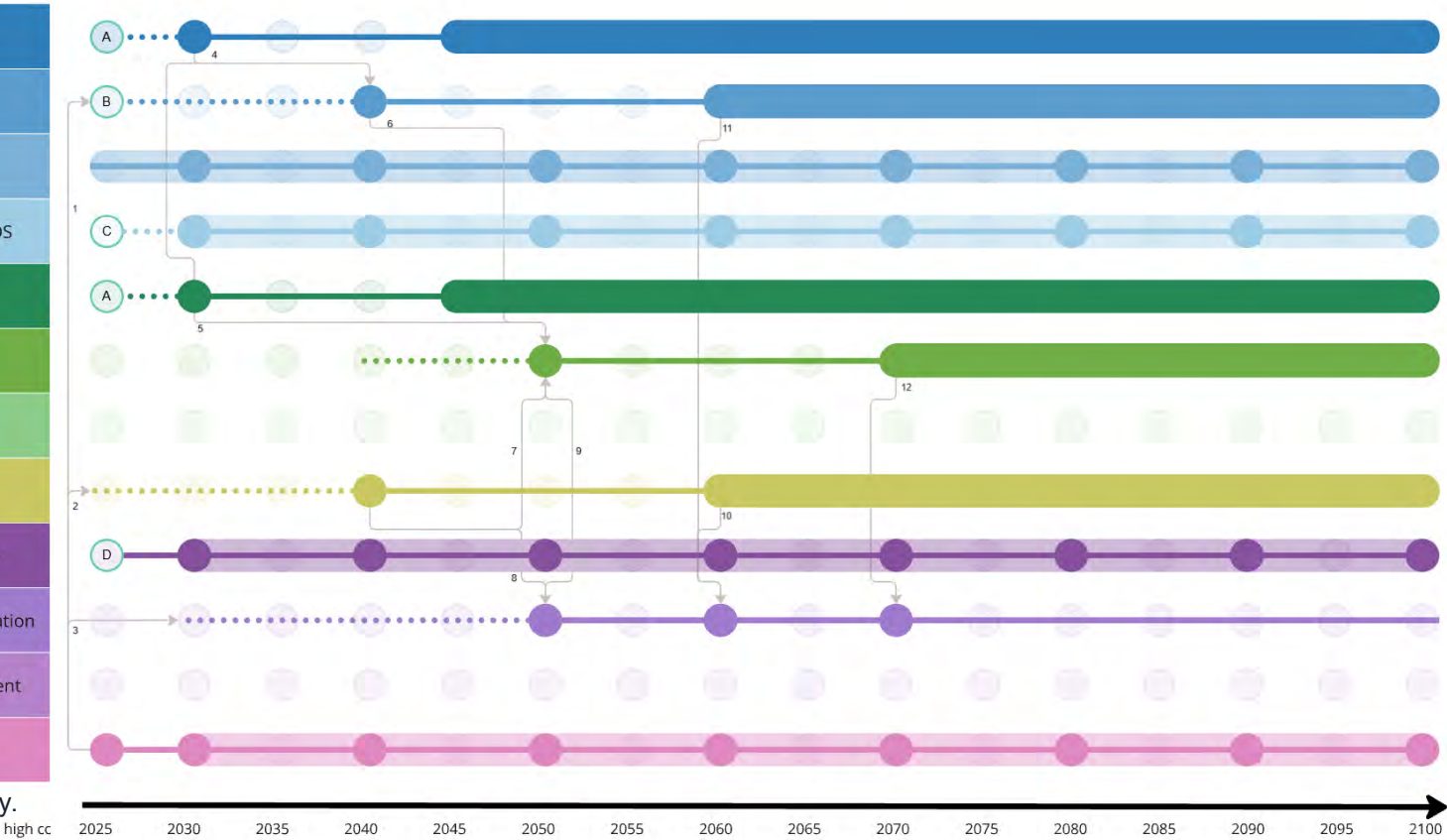


Figure D2.8: Wider Benefit Candidate Pathway.



Supporting information

Dependencies

- 1 – 3. The asset review will inform the need for asset enhancement and delivery of FSAs, permanent linear defences and initial considerations around managed realignment.
4. Delivery of NFM informs where FSAs can be delivered
5. Delivery of In-Channel NFM informs where In-Channel Artificial measures can be implemented
6. Delivery of FSAs informs where In-Channel Measures: Artificial can be implemented.
7. Permanent linear defence feasibility informs how in-channel measures: artificial can be delivered.
8. Permanent linear defence feasibility informs the need for managed realignment.
9. Managed realignment and in-channel measures: artificial inform each other – i.e., do we want to move the water or move people?
10. Performance of permanent linear defences informs the need for managed realignment.
11. Performance of widespread FSA delivery will inform the need for managed realignment.
12. Performance of in channel measures: artificial will inform the need for further managed realignment

Enablers

- A:** Agricultural and land-use policies to support the delivery of NFM and upstream storage. This could include incentivising farmers and rural landowners to adopt NFM adaptation actions.
- B:** Accelerate planning and permitting required for FSA delivery.
- C:** Funding and educational outreach to support uptake of property-level SuDS
- D:** Policy / funding and community outreach to support the rollout of PFR
- Overarching:** Spatial planning policy to integrate FRM considerations and mitigate flood risk to future development.
- Overarching:** Long-term, robust funding & financing is required to enable adaptation. Alternative funding and financing mechanisms are needed to enable scheme delivery and the widespread uptake of NFM and SuDS

Warwickshire Avon

Precautionary Candidate Pathway

Focus area strategy:

This lens aims to maximise flood resilience across the region to mitigate increasing flood risks before they fully materialise.

This candidate pathway starts with enabling actions which look to mitigate future risks and start to build resilience amongst communities early on (e.g., spatial planning policy, behaviour change resulting in the update of PFR and property-level SuDS, etc.). Ongoing delivery of Urban SuDS alongside an early programme of PFR and temporary defences are rolled-out regionally to mitigate risks whilst wider measures are rolled out.

Asset conditions across the area are assessed to determine which assets need to be replaced and which can be enhanced (e.g. can existing reservoirs be enhanced to provide FRM benefits?). Flood mitigation is focused around widespread, phased delivery of almost every portfolio. This is due to the diverse nature of the catchment, limited opportunities to mitigate risks through upstream storage and complex mechanisms of flood risk occurring due to constrained assets.

Based on the activities above, further hard defences are delivered to mitigate increasing risks and depending on the scale and extent of climate change, managed realignment is considered for those at greatest risk.



Supporting information

Dependencies

- 1 – 3. Outputs of the asset review will inform the need for asset enhancement and delivery of FSAs, permanent linear defences and initial considerations around managed realignment.
4. Delivery of upstream storage: NFM informs where FSAs can be delivered
5. Delivery of FSAs informs where in-channel measures: NFM can be delivered
6. Continued delivery of temporary linear defences informs where permanent linear defences could be delivered.
7. Delivery and performance of In-Channel NFM informs where scale at which In-Channel Artificial measures can be implemented
8. Performance of FSA delivery will inform the need for managed realignment.
9. Performance of permanent linear defences will inform the need for managed realignment.
10. Continued deployment of temporary linear defences informs the need for managed realignment.

Enablers

- A:** Agricultural and land-use policies to support the delivery of NFM and upstream storage. This could include incentivising farmers and rural landowners to adopt NFM adaptation actions.
- B:** Accelerate planning and permitting required for FSA delivery.
- C:** Funding and educational outreach to support uptake of property-level SuDS
- D:** Policy / funding and community outreach to support the rollout of PFR
- Overarching:** Spatial planning policy to integrate FRM considerations and mitigate flood risk to future development.
- Overarching:** Long-term, robust funding & financing is required to enable adaptation. Alternative funding and financing mechanisms are needed to enable scheme delivery and the widespread uptake of NFM and SuDS

Warwickshire Avon

Cost Constrained Candidate Pathway

Focus area strategy:

This lens focuses on delivering flood resilience within a cost constrained future. This pathway depends on portfolios that can be implemented within a cost constrained environment or can be delivered by partners / communities to enable flood resilience (e.g., NFM, PFR, etc.).

The approach employed focuses around identifying the areas of highest vulnerability where limited resources will be targeted. As such, the pathway involves the development of a strategy to identify a rolling programme of targeted action (including consideration of FSAs, permanent linear defences, etc.). The programme is reviewed periodically (every 10 years) and actions are reviewed and targeted where needed. Alongside this, existing assets are maintained for as long as possible to maximise their performance.

A key aspect of this approach is to maximise opportunities for partnership-funded delivery of portfolios through enabling and articulating wider benefits; for example, whilst expensive, FSAs are explored as part of a partnership approach offering FRM and water resources benefits.

Due to the targeted management of risk, this candidate pathway relies heavily upon behavioural enablers to build community and personal resilience, alongside receptor modifications such as PFR.



Figure D2.10: Cost Constrained Candidate Pathway.

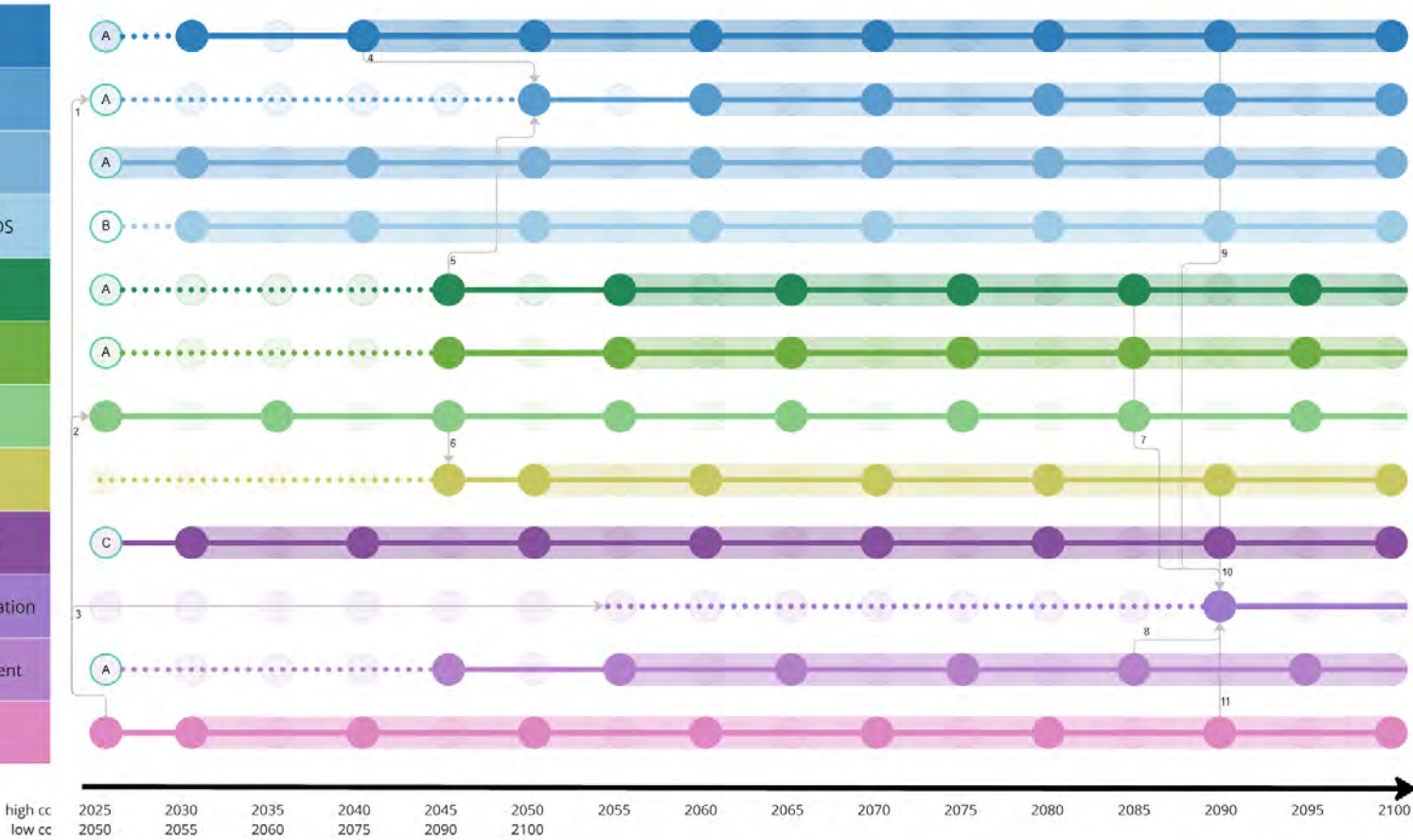
Supporting information

Dependencies

- 1 -3.** Outputs of the asset review will inform the need for asset enhancement and delivery of FSAs, temporary linear defences and initial considerations around managed realignment.
- 4 -5.** Delivery of NFM informs where FSAs can be delivered
- 6.** Continued delivery of temporary linear defences informs where permanent linear defences could be delivered.
- 7.** In-channel measures and temporary linear defences inform the need for managed realignment in the long-term.
- 8.** Hydraulic management schemes inform the need for managed re-alignment in the long-term.
- 9.** Source / storage portfolios inform the need for managed realignment in the long-term.
- 10.** Permanent linear defences and PFR deployment inform the need for managed realignment in the long-term.
- 11.** Regular asset reviews & enhancements inform the need for managed realignment in the long-term.

Enablers

- A:** Mainstreaming partnership and co-funding (e.g. with local authorities, eNGOs, water companies, etc.) to deliver FRM infrastructure alongside other benefits.
- B:** Funding and educational outreach to support uptake of property-level SuDS
- C:** Policy / funding and community outreach to support the rollout of PFR
- Overarching:** Spatial planning policy to integrate FRM considerations and mitigate flood risk to future development.
- Overarching:** Long-term, robust funding & financing is required to enable adaptation. Alternative funding and financing mechanisms are needed to enable scheme delivery and the widespread uptake of NFM and SuDS



Appendix D2

Warwickshire Avon: Candidate pathway appraisal

Key		
Criteria	RAG Score	Symbology
Appraisal	Very positive	
	Positive	
	Likely positive	
	Likely negative	
	Very negative	

The workshops allowed us to test and explore what pathways could look for the Warwickshire Avon focus area. We assessed these outputs and, recognising the limitations of a workshop focused-approach, used them to draw out insights to develop an emerging core pathway. To form the foundations of this pathway, using a qualitative multi-criteria framework, we appraised the outcomes of the candidate pathways against the RSP key themes - indicating the relative performance and cost of overarching pathways of actions. Based on this, we determined which candidate pathway aligned most closely to the vision for the Severn catchment to ‘*be Britain’s most vibrant and resilient river network*’.

	Cost	Pathway outcomes aligned to the RSP Themes							Benefits	Trade-offs / limitations
Wider Benefits	monetary cost	economy	using the river	people	agriculture	flooding & drought	environment	housing	- Focuses on nature recovery and building wider system resilience by prioritising NFM delivery - Delivers wider benefits including economic growth, tourism, and natural capital	- Unable to meet peak flow uplifts and as such, explores managed realignment earlier - Farming incentives are key enablers - Assumes that planning and permitting for FRM infrastructure can be fast-tracked
Precautionary	monetary cost	economy	using the river	people	agriculture	flooding & drought	environment	housing	- Provides the highest-level flood risk mitigation across the catchment - Implements policy and behaviour enablers early to mitigate future risks due to increasing vulnerable receptors	- Requires high monetary / carbon cost to implement - Depends on expedited lead-times for NFM and infrastructure delivery - Requires significant changes to current policies and permitting processes - Requires a strong evidence base / feasibility assessments and increased personnel to deliver multiple portfolios across the catchment simultaneously.
Cost Constrained	monetary cost	economy	using the river	people	agriculture	flooding & drought	environment	housing	- Focuses on building personal and communal flood resilience - Optimises the FRM impacts of existing assets - Targeted adaptation actions optimise resources - Enables no / low regrets spending by delaying portfolios delivery - Capitalises on partnership delivery and co-funding opportunities	- Delivery dependent on widespread community and partnership cooperation - Targeted delivery may lead to areas of the catchment facing increasing risks, and thus, are reliant on individual measures

Preferred way forwards
Based on our high-level appraisal of the candidate pathways against the RSP key themes and an assessment of the benefits provided, we determined that the wider benefits candidate pathway forms the foundation of the Emerging Pathway. We used insights from the broader lenses and further engagement to build upon this thinking, including:

- Agricultural washlands to provide additional storage opportunities especially in the middle catchment
- Early consideration of how managed realignment could be undertaken (e.g. required engagement and planning processes), alongside consideration of the focus area’s long-term priorities – i.e. moving people, moving the river or living with water

Figure D2.11: Benefits and Trade-offs/limitations of each candidate pathway in Warwickshire Avon.

Appendix D2

Warwickshire Avon: Insights from the candidate pathways

This table below explores the commonalities and differences across the candidate pathways for the Warwickshire Avon considering types of actions, sequencing, and interdependencies. These insights helped to identify low / no regrets activities and key interdependencies which, alongside local expertise, informed the development of the emerging core pathways.

	Commonalities	Differences
Short-term	- All candidate pathways identified a series of key enablers which were required upfront for successful pathway delivery. These included the need for spatial planning reforms, NFM incentivisation, behavioural / societal shifts to enable community resilience, etc.) - All candidate pathways identified the need for a review of existing assets to determine asset risks and whether existing assets can be enhanced to mitigate future risks, focusing specifically around increasing channel capacity of culverts as culvert surcharging poses significant flood risk across the catchment. The outputs of this assessment influenced the scale of required delivery of other portfolios - Phased NFM delivery was prioritised, to varying extents, across the pathways. Each pathway looked to support a holistic, catchment-scale approach to FRM which delivered wider benefits whilst building upon ongoing evidence-based schemes (e.g. Arrow & Alne NFM, Nature 4 Water, etc.) - The need for widespread PFR, property-level SuDS and continued urban SuDS delivery was identified across all candidate pathways whilst other adaptation actions are undertaken.	The wider benefits candidate pathway explored the short-term need for river re-naturalisation to both contribute to nature recovery by restoring the blue-green network and moving the watercourse away from homes at risk.
Medium-term	The maximising benefits and precautionary candidate pathways identified the need to maximise upstream storage in the medium-term. However, artificial storage opportunities are limited across the catchment.	- The cost constrained approach explores FSA delivery under the assumption that these can be co-delivered with water companies to respond to water resource pressures and FRM. - The wider benefits candidate pathway explored a medium-term need for targeted managed realignment based on the scale of river re-naturalisation achieved and ongoing asset condition assessments and subsequent enhancements
Long-term	- All candidate pathways explored the policy and cultural context required to undertake managed realignment and identify those areas which may be increasingly undefendable under future climate change projections. Each pathway identified that targeted managed realignment (whether this means realignment of the river or homes) in the long-term. - No candidate pathway was able to achieve peak flow uplift targets through the identified portfolios in the long-term which informs the need to consider the fundamental, long-term ambitions for the focus area and whether we should prioritise moving homes, moving the river, or making space for water.	

Figure D2.12: Identified commonalities and differences among three candidate pathways in Warwickshire Avon.

Appendix D3

Emerging pathway delivery framework

Appendix D3 outlines the delivery framework underpinning the emerging adaptation pathways for each focus area.



Figure D3.1: Focus area maps for the emerging pathway within River Severn Catchment.

Appendix D3

Upper Severn: Emerging pathway delivery framework

To support the diagrammatic presentation of the pathway for the Upper Severn, this page presents the required delivery framework and supporting enabling actions.

