Lessons for Municipal Flood Risk Management from Major Flood Programs

In The kNOW Webinar
October 25, 2022

Jacobs

Challenging today.
Reinventing tomorrow.

Agenda

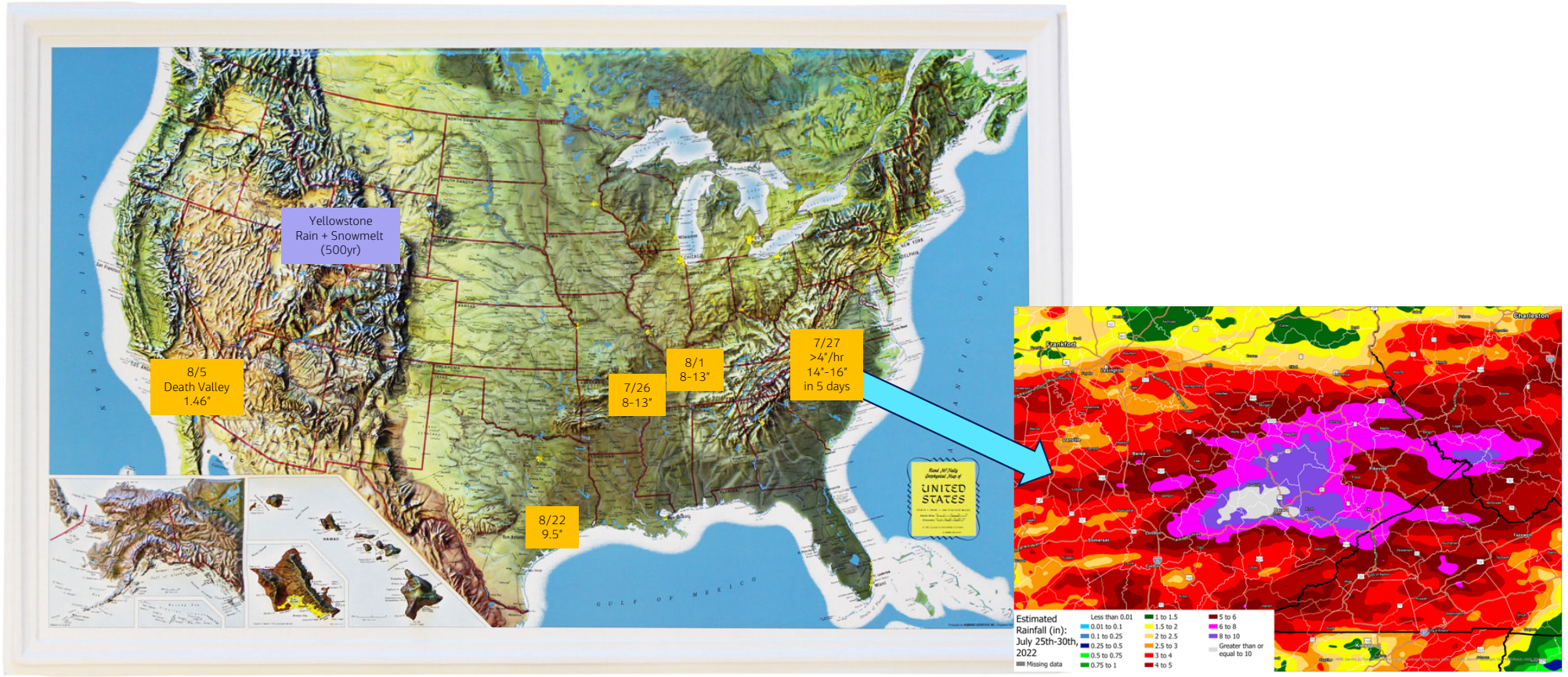
- **Intro and Overview**
  Elise Ibendahl, Jacobs, Global Technology Lead, Flood Modeling and Planning

- **Oxford to Cambridge Arc Flood Risk Investment**
  Ceri Lewis, Environment Agency Oxford-Cambridge Arc Team, Programme Manager
  Joe Clarke, Jacobs, Associate Director of Hydroinformatics, Water Catchment Management – Bristol

- **Central Valley Flood Protection Plan – California's Strategic Blueprint to Improve Flood Risk Management in the Central Valley**
  Kris Tjernell, California Department of Water Resources, Deputy Director for Integrated Watershed Management
  Armin Munévar, Jacobs, Global Technologist, Climate Resilience, and Integrated Water Resource Management

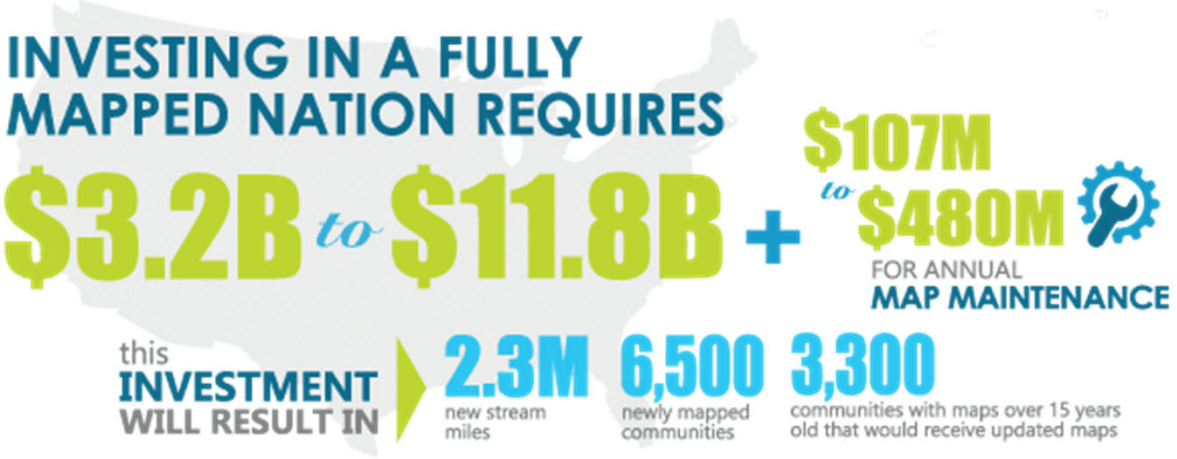
- **Q&A**

Five 1,000-year Rain Events Struck the US in Five Weeks this Summer



What Are We Using to Assess Vulnerability?

- Since 1969, the US has invested $6.6B in flood hazard mapping, resulting in $22B in losses avoided.
  - But only 1/3 of the nation's streams have currently been mapped
- Current regulatory maps in the US do not take climate change into account.



What about Urban flood maps?

CNT (2014) found that when all types of flood insurance claims are aggregated, some Cook County ZIP codes with the highest concentration of payouts *have no land within federally designated floodplains.*

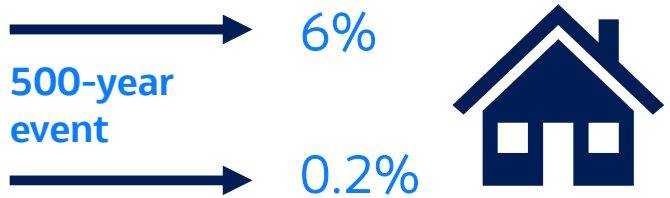
Source: Flood Mapping for the Nation, ASFPM Foundation (2020)

Consider Planning Horizons for Vulnerability Assessment

Are we fully appreciating the risks from flooding?

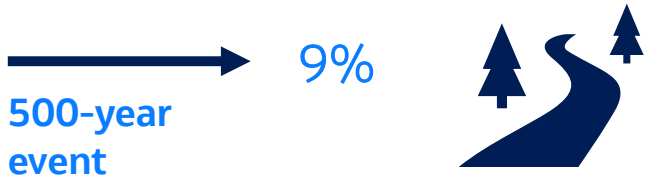
Example: A 30-year mortgage for a home in a new development

- Probability that a 100-year event will occur at least once over 30 years = 26%
- Probability that a 100-year event will occur at least twice over 30 years = 4%



Example: Transportation infrastructure with a 50-year design life

- Probability that a 100-year event will occur at least once over 50 years = 40%



The Value of Resilience? … It depends on the system and can be estimated to justify and prioritize investments. Typically, $4-$11 benefit per $1 invested

- Benefit of resilience can be measured in many ways:
  - damages avoided
  - business losses avoided (traffic interruption)
  - Social impacts
  - Environmental impacts
  - Financial impacts (bond ratings, insurance rates)

- $4 to $11 saved on average per $1 invested in Hazard Mitigation

	ADOPT CODE	ABOVE CODE	BUILDING RETROFIT	LIFELINE RETROFIT	FEDERAL GRANTS
Overall Benefit-Cost Ratio	11:1	4:1	4:1	4:1	6:1
Cost ($ billion)	$1/year	$4/year	$520	$0.6	$27
Benefit ($ billion)	$13/year	$16/year	$2200	$2.5	$160
Riverine Flood	6:1	5:1	6:1	8:1	7:1
Hurricane Surge	not applicable	7:1	not applicable	not applicable	not applicable
Wind	10:1	5:1	6:1	7:1	5:1
Earthquake	12:1	4:1	13:1	3:1	3:1
Wildland-Urban Interface Fire	not applicable	4:1	2:1	not applicable	3:1

Source: "Natural Hazard Mitigation Saves: 2019 Report", National Institute of Building Sciences, 2019

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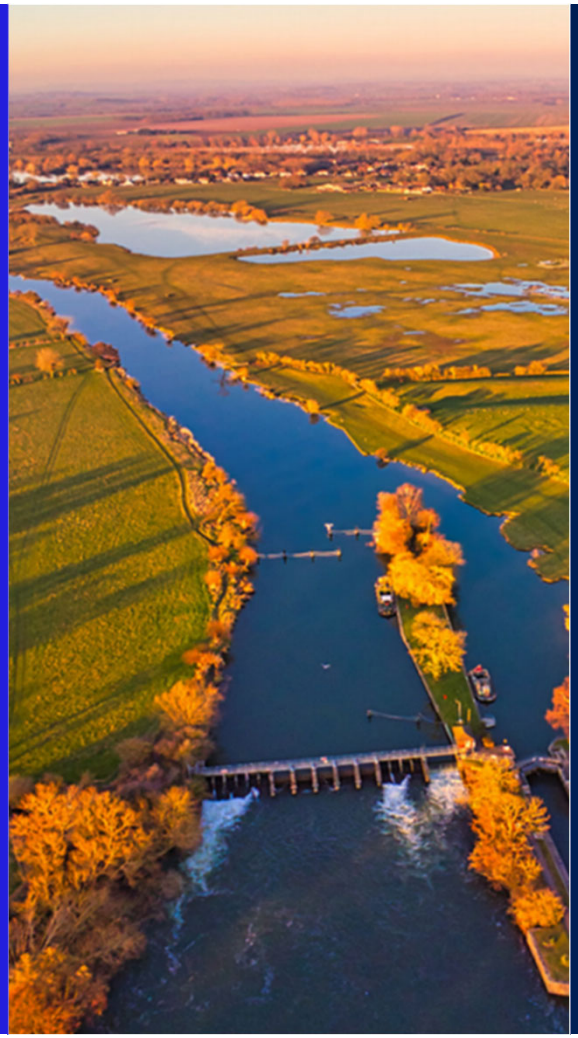
Environment Agency

OxCam Flood Risk Investment Study

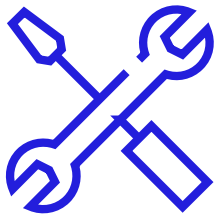
Oxford to Cambridge Arc

Flood Risk Investment Study



Why protect against flood risk?

- Avoiding property damages, interruption to businesses, research and education
- Avoiding loss of critical infrastructure
- Enhanced public safety and wellbeing
- Investments in flood risk infrastructure have traditionally yielded a benefit-cost ratio of 8:1
- There is often compelling economic evidence to invest in specific flood risk protection schemes where the risk exposure can be well-established, but also there are strong social benefits
- The usual approach flood risk investment is to target reducing the risk exposure



Why do we need to think adaptively?

