VCCCAR
think tank report

Climate change and floodplain management in Victoria

vcccar
victorian centre for climate change adaptation research

Victorian Centre for Climate Change Adaptation Research

University of Melbourne
221 Bouverie Street,
Carlton, Victoria, 3010
enquiries-vcccar@unimelb.edu.au
+ 61 (03) 9035 8235
www.vcccar.org.au

Contents

Executive summary

"Floods make enemies, fires make friends" - participant quote.

There are 39 major drainage basins with significant rivers and associated floodplains across Victoria. In these floodplains are towns of all sizes, industrial centres, major infrastructure, and significant agricultural production. Over the last year, we have seen significant impacts on communities, industry and agricultural production due to flooding in these areas.

In particular, the Northern plains area in the Northwest of Victoria is subject to major flooding. This is even true when there have been small rainfall totals, if certain soil types or parts of the landscape are already saturated.

While the impact of climate change in Victoria is uncertain, it presents new challenges for flood management. Potentially climate change impacts will see changes in rainfall patterns that could lead to less frequent riverine floods and more frequent flash flooding events associated with localised storm activity. While riverine flood events may become more infrequent, they may become larger.

Flood management has always been a challenge, but planning for and adapting to floods in northern Victoria will only prove more problematic if long-term trends of forecasted drought are realised. At the *Climate Change and Floodplain Management in Victoria* think tank held on Monday 15 August in Kerang, the community, local and state based agencies, government, emergency services, and experts on flood management came together to discuss the implications of climate change for floodplain management in light of experiences from the 2010-2011 floods in Kerang and other parts of northern Victoria. These floods not only brought devastation to a community, they highlighted some of the frustrations that agencies, local government and community encounter when dealing with a major natural disaster.

Key findings

Many of the tools for managing flooding under climate change are already available. International examples of good practice in flood plain management include:

- Having the right enabling factors in place, including appropriate policies and laws and flood hazard mapping.
- Effective planning controls and enforcement are needed to deter construction of housing or infrastructure in flood risk zones.
- 'Safety margins' can be used to upgrade building standards and flood defences for specified amounts of climate change (in heavy rainfall and peak river flows for example).
- Incentives can be built into insurance policies to encourage people to take steps to reduce their vulnerability to flooding through measures such as temporary defences or water resilient construction.
- Establishing real time river monitoring systems that capture data from remote gauges and convey flood levels in meaningful and accessible ways to the public.

Research needs

- A scientific review of current flood plans and assessments.
- Analysis of the best institutional structure for monitoring and warning systems, how interactions between agencies like Bureau of Meteorology, the SES and the community have changed over time and the role of DSE and the CMA in providing analysis of the potential distribution of water across the landscape.
- Investigation of the effectiveness of different forms of community consultation or debriefing methods following a natural disaster. This would include the participating organisations, governments and departments as well as the value of the outcomes and their usefulness for future events.
- Developing policy responses to complex emergency coordination issues such as cross-border evacuation and emergency management.
- Analysis of how cross-border management of flood waters throughout a catchment might reduce the potential impacts of floods.
- Looking across extreme events such as fires and recent flooding, researching the health impacts on individuals and the community. Exploring related issues of drug and alcohol use in post disaster effected areas and combining this research with some of the pre-planning policy and strategy for disaster management.
- Research around how data collection and forecasting has changed over the years, from observational data to automated data collection, and how this impacts the community.
- Looking at how chronic disease is managed during emergency situations.
- Ensuring the safety of high risk groups, such as people from a non-English speaking background, Indigenous Australians, the elderly and children.
- Analysis of the similarities and synergies between preparing and responding to different types of extreme events and natural disasters such floods, fires and storms.

Policy recommendations

The group discussed a number of issues relating to state and local government policy. Many of these have been recognised in the Interim Report of the Inquiry into the Victorian floods. The following points were emphasised.

- Clarification of roles and responsibilities of different agencies (such as BoM, the CMA, DSE, SES, CFA, State Police and local governments) for warning and response;
- Establishment of appropriate river gauges and monitoring systems;
- Development of standard terminology used in flood warnings;
- Greater recognition of local knowledge and capacity and devolution of incident control to local authorities or bodies; and
- A risk assessment for vulnerable communities to ensure that there is clear understanding of what may be impacted by different levels of river height and that effort and resources for defence are going to protect what has been agreed as the most important assets or infrastructure.

Kerang is surrounded by flood waters at the height of the 2011 floods (photo source unknown)

Introduction

Thirty-four participants joined in the think tank to discuss flood planning and management in Kerang on 15 August 2011. The think tank was sponsored by the Victorian Centre for Climate Change Adaptation Research (VCCCAR). The event gave local government, local agencies, community, and academics a chance to discuss flood management and planning in relation to climate change.