Enablers	Overarching enabling activities: Actions required in the short-term to facilitate AP delivery and a holistic, place-based response to FRM:		
	Policy Enablers - Spatial planning policy reforms are a primary enabler to mitigating future flood risk through considering land-use and influencing the spatial location of development. - Long-term, robust funding & financing is required to enable adaption. This may involve alternative funding & financing mechanisms to drive delivery. - Improved governance driving integrated and co-ordinated catchment responses. - Improved, standardised, and accessible flood warning information and data to enable action. Behaviour Enablers - Improved collaboration through formalised information sharing - Action to enable community resilience and individual action to manage flood risk is important to enable overarching system resilience		
Actions	Short-term	Medium-term	Long-term
	Conduct an asset review to determine which assets need to be replaced and which can be enhanced. Continued delivery of temporary linear defences, particularly whilst broader FRM activities are delivered across the catchment. - Uptake of property-level SuDS to build personal and communal flood resilience requires educational outreach programmes (B1) and a societal shift resulting in a personal and community-led responses to FRM (B2). Assess and start delivery of widespread NFM based on SVWMS opportunity mapping and sub-catchment prioritisation. Widespread NFM delivery requires the appropriate incentivisation for farmers and landowners (P1). Assess and start delivery of Phase 1 FSAs based on the SVWMS assessment to target opportunities offering the most downstream benefits to risk hotspots. FSA delivery in the short-term requires the streamlining of planning and permitting processes enabling fast-tracked delivery of FRM infrastructure (P2). - Whilst broader measures are undertaken, deliver PFR to risk hotspot locations. PFR delivery and enabling flood resilient homes require policy, behavioural and funding to support rollout (P3) and requirements for flood resilient building codes (P4) to ensure water resilient future development.	Explore if managed realignment needs to be undertaken; explore if, where, and at what scale managed realignment may need to be considered. Deliver Phase 2 FSAs informed by the SVWMS assessments and continued monitoring and evaluation of Phase 1 FSA and NFM performance. Phase 2 FSAs will likely include larger scale FSAs to maximise downstream flood resilience.	Assess permanent linear defence feasibility based on the outcomes of the SVWMS, existing assets and outcomes of broader spatial planning and development. Deliver permanent linear defences based on the feasibility assessment. This will inform areas that are increasingly undefendable under climate change peak flow projections. Identify planning processes and engagement that are necessary to undertake managed realignment. Undertake targeted managed realignment (as necessary)
Performance	Estimated peak flow uplifts due to climate change (RCP 8.5)	26%	40%
	Estimated maximum peak flow mitigated as a result of actions	9%	50%
Performance			68%
			74%

Figure D3.1: Suggested delivery framework for Upper Severn emerging pathway.

Appendix D3

Warwickshire Avon: Emerging pathway delivery framework

To support the diagrammatic presentation of the pathway for the Warwickshire Avon, this page presents the required delivery framework and supporting enabling actions.

Enablers	Overarching enabling activities: Actions required in the <i>short-term</i> to facilitate AP delivery and a holistic, place-based response to FRM:			
	Policy Enablers - Spatial planning policy reforms are a primary enabler to mitigating future flood risk through considering land-use and influencing the spatial location of development. - Systematically integrate land-use planning around Local Nature Recovery Strategies with FRM to co-deliver environmental and FRM benefits - Long-term, robust funding & financing is required to enable adaption. This may involve alternative funding & financing mechanisms to drive delivery. - Improved governance driving integrated and co-ordinated catchment responses. - Improved, standardised, and accessible flood warning information and data to enable action. Behaviour Enablers - Improved collaboration through formalised information sharing - Action to enable community resilience and individuation action to manage flood risk is important to enable overarching system resilience			
Actions	Short-term	Medium-term	Long-term	
	Conduct an asset review to determine which assets need to be replaced and which can be enhanced. <i>Upper Catchment:</i> Assess and start delivery of phased NFM based on ongoing schemes and sub-catchment prioritisation. NFM delivery requires the appropriate incentivisation for farmers and landowners (P1). Assess and start delivery of FSAs to provide upstream storage and mitigate flood risk to upstream hotspots (e.g., Coventry, Rugby) FSA delivery in the short-term requires the streamlining of planning and permitting processes enabling fast-tracked delivery of FRM infrastructure (P2). <i>Middle Catchment:</i> - Continued delivery of urban SuDS and temporary linear defences to reduce pressure on existing asset constraints <i>Catchment-wide:</i> - Whilst broader measures are undertaken, deliver PFR based on hotspot locations. PFR delivery and enabling flood resilient homes require policy, behavioural and funding to support rollout (P3) and requirements for flood resilient building codes (P4) to ensure water resilient future development, alongside behavioural / societal shifts to enable the uptake and appropriate implementation of PFR (B3) - Deliver a rolling programme of property-level SuDS, enabled through educational outreach programmes (B1) and behavioural / societal shifts (B2) toward building personal resilience and community action to mitigate flood risk.	Assess and deliver permanent linear defences based on targeted assessments around risk hotspots and localised flood sources. <i>Upper catchment:</i> Assess and deliver washlands in the southern part of the catchment <i>Middle catchment:</i> Assess and deliver river re-naturalisation to realign watercourses to their paleochannels so that receptors are no longer in high-risk areas Assess and deliver washlands in the middle reaches of the catchment by reconnecting low quality agricultural land to the natural floodplain.	As we reach the end of our FRM “toolkit”, and since the catchment is so urbanised along the majority of the length of the watercourse, we will need to consider whether our long-term ambitions align to moving the river, moving homes, or living with water. <i>Middle catchment:</i> Consider and deliver localised bypass channels around risk hotspots - Consider how previous portfolios inform permanent land use classifications (e.g., washlands) and how they inform managed realignment	
Performance	Estimated peak flow uplifts due to climate change (RCP 8.5)	21%	31%	59%
	Estimated maximum peak flow mitigated as a result of actions	13%	21%	21%

Figure D3.2: Suggested delivery framework for Warwickshire Avon emerging pathway.



Appendix E

Monitoring & Evaluation

Contents

This appendix contains:

- E1: Review of existing guidance and case studies
- E2: Indicator longlist



Appendix E1

Indicator longlist

Table E1.1: Longlist of indicators.

ToC	Theme	Indicators
External factors Growth & climate change scenarios	Growth: current and future development	Population growth
		Development
	Climate change scenario	Climate change projections
Supporting factors HOW Enabling activities	Public and stakeholder attitudes	Public attitudes to flood risk
		Institutional attitudes to flood risks
	Legal, policy, and new guidance	Flood risk and / or adaptation legislation, regulation, policy and guidance
Inputs - readiness assessment What we need to deliver / and make decisions?	Data availability	Flood modelling
		Storage potential
	Identification of revenue streams HOW	Funding availability
		Revenue potential
	Skills and capacity HOW	Skills
		Capacity

Appendix E1

Indicator longlist

Table E1.2: Longlist of indicators.

ToC	Theme	Indicators
Outputs How much of the portfolios have been delivered? Is the pathway on track?	Implementation of adaptation actions	Implementation of adaptation actions
	Asset condition	Asset condition
		Future asset condition
	Asset performance	Asset performance
		Future asset performance
Outcomes How are the portfolios that have been delivered performing	River flow	Observed flows
		Projections of future flows
	Flood events	Observed events
		Projections of future events
	Properties	Properties at risk of flooding
	Environmentally sensitive areas	Area of environmental sites at risk of flooding
	Biodiversity receptors	Condition of biodiversity receptors

Appendix E1

Indicator longlist

Table E1.3: Longlist of indicators.

ToC	Theme	Indicators
Impacts How are the overall vision, objectives and wider benefits being achieved?	Flooding & drought	Flood residual damages
		Sustainable water levels
	Using the river	Tourism spend
		River connection
	Economy	Land resilience
		Flood recovery rate
		Green finance availability
	Environment	Nature-based solutions delivery
		Ecological status of water bodies
		Biodiversity Net Gain
	People	Communities at risk
		Resilience of social infrastructure
		Flood mitigation in at risk communities
	Housing	Property resilience
		Household resilience
		New flood resilient homes
	Agriculture	Agricultural land grade
		Rural land use schemes delivery

Appendix E2

Review of guidance and case studies

Guidance on developing monitoring and evaluation frameworks for FCERM

Overview

A guidance document (titled Literature review on an adaptive approach to FCERM, published by the Environment Agency) provides good practice approaches to taking an adaptive approach to FCERM, including M&E. The review provided guidance on what a M&E should include and how it can be developed.

delivering benefits through evidence



Insights:

- Identifies the following attributes are important for M&E framework for adaptive approaches:
 - Indicators, triggers and thresholds should represent what may drive a change in a pathway,
 - Sets out considerations to make when determining indicators including: if it is a direct measure (e.g., river flows) or needs to be calculated from other indicators (e.g. economic losses), the difficulty of measuring it, whether it is currently being measured,
 - Important to have regular review periods,
 - Important to determine who will do monitoring and evaluation and who is responsible for managing it; and,
 - Important to involve stakeholders in the development of the framework.

Thames 2100+

Overview

The Thames Estuary 2100+ FRM strategy identifies how the risks of sea level rise and associated flood risk can be managed in the long term. The strategy has a M&E programme in place. The EA has recently carried out a 10-year review of the strategy and associated programme of adaptation activities and asset management works.



Insights:

- The M&E framework uses 10 indicators and several sub-indicators. The indicators include:
 - Source indicators: sea level rise, extreme water levels,
 - Performance indicators: Thames barrier operations, condition of Thames barrier,
 - Impacts indicators: habitat, erosion and deposition; and,
 - Contextual indicators: people, property, critical infrastructure, policy and public attitudes.
- The framework also measures the social value of assets protected.
- The Thames 2100+ adaptation programme has a regular reporting cycle. Every 5 years they undertake a check on how they are progressing against triggers/thresholds. Every 10 years a review of the whole programme is undertaken.

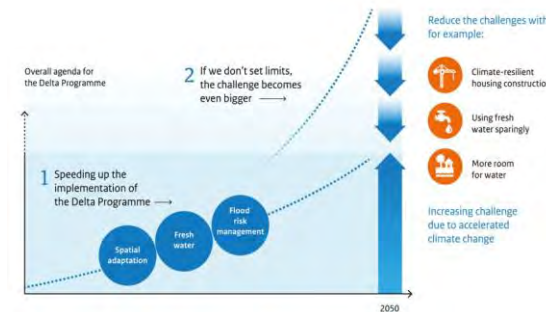
Appendix E2

Review of guidance and case studies

Dutch Delta Programme

Overview

The Netherlands is a low-lying, flood-prone country. The National Delta Programme protects the Netherlands against coastal and fluvial flooding, ensures that there are adequate supplies of fresh water and contributes to spatial planning that considers the water cycle.



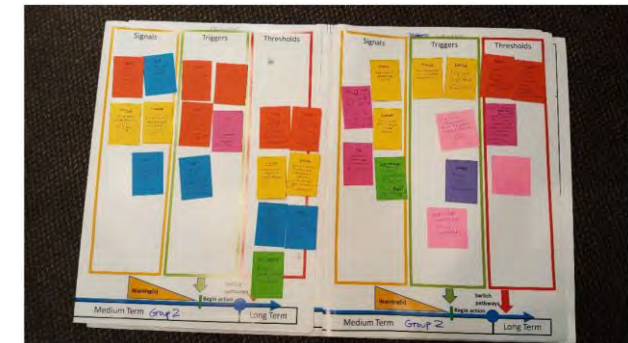
Insights:

- The programme has a 6-yearly report focusing on how they are tracking against the anticipated trends (similar to the 5-yearly report for Thames 2100+) and 12-yearly reviews of the whole programme.
- They have a specific group to determine indicators and monitor thresholds. Indicators represent aspects like sea level rise, flooding, and exposure/vulnerability as well as 'outward facing ones' like public attitudes and evolving technologies.
- Reporting is done by the Dutch Delta Commissioner and is made publicly available to the wide range of stakeholders.

Practice Guidance on signals and triggers, New Zealand

Overview

Te Herenga Waka (Victoria University of Wellington) developed guidance for setting indicators, signals and triggers for adaptation pathways.



Insights:

- Identifies the following attributes are important for M&E framework for adaptive approaches:
 - Indicators, triggers and thresholds should represent what may drive a change in a pathway, exposure/vulnerability (e.g. flooding of residential areas), exposure of things that communities value (e.g. heritage sites)
 - Indicators are the thing that is measured. The triggers and thresholds are what the indicator is measured against.
 - Sets out considerations to make when determining indicators including: if it is a direct measure (e.g., river flows) or needs to be calculated from other indicators (e.g. economic losses), the difficulty of measuring it, whether it is currently being measured.
 - Important to have regular review periods.
 - Important to determine who will do monitoring and evaluation and who is responsible for managing it.
 - Important to involve stakeholders in the development of the framework.



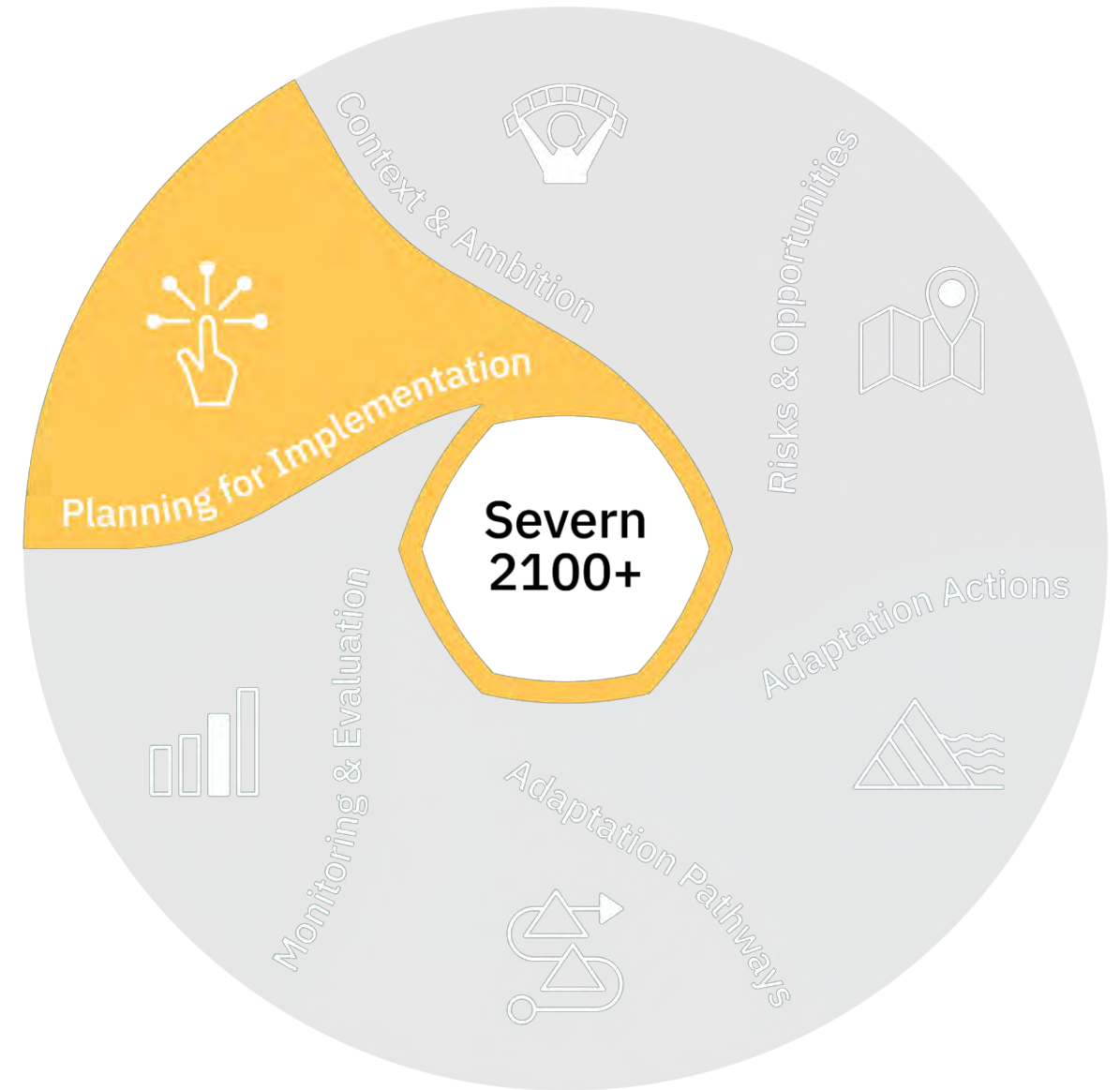
Appendix F

Planning for Implementation

Contents

This appendix contains:

- F1: Governance,
- F2: Funding & finance,
- F3: Policy,
- F4: Behaviour,
- F5: Stakeholder engagement; and,
- F6: Data & information.



Appendix F1

Governance

This appendix contains further information around case studies the OECD principles of water governance, insights into the current governance structure, and detailed information around each of our key recommendations.

Appendix F1

Roles, responsibilities, and membership

We have recommended that the EA establish the following groups to support the development, implementation and monitoring of adaptation pathways:

Adaptation Pathways Leadership Team

The leadership team will have the responsibility to make decisions on new and existing pathways, including when changes to pathways are necessary.

Roles and responsibilities include:

- The leadership team will receive monitoring and evaluation reports and consider these alongside other information (e.g., evaluation of pathways/adaptation actions using benefits toolkit) when making decisions on whether changes to pathways are needed.
- The leadership team will approve new pathways, an activity that will only occur once but which will be more substantive than changes to pathways.

Proposed membership:

- The Area Directors and Managers in the Severn region,
- The Strategic Leadership Group (part of the RSP), and
- Other adaptive pathways projects the EA is undertaking.

Adaptation Pathways Advisory Unit

The advisory unit will support the design, implementation, monitoring and evaluation and review of adaptation pathways, by bringing together experts across the EA.

Roles and responsibilities include:

- The Advisory group, in collaboration with the West Midlands EA undertake monitoring and evaluation in the Severn Region. This will bring together the technical knowledge of adaptation planning from the Advisory group with the local knowledge of West Midlands EA.
- The results from the monitoring and evaluation are considered by the Advisory group to develop recommendations to the Leadership group.

Proposed membership:

- Technical experts,
- Communications and engagement specialists, and
- Other adaptive pathways projects the EA is undertaking.

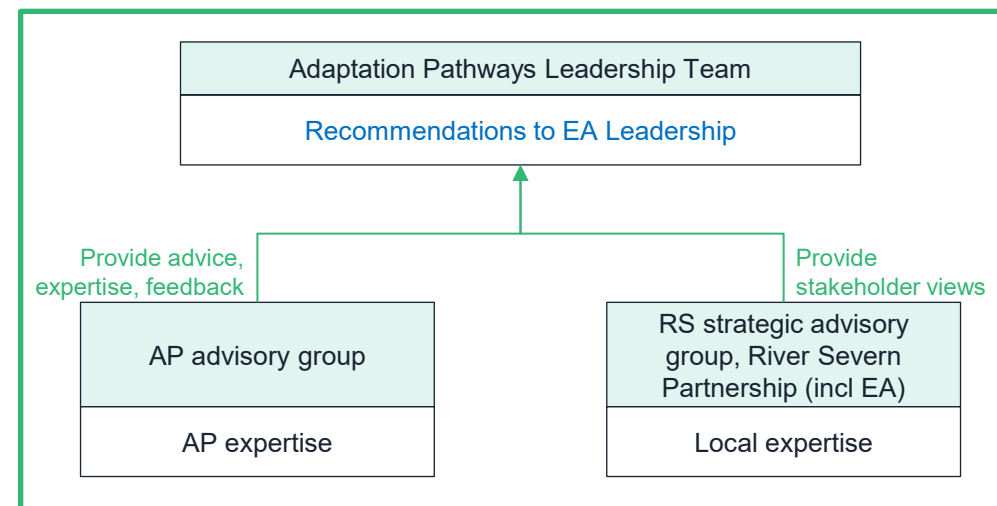


Figure F1.1: Illustrative relationship between the AP Leadership team, advisory unit, and the RS strategic advisory unit of the River Severn Partnership.