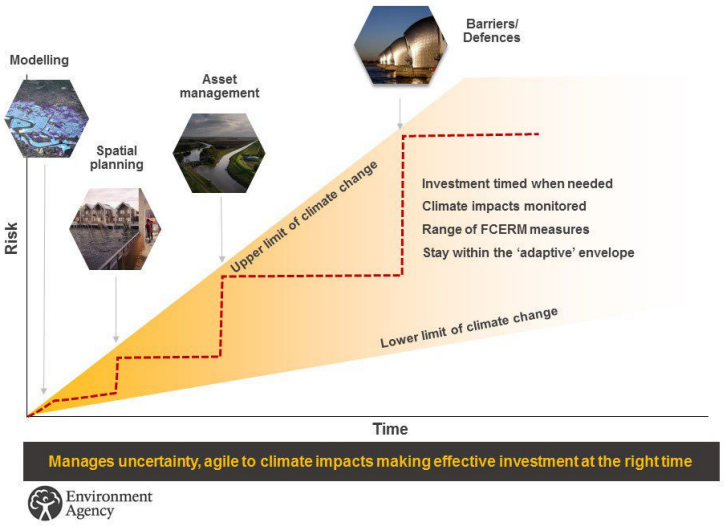
- But what if we want to plan further into the future?
- We don't want to fixate on a singular future scenario and focus our efforts on investing and planning around it, only to find that it is not realized
- There are two main causes of uncertainty when we think about future flood risk:

The Risk Source
Changed patterns of flooding, for example the affect that climate change will have on the frequency, duration and scale of flooding

The Receptors
The change to the human landscape, for example where and many new residential and commercial buildings will be built

The project opportunity

- The Environment Agency have an Adaptation Pathways Programme
- The purpose of this programme is to help the Environment Agency and other risk management authorities plan for and fund the right investment in flood and coastal resilience, at the right time, to achieve the maximum benefit for people and places
- In 2019, this programme was looking for case studies to ‘front run’ this approach



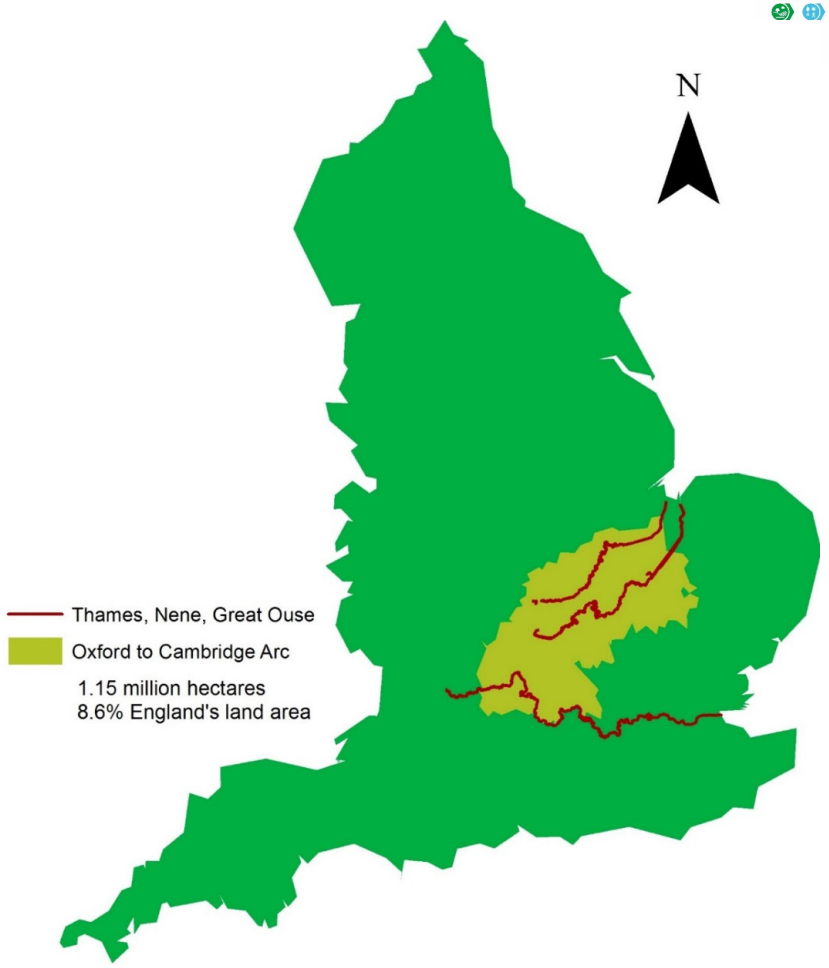
An **adaptive approach** to managing climate uncertainty

An adaptive approach builds the capacity to adapt from the outset. We are able to delay investment until it is needed and embed flexibility into our approach by planning for a range of future climate change scenarios. We are also able to consider other flood resilience tools above and beyond traditional flood and coastal defences. There are some limited examples of where we’re taking this approach, but we need to do more.

The project opportunity

- The **Oxford to Cambridge Arc** (OxCam Arc)
- It was identified by the British Government as an ideal location for accelerated growth over the next 50 years
- In response to this , the Environment Agency created a team dedicated to ensuring that we harness this growth to improve the environment

- This **EA OxCam Team** was given a mandate to test and trial different approaches
- The region has often suffered from flooding in the past, and with the proposed growth and expected climate change there is concern this will get worse



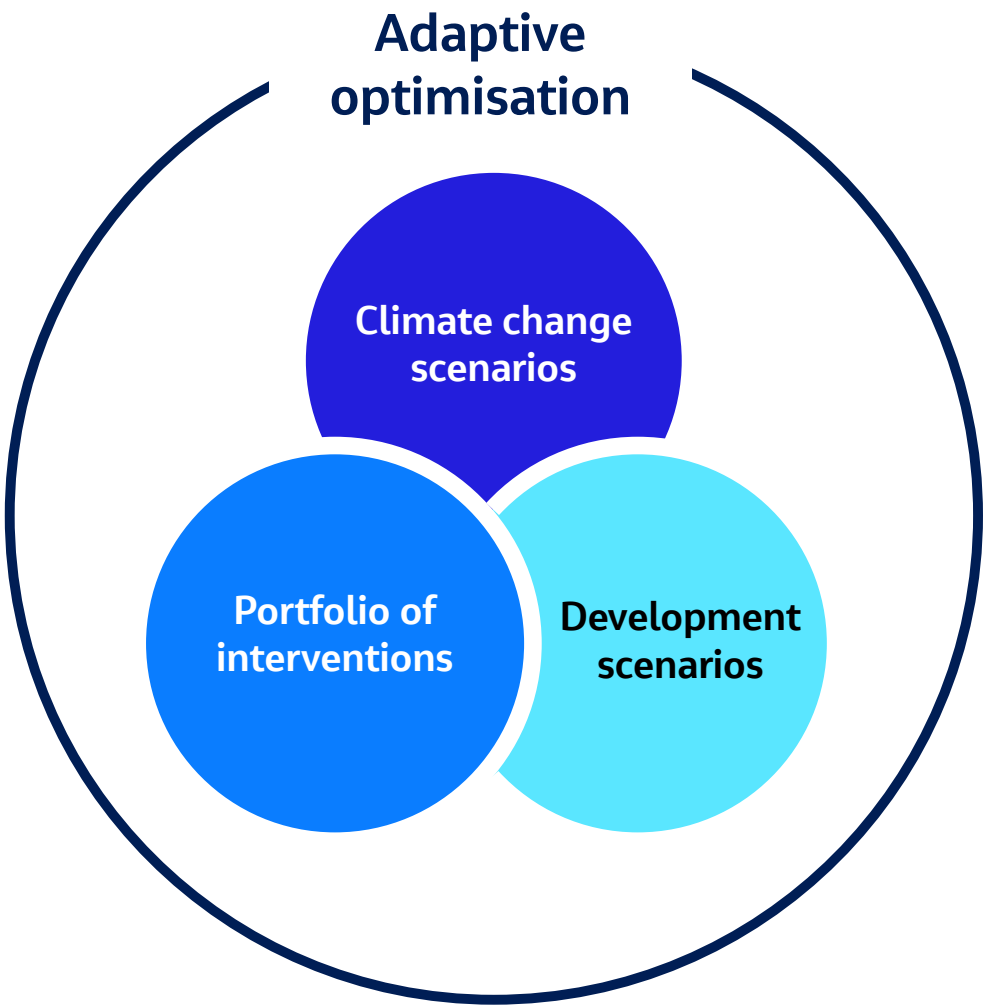
The project opportunity

- The project originates from two places:
  - The need for case studies for the Adaptation Pathways Programme to test and trial the approach.
  - The opportunity of using the 'test and trial' mandate within the OxCam Arc - in this case to build an evidence base which supports flood risk protection investments from a purely monetary viewpoint.

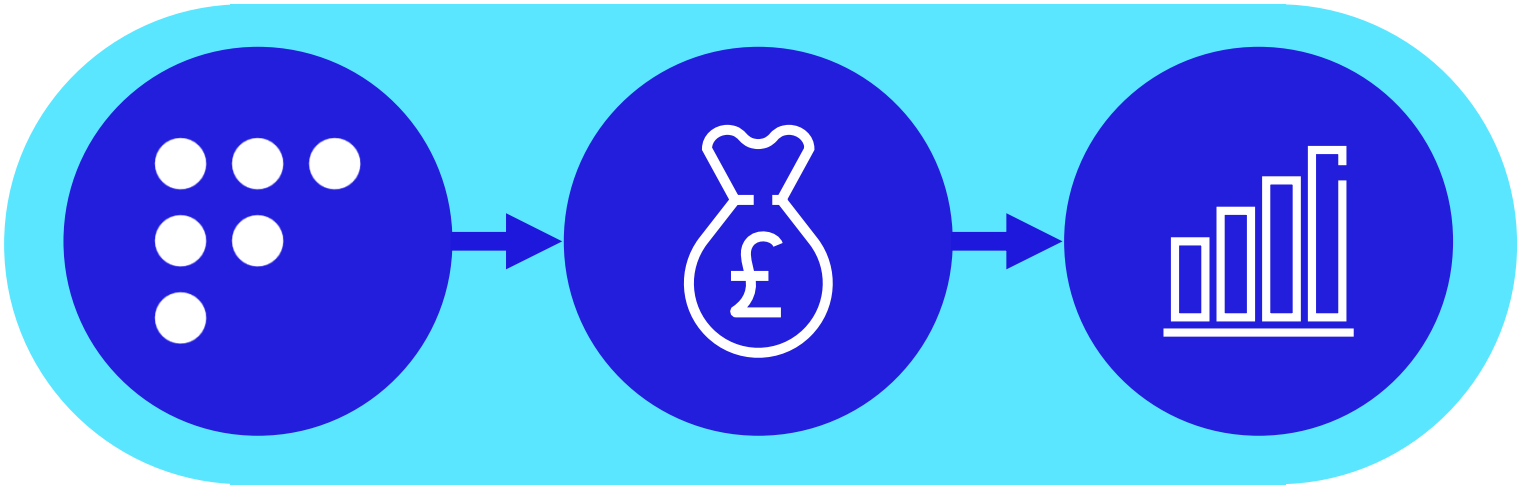
- Therefore, there were two distinct aims:

To identify the optimum level and timing of investment in flood protection in the Oxford to Cambridge Arc.

To learn from a study on this topic and this complexity to share learnings.


Adaptive optimisation
Climate change scenarios
Portfolio of interventions
Development scenarios

End-to-end spatial data management



Flood platform

Automated processes to build and run 45,000 flood simulations for over 700 models