The main goals of the think tank were to examine the strategies for flood risk assessment and management and to analyse current approaches in flood management based on the recent flooding in Victoria. It aimed to consider the changing demographics, urban development, settlement, and land use as factors, and how the flood management around the recent flooding affected these factors. The workshop aimed to provide guidance on improving longer-term approaches for flood risk assessment and to identify research needs to support improved floodplain management in a changing climate.

Director of VCCCAR, Rod Keenan, began the day with an introduction to climate change adaptation as a social learning process. He also outlined the goal of developing ideas for future research during the think tank. Professor Rob Wilby, a VCCCAR visiting fellow from Loughborough University in the United Kingdom, discussed the flood management, monitoring, and modelling systems that are being utilised in the UK. Professor Roger Jones from Victoria University gave a local perspective of the 2010-2011 floods in Kerang and the issues that arose in how forecasts were made for those floods.

Further talks by Jonathon Pollock and Phillip Douglass from the Bureau of Meteorology, Brendan Christy from the Department of Primary Industries, and Steve Muncaster from the Department of Sustainability and Environment highlighted some of the work that agencies are doing to improve flood forecasting. A panel discussion with Camille White, from North Central CMA, Rosanne Kava, CEO of Gannawarra Shire, Andrew Sheehan from Vic SES, and Dee Gilby from the Department of Health in Bendigo, discussed some of the issues that arose during the 2010-2011 floods in Kerang.

List of participants

Brendan Christy	Department of Primary Industries
Greg Deveson	Victoria Police, Kerang
Philip Douglas	Bureau of Meteorology
Max Fehring	Gannawarra Shire Council
Ross Frantz	Retired Goulburn Murray Water
Dee Gilby	Department of Health
John Ginnivan	Goulburn Murray Water
Julie Hoy	Department of Justice
Karen Hudson	Goulburn Murray Water
Patricia Ibbotson	CSRC, La Trobe University Bendigo
Daniel Irwin	Goulburn Murray Water
Damian Jones	Department of Primary Industries
Elaine Jones	Kerang Model Farm
Roger Jones	Victoria University
Rosanne Kava	Gannawarra Shire Council
Rod Keenan	VCCCAR
Paul Lacy	NVIRP
Daniel Lovell	Goulburn Murray Water
John Martin	CSRC, La Trobe University Bendigo
Neil McBeath	Department of Primary Industries
Thomas Mitchell	Department of Health
Steve Muncaster	Department of Sustainability & Environment
Colin Myers	Resident of Kerang, Flood Warden
Sandra Neivandt	Goulburn Murray Water
Guy Ortlipp	Goulburn Murray Water
Jonathon Pollack	Bureau of Meteorology
Geoff Rollinson	Gannawarra Shire Council
Lindsay Shultz	Resident of Murrabit, Flood Warden
Andrew Sheehan	VICSES
David Thompson	Gannawarra Shire Council
Lily Weinberg	VCCCAR
Camille White	NCCMA
Rob Wilby	Loughborough University
Ivan Zwart	Environment & Natural Resources Committee

Presentations

Introduction by Professor Rod Keenan, University of Melbourne and VCCCAR Director

Rod Keenan began by emphasising that the main priority of the think tank was to define future research topics about flood preparation and management. He asked everyone to introduce themselves and to identify their reasons for attending the workshop. The main reasons were to learn:

- More about flood management;
- About climate change and how it relates to floods;
- About different agencies response or planning mechanisms;
- How to improve community awareness and knowledge; and
- How to improve the way planning, flood mitigation and flood monitoring are done locally in Kerang.

Speaker 1: Professor Rob Wilby, Loughborough University and VCCCAR visiting fellow

Rob Wilby is a Professor of Hydroclimatic Modelling at the University of Loughborough in the UK, and was VCCCAR's 2011 Visiting Fellow. While there is greater predictability around some aspects of climate change such as global temperature increases and sea level rise, in Australia and in the UK there is greater uncertainty about potential changes in the amount, intensity and seasonal distribution of rainfall. As such, there is a need to build up resilience within the community, agencies and industry to be able to cope with greater uncertainty. He gave examples of international ideas about improving flood planning and management.

- In the UK there are 'safety margins' in place for infrastructure planning so that industry can simply look up the margin of predicted change in the rainfall or climate in an area and make decisions as to how to build infrastructure that will comply with those forecasts.
- In the Netherlands they've built incentives into insurance policies to encourage people to take steps to decrease their vulnerability to flooding through simple measures in buildings.
- In the USA they have an excellent real time monitoring system which utilises remote gauges monitoring river systems. Anyone can sign on to the website and see what is going on in their area.