Appendix F1

Review of relevant governance lenses

Review of good practice

We have undertaken a rapid desktop review to identify key attributes of good governance and develop our recommendations. We focused our review on literature and case studies which offered the most insight which could be applied to the River Severn region. We reviewed the following sources framed around the following ‘lenses’ (or themes):

- Water governance (including the OECD principles on water governance, shown in Table 1 below).
- River basin or catchment governance
- Adaptive governance
- Transboundary governance (national and international)

Table F1.1: Sources to inform themes of good practice.

Water governance
• OECD: Principles for Water Governance
River basin or catchment governance
• Environment Agency: Understanding effective FCERM governance in England and Wales • Case Study: UK – Cumbria Natural Courses • Case Study: New Zealand – Whanganui River
Adaptive governance
• Water International: Literature review of governance attributes for building water resilience • Case Study: Netherlands – Delta 2100 Programme • Case Study: UK – Climate Ready Clyde • Case Study: UK – Humber APP
Transboundary governance
• Case study: USA & Canada: Great Lakes Ontario and St. Lawrence river basin • Case study: Wales & England, Marches Forward Partnership

We have undertaken a rapid desk-top review to identify key attributes of good governance to enable adaptive water management. We focused our review on literature and case studies which offered the most potential for learning to be generated which could be applied to the River Severn region. We reviewed the following sources framed around the following ‘lenses’ (or themes):

A summary of insights from our review are described on the following pages.



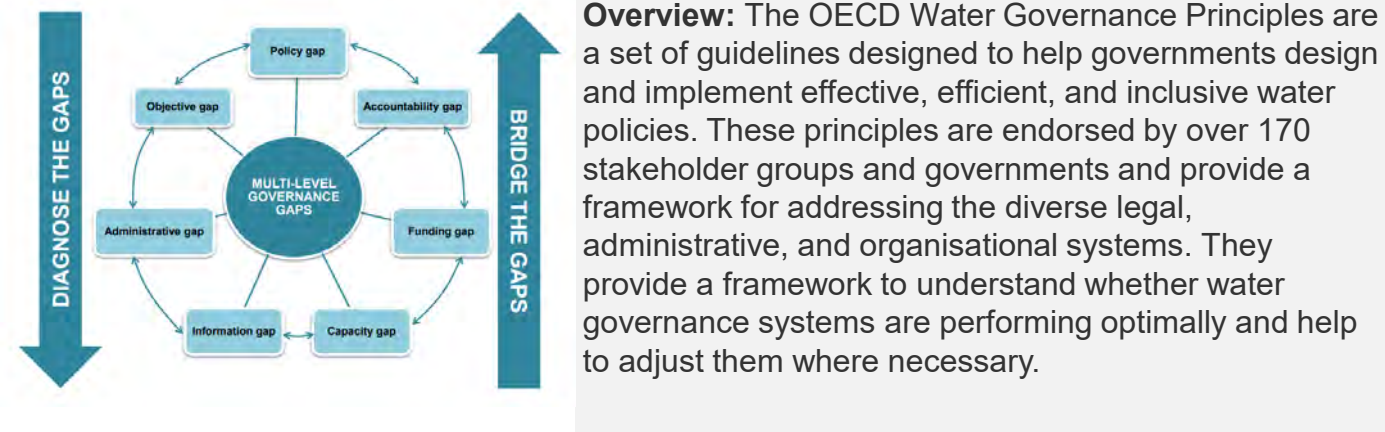
Figure F1.2: The Netherlands Delta Programme [\[1\]](#)

Appendix F1

Water governance

Insights from our review of good practice around **water governance** are outlined below:

OECD: Principles for Water Governance



Insights:

OECD evidence shows that there is **not a one-size-fits-all** solution to water challenges worldwide, but rather a large diversity of situations within and across countries. Governance is **highly contextual** and water policies need to be tailored to different places and designed according to the challenges they are required to address.

Recognising this, the OECD have developed a series of **Principles on Water Governance** that contribute to tangible and outcome-oriented public policies around water governance. The Principles, as described opposite, are rooted in broader principles of good governance: legitimacy, transparency, accountability, human rights, rule of law and inclusiveness. They are framed around three mutually reinforcing dimensions of water governance: **effectiveness, efficiency, trust & engagement**.

The Principles aim to enhance water governance systems in a sustainable, integrated and inclusive way, at an acceptable cost, and in a reasonable time-frame. They consider that governance is good if it can help to solve key water challenges, using a combination of bottom-up and top-down processes while fostering constructive state-society relations.

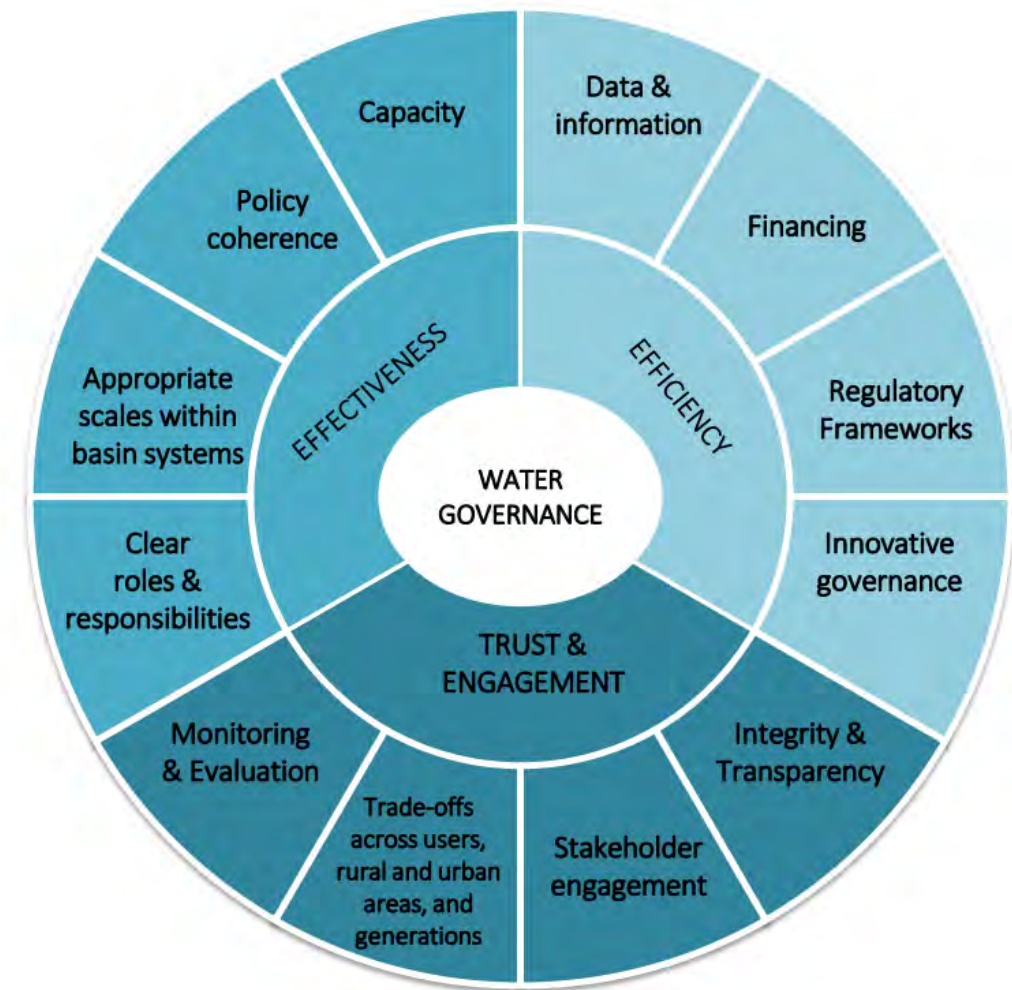


Figure F1.3: OECD Principles for Water Governance [2]

Appendix F1

River basin or catchment governance

Insights from our review of good practice around **river basin or catchment governance** are outlined below:

Environment Agency: Understanding effective FCERM governance in England and Wales



Overview: In the wake of recent and substantial flooding in the UK (winter 2019 to 2020) and the launch of the revised national FCERM strategies in England and Wales, this EA research provides a timely assessment of the effectiveness of current FCERM governance and opportunities to ensure it is fit for the future. This research draws from around 60 interviews with policymakers and practitioners operating nationally and locally, carried out to examine existing governance practices.

Insights:

Effective governance for flood and coastal erosion risk management (FCERM) is essential for building and maintaining national resilience, wellbeing and sustainable development in the face of increasing risks posed by climate change. Ensuring the best possible arrangement of actors, rules, resources and bridging mechanisms for multi-level governance is not only necessary for effective FCERM but is pivotal to the nation's ability to adapt to the declared climate emergency. Key themes of recommendations include:

- **Reconciling complexity** through coherent governance arrangements,
- **Resourcing effective** FCERM governance – with long-term funding and a coherent strategy,
- Addressing governance **barriers to adaptation** – a greater sense of urgency is required,
- Establishing climate resilient places through **spatial planning and resilient design**,
- Facilitating **socially just recovery and building back better** through flood insurance,
- Maximising opportunities for FCERM through **land-use management and agricultural policy reform**; and,
- **Aligning** nature recovery and FCERM agendas.

Case Study: UK – Cumbria: *Natural Course*



Overview: Cumbria is one of the wettest locations in the UK, yet West Cumbria faces future water shortfalls and only 55% of waterbodies meet 'good' ecological status. Natural Course is designing projects to better understand and overcome some of the biggest barriers preventing the achievement of 'good ecological status' under the EU Water Framework Directive in the North-West River Basin District. They have undertaken a review of water governance to recommend a suitable structures for Cumbria.

Insights:

The findings from the review include:

- **Integrate** water with broader agendas e.g. health and biodiversity (possibly align to 25 YEP),
- **Focus geographically on the 'county system'** – i.e. large enough to get senior involvement, would be led from county but incorporate the catchments,
- **Bring together the planning authorities** from across the catchments to make joined up decisions,
- Encourage **collaborative working**, recognising that this means that everyone will need to compromise some control. Focus where co-ordination brings greatest benefits rather than gaps and overlaps,
- Focus on **long-term planning** to influence existing plans (co-ordination not integration),
- Have sufficient input from those with expertise and local knowledge to make sound **evidence-based recommendations** in technical working groups,
- **Engage those impacted** (either through an outreach group or via Catchment Partnerships and local groups),
- Encourage a system of **payments for ecosystem services** through compensation or incentivisation mechanisms or nature based solutions; and,
- Work to the normal good governance principles of **transparency, fairness, participation** etc.

Appendix F1

River basin or catchment governance

Insights from our review of good practice around **river basin or catchment governance** are outlined below:

New Zealand – Whanganui River



Overview: The Whanganui River in Aotearoa New Zealand, given the rights of a legal person under Te Awa Tupua (Whanganui River Claims Settlement) Act 2017. Research has been undertaken to investigate two cases of emerging forms of river governance at the local level, which are being developed as ways of implementing the Act.

Insights:

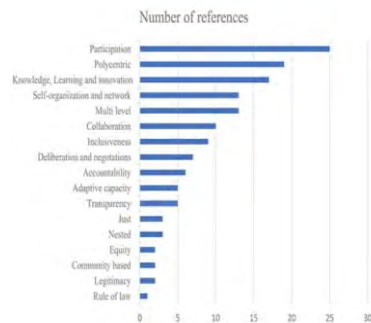
- The Te Awa Tupua Act clearly states the role of the river iwi (Maori tribes), the Crown, local authorities and other interests (e.g. fishing, recreational and commercial) in the management of the river,
- The Act establishes a strategy group Te Kōpuka, consisting of iwi, Crown agencies, local authorities and other interests to develop a strategy for the river. This strategy must be implemented through other legislation and the group itself has statutory powers in some cases; and,
- This case study demonstrates the importance given to involving a wide range of interests in decision-making, and clearly stating their role in it. It also demonstrated the need to involve a wide range of people in these discussions.

Appendix F1

Adaptive governance

Insights from our review of good practice around **adaptive governance** are outlined below:

Water International: Literature review of governance attributes for building water resilience



Overview: Resilience has gained prominence in many fields of research and practice globally. In the water sector, efforts to build resilience have become a central feature of water governance. There is limited knowledge about what the adaptive governance agenda means as a technical approach to water governance in achieving resilience. This paper clarifies these linkages through a review of the literature and identifies key attributes of adaptive governance.

Insights:

Resilience in theory and practice across all sectors signals a shift towards more integrative approaches for navigating increasingly complex and uncertain conditions. Contemporary frameworks in water services and resource management prioritise resilience and adaptive thinking. Adaptive governance has been widely articulated in the literature as the adequate approach to managing uncertainty and complexities. Based on the review, key attributes of adaptive governance are identified opposite. Additional insights include:

- **Good governance and adaptive governance are interlinked,**
- Role of adaptive governance is not just about managing resources and environment but also having the **ability to adapt to change**. It should enable cross-scale and collaborative interaction to self-organise; and,
- **Water systems are coupled social and ecological system.** Conventional approaches treat social systems and ecosystems as distinct entities - failing to achieve effective, equitable and sustainable outcomes. A fundamental step in building water system resilience is to identify the broader system before embarking on collectively working to build resilience – including what are the critical components? Who manages these, and how are they managed?



Figure F1.4: Attributes for adaptive and good governance

Key attributes of adaptive governance include:

- **Participation:** Relevant stakeholders at appropriate levels and across sectors and scales meaningfully contribute and actively participate enabling informed choices on citizens needs,
- **Multilayered or polycentric systems:** Recognises governance tasks are performed by multiple organizations and centres of decision-making at different scales, with each of them having a certain degree of autonomy,
- Learning, adaptation and self organization (**Adaptive capacity**): The system must be prepared with adequate capacity to identify and evaluate changes, detect hard-to-reverse thresholds on time, learn, self-organize, adapt and take new measures,
- **Collaboration:** Helps collective decisions to

be discussed, reached, implemented, and evaluated at different levels and across sectors in an integrated manner in collective forums,

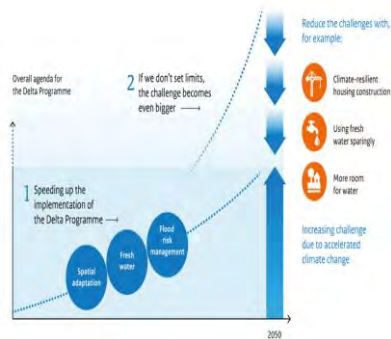
- **Deliberation/consensus oriented:** Meaningful participation and reaching a consensus is critical,
- **Accountability:** Accountability, autonomy, flexibility system, constituted of strong multilevel and multi-actor networks, can help achieve resilience through improved credibility and legitimacy and by building trust; and,
- **Transparency:** Transparent processes are open and honest in their information to the public, so there is clarity on government rules and processes. Organisational decentralisation, autonomy, responsiveness, flexibility and experience are crucial.

Appendix F1

Adaptive governance

Insights from our review of good practice around **adaptive governance** are outlined below:

Case Study: Netherlands – Delta 2100 Programme



Overview: The Netherlands is a low-lying, flood-prone country. The National Delta Programme protects the Netherlands against flooding, ensures that there are adequate supplies of fresh water and contributes to climate-resilient and water robust spatial planning. Under the Delta Programme, the government has entered into innovative collaborations with residents, businesses, knowledge institutes, and NGOs. The Delta Programme Commissioner is the government official responsible for the Delta Programme.

Insights:

- The core of the Delta Programme is a **national approach**, with room for **regional interpretation** and the **involvement of all parties**. The national government, provincial and municipal authorities and water authorities have **shared responsibility** and shared ownership. There is **coherence** and uniformity between regions. There are regional administrative alliances with support of a National Delta Programme Steering Group who report to the Delta Programme Commissioner.
- The Programme is driven by a **holistic long-term vision**, with scenarios, models and research looking out to 2020, 2050, 2100. There are three co-ordinated national policy frameworks: flood risk management, fresh water and spatial adaptation.
- **Knowledge is crucial** for the Delta Programme. It serves as the basis for important decisions in areas including safety, the economy and the living environment in the Netherlands. Key elements of the programme include: Knowledge conferences & a knowledge network, Delta Scenarios and a Signal Group.
- A Delta Fund of about 1 billion euros per provide **stability in financial resources**, reducing dependency on economic developments and securing continuous political attention.

Case Study: UK – Climate Ready Clyde



Overview: Climate Ready Clyde (CRC) is a cross-sector initiative funded by 13 member organisations and supported by the Scottish Government to create a shared vision, strategy and action plan for an adapting Glasgow City Region. CRC have developed a Strategy which sets the direction for Glasgow City Region's adaptation efforts. This is supported by 16 large-scale, high-ambition actions where there is strong consensus on the need for progress and transformation adaptation.

Insights:

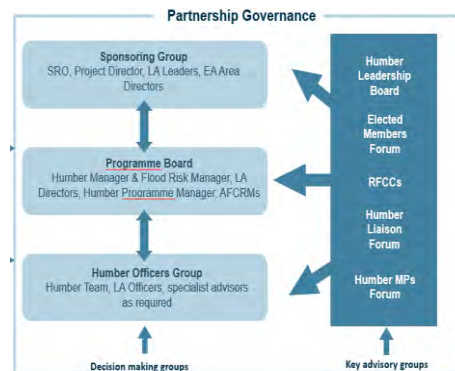
- Climate Ready Clyde was established on the basis that adapting is cheaper, easier and more effective when done together.
- Climate Ready Clyde is a **regional approach** based on the Glasgow City Region which includes Glasgow City + 7 surrounding Councils which make up the Clyde River Basin.
- During the Strategy development process, CRC **engaged with many new and different actors** from within Glasgow City Region to map the systems relating to culture, governance and delivery of adaptation. CRC gives a clear focal point to allow the coordination of climate risk and adaptation in Glasgow City Region, but more could be done to make it more inclusive.
- The flagship actions recognise that physical changes are not enough, and true **resilience requires changing cultures, finance, governance and institutions**.
- They **adopted a new governance structure** to help take transformative climate adaptation action in the region action to the next level. This collaborative structure includes an Action Group, a Technical Secretariat, and Independent Ambassadors who champion adaptation action and provide accountability.

Appendix F1

Adaptive governance

Insights from our review of good practice around **adaptive governance** are outlined below:

Case Study: UK – Humber APP



Overview: As part of the Discovery phase to inform the development of the Design phase of both the Humber Adaptation Pathways (HAP) and the South Yorkshire Adaptation Pathways (SYAP) Pilot Projects, a review of governance was undertaken to understand the needs and recommendations to enable an adaptation pathways approach to be implemented across the region.