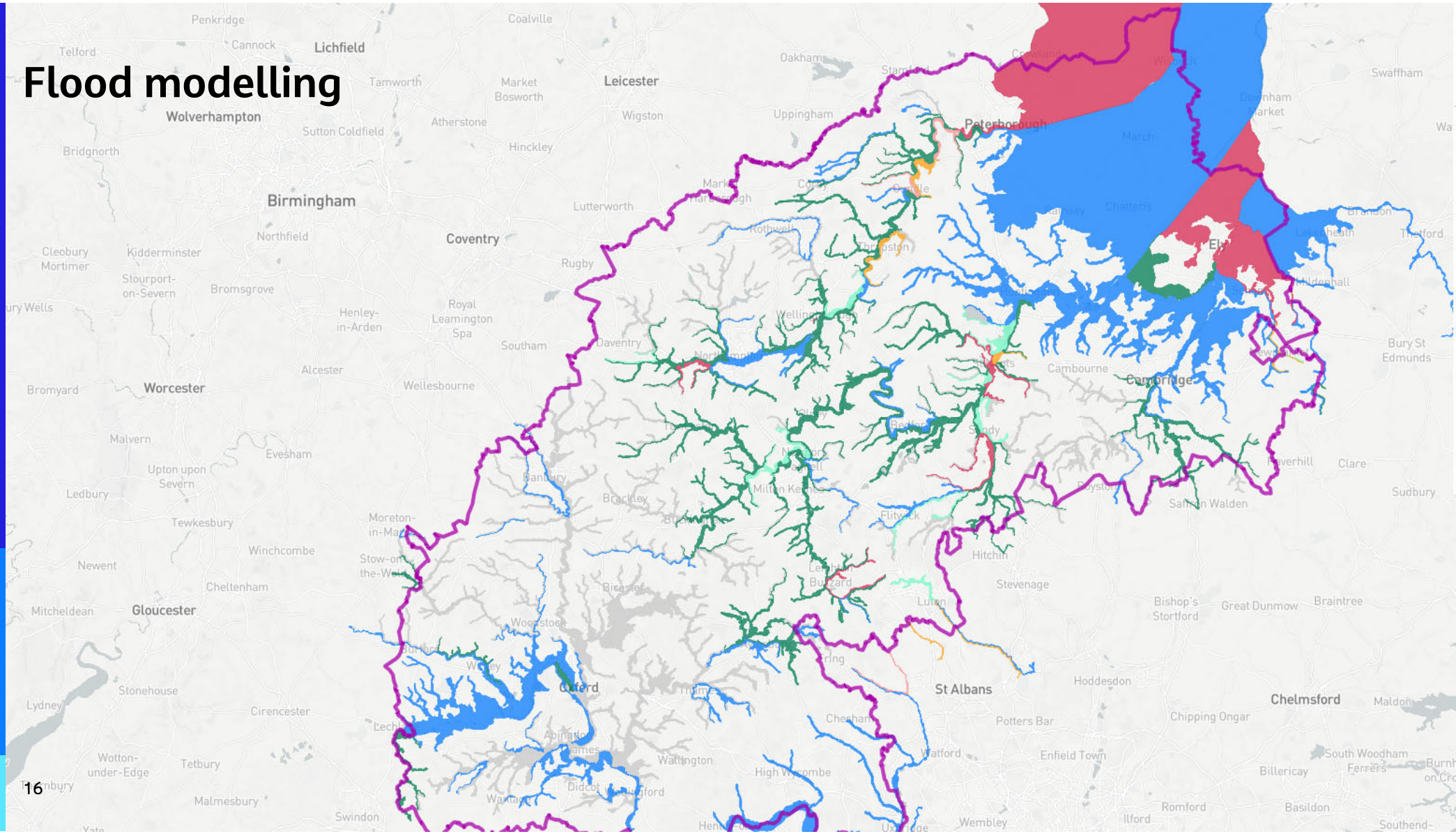
Economic analysis

Understanding flood risk under 27 futures representing uncertainty in climate change and future development

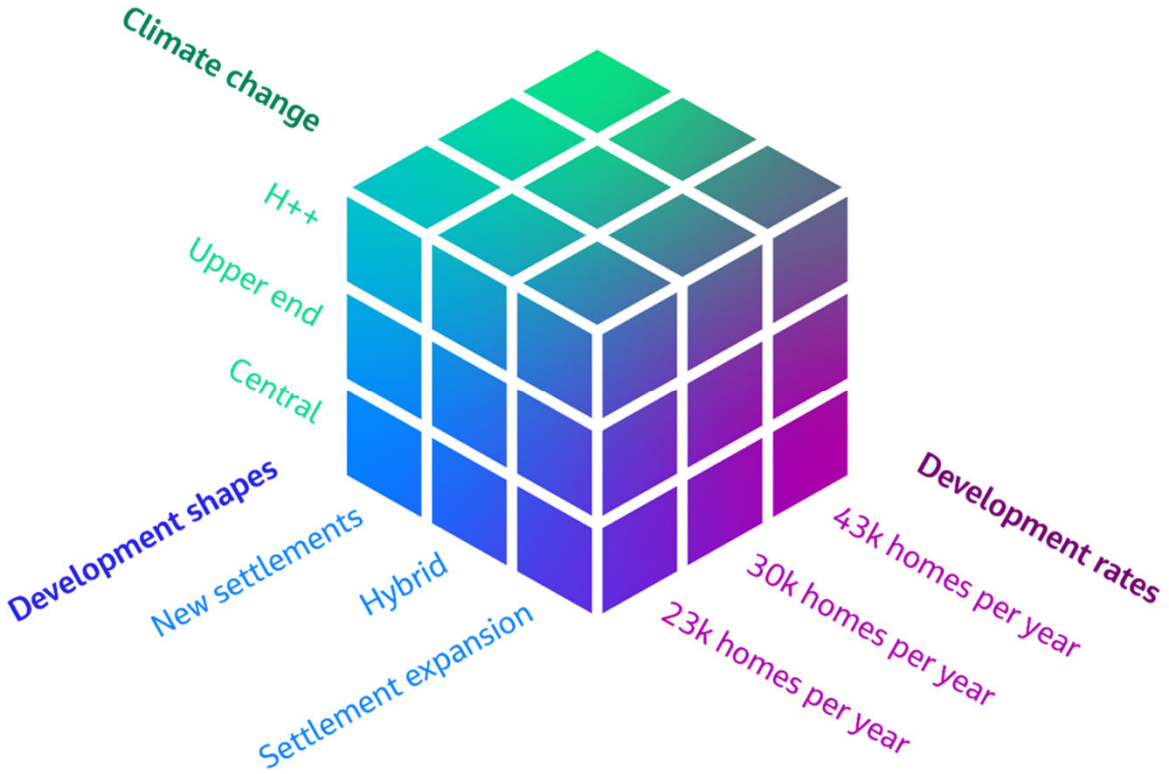
Optimisation

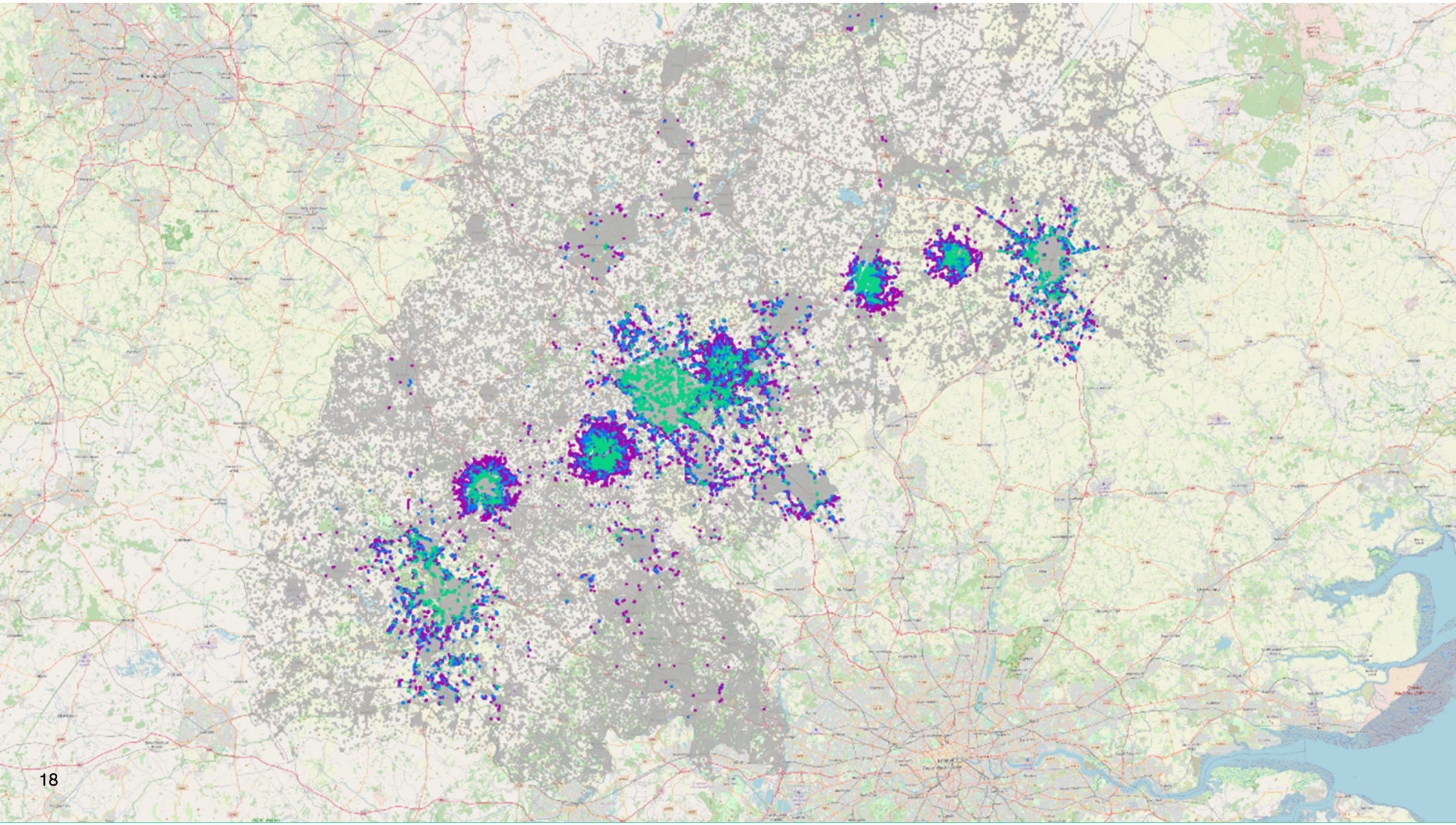
Optimising investment in a portfolio of catchment flood interventions to deliver robust resilience under the range of possible futures