Wilby gave these examples to highlight the types of successful flood management techniques that are being utilised in countries with similar levels of uncertainty and variability in rainfall as Australia. Other examples of adaptation options for flood impacts include:

- Ensuring that enabling factors are in place, including planning and policy arrangements and hazard and risk mapping. This includes consideration of 'indirect' impacts, such as potential loss of power, water or transport.
- Building greater community understanding of risks through education and gaming tools and ensuring the community and emergency services can learn from role-play exercises.
- Design arrangements to 'make space' for water and use natural systems such as wetlands, marshes and river beds to take the brunt of floods.

There was considerable discussion within the group about how to make a convincing argument that building more flood resilient infrastructure or providing extra capacity is beneficial when the economic argument is to not invest extra unless agencies or companies are sure about the risks. This included adding in the social and health costs which are hardly ever included when considering building stronger infrastructure for flood management.

During the discussion, the community emphasised that there was confusion over what certain water levels mean to individuals and their properties. Wilby discussed the Environment Agency's solution to this problem which is automated telephone systems that dial individuals to inform them of river levels and the actions that need to be taken for that level of water.

Speaker 2: Professor Roger Jones, Victoria University

Roger Jones is a Professorial Research Fellow in the Centre for Strategic Economic Studies at Victoria University. Roger uses an interdisciplinary approach to climate change risk, economics, policy, and science and how to manage those risks through both mitigation and adaptation. Roger also grew up in the local area and was in Kerang at the time of the floods. At the think tank, Jones provided his perspective (see Appendix 2) on:

- His personal experience during the recent flood;
- Historical knowledge of past floods;
- Modelling used to try and determine climate change's impact on the 2010-2011 floods;
- A meteorological explanation of two of the weather patterns that impact Victoria, and eastern Australia's weather, the Indian Ocean Dipole and La Niña; and
- A hypothesis that due to the fact that the floods occurred in December and January, i.e. much later than floods are usually experienced in Kerang, and the humidity and heat that accompanied these floods, there is a possibility that increased greenhouse gases might have intensified the weather system of a negative Indian Ocean Dipole and a La Niña.

The group discussion after Jones' talk focused on the natural variability of the climate system and the signs or indications of climate change for North Western Victoria.

Speaker 3: Jonathon Pollock, climatologist, and Phillip Douglass, flood forecaster, Bureau of Meteorology

Jonathon Pollock gave an overview of the extremely variable rainfall over Victoria and the drying trend from the 1970s onwards. He also discussed the seasonal outlooks that the Bureau puts out every three months and how to use those forecasts.

Phillip Douglass summarised the Bureau's flood forecasting services which include collecting data and using it in models for forecasts, monthly hydrological predictions, and providing guidance on flood warning systems. The Bureau also has plans to increase remote sensing technology and improve rainfall forecasting systems.

The Bureau warnings are for rainfall and river height. They do not provide any indication of how this type of river height might be distributed across the landscape as flood-levels.

The group discussion focused on the need for better warning systems and more effective ways of communicating those warnings to communities.

Speaker 4: Brendan Christy, Department of Primary Industries

Brendan Christy works on Catchment Hydrology and Climate Change for the Department of Primary Industries. Christy uses a Catchment Analysis Tool (CAT) which is a landscape model that focuses on giving localised impacts from floods and ground water. The way in which water moves in the landscape will depend on landscape features such as farm dams, vegetation cover and physical barriers such as levees as well the underlying geology and the extent of previous water storage. His model utilises landscape features, taking into account what parts of the land are grazed, used for cropping, forested, and what impact groundwater might have on riverine areas. While often past floods are used as an indicator to predict what will happen, Christy's model utilises farm dams and wetlands and other landscape features to forecast flooding.

The group discussion around Christy's modelling technique revolved around the practical uses for this type of modelling and its accuracy in predicting the impacts of flooding.

Road out of Kerang, Jan 2011. Credit: Sam Mowat

Speaker 5: Steve Muncaster, Department of Sustainability and Environment

Steve Muncaster discussed some of the initiatives that Department of Sustainability and Environment (DSE) has put in place since the flooding in 2010-2011, including:

- An improved warnings system;
- Repairing the flood warning network with more capacity to assist the Bureau to make better predictions;
- Improving access to gauges and real time data; and
- Updating the Victorian flood database to provide a source for shared information.

Muncaster also provided the DSE's answer to the question: 'how do you make a gauge that makes sense to other people?' Their solution is flood mapping, which combines local knowledge and flood data to create maps that would aid relief agencies and help communities understand flood risks. Flood mapping would also show the infrastructure and properties which potentially could be affected at different flood heights. The major challenge highlighted was that in the pilot communities where this mapping was being implemented, it was hard to get community input during those times when floods have not been seen as a major risk, for example during the dry period of the late 1990s and 2000s. This was emphasised in the Interim Report of the Victorian Flood Review also: that communities were focused on drought prevention and had difficulties planning for or concentrating on flood management during that period (Comrie 2011).