Insights:

- In April 2023, the Humber 2100+ Partnership comprised the Environment Agency and 11 Local Authority Partners. The Partnership is currently led, administered and funded by the Environment Agency, with a goal of developing the Humber 2100+ Strategy. The EA are working with partners to see how they can achieve more **distributed ownership and shared decision making**. However, participation is voluntary and the partnership has not yet been tested in terms of making significant decisions,
- It was recognised that not all Partners had the same start point knowledge and it was important to get to a **common knowledge baseline** so all partners can participate on the forward journey. Ensuring all partners have access to the platforms used to store and share information is a very important part of sharing ownership and building trust,
- Important to have **catchment-wide consensus on what matters most** (for example outcomes sought and benefits needed); and,
- Recognition of the need to **monitor short and long-term background changes**. Partner stakeholders will need to review this information and together decide if there is a need to adapt the approach taken.

Appendix F1

Transboundary governance

Insights from our review of good practice around **transboundary governance** are outlined below:

Case Study: USA & Canada: Great Lakes Ontario and St. Lawrence river basin



Overview: The Lake Ontario-St. Lawrence River waterway supports multiple users in the U.S. and Canada that live, visit, or conduct business in the region. Representatives of both countries serve on a commission that implements Plan 2014, which governs water releases from the lake into the river. An exploratory case study review of this plan in the Great Lakes Ontario and St. Lawrence River system in North America was undertaken to examine flexible FRM approaches.

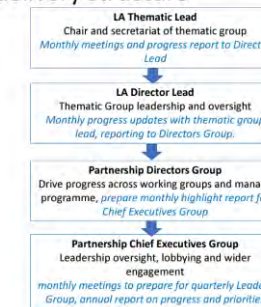
Insights:

- Water issues managed since the 1970s by the International Joint Commission (IJC), with three Commissioners from each country. This group makes the decisions (i.e. regulates water quantities via dam management / clear and strict water release rules). There was controversy when record floods in 2017 pitted the interests of Americans against Canadians, experts against politicians etc.,
- Best practices for transboundary FRM include **data exchange, clear treaties, harmonized efforts, local knowledge, and trust**,
- An **integrated setting** where stakeholders have a common perception of the issues, similar mindsets and responsibilities, can be particularly helpful in managing the complexity of issues such as uncertainty,
- **Trusted and adopted scientific evidence** and **transparent information** is also necessary to ensure that epistemic uncertainty is minimised; and,
- Comprehensive ecosystem management can be a successful tool for transboundary FRM as this prioritises natural boundaries over international borders, focusing on **basin-wide** rather than national tools for flood risk management.

Case Study: Wales and England: Marches Forward Partnership



Our joint delivery structure



Overview: Memorandum of Understanding (MOU) between Shropshire Council, Herefordshire Council and Monmouthshire and Powys County Council's for collaboration as a Marches Forward Partnership.

Insights:

- Geographically, the neighbouring local authorities cover a contiguous area which straddles **over 80% of the English and Welsh border**. Commuting patterns and access to retail, education, business support and healthcare services all reflect the functional profile of the area,
- The local authorities are bound together by common purpose based on a high quality rural environment, but with consequent more expensive access to services, changing service demands from an ageing population and low levels of productivity and employment growth. Given this profile, the local authorities are keen to explore a shared ambition for rural based growth, identifying opportunities for strategic collaboration on agreed projects and initiatives. This approach is aimed at ensuring effective local joint working and provides a basis, using the power of the collective area, to **develop investment propositions for Government and partners**; and,
- Significant opportunity is provided by the development of the Marches Forward Partnership. The Partnership provides a **flexible umbrella framework for joint working** which supports local service delivery based around how people and places function rather than being confined within organisational or geographical boundaries.

Appendix F1

Recommendation 1: AP Leadership Team

Table F1.2: Governance Recommendation 1.

OECD principle	Attributes from review of lenses	Examples of implementation	Observations and feedback against as-is governance	Opportunity
Clearly allocate and distinguish roles and responsibilities for water policymaking, policy implementation, operational management and regulation, and foster co-ordination across these responsible authorities.	- Clear roles, responsibility and accountability are key. As part of this, a governance system should enable appropriate levels of autonomy and flexibility, with strong multi-level networks to drive action alongside building trust. - Systematic and coherent coordination is essential across complex catchments. Coordination requires clear and distinct roles and structures. - Both capacity and authority matter - responsibility needs to be held by those with the right capacity and authority to make robust decisions in a timely manner.	- In Climate Ready Clyde, the Action Group drives delivery of the Adaptation Strategy, led by Glasgow City Council and funded by 13 member organisations. Separately, a Technical Secretariat enables the Action Group, identifying funding opportunities and monitoring progress. - In Cumbria, more systematic and formalised coordination supports water governance. Steps towards a more coherent structure include partnerships operating as strategic decision-making groups under an MoU with a separate, but linked, funding mechanism operating as a company limited by guarantee. In the long term, they are considering a new single entity (led by a board or consortium) for water governance with full responsibility and accountability (and sufficiently funded).	- Interview feedback identified that the current process lacks an overarching body that can make decisions about water (including water resources) in the catchment. This could be a catchment partnership/alliance that is formalised or given authority. - There are a number of catchment groups and partnerships (e.g. Catchment-based Groups, River Severn Partnership (RSP) present across the catchment which support collaboration amongst internal EA & external parties. However, there is not full clarity on roles and contributions, and these groups don't have clear autonomy or decision-making power, potentially limiting their effectiveness. - National legislation provides a clear articulation of the roles of organisations in FCERM – despite this, FCERM roles/responsibilities is a complex landscape. - Within the EA, the roles and decision-making responsibilities within the Project Board are clear and distinct.	Medium

Recommendation for the River Severn.

We have also recommended that the EA clarify the roles and responsibilities of other organisations in RECOMMENDATION 8.

1

Summary:

We recommend that the EA set up and resource an adaptation pathways leadership team to have ultimate responsibility to make decisions on new and existing pathways.

This team could consist of :

- the Area Directors and Managers in the Severn region
- Stakeholder representative who have the authority to convey the views of stakeholders (eg the Strategic Leadership Group in the River Severn Partnership)

The EA could consider giving stakeholders decision-making powers once it has established the body.

Detail:

Following the initial development of pathways in the pilot areas, decisions may need to be made on changes to pathways. Additionally, if the EA is likely to develop pathways for other catchments, decisions on what those pathways will look like will need to be made.

The EA will need to determine who will make these decisions (changes to existing pathways and what initial pathways look like). In order to consider what this group will look like it is important to note that:

- decisions on changes to pathways will likely only occur every 5 to 10 years. Changes may be required on a more frequent basis but this is unlikely to occur often
- decision on new pathways will only occur once but be the more substantive than decisions on changes to pathways.

Given the above it is likely that the membership of this decision-making body will change on a case by case basis. Therefore it is important to establish principles on who the decision-makers in this group should be. We recommend that it include Area Directors and Managers (in the Severn region) as they have the authority and capacity to make these decisions.

The body could also include stakeholder representatives from the groups. It will be important to include these stakeholders have the authority to carry their organisation's position

To be successful, this body will need to inform their decisions with advice from technical experts and feedback from stakeholders and communities. This could be provided by the AP advisory group.

Appendix F1

Recommendation 2: Adaptation pathways to inform local interventions

Table F1.3: Governance Recommendation 2.

OECD principle	Attributes from review of lenses	Examples of implementation	Observations and feedback against as-is governance	Opportunity
Manage water at the appropriate scale(s) within integrated basin governance systems to reflect local conditions, and foster co-ordination between the different scales.	- Managing water at the catchment scale prioritises natural boundaries. - Multi-layered systems need to link local, regional, and national governance - to enable and support local decision makers to engage with national direction, strategy and funding; and alternatively using local information to inform national strategy.	- Climate Ready Clyde is a regional approach that manages water at the catchment scale, involving a partnership between all eight Councils within the Clyde River Basin. - In the Lake Ontario-St Lawrence River Plan 2014, decisions were delegated to local operators which, although allowed for more flexibility, left the operators open to criticism; devolving decisions needs to consider capacity, authority, and ongoing support. - The core of the Delta Programme is a national approach, with room for regional interpretation.	- The current approach is problem-focused, starting with a local problem and identifying a project to resolve this. Catchment groups can link these projects together, escalating to the national level for approval. There is an opportunity to make this process more strategic. - The EA has levels of local, regional and national governance (cf. observation above). However, regional governance appears an area with opportunity to further consider or develop roles of (linked to principle above): - Catchment Based Groups are spaces for internal collaboration but work in silos with no overarching governance regionally across them. With no formal decision-making powers they are mostly spaces for collaboration and largely look at existing risks (as opposed to long-term decision-making) - The RSP, CRS with the addition of the external Project Steering Group, has been formed to provide a regional steer for decision-making – however it is yet to formally identify how it influences or steers decisions.	Medium
Recommendation for the River Severn <i>We have also recommended that the EA clarify the roles and responsibilities of other organisations in RECOMMENDATION 8.</i>				2

Summary:

We recommend the EA use adaptation pathways that have been developed for the catchment scale to help evaluate and prioritise individual interventions at the local level.

Detail:

Under current FCERM processes the EA and RMAs get together to identify and prioritise interventions in specific areas. Currently, this process is done on a case-by-case basis with limited direction on which interventions should be prioritised.

Adaptation pathways, particularly those developed for large catchments/sub-catchments (like those we are developing for the RS APP) will likely be more strategic in nature and identify portfolios of interventions needed to address flood risk across the catchment. These portfolios could identify where specific interventions are needed and/or what types of interventions are needed.

Given that APs for large catchments/sub-catchment will be strategic in nature there is an opportunity to use them when identifying, evaluating and prioritising local or at place interventions. [The EA should consider developing regional guidance on how to align local schemes to strategic-scale APs.](#)

Appendix F1

Recommendation 3: AP advisory group

Table F1.4: Governance Recommendation 3.

OECD principle	Attributes from review of lenses	Examples of implementation	Observations and feedback against as-is governance	Opportunity
Adapt the level of capacity of responsible authorities to the complexity of water challenges to be met, and to the set of competencies required to carry out their duties	- Decision makers at all levels need to have the capacity and competencies to make, communicate, and be responsible for their decisions. - Adaptive management requires new learning and competencies at all levels, to better understand the specific challenges associated with adaptation activities and the adaptive pathways approach.	- Communication and adaptive capacity gaps were identified during the implementation of the Lake Ontario and St Lawrence River Basin Plan 2014. The USA Government Accountability Office recommended a review and update of the communications and adaptive management strategies (including good practice), to support better implementation of the plan. - Since the launch of the Delta Programme, the national government, water authorities, and provincial and municipal authorities have been working to grow knowledge across the region with input from knowledge institutes, stakeholder organisations, business and citizens.	- The adaptation pathways pilot within the EA is supporting it to develop capability and capacity to design, implement and monitor adaptation pathways. However, these people are often working on other projects. - The RSP brings together knowledgeable and engaged experts from across the catchment and has started to provide capacity and awareness building to grow competencies around adaptation and water system management; however, this is informal and not yet a structured sharing process, and there is no mapping of the existing competencies/skills and future needs of the Severn2100+.	Medium

Recommendation for the River Severn	3
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Summary: We recommend that the Environment Agency establish and AP advisory group to support the development, implementation and review of pathways. We recommend the EA that the following initial steps to do this: - Capturing and communicating the lessons and skills EA staff involved in the programme have learned - Identifying initial 'AP champions' whose role (or part of their role) is to support their colleagues in working through the adaptation pathway process - Supporting people within the EA to focus on developing/implementing/ reviewing adaptation pathways. This may require them to reprioritise or offload their other responsibilities.	Detail: As the development and implementation of adaptation pathways is new to the EA it will need to consider how to support it in the long term. This will include ensuring it has the capability and capacity to develop, implement, monitor and evaluate, and review pathways. The EA colleagues involved in the implementation of the AP programme are developing the skills and experience needed to support the development/review of adaptation pathways. There is an opportunity for the EA to build on and imbed this by supporting an 'adaptation pathways advisory group' to lead and/or support the development, implementation, monitoring and evaluation and review of pathways going forward. The EA will need to consider what skills and experience this group will need and may need to undertake mapping to identify where gaps need to be filled. While the establishment of an advisory group would be a significant undertaking for the EA there are some interim actions the EA could take to 'get the ball rolling' on its establishment. These steps are: - Capturing and communicating the lessons and skills EA staff involved in the programme have learned. - Identifying initial 'AP champions' whose role (or part of their role) is to support their colleagues in working through the adaptation pathway process. - Supporting people within the EA to focus on developing/implementing/ reviewing adaptation pathways. This may require them to reprioritise or offload their other responsibilities.
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Appendix F1

Recommendation 4: Adaptation mindset in business cases

Table F1.5: Governance Recommendation 4.

OECD principle	Attributes from review of lenses	Examples of implementation	Observations and feedback against as-is governance	Opportunity
Ensure that governance arrangements help mobilise water finance and allocate financial resources in an efficient, transparent and timely manner	- Effective FCERM governance requires sufficient financial resources. - Having continuity and stability of funds is essential for effective adaptive water management; to allow for multi-year programming and support the realisation of longer-term goals.	- In the Delta programme, the Dutch Government has established a fund of about €1 billion/ year to provide stability in financial resources, reducing dependency on economic developments and securing continuous political attention. - Climate Ready Clyde has a team (separate to the delivery team) to support with the enabling environment (the Technical Secretariat), and secure funding - this is unlocked from a number of sources, including CRC's fifteen members and the European Union's climate innovation hub, EIT Climate-KIC.	- FCERM funding is coordinated and approved by the relevant RFCC in a well-established and clear business case development process. - Interviewees mentioned challenges with existing funding mechanisms, including an inability to fund wider or additional benefits within schemes; risk-averse attitudes meaning innovative approaches are less likely to be supported; and challenges in securing longer term / strategic funding. - Funding sources from relevant case studies include Defra/EA Grant in Aid funding, European Regional Development Fund, Local Levy, WINEP or Price Review funding (for relevant water company partnership projects).	High
Recommendation for the River Severn				4

Summary:

We recommend that the EA start introducing content in business cases to encourage applicants to adopt an adaptation mindset and start developing (initially basic) adaptation pathways under different climate scenarios. Similar to the introduction of carbon data and implications in business cases, the EA should take a staged approach to this. Initial considerations for inclusion could be demonstrating the response to an exceedance of design levels, and the impact that two climate scenarios will have on a proposed intervention.

Detail:

The EA requires business cases to be submitted before allocating funding for FRM projects. Our assessment found that business case requirements could be adjusted to encourage applicants to consider how their interventions could respond to the uncertainties of climate change. The EA's introduction of carbon calculator to business cases is a good model/precedence for this where a staged approach was taken to introduce data and information requirements; and over time the changes became more embedded and influential to the point that these now inform and drive decisions.

The EA should take an incremental approach to this and increase information requirements over time. These incremental steps could be:

- response to an exceedance of design levels
- impact of two scenarios on an intervention
- flexibility of an intervention to respond to different climate scenarios
- an adaptation pathway for two interventions
- how the proposed phasing of interventions maintains flexibility for changes to interventions over time

Business cases could also require information on how the proposed interventions link to and implement higher level strategies or adaptation pathways.

The EA has an internal team that updates business case templates and the partnership calculator. As well as this team the EA should draw on the experience of the people involved in the introduction of carbon implications.

Appendix F1

Recommendations 5 and 6: Benefits period and operational funding

Table F1.6: Governance Recommendation 5 and 6.

OECD principle	Attributes from review of lenses	Examples of implementation	Observations and feedback against as-is governance	Opportunity
Ensure that governance arrangements help mobilise water finance and allocate financial resources in an efficient, transparent and timely manner	- Effective FCERM governance requires sufficient financial resources. - Having continuity and stability of funds is essential for effective adaptive water management; to allow for multi-year programming and support the realisation of longer-term goals.	- In the Delta programme, the Dutch Government has established a fund of about €1 billion/ year to provide stability in financial resources, reducing dependency on economic developments and securing continuous political attention. - Climate Ready Clyde has a team (separate to the delivery team) to support with the enabling environment (the Technical Secretariat), and secure funding - this is unlocked from a number of sources, including CRC's fifteen members and the European Union's climate innovation hub, EIT Climate-KIC.	- FCERM funding is coordinated and approved by the relevant RFCC in a well-established and clear business case development process. - Interviewees mentioned challenges with existing funding mechanisms, including an inability to fund wider or additional benefits within schemes; risk-averse attitudes meaning innovative approaches are less likely to be supported; and challenges in securing longer term / strategic funding. - Funding sources from relevant case studies include Defra/EA Grant in Aid funding, European Regional Development Fund, Local Levy, WINEP or Price Review funding (for relevant water company partnership projects).	High

Recommendation for the River Severn: recommendation 5 - benefits period 5

Summary: We recommend that the EA encourage applicants to apply for funding for pathways of interventions by adjusting the benefits period from the time until the next intervention to the time the intervention is expected to provide protection.	Detail: The EA provides funding to FRM projects for Risk Management Authorities (RMA). Applicants need to use the partnership funding calculator to determine how much funding a project can receive. This involves calculating the net present value (NPV) of an option over a benefits period. The benefits period is the shortest of either the expected duration of a project, or the time until another 'major investment' on that project occurs. This method means applying for an intervention at a point in time rather than a pathway of interventions over time yields a higher NPV. This does not reflect an adaptation pathway where multiple interventions over a long time period are considered, or capture the cumulative effects and adaptation pathway may have. The EA has also recently introduced OM2B which allows for households that aren't currently at risk, but will be in future, to be included in benefit calculations. This change the future impacts of climate change to be considered.
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Recommendation for the River Severn: recommendation 6 - operational funding 6

Summary: We recommend that the EA consider funding some of the expenditure for EA led adaptational actions that have an operational component to them (eg funding catchment markets or engaging in development applications).	Detail: Adaptation pathways are likely to include a range of adaptation actions that will involve both capital and operational expenditure. Adaptation actions may involve operational components (e.g. engaging on development applications and/or paying farmers to provide flood attenuation and storage). Current funding rules allow the EA to cover operational expenditure for EA projects, however it is not clear if this will include operational expenditure associated with operational adaptation actions led by the EA. Additionally, there is an opportunity for the EA to work with partners to determine who funds what. The EA should consider: - clarifying that it is able to fund the operational expenditure for EA led adaptation actions, or - if funding isn't available for operational adaptation actions, consider funding them alongside other sources.
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Appendix F1

Recommendation 7: Learning from other projects

Table F1.7: Governance Recommendation 7.

OECD Principles	Attributes from review of lenses	Examples of implementation	Observations and feedback against as-is governance	Opportunity
Ensure that sound water management regulatory frameworks are effectively implemented and enforced in pursuit of the public interest	<i>No further attributes or examples identified from good practice review</i>		The EA operates within a sound regulatory framework accompanied by strong legislation and policy.	Low
Promote the adoption and implementation of innovative water governance practices across responsible authorities, levels of government and relevant stakeholders	<i>No further attributes or examples identified from good practice review</i>		- The DEFRA innovation programme, the APP, is offering an opportunity to trial innovative water governance processes. Alongside this, the development of the RSP offers a clear demonstration of trailing an innovative approach to managing water at a regional level. - At the project level, innovative approaches need leadership and support to be successful; the risk-averse nature of existing processes and actors is a challenge.	Medium

Recommendation for the River Severn	7
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Summary: We recommend that the Environment Agency should meet with people working on the Dutch Delta Programme and Great Lakes Commission to share experiences on how they are addressing the challenges and opportunities involved in the adapting to climate change and cross boundary governance.	Detail: The Dutch Delta Programme aims at safeguarding the Netherlands against flooding, ensuring sufficient freshwater supplies, and enhancing climate resilience. The role of the Delta Commissioner was established in 2012 to engage with and consider the views of many stakeholders, work through alignments and trade-offs, and to engage with the relevant Government and regulatory bodies. The Great Lakes Basin is located in both Canada and the United States. The Great Lakes Commission, which includes representatives from both countries was established in 1955 to promote the integrated management of the catchment. Both the Dutch Delta Programme and Great Lakes Commission are likely to have a large amount of learning and experience that the EA can draw from, including areas like cross boundary governance, aligning and trading-off multiple priorities, and engaging with a wide range of stakeholders. The EA should consider reaching out to these organisations to meet with them and share experiences.
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Appendix F1

Recommendation 8: External roles and responsibilities

Table F1.8: Governance Recommendation 8.