Flood modelling



Future scenarios





Residential properties

Non-residential properties

Alternative accomodation

Mental health costs

Business continuity

Gross Value Added

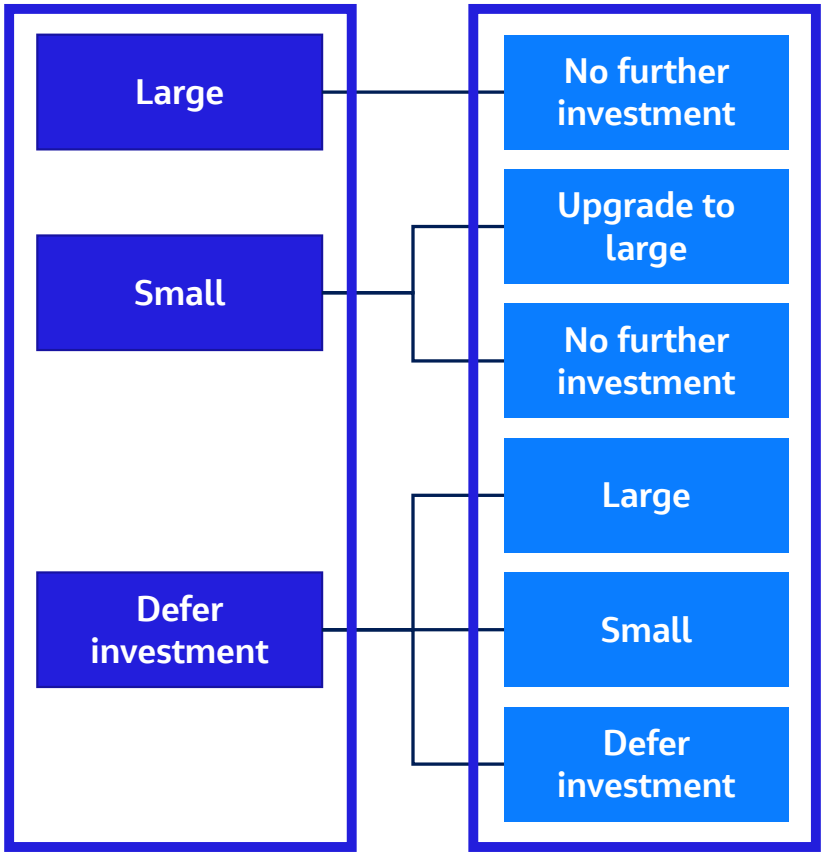
Traffic delays

Agriculture

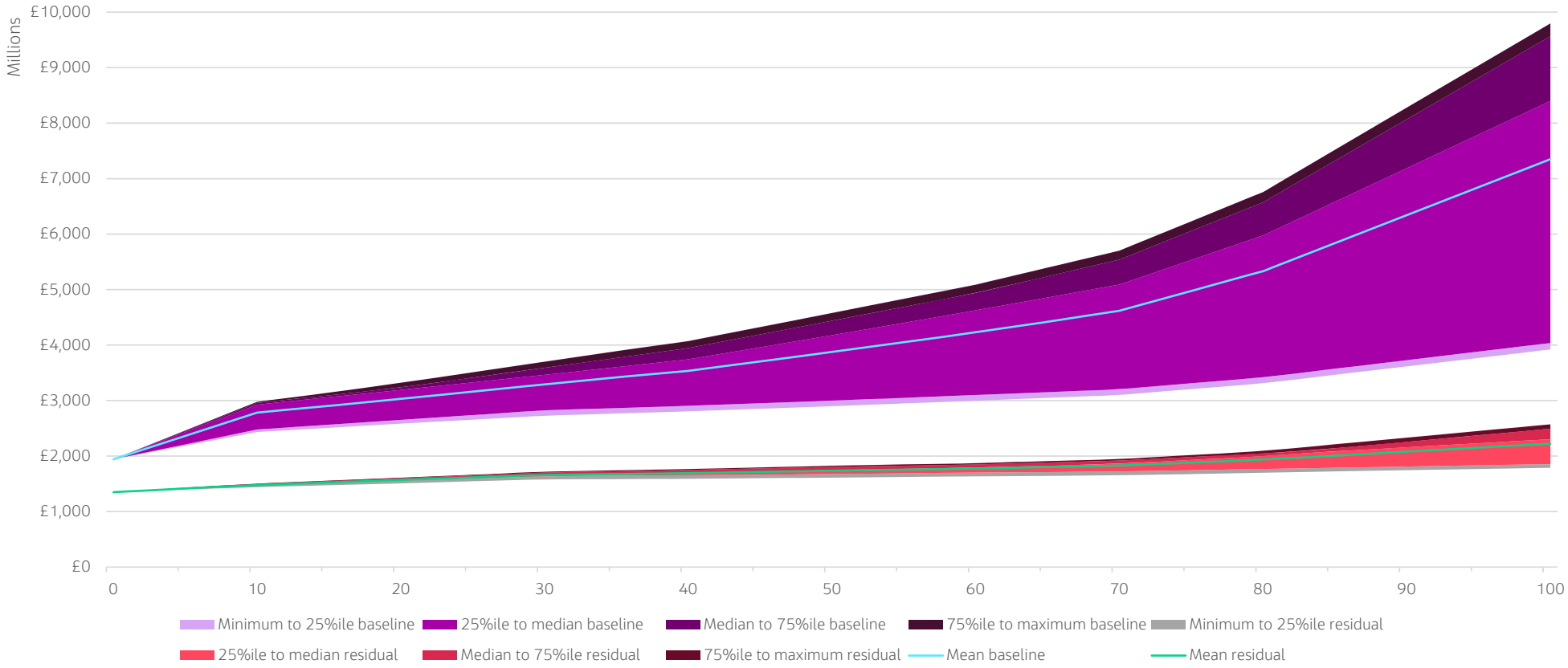
Carbon cost of recovery

Flood interventions

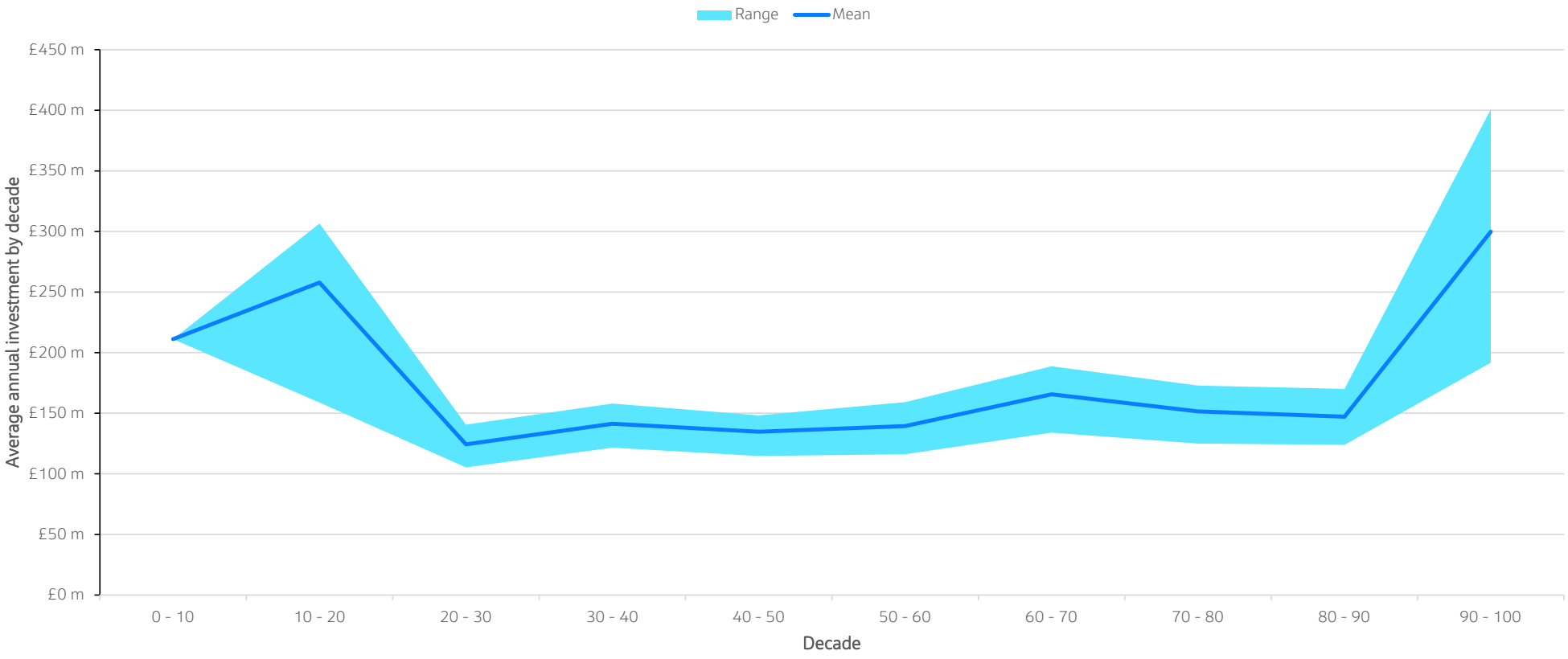
Optimisation



What have we learnt?



What have we learnt?

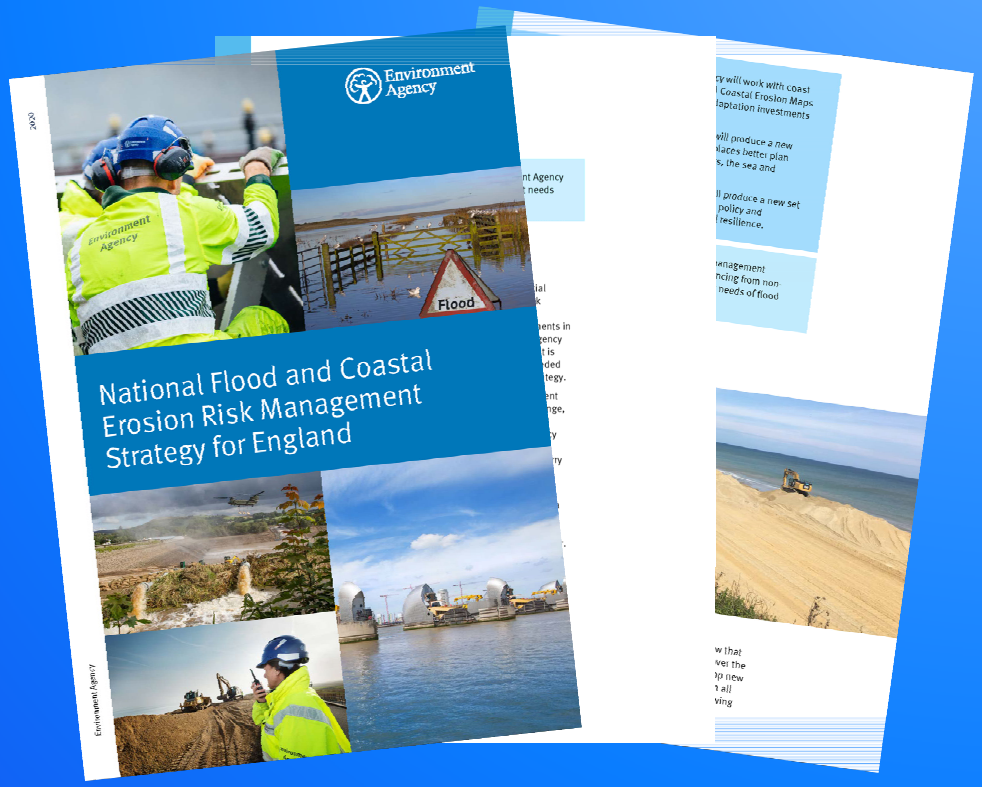


- **Strategic objective A:** Between now and 2025 the Environment Agency will have better evidence to inform future risk and investment needs for managing all source of floods and coastal change.

  - **Measure A.1:** By 2023 the Environment Agency will work with coast protection authorities to improve the National Coastal Erosion Maps to strengthen the evidence base for coastal adaptation investments and decisions.

  - **Measure A.2:** By 2024 the Environment Agency will produce a new national assessment of flood risk that will help places better plan and adapt to future risks from flooding from rivers, the sea and surface water.

  - **Measure A.3:** By 2025 the Environment Agency will produce a new set of long-term investment scenarios to inform future policy and investment choices for achieving flood and coastal resilience.



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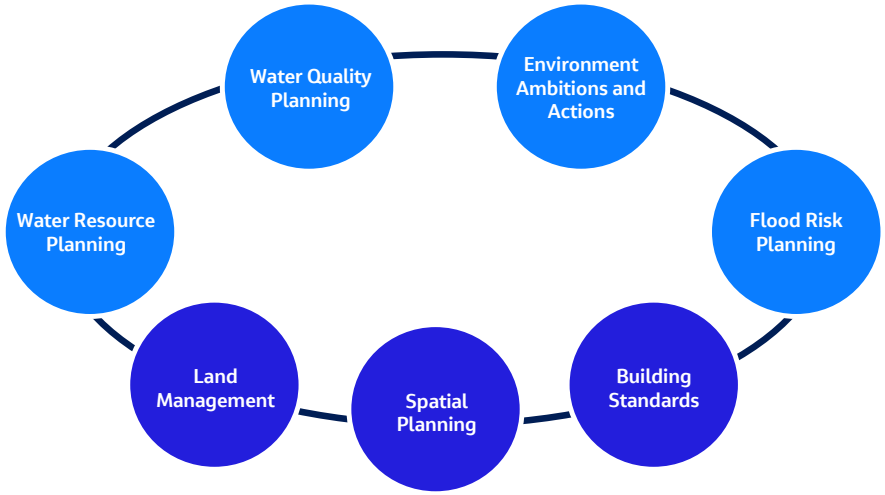
Ongoing work in the Environment Agency

OxCam Arc Team
Integrated Water Management Framework



Adaptive Approaches
The four locations in the current portfolio:

The four locations in the current portfolio:

- Thames Estuary TE2100

How do we manage tidal flood risk

- Humber Strategy 2100+

Strategy to manage tidal flood risk

- River Severn Partnership

Flood risk , water quality, water resources and environmental enhancement

- Yorkshire

Flood resilience and coastal erosion

Long Term Investment Scenarios 2025

Poll Question

1. **When planning flood risk management investment are you considering?**

   a) Current/observed flood events only

   b) Potential change due to climate change

   c) Multiple climate scenarios

   d) Multiple climate and development scenarios

Central Valley Flood Protection Plan – California's Strategic Blueprint to Improve Flood Risk Management in the Central Valley

Kris Tjernell, California Department of Water Resources | Armin Munévar, Jacobs

Today's Speakers

Kris Tjernell

California Department of Water Resources
Deputy Director for Integrated Watershed Management

Armin Munévar

Jacobs
Global Technologist, Climate Resilience and Integrated Water Resource Management

Flood Risk in the Central Valley

- California's history of drought interrupted by storms and floods
- Climate change is intensifying extreme weather patterns and flood risk
- CVFPP calls for flood management that is resilient to the impacts of climate change

$223 billion

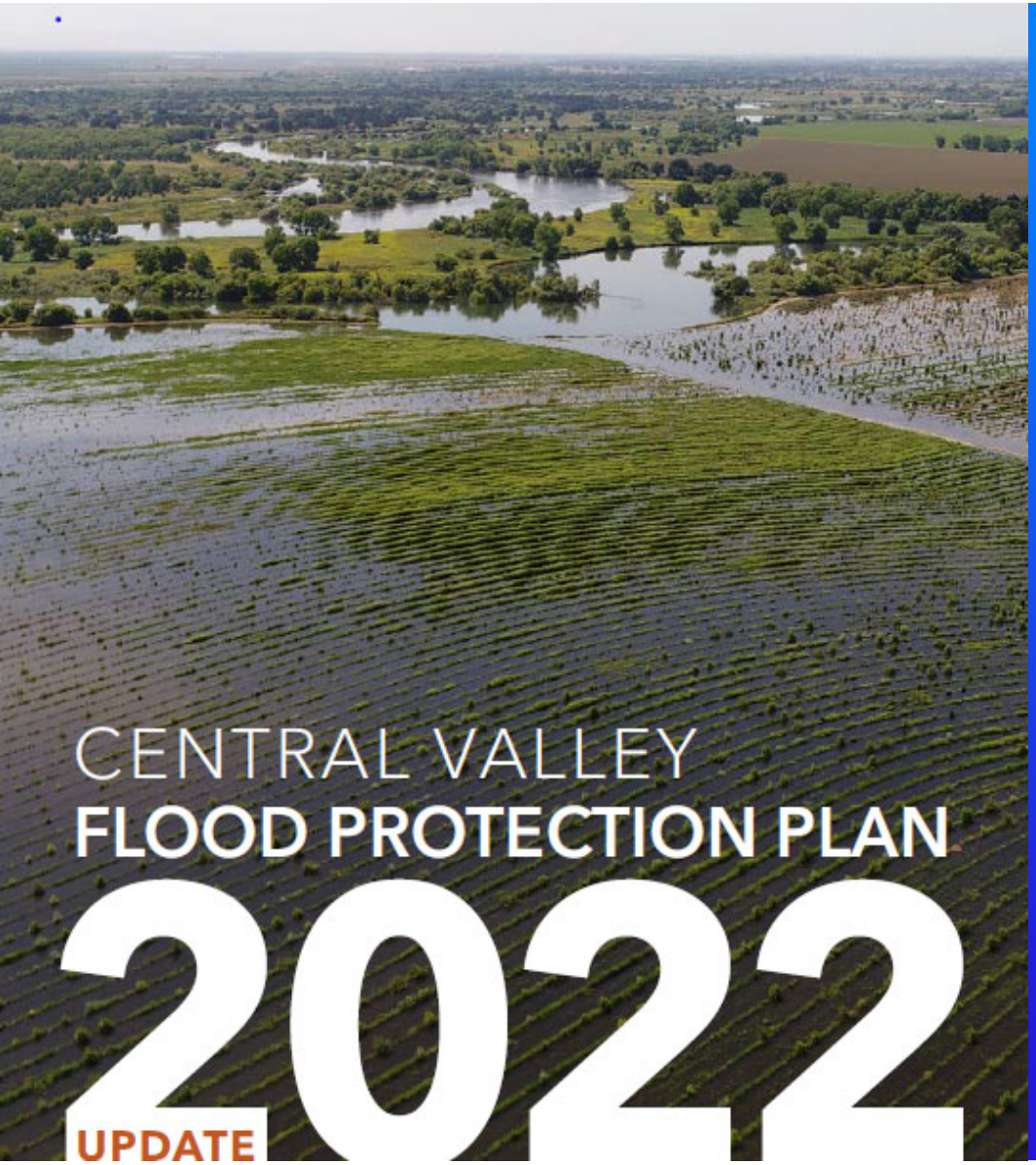
of structures and contents

$17 billion

of agricultural economic activity is at risk

1.3 million people

Live and work in Central Valley floodplains



500%

Climate change is likely to drive up to five-fold increases in peak flood flows adjacent to urban population centers

70%

of Central Valley listed species depend on aquatic or riparian habitats in the flood system

200%

Historically redlined neighborhoods have higher flood risks. For instance, redlined neighborhoods in downtown Sacramento are twice as likely to flood.

State Plan of Flood Control

- 1,600 miles of State-federal levees and an extensive system of bypasses and floodways
- 2 unique river basins
  - Sacramento
  - San Joaquin
- Major urban centers, small communities, and rural and agricultural areas

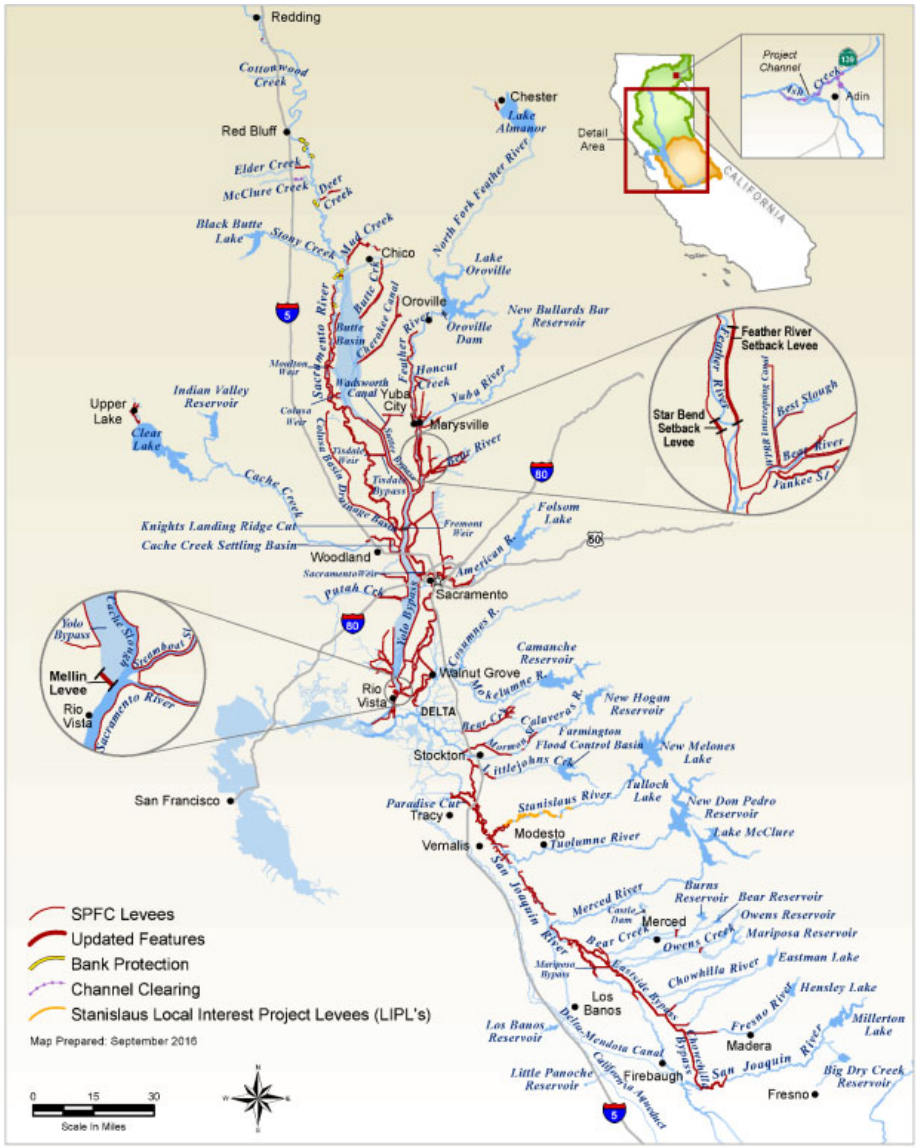


Figure G-1. Geographic Overview of the State Plan of Flood Control (Updated)

Policy Recommendations to Support CVFPP Implementation

Land Use and Floodplain Management

Residual Risk Management

Flood and Ecosystem Performance Accounting

Operations and Maintenance of the Flood System

+

Equity

Governance and Institutional Support

Coordination with Federal Agencies

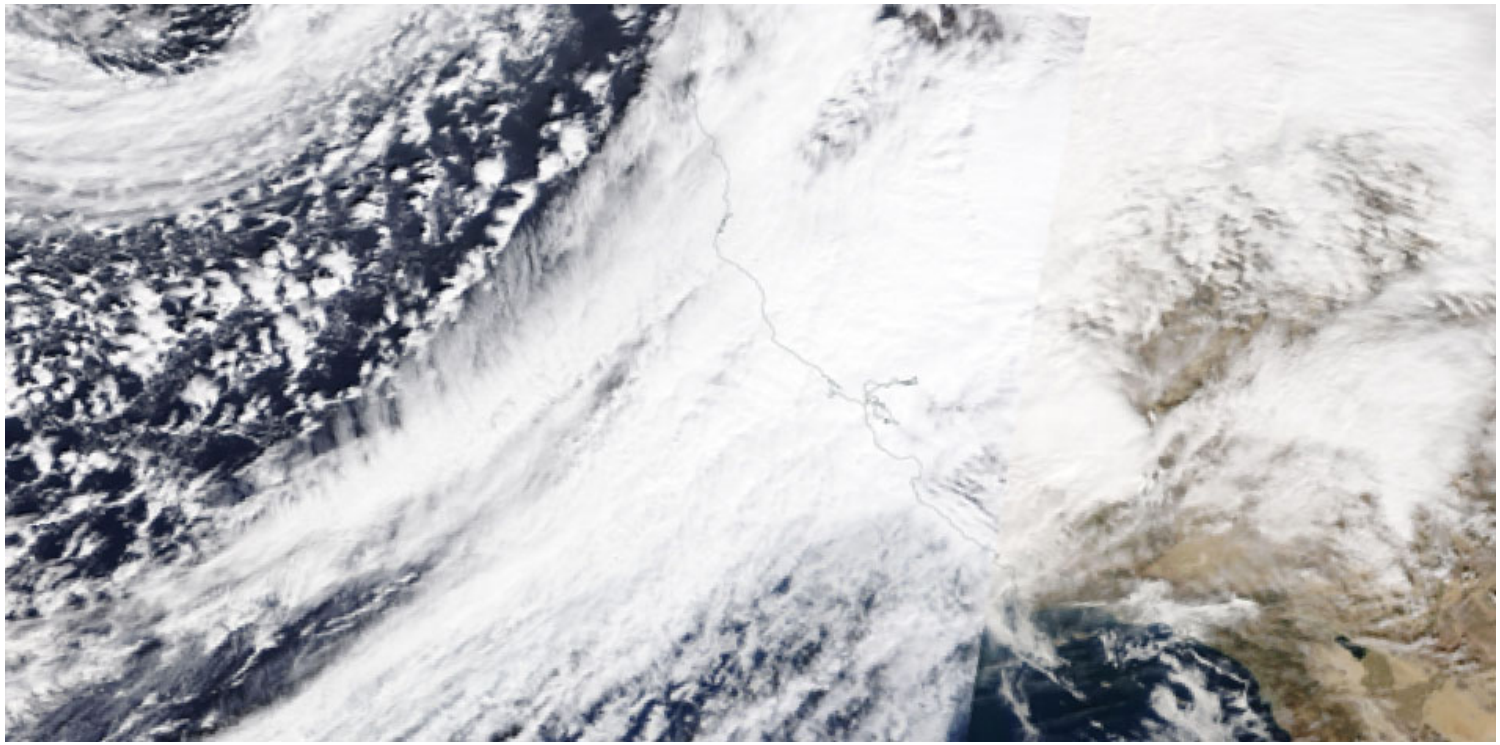
Funding

Multi-benefit Projects

Climate Change and Flood System Resilience

Climate Change is Affecting California Now …

October 2021 Northeast Pacific Bomb Cyclone



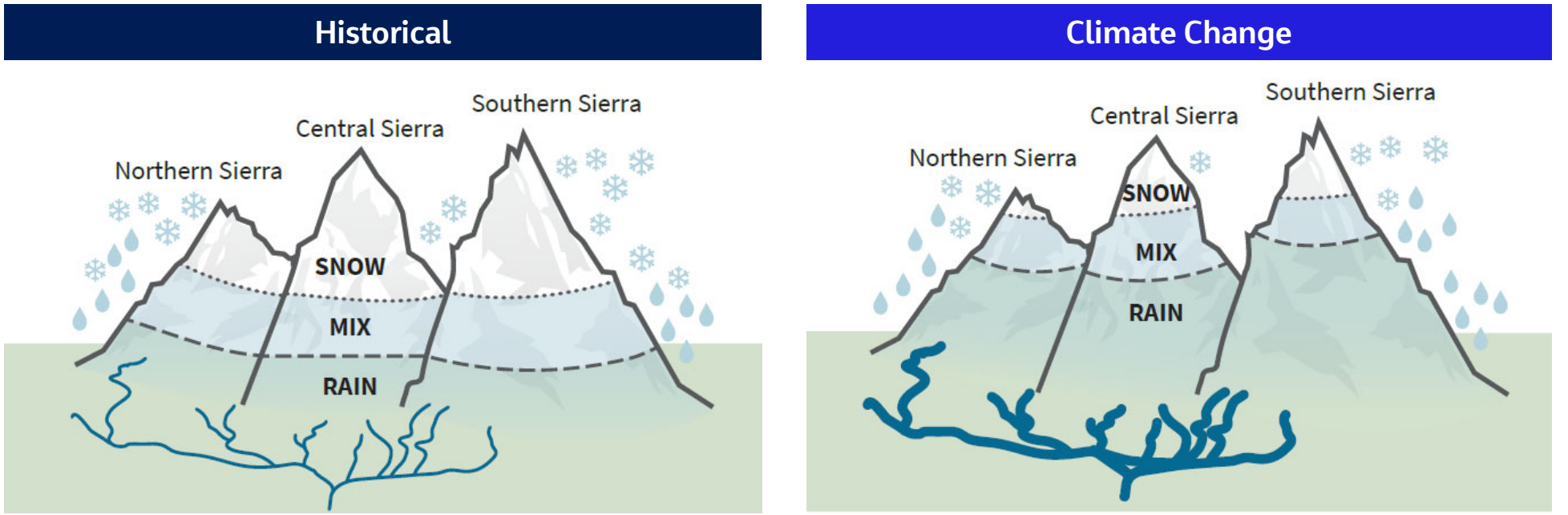
Current Trends and Climate Projections

Climate change component	Studied in CVFPP	Current trends	Projected trends	Confidence for future change
Air Temperature	2017 & 2022	Increasing	Increasing	Very high
Water Temperature	NA	Increasing	Increasing	Medium
Extreme Precipitation	2017 & 2022	Increasing	Increasing	Medium high
Snowpack	2022	Decreasing	Decreasing (less snow and more rain)	Very high
Sea Level Rise	2017 & 2022	Increasing	Increasing	Very high
Hydrograph Characteristics	2017	Shift in streamflow to the earlier months	Shift in streamflow to the earlier months	Very high
Unregulated Flood Volume	2017 & 2022	N/A	Increasing	Very high
Regulated Flow	2017 & 2022	N/A	Increasing (varies based on location)	N/A
Regulated Stage	2017 & 2022	N/A	Increasing (varies based on location)	N/A