OECD principles	Attributes from review of lenses	Examples of implementation	Observations and feedback against as-is governance	Opportunity
Promote stakeholder engagement for informed and outcome-oriented contributions to water policy design and implementation	- Promote integrated management in a participatory and inclusive way. Relevant stakeholders at appropriate levels and across sectors and scales meaningfully contribute and actively participate in decision-making so that authorities can make informed choices. This should include engagement with those impacted and draw on local knowledge and expertise. - Collaboration is a key characteristic of adaptive, water governance as it is the process that helps collective decisions to be discussed, reached, implemented, and evaluated by stakeholders at different levels and across sectors	- In Cumbria, local knowledge and expertise is recognised to be held by those living and working in catchments which can be used to make expert judgements. It was recommended to harness this information more effectively through structured engagement. - The Netherlands Delta Programme has regional administrative alliances which enable cross-sector decision-making. - For Climate Ready Clyde, community outreach and awareness was critical. News, arts, media and cultural organisations told stories about the climate crisis and opportunities to adapt with the cultural sector and media institutions supported in raising public awareness, playing a key role as hubs for community resilience. New forms of technology and consultation approaches to better involve and engage citizens. - In New Zealand, they have elevated human to non-human relationships, but in a holistic and collaborative approach, devolving decision-making to allow more equitable participation by communities.	- There are a number of internal and external groups and partnerships, e.g. the Catchment Based Groups, the Catchment Based Approach Groups, RSP (incl. the demonstrator groups), which are enabling collaboration and broad participation from a range of stakeholders across the region. However: - Internal consultation with broader EA parties (e.g. water resources, environment etc) on decision-making at a project/local level in the EA is not systematic and often varies project to project (e.g. 'depends on who's in the room' or networks of current project boards). - Public participation is largely constrained to public consultation processes once schemes/projects have been identified. External local knowledge is not readily drawn upon in a structured process - The RSP and EA are working towards forming a Project Steering Group for the CRS but there is uncertainty about how this group will enable support or enable collective decision-making.	Medium
Recommendation for the River Severn				8

Summary:

We recommend the EA work with Natural Resources Wales to determine how they will work together on the RS AP. They should consider various models when doing this, including the Great Lakes Commission model.

The EA should also clarify and articulate the roles and responsibilities of the RSP and other stakeholder groups in the Severn region. This work should include how they interact with EA, and the level of influence they are able to have over decision-making.

Detail:

The development of the pilot adaptation pathways has involved extensive engagement with stakeholders including local authorities, water companies and environmental interest groups.

As part of the River Severn Catchment is in Wales, the EA will need to engage with Natural Resource Wales (and other parts of the Welsh Government) to determine how they will work together on the implementation and review of the RS AP. The EA and NRW should consider various models for working together, including the Great Lakes Commission model. In this model states from the US and Canada make joint decisions on management of water resources in the Great Lakes. The Federal Governments act as observers.

It is important that the EA clarify the role of stakeholders in adaptation pathways, and at what stages in the process they will be engaged with. Further, some adaptation pathways may identify actions that are not in the remit of the EA (e.g. lifting minimum floor levels, avoiding development in at-risk areas). The EA may also work with stakeholders to discuss how the costs of particular interventions can be shared.

Appendix F1

Recommendation 9: Encouraging policy coherence

Table F1.9: Governance Recommendation 9.

OECD principle	Attributes from review of lenses	Examples of implementation	Observations and feedback against as-is governance	Opportunity
Encourage policy coherence through effective cross-sectoral co-ordination , especially between policies for water and the environment, health, energy, agriculture, industry, spatial planning and land use	- Joined-up policy landscape and co-ordination to make coherent decisions, plans and actions, including connecting land-use to water policy more effectively. - A holistic long-term vision, and related policy objectives which are translated from national to local levels - providing a common compass for the direction of travel. - There should be a focus on the long-term policies and planning - using these to influence existing plans. - Adaptive system-wide governance models should enable deliberation that facilitates open communication, reflection, understanding, debate, dissent, mediation and negotiation. - Collaboration & compromise is key - with a recognition that this involves compromising on control. - To enable collaboration, a clear conflict resolution process that helps to manage trade-offs.	- The Delta programme enables the delivery of three National Policy Frameworks, three themes are co-ordinated administratively: flood risk management, freshwater and spatial adaptation. - Climate Ready Clyde have a long-term vision provides direction (via the Glasgow City region Adaptation Framework). The Adaptation Strategy sits within the Glasgow City Region Adaptation Framework. The Framework provides the vision out to 2050, while the strategy includes 11 interventions (and 42 sub-interventions) , providing strategic direction to 2030. There is an action plan (2021-2025) that sits below the Strategy with broader city region contributions and 16 flagship actions.	- There is a National FCERM Strategy for England which provides a long-term vision. However, this hasn't been translated into a long-term regional vision and priorities. The River Severn Partnership (RSP) provides a vision statement but further clarity is required for it to provide a clear guide for decision-makers. The Climate Resilience Strategy provides an opportunity to provide long-term regional coherence and direction. - There is a lack of systematic consideration of land-use, water resources and pollution; interviewees mentioned challenges in managing trade-offs and conflicting priorities. There is an opportunity to connect with the Environmental Land Management Scheme (ELMS: England) (in place) and Sustainable Farming Scheme (SFS: Wales) (commencing 2025) to strengthen policy integration between FCERM and land use management (as noted in the 2021 EA evaluation of FCERM governance in England and Wales). - Project selection is currently problem-led: local problems are identified; high level projects are developed, and once approved, are automatically added to the regional programme for business cases development. This is reactionary decision-making which could be better linked to wider policies / National strategies. - The current governance model facilitates open communication & collaboration with key internal parties and stakeholders. Internally, decision-making focuses around a Project Board and Catchment-Based Groups support identifying synergies across schemes; whilst externally the RSP provides a forum to discuss and deliberate amongst regional parties. However, both internally and externally there is a lack of a process which helps to manage trade-offs.	High

Recommendation for the River Severn

9

Continue to consider the position and influence of APs on wider plans and strategies (including RBMPs). With the other APs, develop a coherent approach to policy changes needed to facilitate an adaptation pathways approach. Part of the AP process has involved identifying relevant policies, plans and strategies which we will consider when identifying and evaluating pathways. The EA should continue to do this when reviewing pathways and making changes to them. The Climate Resilience Strategy provides an opportunity to provide long-term regional coherence and direction.

We have recommended the EA uses adaptation pathways to identify and prioritise interventions in RECOMMENDATION 2. The EA is seeking and will consider feedback from stakeholders (including the RSP) throughout this process.

Appendix F1

Recommendation 10: Integrity, transparency and EDI

Table F1.10: Governance Recommendation 10.

OECD principle	Attributes from review of lenses	Examples of implementation	Observations and feedback against as-is governance	Opportunity
Mainstream integrity and transparency practices across water policies, water institutions and water governance frameworks for greater accountability and trust in decision-making	Transparent processes, information and decision-making which are honest and open are fundamental across all facets of governance activities. This helps to build trust with partners and the public enabling buy-in around the decisions made.	- The Netherlands Delta Programme looks to enable joint fact-finding to develop a common knowledge base and has a transparent structured process to developing Strategies. This process is supervised by independent Senior Officials. - For Climate Ready Clyde, independent ambassadors champion CRC and advocate for adaptation. - In the US & Canada, trusted and adopted scientific evidence and transparent information has been used to promote defensible transboundary decision-making.	- The EA decision-making process for projects and schemes is clear and transparent, following the structured 5-Case Business Model and driven by the Project Board. However: - It was not always evident there was a clearly articulated process to developing Strategies and defining projects. - This process is not always understood across the EA teams and externally across the public/partners. - Decisions by Project Boards tend to draw upon the existing knowledge base of those present. - The catchment partnerships (and other collaborative groups) facilitate greater transparency between catchment actors; these partnerships can rely on the availability / capacity of engaged individuals.	Medium
Recommendation for the River Severn				10

Consider and develop approaches on how to engage with hard-to-reach communities, [third sector organisations](#), and how to design and communicate APs to promote equitable decisions around flood risk management. The EA is developing integrity, transparency, and EDI policy for the organisation, which could be adapted for APs.

Appendix F1

Recommendation 11: Monitoring and evaluation

Table F1.11: Governance Recommendation 11.

OECD principle	Attributes from review of lenses	Examples of implementation	Observations and feedback against as-is governance	Opportunity
Encourage water governance frameworks that help manage trade-offs across water users, rural and urban areas, and generations	Our case studies were less focused on water allocation and use which is a key driver behind this principle.		Equitable water use based on sustainable abstraction is less related to FCRM. There are links e.g. in terms of impermeable area runoff reducing recharge, but this is considered to be more incorporated within Principle 3 on policy coherence.	Medium
Promote regular monitoring and evaluation of water policy and governance where appropriate, share the results with the public and make adjustments when needed	- Enabling learning, adaptation and self-organisation (adaptive capacity) is a cornerstone to supporting an adaptive approach. - Provision for continuous monitoring and evaluation over the long-term. A governance system must enable changes to be identified and evaluated to inform periodic updates to the regions approach (e.g. adaptation pathways). There must be organisational arrangements which systematically accommodate adjustments and a decision-making process that links directly to its output. - Inherent in the above is the need to manage uncertainty, within a narrative that partners and stakeholders support.	- The Netherlands Delta Programme places monitoring and evaluation at the core of its approach. A key role with their governance is the Delta Programme Signal Group. This group monitors changes in the climate, sea level, hydrology and land use with indicators that relate to both the past and the future. This makes it clear when changes may be required to the course or pace of the Delta Programme. - For the Climate Ready Clyde, monitoring and evaluation takes place via the technical secretariat. The Technical Secretariat acts as a catalyst, creating an enabling environment for delivering the strategy they lead on communications and engagement, identifying funding opportunities, monitoring and evaluating progress.	- Current monitoring & evaluation is focused around: - National EA monitoring the delivery of the programme and achievement of the EA's outcome metrics. - Local Outcome Plans (LOP) which are refreshed annually. - Lagging indicators, e.g. asset management teams monitor defences, but this is just against performance against existing designs/standards. There is currently no defined role/responsibility which manages a process of long-term systematic monitoring and evaluation of both regional impact towards a desired ambition and of changes in the environment. - There is no formal decision-making framework which enables rapid action when it is identified an adjustment in approach is required (e.g. if a trigger level is identified). - There are pockets of learning (e.g. the DEFRA innovation process) across the EA but more could be done to capture lessons learnt systematically and share learning amongst EA teams and partners. - There is no clear articulation of how uncertainty is managed at present.	High

Recommendation for the River Severn

11

The monitoring and evaluation framework will help the EA understand where they are along a pathway and if a change in pathway is needed. The framework will identify who is responsible for carrying this out and how it informs decision-making. Further information in this is provided in the monitoring and evaluation chapter of the report.

Appendix F1

Recommendation 12: Data and information

Table F1.12: Governance Recommendation 12.

OECD principle	Attributes from review of lenses	Examples of implementation	Observations and feedback against as-is governance	Opportunity
Produce, update, and share timely, consistent, comparable and policy-relevant water and water-related data and information , and use it to guide, assess and improve water policy	- Collecting, understanding, and communicating data and information is essential for adaptive planning in water management to enable evidence-based decision making. - Developing a common evidence-base across stakeholders is important for building trust amongst partners and making robust decisions in complex environments. - Data, models and information should look long-term (this can be qualitative and quantitatively) and consider different versions of the future (or climate scenarios) to inform decision-makers.	- The Delta programme has established the National Water and Climate Knowledge and Innovation Programme (NKWK), in collaboration with government authorities and knowledge institutes, to grow the knowledge base and support open data. - The Delta Scenarios: The Delta Programme looks ahead to 2050 and 2100 and outlines possible futures. Working with different visions of the future ensures that the Netherlands is well prepared. - During a review of Plan 2014 in the Lake Ontario and St Lawrence River Basin, the USA Government Accountability Office recommended establishing data sharing MOUs with potential partner agencies to support data accessibility, information and tools.	- Internally, the EA are developing national modelling datasets to provide a common evidence base of flood risk across the nation which will, in the future, draw upon local modelling to act as a common evidence base for decision-making. Beyond the National FCERM Modelling datasets, there is no common evidence base which is used regionally to drive decision-making. - The RSP has recognised this as a key opportunity for the region and is exploring how it can develop a common base of evidence. - The development of Long-term Investment Scenarios start to identify potential scenarios of the future to inform decision-making. However, these have not been produced at a regional level and only look at key drivers of flood risk, population growth and aging assets.	Medium

Recommendation for the River Severn	12
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An Information Management Plan, which identifies what information/evidence was needed to develop adaptation pathways, and who should own and manage that data, is provided in the data and information section of this report. The adaptation pathways have been developed using existing flood modelling. If future, they could also be informed by updates to the National Flood Risk Assessment. We have used (or projected) long term scenarios (e.g. for growth) in the development of the adaptation pathways.

Appendix F1

Zoom in 1: Adaptation pathways planning process

Recommendation: 1

Adaptation Pathways to inform local interventions

We recommend the EA use adaptation pathways that have been developed for the catchment scale to help evaluate and prioritise individual interventions at the local level.

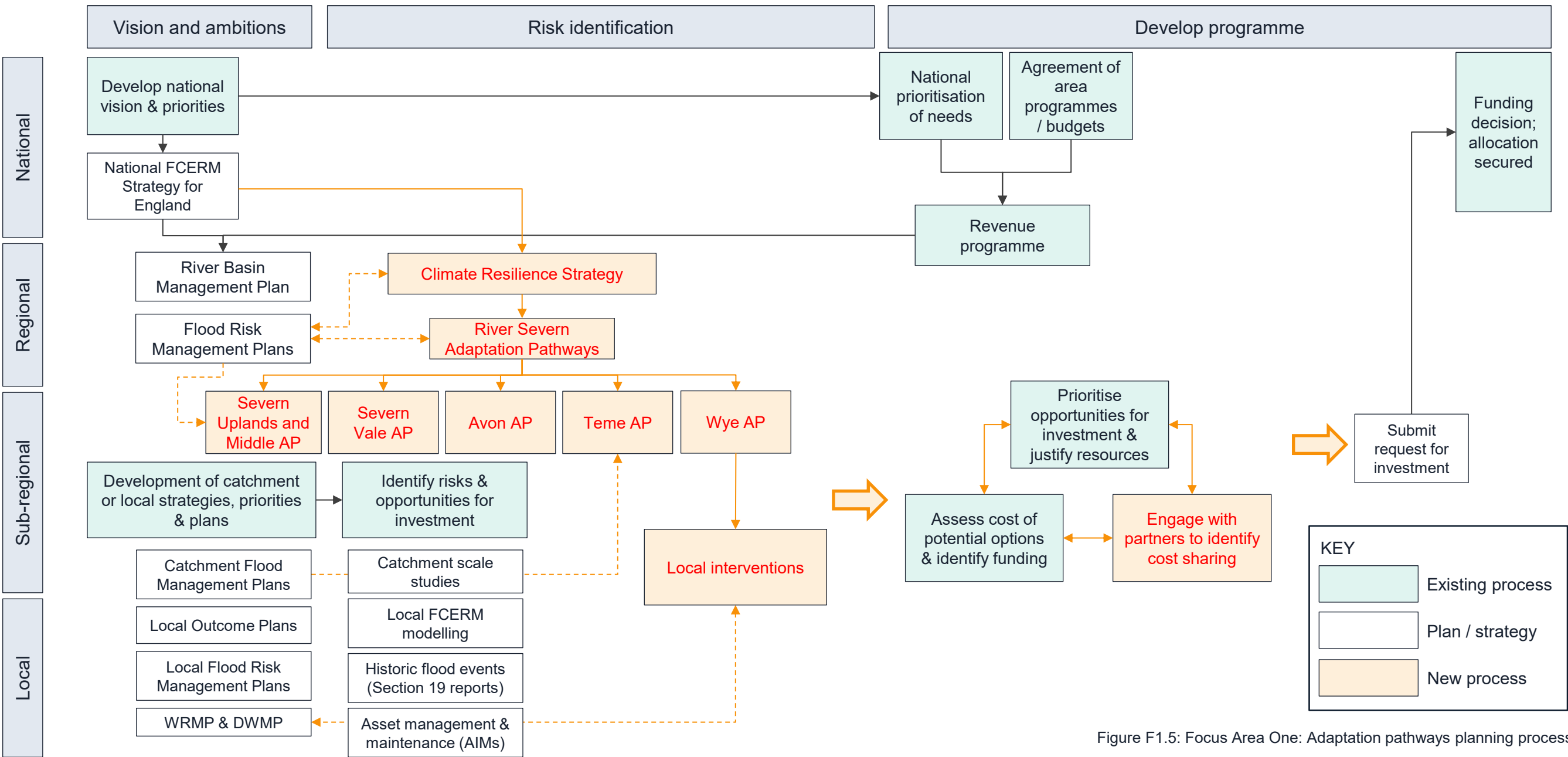
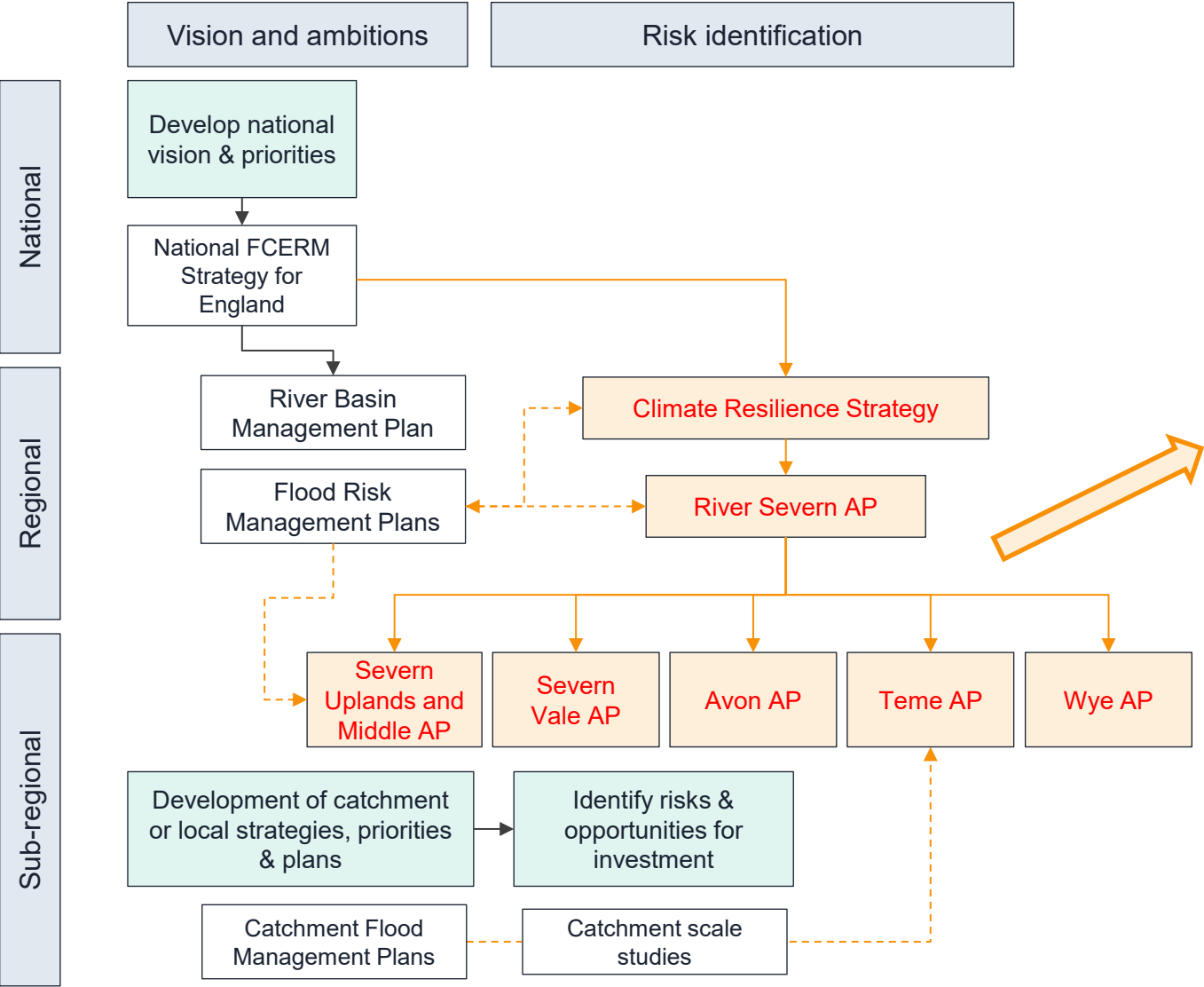


Figure F1.5: Focus Area One: Adaptation pathways planning process.