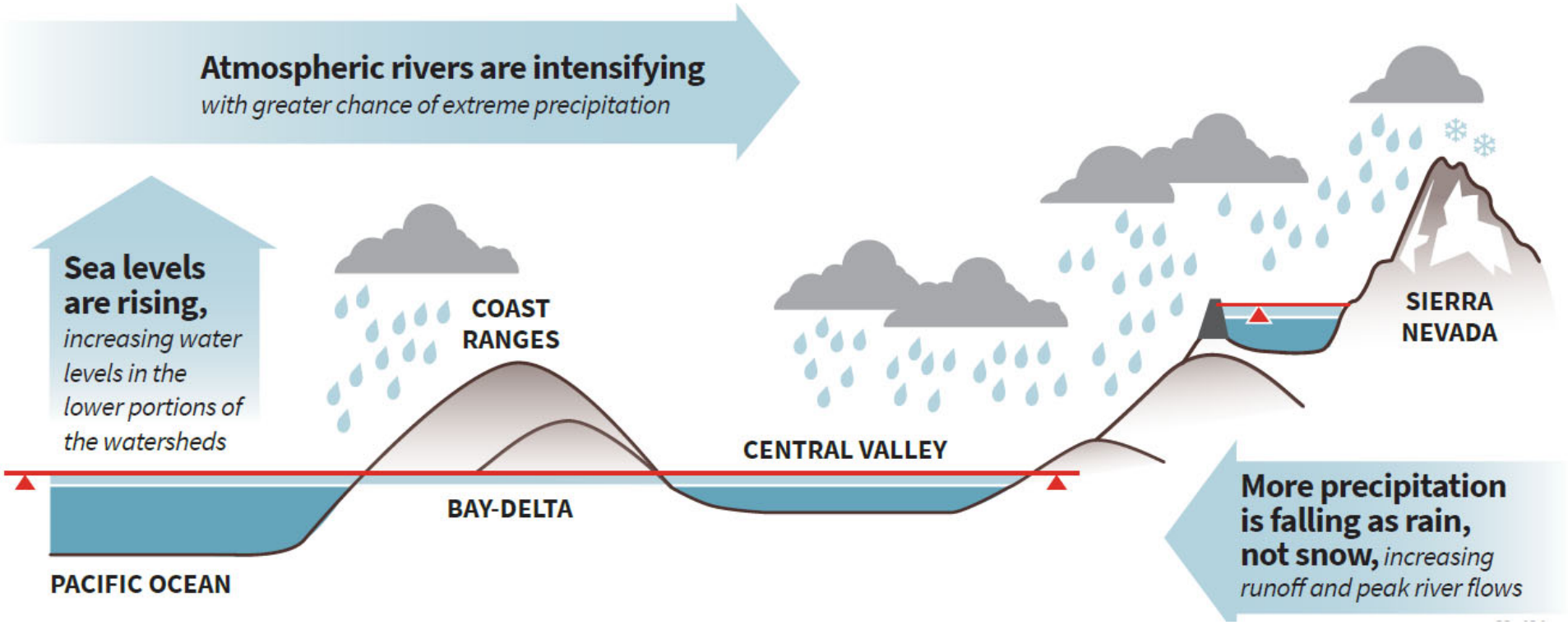
Unique Climate Impacts in the Central Valley Watershed

Figure 1.1 Precipitation Patterns and Form will Change Throughout the Central Valley Watershed

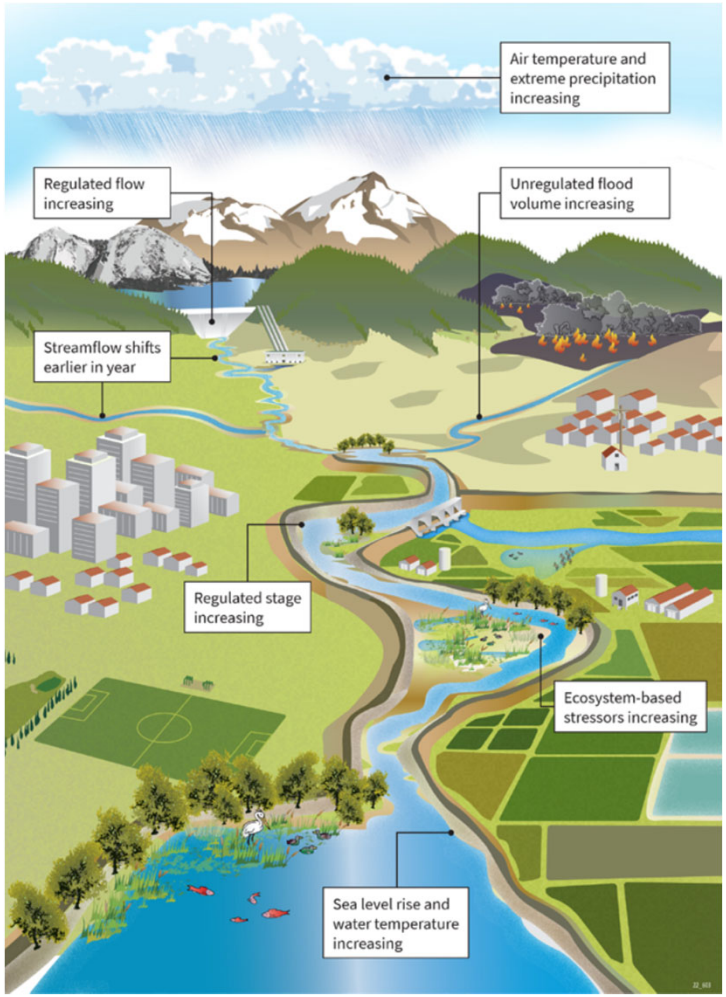
A temperature increase of 1℃ moves to the snow-level elevation 500 feet higher.

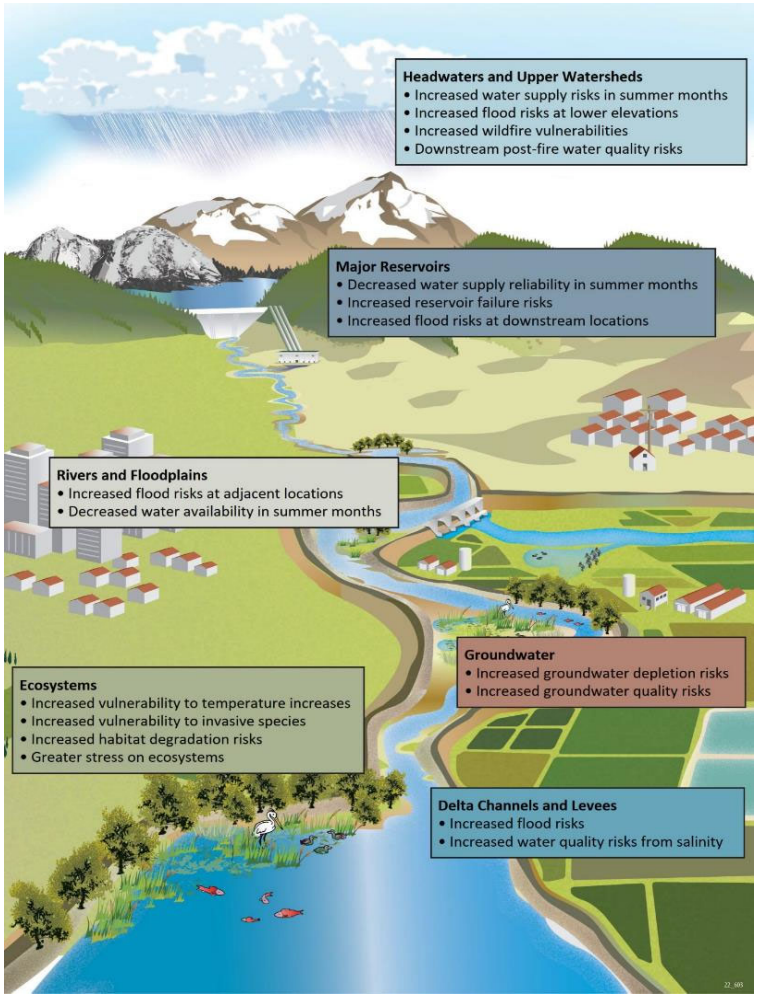


Triad of Climate Changes Amplify Flooding Impacts



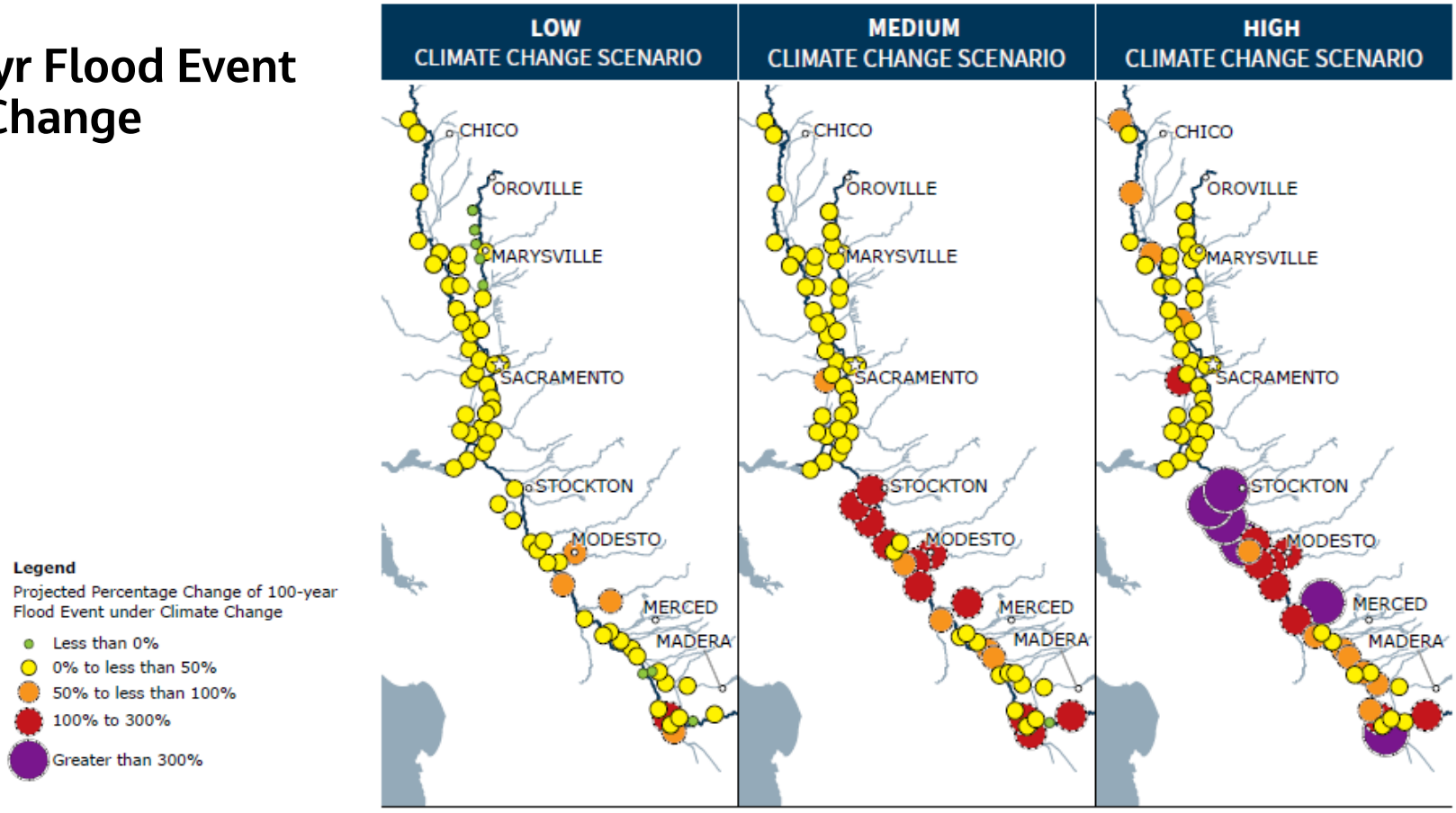
Watershed Response and Resource Impacts to Climate Change





Climate Risks Vary throughout the Central Valley

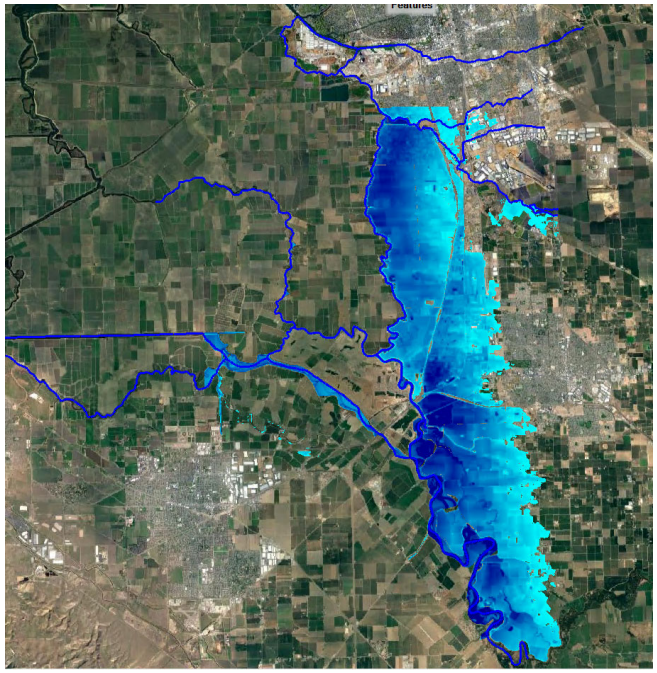
Change in 100-yr Flood Event Under Climate Change



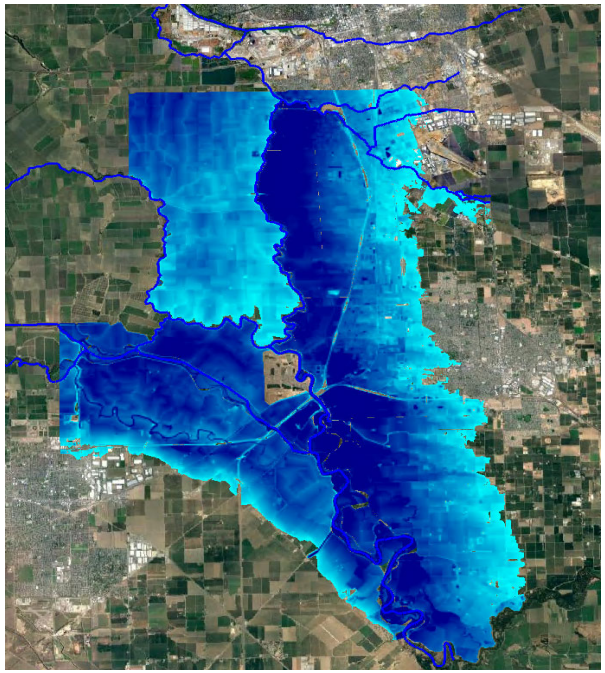
Sea Level Rise Exacerbates Flood Impacts in Some Regions

Lower San Joaquin Flood Extent: 200-yr Flood

Current 200-yr Flood

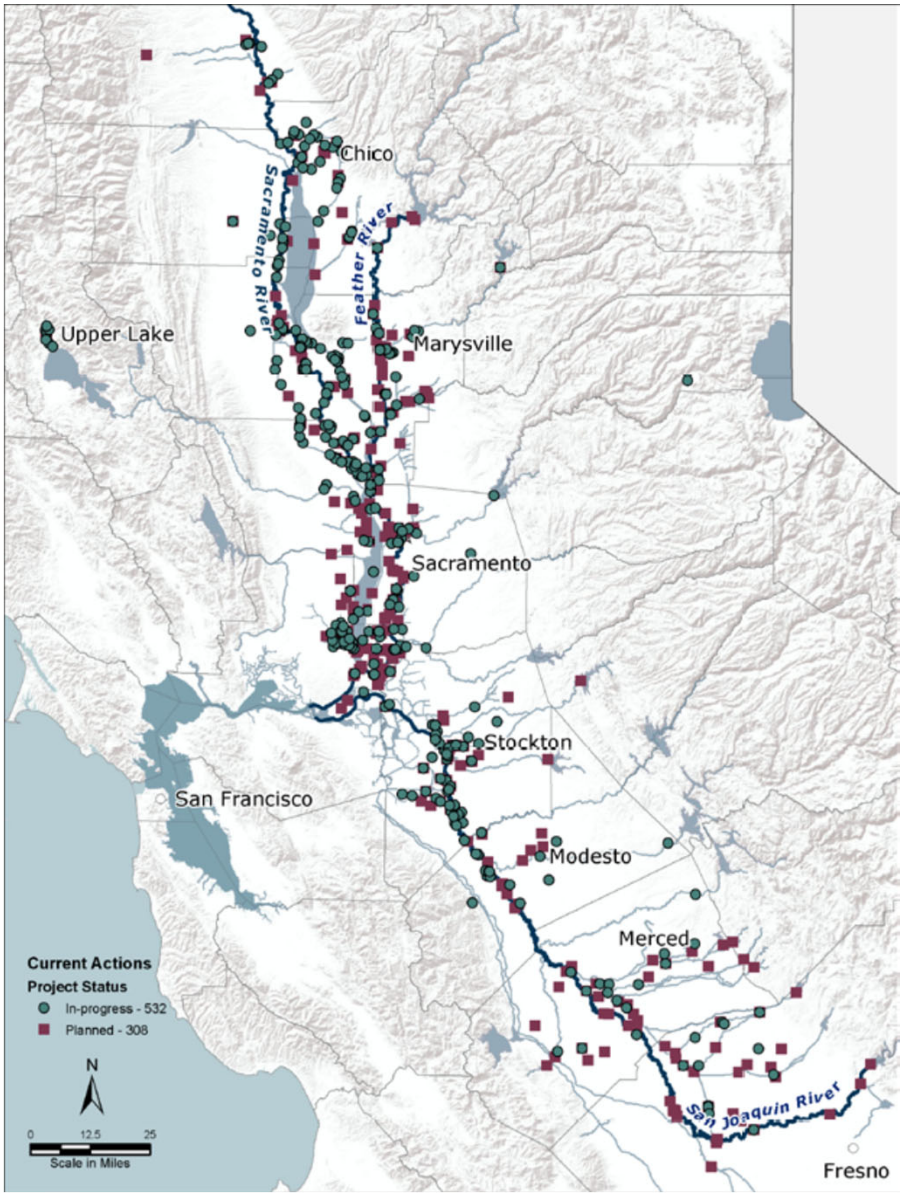


Median Climate Change
+ 3.7 ft of Sea Level Rise in 2072



State Systemwide Investment Approach (SSIA) Portfolio

- Flood risk management actions throughout the Central Valley
- Over 800 projects
- Portfolio management actions in four areas of interest:
  - Systemwide
  - Urban
  - Rural
  - Small Community



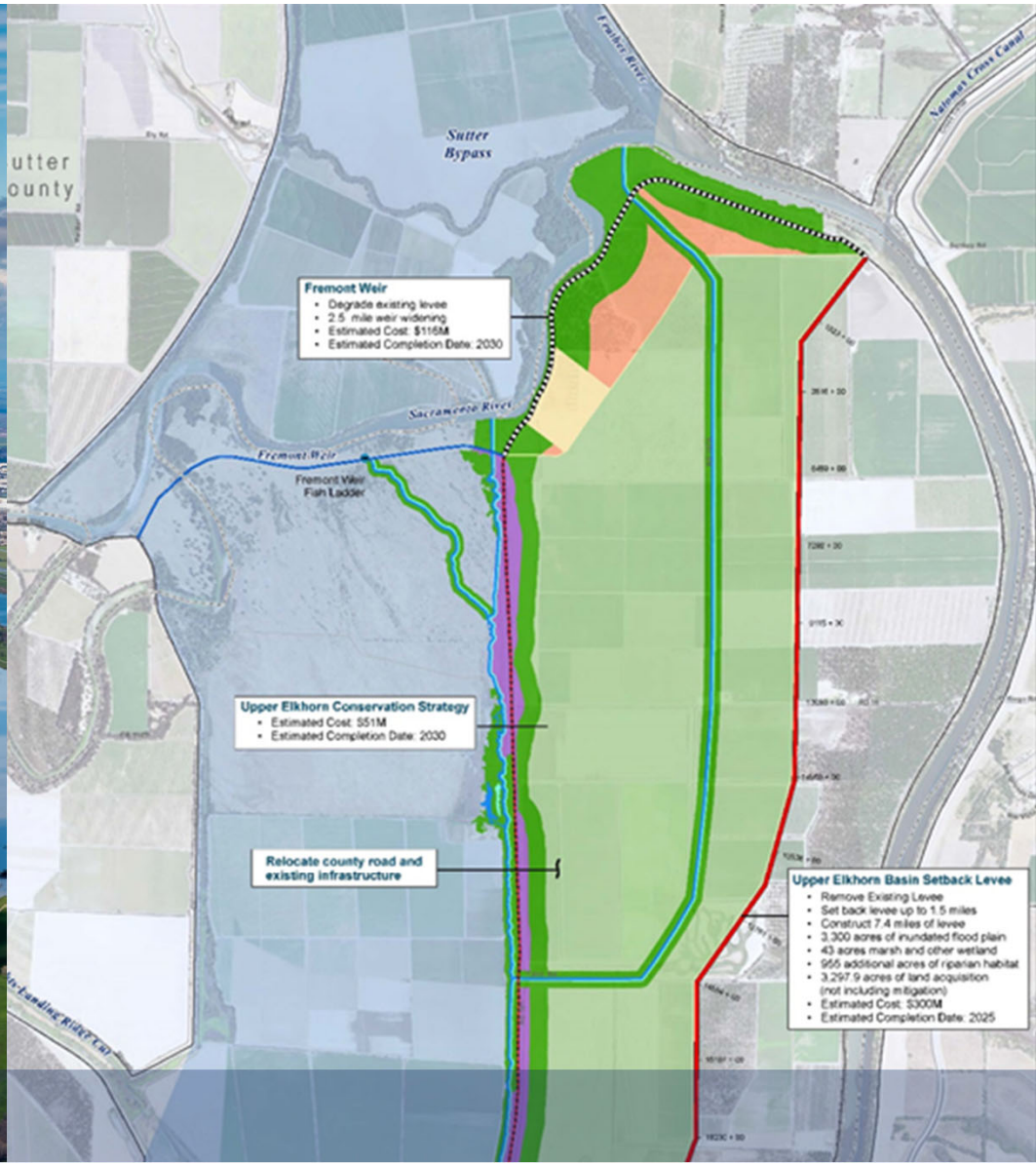
Reservoir and River System Operations

- Reservoir operations
- Floodplain storage operations
- Diversion and bypass operations
- Groundwater and recharge storage operations

Folsom Dam
Modification Project

New Bullards Bar Dam
Atmospheric River Control
spillway
Source: Yuba Water Agency