Appendix F1

Zoom in 2: Adaptation Pathway's Leadership and Advisory Group



Recommendation: 2

Adaptation Pathways Leadership Team

We recommend that the EA set up and resource an adaptation pathways leadership team to make decisions on changes to pathways, or when required, the development of new pathways outside of the pilot areas.

This team could consist of representatives from:

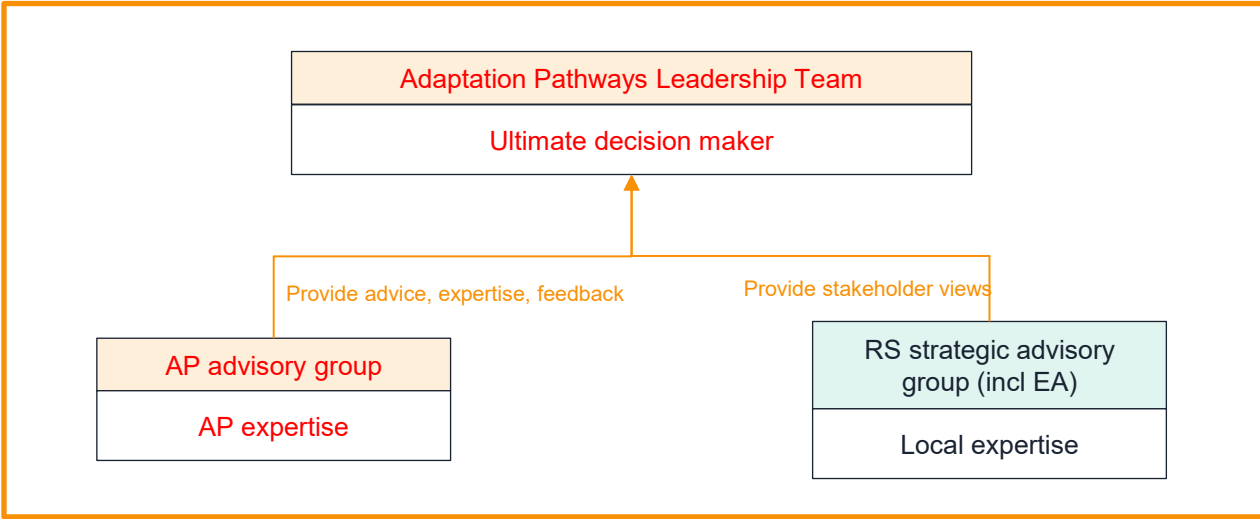
- the Area Directors and Managers in the Severn region
- the RFCC
- the Strategic Leadership Group (part of the RSP)
- other adaptive pathways projects the EA is undertaking

Recommendation: 3

Adaptation Pathways Advisory Unit

We recommend that the EA setup and resource a group of people to support the design, implementation, monitoring and evaluation and review of adaptation pathways across England.

This group should consist of technical experts and communications, engagement specialists (to consider EDI), and third sector organisation.



Illustrative relationship between the AP Leadership team, advisory unit, and the RS strategic advisory unit of the River Severn Partnership

Figure F1.6: Focus Area Two: Adaptation Pathways Leadership and Advisory Group.

Appendix F1

Zoom in 3: Adopting an adaptation pathways mindset in business cases

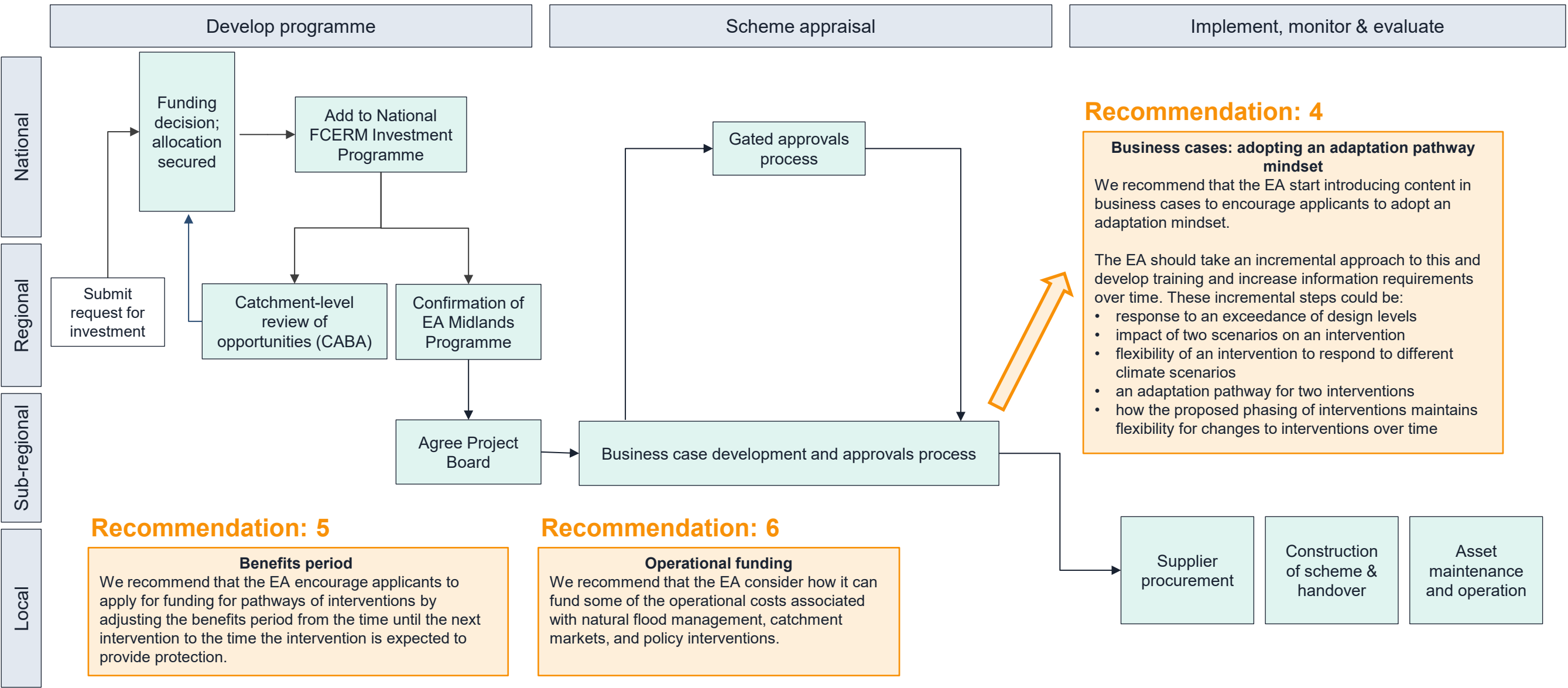


Figure F1.7: Focus Area Three: Adopting an adaptation pathways mindset in business cases.

Appendix F2

Funding & Finance

This appendix contains further information around the challenges and opportunities faced under the current GiA funding and finance system, typically utilised to deliver FRM schemes.

We have, in detail, explored the strategic context, the problems, the opportunities, and the barriers that the EA face to deliver a holistic, partner-based approach to FRM delivery.

We have outlined case studies to provide examples of good practice, a draft terms of reference that should co-developed with the required stakeholders at the inception of a funding & finance working group.

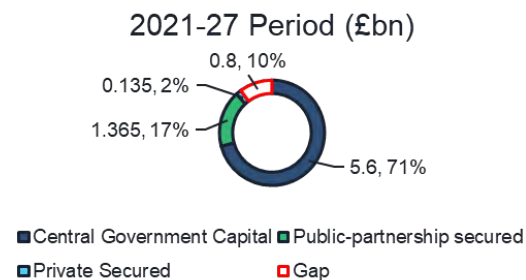
Appendix F2

Recommendations context

Challenge

Current spending on flood management is heavily reliant on property-value-based government Grant in Aid (GiA) funding. For the 2021-27 period, £5.6bn of capital funding has been committed [3]. It is estimated that £2.3bn of partnership funding is required to supplement this central government funding. As of July 2023, £800m of this was yet to be secured and only 9% of the amount secured is from the private sector [4]. The government has ambitions to bring in £500m of private investment to nature recovery by 2027 and £1bn by 2030 [5], some of which may be used within FRM. To address the current funding gap and unlock future private sector resources to support the likely increase in resilience expenditure, new approaches to attract private sector funding are required. If not addressed, there is a risk that opportunities could be missed, or funding misdirected.

Figure F2.1:
Available
funding
sources and
gaps for
Severn2100+.



Opportunities

A successful funding and finance strategy must match the strengths of the River Severn catchment. Its rurality and agricultural nature is its key differentiator, and while this means less opportunity to raise finance directly through business or innovation zones, the catchment is well-placed to leverage private investment through large scale landscape restoration and WwNP. The Green Finance Institute identified five drivers for investing in natural flood management [6]:

- Avoided costs, e.g., insurers investing to reduce liability,

- Co-benefits, e.g., carbon sequestration,
- Sustainability disclosures, e.g., ESG and CSR reporting,
- Investment for financial return, e.g., revenue generation, Regulatory drivers, e.g., BNG/NBB.

At a programme level it will be critical to align with programmes that also intersect economic growth, nature and flood risk such as the Marches Forward Environment Investment Zone (EIZ) or Environmental Land Management Scheme (ELMS) and other RSP opportunities. Learnings can be taken from case studies such as the Norfolk Water Fund (with The Nature Conservancy). Influencing and leveraging the potential changes to partnership funding will also be important.

Mechanisms

To effectively deliver resilience there needs to be a range of and flexibility in mechanisms to leverage various investor types and appetites.

- **Blended finance** involves using public or third-sector funding to de-risk investments and encourage private investment into a scheme.
- **Bundled schemes** attract investment into a project by selling multiple benefits e.g. flood mitigation, carbon sequestration and BNG/NBB from one scheme to different beneficiaries as well as aggregating multiple schemes to make an investable package.
- **Environmental markets** can be used to trade ecosystem services between organisations in a market-based system. BNG/NBB, carbon (higher maturity currently compared to others), flood management and nutrient markets (lower maturity) already exist in the UK.

Barriers

While it is true that the sources, scale and drivers of investment vary, there are also multiple barriers preventing

the rapid upscaling and deployment of investment into appropriate schemes. These include:

- Widespread landowner coordination requirements
- Lack of appropriate policy, legislation and guidance to encourage private investment
- Poor knowledge and information leading to lack of confidence e.g. common standards, datasets, best practice
- Financial e.g. monetising benefits appropriately
- Economic e.g. stacking of benefits into investable packages

What role does the EA play to overcome these barriers?

The future landscape of funding and financing to enable adaptation planning and pathways will likely look very different from BAU today. The EA is well-positioned to play a significant role in overcoming existing barriers. If executed correctly, either through direct action or its influence, the EA can help unlock funding and financing to help deliver the outcomes of the CRS.

Fundamentally, the EA needs to rapidly determine its role and scale of ambition in the quickly evolving landscape of funding and financing for climate resilience, landscape and nature schemes. This could be formally partnering with existing organisations, building collaborative relationships with these bodies or deciding to forge its own path and approach towards maturity. Key to this is determining the EA's willingness and capacity to own and control the processes (and risk) that can enable funding and financing to be channelled into the catchment or whether, due to the EA's current remit, it is better placed to partner with other organisations to deliver optimal outcomes for the Severn 2100, the EA's interests in the catchment and the catchment as a whole.

Appendix F2

Changes in FRM strategy and pressures on funding

Definitions

Funding is the money provided by an organisation for a specific purpose, usually free of charge but not without contractual arrangements.

Financing is the process of obtaining money for a specific purpose, usually with an obligation to repay, often with interest.

Future direction

According to the National Flood and Coastal Erosion Risk Management (FCERM) Strategy [7], as the population grows and climate change impacts are realised, the number of properties in the flood plain will almost double over the next 50 years. Wider resilience issues of drought and water quality are also set to worsen.

Both the Environment Agency National FCERM Strategy and the Welsh Government's Strategy for FCERM in Wales [8], aim to improve the climate resilience of places and enhance communities' capacity to respond and adapt. The Environment Agency's strategy takes a longer-term (100-year) approach but both place great emphasis on the importance of catchment-level analysis and taking a whole-systems approach. The National FCERM strategy [7] states changes from previous approaches, including Risk Management Authorities (RMAs) working with partners to:

- Develop adaptive pathways to better plan and adapt,
- Maximise working with farmers and land managers,
- Make greater use of nature-based solutions that take a catchment-led approach and improve resilience to both floods and droughts; and,

- Deliver practical and innovative actions.

Delivering adaptation pathways will require new funding streams to cover the revenue aspects such as monitoring and evaluation as well as funding to be available when thresholds are met and new pathways may need to be chosen. Due to misalignment between catchment and local authority boundaries, a catchment-led approach will also require a shift in funding approach. Larger schemes also introduce different risks and may involve multiple stakeholders, again calling for reconsideration of funding approaches.

Funding trends and pressures

Current spending on flood management is heavily reliant on property value based government Grant in Aid (GiA) funding. This spending is variable annually in response to extreme weather events and changing budgets. Overall, the long-term trend of expenditure has been increasing; the five-year average up to 2004/05 was £620 million compared to the £1,050 million average in the five years to 2022/23, (in 22/23 prices). For the 2021/27 period, £5,600 million of capital funding has been committed [3].

Despite these increases in funding, the absolute number of at-risk properties forecast to be protected is fewer than originally predicted due to inflationary pressures, skills and capacity shortages, and changes to funding rules resulting in business cases taking longer to deliver. At the start of the 2021/27 period, 336,000 houses were predicted to be better protected, this has been revised down by 40% to 200,000 properties [4].

The National Audit Office report [4] states that, by 2027, even

fewer than the revised 200,000 properties could be better protected, partly due to the pressures on attracting partnership funding. It is estimated that £2,300 million of partnership funding is required to supplement the central government funding. As of July 2023, £800 million of this was yet to be secured.

Critically, only 9% of partnership funding is expected to come from the private sector. In absolute terms, this represents £128 million - an increase of £89 million from the previous capital programme where only £39 million was secured. In comparison, 27-57% of estimated economic costs of flood damage are attributed to businesses.

The need for greater private sector funding

It is clear from the increasing risk that climate change poses, and the diminishing ability of government capital expenditure to deliver the required protection; a change in funding approach is required.

Without being able to reduce the cost or complexity of defending properties against flooding (and other resilience issues), it is imperative to leverage the significant untapped private sector funding that can help deliver resilience.

A key recommendation by the National Audit Office was for Defra and the EA to: "engage over the next year with the private sector at a national and local level to publicise the benefits the private sector derives from the capital programme and encourage increased private sector financial contribution to the capital programme to reflect these benefits. It was also recommended that Defra should also set a target for private sector partnership funding contributions for the next capital programme" [4].

Appendix F2

Why we need a new approach for the River Severn

River Severn context and economy

The River Severn catchment is dominated by agriculture, with nearly 90% of the land cover by area being used for this purpose. Income from agriculture is therefore significant with over £3bn generated annually in recent years and employing over 40,000 people [9].

The Severn catchment also relies heavily on tourism for its economy. The areas of natural beauty, historic towns and villages attract many visitors, providing over £4bn to the economy annually.

Despite this rural nature of the catchment, there are nearly 50,000 residential properties and 10,000 businesses at risk of fluvial flooding [10].

Limited GiA funding opportunities

The challenges outlined in the Strategic Context are particularly acute within the Severn region. Due to the rural nature of the catchment, sourcing GiA funding on the basis of flood damages avoided is much harder compared to urban areas such as London where there is high density of properties and higher value business. The challenge of making schemes cost beneficial is also impacted by lower average property values.

Limited partnership funding available

Barriers to GiA funding are compounded by a shortfall of partnership funding. With the economy dominated by distributed sources, such as agriculture and tourism, there are fewer large-scale opportunities to leverage direct private sector partnership funding.

Land use and environmental land management

- The Severn region must play to its strengths, which is the rural economy, and capture the opportunities offered by new environmental policy, such as the Environmental Land Management Schemes (ELMs).
- New land management and nature market opportunities offer the chance to leverage private investment, although there are significant challenges to address to realise the full benefits, including reduced flood risk.

Reducing flood risk long-term in the catchment will require landscape scale change across the Severn (with change extending across the administrative boundaries of England, Wales and local authorities). Nature-based and land management interventions offer an exciting solution but also present significant challenges, particularly in the delivery of flood schemes due to

the increased complexity of stakeholder management. New approaches and incentivisation mechanisms are therefore required to drive change and deliver schemes across these areas. Delivery will require a significant increase in stakeholder management resources to coordinate the above and create investable projects of the scale to attract private investment.