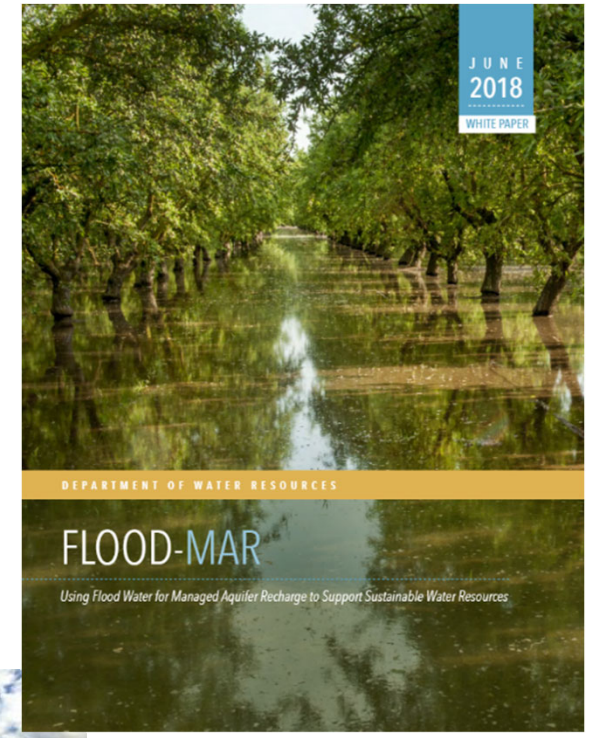
Yolo Bypass


Sutter Bypass
Fremont Weir
• Degrade existing levee
• 2.5 mile weir widening
• Estimated Cost: $116M
• Estimated Completion Date: 2030
Sacramento River
Fremont Weir
Fremont Weir Fish Ladder
Upper Elkhorn Conservation Strategy
• Estimated Cost: $51M
• Estimated Completion Date: 2030
Relocate county road and existing infrastructure
Upper Elkhorn Basin Setback Levee
• Remove Existing Levee
• Set back levee up to 1.5 miles
• Construct 7.4 miles of levee
• 3,300 acres of inundated flood plain
• 43 acres marsh and other wetland
• 955 additional acres of riparian habitat
• 3,297.9 acres of land acquisition (not including mitigation)
• Estimated Cost: $300M
• Estimated Completion Date: 2025

Southport Levee Setback Project and Riparian Plantings

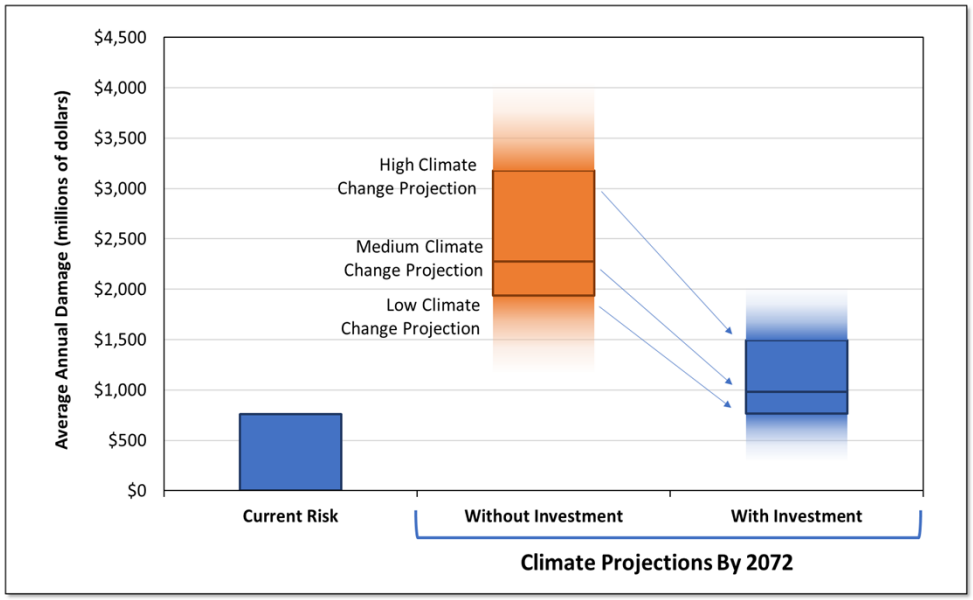
Watershed and Floodplain Management

- Adaptive storage capacity in floodplains
- Improve sediment and post-fire debris detention
- Floodplain mapping to improve consistency of floodplain delineation and assessment of flood risk
- Promote risk-informed land planning

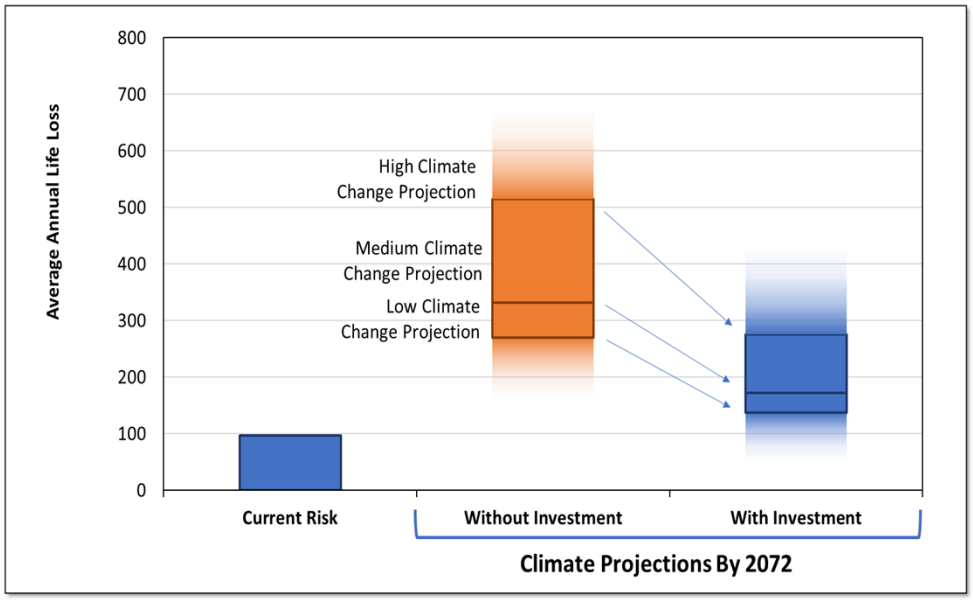


Buying Down Climate Risk with SSIA Investment

Annual Damages ($M)



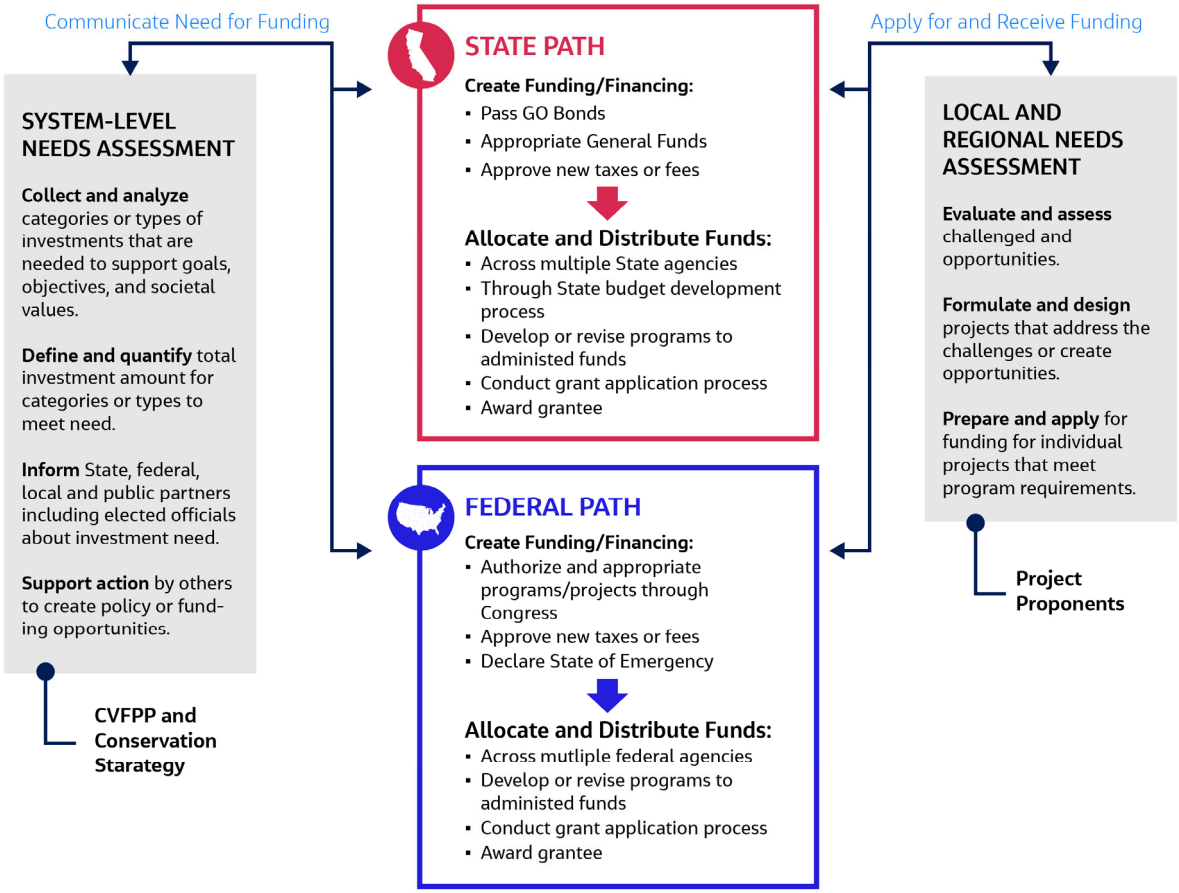
Annual Life Loss



Guiding Current and Future Flood Risk Management Investments

- CVFPP guides the State flood strategy and investments
- Supporting on-going flood risk reduction and floodplain restoration projects
- Identified $25-$30b of needed investment over next 30 years
- Guides state and federal funding

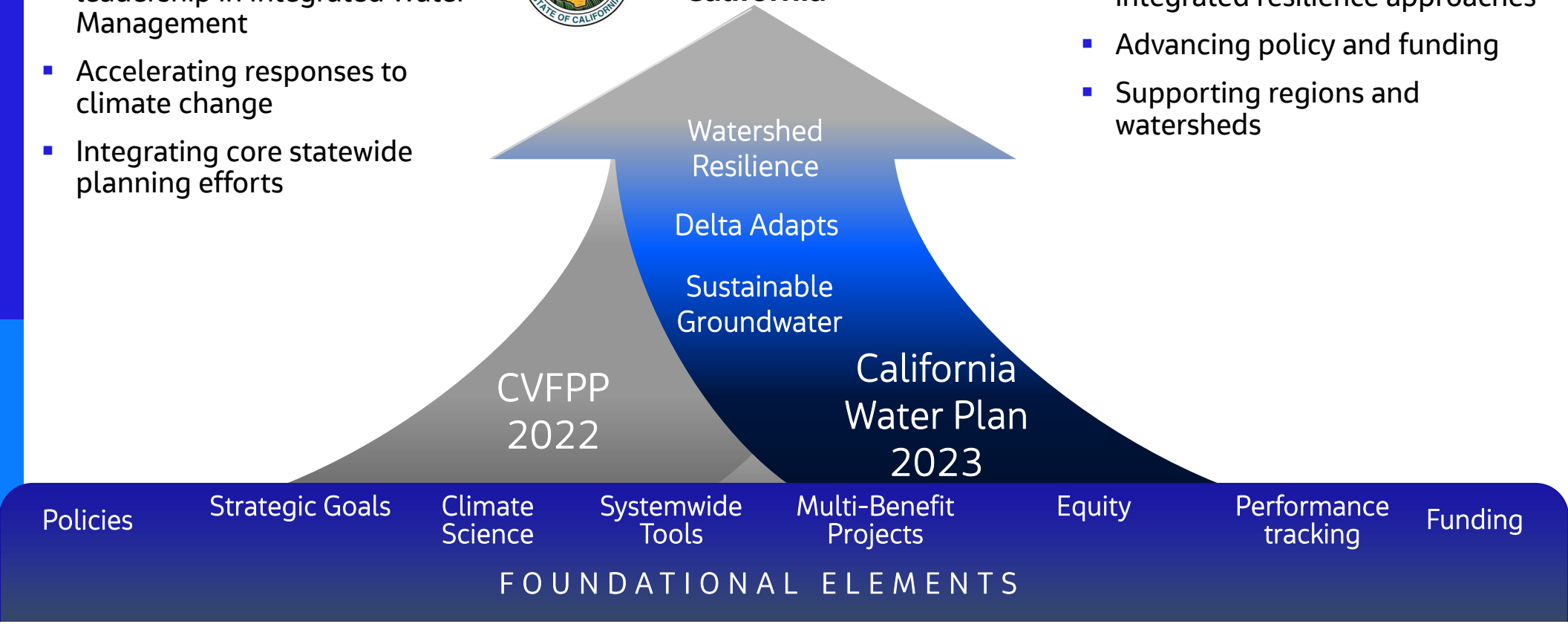
Figure 4.1 How the CVFPP Guides Funding Development for Programs



Moving Forward

- California is continuing its leadership in Integrated Water Management
- Accelerating responses to climate change
- Integrating core statewide planning efforts

Water Resilient California



- Aligning agencies to support integrated resilience approaches
- Advancing policy and funding
- Supporting regions and watersheds

Poll Question

2. **What level of flood risk data do you have?**

a) Anecdotal flood incident records

b) Historic event mapping

c) Insurance (incl. FEMA) mapping

d) Present day 2D flood modeling

e) Future scenarios modeling

Q/A

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Important

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