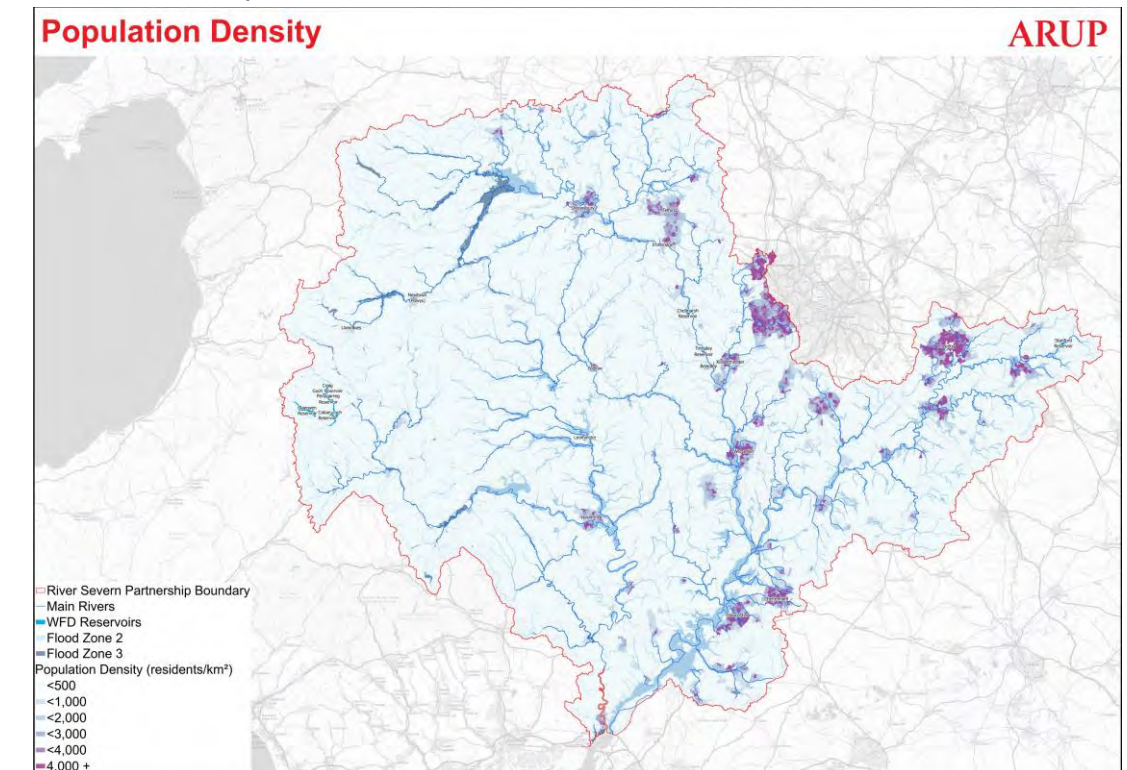


Figure F2.2: Population density map of River Severn Catchment.

Appendix F2

Building on the strengths of the catchment to unlock funding

What opportunities does the Severn present?

To be successful, the funding and finance strategy must match the strengths of the catchment. Its rurality and agricultural nature is a key differentiator, and while this means less opportunity to raise finance directly through business or innovation zones, the catchment is well-placed to leverage private investment through large scale landscape restoration.

Funding sources

The opportunity to bring wider sources of funding and finance into nature and environmental projects is growing. It is estimated that \$35bn (18%) of investment in nature-based solutions annually comes from private sources [11]. This investment is made up of non-voluntary sources e.g. driven by regulation as well as voluntary and philanthropic sources. As the challenges of climate change heighten, the benefits and drivers for investing in nature and climate change mitigation become more important. The Green Finance Institute identified five drivers for investing in natural flood management [6]:

- Avoided costs e.g. insurers investing to reduce liability,
- Co-benefits e.g. carbon sequestration,
- Sustainability disclosures e.g. ESG and CSR reporting,
- Investment for financial return e.g. revenue generation; and,
- Regulatory drivers e.g. BNG.

Mechanisms

To deliver resilience there needs to be a range and flexibility of mechanisms to leverage different investor types and appetites. New funding sources inherently carry higher risk and are less suitable for large projects. As these mechanisms mature through increased uptake, their risk reduces, and they begin to rapidly

increase in scale as more projects are funded or supported. When the mechanism is fully mature, risk is low enough that the largest projects can be funded, and the mechanism becomes fully integrated into the wider FRM market.

Blended finance involves using public or third-sector funding to de-risk investments and encourage private investment into a scheme. The Natural Environment Investment Readiness Fund is a strong example of blended finance. The fund provides grants of up to £100,000 that helps projects develop to a point that they can mobilise further private finance on their own. Other examples include the UK Infrastructure Bank or The Development Bank of Wales.

Bundled schemes attract investment into a project by selling multiple benefits e.g. flood mitigation, carbon sequestration and BNG from one scheme to different beneficiaries as well as aggregating multiple schemes to make an investable package.

Environmental markets can be used to trade ecosystem services between organisations in a market-based system. BNG, carbon, flood management and nutrient markets already exist in low-maturity in the UK.

Marches Environmental Investment Zone (EIZ)

Although not currently publicly referenced, there are already plans to leverage additional private funding into the River Severn catchment. For example, the Marches Forward Partnership is proposing to develop an EIZ to grow and unlock potential across the rural economy that makes up a significant proportion of the partnership area. Since this area has significant overlap with the Severn 2100+ region, it is imperative that the projects are closely aligned and attracting funding and financing in a collaborative way to achieve common goals.

Case Study: Wyre NFM [12]

The Wyre Natural Flood Management (NFM) project has successfully secured funding, through the sale of ecosystem services, to deliver 70ha and more than 1,000 targeted measures. The measures will store, slow and intercept water, reducing peak flow to flood effected communities in the upper Wyre Catchment. The Wyre Catchment Community Interest Company (C.I.C.) has been established and has successfully secured £1.5 million of capital to pay for a catchment scale NFM Intervention.

This is made up of £650k grant from the Woodland Trust and £850k from a nine-year private loan facility. The loan facility will be repaid from buyers of ecosystem services who seek to benefit from the intervention. The cost savings from the implementation of NFM measures will generate a long-term revenue stream for repayment of upfront investment in reduced flood risk. These buyers include Flood RE, United Utilities, the EA, Wyre Council and Northwest Regional Flood and Coastal Committee. These revenue streams enable the payment or financial mechanism by which required upfront capital can then be secured from investor to pay for the NFM measures.

Farmers and landowners can therefore be paid to host and maintain a range of NFM interventions including tree planting, water storage areas and hedgerow planting.

The Wyre Rivers Trust have been working and engaging with the local farming community for many years and co-design an attractive commercial offer which acknowledges them becoming early adopters of NFM through an innovative contracting structure.

Appendix F2

Barriers to implementation

While it is true that the sources, scale and drivers of investment exist, there are also multiple barriers preventing the rapid scaling and deployment of investment into appropriate schemes.

Coordination with landowners

To deliver landscape scale change, especially where land ownership is not within the control of one organisation (e.g. the EA), significant coordination and management is required to drive a strategic approach that aligns interventions to complement each other.

Policy and guidance

There is a lack of policy, strategy, or framework to help bring more private investment into resilience development. There is limited government guidance or support to help unlock private funding and financing. This is compounded by a lack of coordination between potential investors and those in a position to deliver schemes. Policy and regulation also differs between England and Wales, complicating delivery of cross-border schemes further.

Knowledge and Information

The complex nature of investment in environmental schemes can also limit investment and there are key information and knowledge gaps on routes to market for certain projects (e.g. how best to take a nature restoration project from concept to market). There is also limited guidance, common standards and mature examples to provide evidence of best practice. Financial data from past or existing projects within this space is also limited which impedes the ability to compare and quantify investments. These factors combined lead to an overall lack of confidence within this space, although research and pilot projects are moving at pace to plug this gap.

Financial

Compared to more traditional investments, it can be hard to quantify and then monetise many of the benefits generated from investment. It is also challenging to generate consistent and long-term revenue from schemes, especially where assets are commonly illiquid or require a very long-term payback period. To attract large scale investment, the schemes themselves need to be scaled up. This can be challenging across a large catchment where local context and specific constraints can limit the replication and rollout of schemes. Long-term revenue is also required for the increased M&E input associated with AP compared to BAU.

Economic

Adequate stacking of benefits (packaging benefits across one or more schemes) is a significant barrier to progress. This limits the ability for schemes to attract a broad range of investors to deliver schemes. Without it, schemes are left without the ability to truly value and then sell the full range of benefits of the scheme.

What role does the EA play to overcome these barriers?

The future landscape of funding and financing will look very different from BAU today and the EA has potential to play a significant role in overcoming the barriers that exist. If done correctly, either through direct action or its influence, the EA can help unlock funding and financing to help deliver the outcomes of Severn 2100+.

Case Study: Weald to Waves Nature Recovery Corridor [13]

This landscape scale recovery project aims to connect over 20,000 hectares of habitats to leverage the power of combined conservation efforts to counter biodiversity loss and improve local ecosystems.

This is a land-manager led project which requires coordination across multiple partners who traditionally haven't worked together. It also involves national and international level organisations that are providing support. So far about 16% of the corridor has been pledged.

Lessons can be taken regarding the management of landowners and aggregation of opportunities across a large scale in order to deliver a vision. (More information to be added later)



Figure F2.3: Nature Corridor Map from Weald to Waves project [13].

Appendix F2

Examples of concurrent projects that are developing novel F&F approaches to FRM and wider nature investment from the private and third sector. These could provide opportunities for learning and/or partnering.

The Norfolk Water Fund [\[14\]](#)

Norfolk Country Council established the Norfolk Water Strategy Programme (NWSP) in February 2021 with the aim of increasing focus on water security challenges and kickstarting innovation in dealing with them. In partnership with Anglian Water, Water Resources East (WRE) and The Nature Conservancy (TNC) the programme aims to develop a water fund to help deliver nature based solutions to address the county's challenges.

In February 2024, the NWSP published its business plan that set outs a £30million portfolio of NBS across four of the county's river catchments that will be delivered through the developing environmental markets for Nutrient Neutrality (NN) and Biodiversity Net Gain (BNG). The portfolio of NBS will deliver a cost benefit ratio of 6.7:1 and for investors it would deliver a revenue cost ratio of 1.5:1 with £14.8million of net present value revenue generated.

Having modelled the opportunities and developed the business case, the next stage of the project is set up the specific legal and governance framework of The Fund so that it can act as a robust and investable delivery vehicle. In the meantime, NWSP aims to ramp up the funding for feasibility studies and implementation of pilot projects as well as a monitoring protocol that will help build the evidence base for future projects.

The NWSP has identified the key role of the private and third sector in supporting the development of NBS at scale. The third sector is able to help de-risk investment programmes that the private sector is less able to do. Beyond the private sector investing for financial return, organisation's corporate social responsibility budgets will be targeted to help fund specific conservation outcomes as part of the programme. There is also a requirement for upfront funding to cover the design and implementation of schemes before NN and BNG units can be sold as well as to cover the costs of management and maintenance of assets and the system itself.

NWSP has identified 227 potential actors that it could approach for funding such as British Sugar, Sainsbury's, Lidl and Britvic. Further investigation into new NBS such as for sewage treatment are being explored to attract further funding, from water companies, into the programme.

Marches Forward Environmental Investment Platform [\[15\]](#)

The Marches Forward Partnership is an initiative of four local authorities that straddle the English and Welsh border (Herefordshire, Shropshire, Powys and Monmouthshire). The partnership aims to address the challenges across the region and unlock investment in the area by leveraging the region's unique rural characteristics to deliver green growth.

The EIP is developing a framework and vehicle to attract private sector funding into the catchment to address climate change challenges that the region is facing. The partnership is setting up a *Smart Secretariat* that will lead the development of the platform. This will involve understanding key skills gaps, extensive stakeholder and investor engagement, necessary policy levers and development of appropriate value capture mechanisms.

The sources of funding that the partnership will target include public (local and central government), private investors (insurers, pension funds, asset managers, banks, impact investors) and philanthropic sources (corporate, foundations).

The mechanisms used by the partnership could range from a *Green Investment Zone*, using blended and bundled investment, setting up a specific fund, creating a special purpose vehicle (SPV) or joint venture (JV) or encouraging direct investment.

Warwickshire Avon Water Fund [\[16\]](#)

The Nature for Water partnership between TNC and Pegasys consulting is aiming to develop investment into the Warwickshire Avon catchment. Working with Warwickshire Wildlife Trust (WWT), Warwickshire County Council, Severn Trent Water and the EA, they are aiming to scale NBS adoption in the catchment to enhance water resilience by taking a coordinated approach at the catchment scale. They are in the process of identifying new funding sources and mechanisms and are developing a business case that will bring existing analysis into a proposition for investors.

Appendix F2

Working Group Terms of Reference

A draft summary of the Terms of Reference is shown below, these should be co-developed with the required stakeholders at the inception of the working group.

1. Define Purpose

The purpose of the Funding and Finance (F&F) working group is to effectively plan, coordinate and manage the stakeholders and activities involved with providing sufficient and sustainable F&F to deliver the CRS programme. This will need to align with the Scale of Ambition (recommendation 2).

Up to when the CRS is produced it will be concerned mostly with setting up the required governance, roles, processes and engagement.

2. Membership

The membership of the working group should include representatives from across the catchment who will be involved in engaging, unlocking, delivering and managing F&F of the CRS. This should include EA (CRS leadership, area representatives, funding team), NRW,

Up to when the CRS is produced the membership will grow and transition into a formalised resource for delivery and management of F&F.

3. Scope of activities

Define the scope of the group's activities. This will need to align with the Scale of Ambition (recommendation 2). Measurable KPIs for goals and activities will need to be set.

4. Roles and responsibilities

Define the roles and responsibilities of the membership in line with the scope of activities. This may change once the CRS has been developed.

5. Resources

Agree the resources provided by the membership in line with the scope of activities. This will need to be completed in conjunction with the capability assessment (recommendation 3).

6. Reporting

Reporting against progress will be key to measuring and demonstrating progress against goals (both internal and external). Requirement for the reporting will need to be defined in terms of content, regularity and the required data & information.

7. Review

The group will need to determine a regular review process in line with the reporting process. This will inform updates to group activities, membership and goals.

Appendix F2

Recommendations and actions

Table F2.1: The Summary of our recommendations to improve funding and finance capability and processes.

Recommendation	Implementation Actions & Examples	Category
F1. Create a F&F working group Immediate Action EA to lead	- Develop the governance model of the working group. The working group would likely sit within the AP Advisory Group (see Governance Recommendation 3) - This could range from formally joining an existing organisation/partnership e.g. Marches Forward, developing a relationship with existing bodies or developing its own approach in isolation from other bodies. - Co-develop terms of reference (see Appendix for example) however this will be dependent on F2 and outcomes of other recommendations. - E.g. Marches Forward are creating a <i>Smart Secretariat</i> to coordinate funding and financing for their Environmental Investment Zone - E.g. . Norfolk Water Strategy Programme (NWSP) has convened partners from local council, water companies and NGOs to develop its <i>Norfolk Water Fund</i> (see case study for more detail)	Working groups 
F2. Establish scale of ambition Immediate Action EA to lead	- The working group should determine its approach and ambition to attracting new funding and finance. This may evolve over time as process and capability assessments are carried out (F3 & F4) and as the funding and finance landscape evolves. - Determine the types of funding and finance that will be targeted and necessary to match scale and outputs of CRS. - Set and establish KPIs to track progress. - Share scale of ambition with stakeholders and partners to begin developing beneficial relationships and knowledge sharing e.g. Norfolk Water Strategy Programme (NWSP) have set up <i>The Norfolk Water Hub</i> which is a “collective action platform” which aims to disseminate, connect and influence delivery and adoption of NBS. - Publish materials that can show the development of the approach, the evidence base and business case for investment (e.g. a prospectus for investors) so that trust and buy-in from stakeholders can be developed.	Working groups 
F3. Identify required process changes Immediate Action Opportunity to partner	- Understand the requirements to develop an investable vehicle for private sector investment to be channelled into the catchment. It is unlikely that the EA, as an Non-departmental Public Body (NDPB), will be able provide or deliver this in isolation without creating or supporting a new entity. The EA would still need to be able to regulate (or even prosecute) such an entity so would need to remain clear of conflicts of interest. E.g. NWSP are setting up the <i>Norfolk Water Fund</i> which is the delivery vehicle for the programme. The exact legal and governance framework is to be finalised but significant engagement with key funders and delivery partners will be required. - Identify processes required to unlock new F&F mechanisms e.g. markets and incorporate into EA ways of working as well as future AP requirements. - Determine how externally funded projects can fit with existing EA governance and business case processes or whether these will be required to be updated to incorporate private sector funding.	Processes 
F4. Assess current and required capability Immediate Action Opportunity to partner	- Depending on the make-up and remit of the working group and the EA’s role, determine what internal resourcing and capability is needed to unlock F&F such as stakeholder and investor engagement, legal, process development, increased commercial and procurement functions etc. - Understand where changes are needed. This should include what is required to support F&F and linkages between what is needed for AP and other parts of the EA (e.g. Future Funding Team) should be drawn. - Determine what resources other River Severn stakeholders have e.g. RSP, NRW and wider catchment to support F&F activities e.g. attracting and managing F&F.	Capability 

Appendix F2

Recommendations and actions

Table F2.2: The Summary of our recommendations to improve funding and finance capability and processes.

Recommendation	Implementation Actions & Examples	Category	
F5. Map existing policy landscape and identify opportunities to support policy development • Immediate Action • EA to lead	• Understand current policy landscape for developing and implementing green finance sources and mechanisms. • Identify potential new policy opportunities to develop sources and mechanisms e.g. BNG emergence in Wales, SuDS adoption for England, benefits stacking. • Particular emphasis should be placed on developing new policy and evolving existing policy that can enable cross-border funding and delivery of schemes between Wales and England.	Policy	
F6. Map and engage key stakeholders • Immediate Action • Opportunity to partner	• Significant mapping and engagement with potential partners and investors will be required. This could include private sector investors (e.g. supermarkets, insurers), developers), philanthropic organisations, eNGOs, impact investors, development banks, utilities (e.g. opportunities through the advanced-WINEP programme), local councils. • E.g. NWSP have identified 227 potential private sectors actors that could be approached for engagement. • There will likely be a significant lead-time to attracting investors and so this process should be started as early as possible to allow the level of secured funding to ramp up in time for the start of delivering the CRS. • Monitor wider private investment into the catchment and engage with those investors already investing.	Stakeholder engagement	
F7. Map, engage and support existing projects • Immediate Action • Opportunity to partner	• Identify schemes that can be used as pilot schemes to test various market mechanisms and enable the development of novel processes. • Compile a robust base of evidence from within the catchment as well as global best practice. • Beyond FRM opportunities it will be critical to engage with programmes that are looking to deliver other benefits such as nutrient neutrality, biodiversity net gain and other climate or resilience drivers. This will enable funding to be pooled more effectively and generate a more investable proposition to deliver change at scale. • Engage with existing local projects e.g. Marches EIZ, that illustrate novel funding and financing mechanisms and understand what further support they might need or could have benefited from. Begin to support these projects so that influence on CRS can be realised. • Engage with existing national projects e.g. Landscape Scale Recovery projects such as Weald to Waves, and associated funders, that illustrate novel funding and financing mechanisms to understand what strategies are being developed by other organisations. Engage with other APP projects e.g. Thames 2100 to share learnings.	Project engagement	
F8. Formalise F&F team and grow capability to begin attracting funding • Post CRS Action • EA to lead	• By the time the CRS is being implemented a robust F&F team and delivery vehicle (in whatever form was agreed) needs to be in place so that funding can be secured and schemes can be delivered as soon as the strategy is developed. There will need to be a level of committed funding to begin delivering schemes but also provide a proof of concept for new investors to be attracted to the approach. • The governance and legal framework will need to be defined and agreed by the working group. • Develop internal resources, skills and capacity to ensure the EA can engage with projects to deliver on targets e.g. engage staff in relevant training, strategic hiring of experts with private sector funding experience.	Working groups Capability	

Appendix F2

Recommendations and actions

Table F2.3: The Summary of our recommendations to improve funding and finance capability and processes.

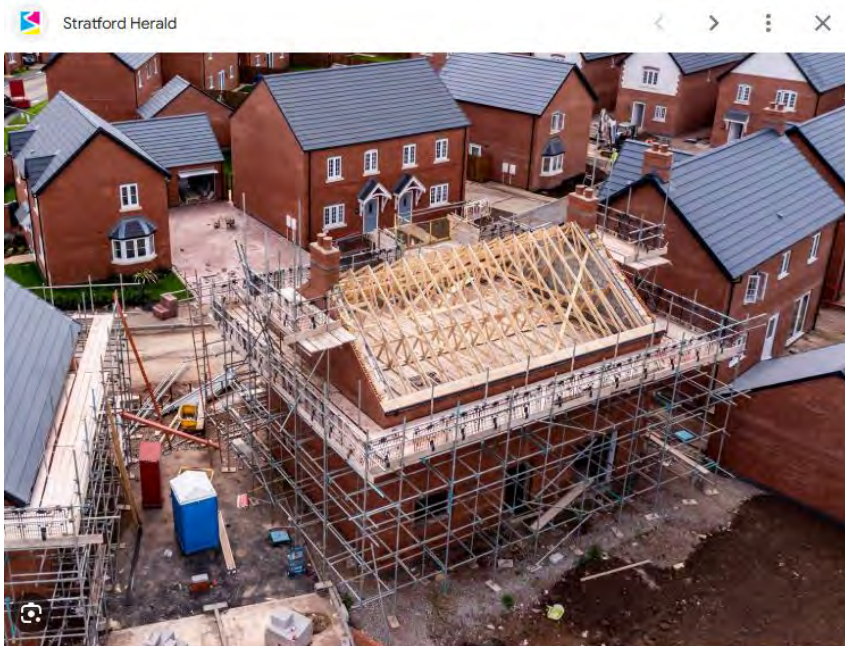
Recommendation	Implementation Actions & Examples	Category
F9. Build portfolio of projects and develop investment prospectus • Post CRS Action • Opportunity to partner	• Develop and support pilot projects funded through the most promising funding and financing mechanisms identified through the working group and wider roadmap stages. • Take learning opportunities from initial projects to apply to future pipeline or to adjust processes. • Compile a portfolio of projects and an investment prospectus demonstrating the business case for success. • Identify where projects can be bundled into significant investment opportunities as the funding pool grows.	Project engagement 
F10. Develop and grow investor and stakeholder pool • Post CRS Action • Opportunity to partner	• Develop and grow investor and stakeholder pool as the number of successful schemes grow. • Continue to develop relationships and routes to market for investors and stakeholders. Explore new stakeholders and investors who maybe able to benefit from investing in the catchment.	Stakeholder engagement 
F11. Influence and develop supportive policy • Post CRS Action • EA to lead	• Develop policy that supports the implementation of adaptation pathways and engage with national and local policy makers to provide input into existing and future policies. • Contribute to policies that also impact funding and financing or have implications on it, (e.g. engage with the British Standards Institute in their nature markets standardisation piece, e.g. collaborate with insurance companies to use revenue from selling home insurance to customers, ensuring funds go to the nearest catchment-based project). • Particular emphasis should be placed on developing new policy and evolving existing policy that can enable cross-border funding and delivery of schemes between Wales and England.	Policy 

Appendix F3

Policy

Objective

Appendix F3 identifies the importance of policy enablers to adaptation pathways and the Severn 2100+ region. It describes a series of policy enablers that underpin the successful, and timely delivery of adaptation pathways. Our recommendations are underpinned by other recent reviews of the FRM sector (e.g. National FCERM Strategy for England, National Infrastructure Commission Wales: Managing Flood Impacts in Wales 2050), consultation with planning and policy experts, and engagement with the RSP.



SDC overruled after rejecting “overly cramped” development for 109 homes
Figure F3.1: Cramped housing development [14]

Visit >

Appendix F3

Recommendations

The table below outlines our policy-related recommendations, with tangible next steps that the EA and regional partners could take forward enable action.

Table F3.1: Policy recommendations.

Policy Enabler	Immediate next steps	Programmed date		
		Short-term	Medium-term	Long-term
P1. Spatial planning reforms: Spatial planning policy reforms are a primary enabler to mitigating future flood risk through considering land-use and influencing the spatial location of development.	- RSP & the EA to explore how FRM and local / regional spatial planning can align to enable resilient growth. Consider how Local Authorities can align their draft local plans to the regional CRS and adaptation pathways - Identify supporting information required from the EA to influence spatial planning			
P2. Alignment of strategies and plans: Systematically integrate land-use planning around Local Nature Recovery Strategies (LNRSs) with FRM to co-deliver environmental and FRM benefits.	- EA and relevant responsible authorities should explore how LNRSs can support FRM ambitions. They should identify how they can offer co-benefits to FRM for the region. - EA and RSP to consider the integration / alignment of broader regional plans and how they can be influenced to support FRM ambitions.			
P3. Funding & financing: Long-term, robust funding & financing is required to enable action. Alternative mechanisms need to be mainstreamed to enable widespread delivery of FRM portfolios (incl. NFM).	- EA and SVWMS Partners should build on ongoing funding and financing work for the SVWMS and explore how the findings can be broadened across the region - Collate learning from others and case studies (e.g., Thames 2100, EnTrade), bringing them together into a learning playbook which support regional decision-makers			
P4. Flood resilient housing reforms: Requiring flood resilient measures to be incorporated into homes within certain risk areas.	- EA to review and determine opportunities around influencing policy around flood (or water) resilient homes – including what thinking has been undertaken to date in the EA. - Depending on the above, the EA could identify the range of flood resilient building standards that could be incorporated into the region and where requirements for flood resilient homes could apply			
P5. Information sharing: Accessible and more bespoke information and early warning systems enabling communities to be acutely aware of imminent risks so that they can prepare accordingly.	- EA and the RSP to explore how regional collaboration and information sharing could be improved to: - Inform more localised flood risk dissemination information - Inform bespoke early warning systems - Facilitate a shared evidence base around flood risk and actions being undertaken in response			
P6. Governance: Policy / legislation which drives integrated catchment management across diverse managing bodies and enables a joined-up, streamlined response. This needs to consider how trade-offs and decisions around future land-use will be made.	- EA and RSP to trial integrated catchment management through the SVWMS. Learnings should be captured and shared regionally to influence broader schemes across the catchment. - EA and RSP to start to consider how decisions involving trade-offs can be made (e.g., decisions around how land is utilised across the catchment). This should include identifying who needs to be involved and the information that might be required to make a decision.			

Appendix F4

Behaviour

Objective

Appendix F4 considers the behavioural changes that are required to enable the successful, and timely delivery of adaptation pathways. Our recommendations are underpinned by other recent reviews of the FRM sector (e.g. National FCERM Strategy for England, National Infrastructure Commission Wales: Managing Flood Impacts in Wales 2050), and engagement with the RSP.

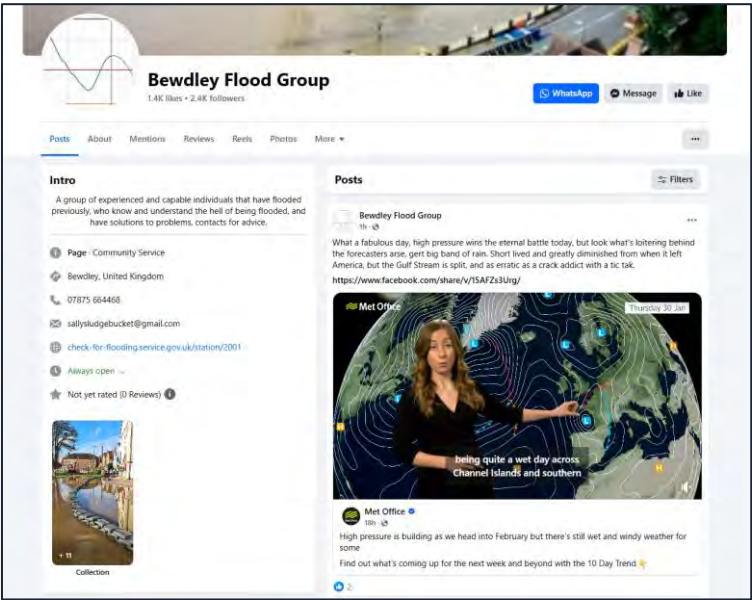


Figure F4.1: Bewdley Flood Group, Facebook.

Appendix F4

Recommendations

The table below outlines our behavioural-related recommendations, with tangible next steps that the EA and regional partners could take forward enable action.

Table F4.1: Behavioural recommendations.

Behaviour Enabler	Immediate next steps	Programmed date		
		Short-term	Medium-term	Long-term
Community Engagement	B1. Undertake effective community engagement: Improved community engagement enables the uptake of further behavioural change to respond to FRM.			
	B2. Understanding of roles & responsibilities: improved personal awareness around which agencies / individuals are responsible for various FRM practices			
Flood Communications	B3. Improved flood risk awareness: Improvements in communications around how the public can access what their level of flood risk is to inform how they prepare for flood events.			
	B4. Improved communication of flood risk and warnings: Improves and expands on existing flood risk information and warning systems by offering accessible and more bespoke information and early warning systems, that meet the individuals preferred communications style.			
Personal & Community Resilience	B5. Personal Resilience: Through education and campaigns, there is a shift in public perception and behaviour. Communities understanding how to 'live with flooding' and adapt to a changing landscape impacted by climate change.			
	B6. Community Ownership of FRM: Enable community resilience and individual action to manage flood risk through participatory and place-based approaches including the development of community flood resilience plans.			

Appendix F5

Stakeholder Engagement

Appendix F5 identifies stakeholder engagement needs to support the development and implementation of adaptation pathways across the Severn 2100+. As part of this section, we have considered:

- A review of the relevance of stakeholder engagement including specific relevance to the Severn region.
- An overview of engagement undertaken across the catchment to date, and the insights developed.
- The development of a stakeholder engagement plan which describes a proportionate approach for developing pathways across the region.

Appendix F5

Developing our approach to stakeholder engagement

Our approach to engagement for development of adaptation pathways

An extract of the engagement plan is outlined below. Please contact the EA West-Midlands to access the full Engagement Strategy and Plan developed for a regional strategy.

Approach

To develop an engagement plan for the CRS, a stakeholder mapping exercise was undertaken to identify the relevant groups and their level of interest/influence to place them into a stakeholder classification - see Figure F5.1.

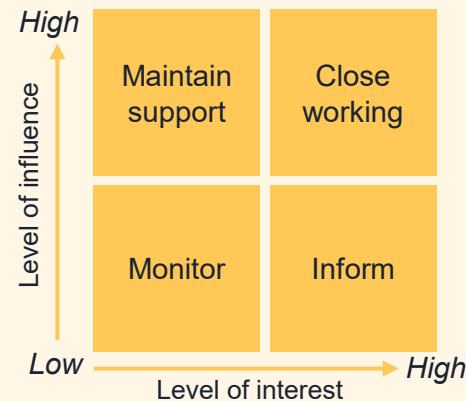


Figure F5.1: EA engagement classification matrix

Based on the stakeholder mapping, engagement objectives, activities and timescales were identified for each stakeholder group. Through engagement with the EA, this was developed into a programme which would sit alongside the development of regional adaptation pathways. Measures of success were then identified to measure the successful implementation of the plan and achievement of the original engagement objectives. The full stakeholder engagement plan with timelines is available in the CRS Engagement Plan document.

Key groups we are engaging with

The proposed stakeholder groups and form of engagement is shown in the table below. For a more detailed breakdown of engagement activities with specific stakeholders, see the CRS Engagement Plan.

Table F5.1: Key groups and stakeholders

Group	Organisations in the Group	EA classification	Activities
RSP	RSP partners, Senior Leadership Group	Close working	Sub-catchment focused workshops, 1-2-1s: to seek agreement on key matters in the catchment.
NRW	Natural Resource Wales and Welsh Government (if interested)	Close working	
Wider EA	Senior Leadership in the EA and local area managers	Close working	Workshops: to seek agreement on key matters and progress APP development.
Political advocates	MPs and councilors in the River Severn Region	Maintain support	MP caucus, councillor meetings: to update stakeholders and provide feedback.
Interest groups	Organisations and groups across agriculture, infrastructure & development, environment & heritage, community and resilience, and business	Inform & Monitor	Focus groups with organisational representatives: to discuss the APP and provide feedback.
Communities	Local communities across the River Severn region	Inform & Monitor	Citizens panel: to provide feedback and recommendations.
Sustainability Appraisal Groups	Natural England, Historic England, EA, NRW, Cadw	Inform & Monitor	Specific consultation process: to provide feedback on the sustainability appraisal.

Appendix F5

Engagement plan

The table below outlines the engagement programme over 2025 and 2026, including the major activities and relevant focus topics. For a detailed version of the engagement programme, see the CRS Engagement Plan.

	2025: Apr to Jun	2025: Jul to Sep	2025: Oct to Dec	2026: Jan to Mar	2026: Apr to Jun	2026: Jul to Sep	2026: Oct to Dec
RSP	Workshops: • Mobilisation • C&A		Workshops: • Sub-catchment priorities • Risks & opps	Workshops: • Adaptation actions		Workshops: • Developing pathways	Workshops: • Pathway selection • Implement M&E
EA & NRW	Including NRW EA senior leadership meeting		Including NRW EA senior leadership meeting	Including NRW EA senior leadership meeting		Including NRW EA senior leadership meeting	Including NRW EA senior leadership meeting
Political advocates	MP caucus: AP introduction Councillor meeting: AP introduction			MP caucus: Progress update Councillor meeting: Progress update			MP caucus: Progress update Councillor meeting: Progress update
Sustainability appraisal					Sustainability appraisal feedback: Stage 1		Sustainability appraisal feedback: Stage 2
Interest groups				Focus group: Sub-catchment priorities, risks & opps	Focus group: Adaptation actions, emerging pathways	Focus group: Pathways, implementation	
Community		Citizen Panel: Recruitment	Citizen Panel: Engagement programme & approach	Citizen Panel: Sub-catchment priorities, risks & opps	Citizen Panel: Specific issues for feedback		
All stakeholders	Website, newsletter, social media: Intro to project		Website, newsletter, social media: Progress update				Website, newsletter, social media: Progress update

Appendix F6

Data & Information

Objective

Appendix F6 considers data and information needs to support the development of adaptation pathways across the Severn 2100+ region. It identifies the information that has informed the APP to date, alongside key recommendations for future studies and any key gaps.



Figure F6.1: Collation of ongoing projects and datasets across the River Severn catchment at an RSP workshop in autumn 2023.

Appendix F6

Overview and Insights

The table below provides a summary of the data & information utilised throughout the AP. We have drawn out specific insights, findings, and recommendations associated with each chapter.

Table F6.1: Key overviews and finding from Severn2100+.

Chapter	Data & Information Overview	Insights, findings, and recommendations
Context & Ambition	There are multiple spatial datasets utilised (GIS layers) to inform the strategic context of the Severn catchment including layers such as flood zones 2 & 3, land use, agricultural land use classification, national receptor datasets, etc.	- A large number of data-sets were accessible, which enabled us to develop a comprehensive understanding of the catchment across various lenses. This informed a picture of key receptors at risk across the catchment - Layers that had to be requested through NRW took significant processing and approval time, leading to placeholders in initial versions of chapter deliverables RECOMMENDATION D1: Collate and track ongoing projects and project data to promote catchment-wide cooperation, data sharing, and encourage the update of adaptive thinking.
Risks & Opportunities	Growth: Growth projections included the collation of ONS population trends by LSOA boundary, compared to a review of the local plans and local development plans across the region. Flood risk & climate change: The collation of local hydraulic models represented future hazards across the focus areas under two possible climate change futures.	- Census data was readily available which provided a picture of population growth. However, determining local development plan growth projections was challenging as projections are split across 25+ plans, i.e. there is not regional picture of growth. - Additionally, local / regional planning processes and associated growth projections have shifted significantly since the new government has come into power RECOMMENDATION D2: Develop a workspace to aggregate local plans and local development plans to inform future catchment development projections. Engage consistently with local authorities to identify areas earmarked for development to help inform FRM-decision making. - Climate change uplifts were not consistent across available models requiring additional time and resource for expert input around which extents correspond to each climate change scenario - Substantial resources were required to 'stich' together local modelling outputs to inform risks & opportunities - We only used models that have been previously developed and currently available for use, with the anticipated release of NaFRA2, additional work is required to determine if it is fit for purpose to inform pathway development and decision-making. RECOMMENDATION D3: Review NaFRA2 data when available and identify how this may support the development of adaptation pathways.

Appendix F6

Overview and Insights

Table F6.2: Key overviews and finding from Severn2100+.

Chapter	Data & Information Overview	Insights, findings, and recommendations
Adaptation Actions	Opportunity mapping informs where adaptation actions and portfolios are applicable across the catchment. The opportunity maps for the two focus areas were developed utilising different approaches, a data-driven approach in the Upper Severn (aligning to the SVWMS) and an expert-driven approach in the Warwickshire Avon.	- Data-driven enabled a better understanding of scale of opportunities and performance. - However, we were still able to determine opportunities through local expertise, enough to inform the development of pathways. RECOMMENDATION D4: Undertake detailed catchment-wide opportunity mapping to understand the scale of feasibility across all portfolios.
	Portfolio performance determines the scale and type of adaptation actions that are required to mitigate peak flow uplifts aligning to high and low climate change future projections.	- The portfolio performance for the Upper Severn focus area was largely lifted from the ongoing SVWMS as they had run an aggregate storage model to assess the peak flow mitigation potential of implemented adaptation actions. - The portfolio performance for the Warwickshire Avon focus area was based on expert opinion, results from recent / ongoing schemes, and broad assumptions. RECOMMENDATION D5: Develop targeted modelling to assess the performance of adaptation actions.
Adaptation Pathways	The development of the emerging pathways was underpinned by mitigating projected peak flow uplifts by the performance outlined by the adaptation actions.	- This approach enabled the rapid development of pathways in a workshop setting - This approach resulted in a series of static pathways that have been stress-tested against future trends (i.e. growth and climate change) RECOMMENDATION D6: Undertake targeted modelling of the pathways to inform sequencing and overall performance of the pathway.
Monitoring & Evaluation	Successful monitoring and evaluation of the pathways is underpinned by gathering data on the indicators set out in the discovery and design report.	- The ToC provided a comprehensive framework indicators could be defined against - Indicators and the data required to measure them is applicable across the region, but triggers and thresholds are dependent on the characteristics of each catchment RECOMMENDATION D7: Create a live M&E database that is available to support the M&E framework.
Benefits Toolkit	The proof-of-concept Benefits Toolkit supported appraisal of pathway outcomes across ten wider benefits, drawing valuations and methodologies from sector best practice.	- The Benefits Toolkit enabled a rapid assessment of benefits associated with the adaptation actions. This was feasible even in a data-scarce catchment, helped by the combination of qualitative and quantitative metrics. - There are gaps in information, which further analysis of interventions should support. RECOMMENDATION D8: Develop methods to evaluate adaptation pathways benefits under a range of scenarios.

If you have any questions relating to the content in this report, please
email: enquiries@environment-agency.gov.uk

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