The group discussion around DSE's flood mapping highlighted general community concern in getting 'buy in' or ownership from the community as well as how these maps would best reflect the vast amount of community knowledge that exists.

The submissions of the Planning Institute of Australia to the Victorian Flood Review highlighted a key concern for the people of Kerang. While researching best practice strategies and the technologies that could help to inform and prepare communities in the face of a disaster, these mechanisms must be in combination with implementation plans and well-resourced to be effective. The Planning Institute of Australia observed that this is 'something which is notably absent from the terms of reference' within the Victorian Flood Review (Worn 2011). This is reflected in a community like Kerang where there is a lot of knowledge, but not a lot of resources, and the need to come up with clear implementation strategies of these technologies.

Panel discussion: Camille White, North Central CMA, Rosanne Kava, Gannawarra Shire Council, Andrew Sheehan, VIC SES, and Dee Gilby, Department of Health Bendigo

The panel discussed the challenges faced and the lessons learned by their respective agencies. Camille White started off by outlining the need for:

- Better communication between CMA and the community;
- More effective methods of delivering flood intelligence;
- Getting predictions out there – even not 100 per cent accurate ones – are imperative to help the community to decide whether to fight or evacuate; and
- Community to feel that they are taking action during the floods.

Rosanne Kava is the CEO of the Gannawarra Shire Council. She emphasised some of the planning mechanisms that the Shire wants to improve, such as using social media to help spread warnings as well as more traditional methods, like newspapers and radio. Kava noted that there was a need for:

- Better coordination between the Shire and other agencies like the CMA and Vic SES would help improve data collection and monitoring;
- Better plans and evacuation methods which might include interstate efforts; and
- Questioning whether evacuation should have been considered earlier in the 2010-2011 flood.

She discussed the incredible effort made by the people of Kerang to protect their sub-power station, but also questioned why it was up to the community to make that effort. Kava also talked about the potential cost of losing the levies and the emotional and health impacts on the community from the trauma of the floods.

Andrew Sheehan from the Vic SES talked about some of the challenges faced by Vic SES during the flooding events and increasing general demands on SES services, with a 200 per cent increase in calls for assistance in the last 10 years. Different regions in Victoria also had different challenges. Recent surveys indicated that 50 per cent of people were not well prepared for floods, only one-third had flood kits and 30 per cent of surveyed people had driven through flood waters. In the recent Victorian events, flooding was so widespread that resources were really stretched and there was a need to focus on building capacity to respond to very large events. It became clear:

- That community knowledge and experiences were not being utilised enough.
- That there needs to be much more community education on what to do in flood situations and risks involved.

Sheehan recognised things that SES could do to improve flood preparation and response. Part of that would be to branch out from just being a response organisation and into identifying risk mitigation and community safety. The SES also aims to improve:

- Networking and partnerships with other agencies to deliver better communications and response actions.
- Ability to address specific regional issues by appointing regional communication officers so that they will have the capacity to connect and consult with the community.

Dee Gilby from Department of Health Bendigo addressed several issues from a community health perspective.

- There are a lot of health messages that need to be communicated in response to flooding, including water quality, disease, mental health and trauma and evacuation-related health issues.
- Health impacts of floods can been exacerbated in communities that have previously been under stress due to drought.
- Communication needs to flow both ways between the community and the Department of Health.
- The possibility of having to evacuate hospitals or an old persons' home and what was the procedure to safely evacuate those people. Rochester and Elmore District Hospital and Charlton Hospital both evacuated during floods. A few elderly people from a private aged care in Kerang were evacuated when the town was isolated due to flood waters.
- Emerging issues - ensure relief and recovery centres have primary health care services, including access to pharmacists, available to respond to people with chronic disease.
- Mould and resulting respiratory illnesses as well as needing to monitor mosquitoes and the diseases they carry.

There have already been major efforts to control mosquito larvae in preparation for summer. With Rosanne Kava, Gilby discussed the arrangements for children during the flood. On the part of the Department of Health, no special arrangements for children had been made other than provision of a range of recovery services offered by recovery organisations, however studies show that children and teens do need special care to process the trauma of a natural disaster. Kava also mentioned that there was a children's entertainment group that came to recovery services which had an uplifting effect on the children and that Council would consider making sure that type of service was provided in future disasters. Maintaining sporting events has also been important in bringing a sense of normality to some sections of the community.

In the Municipal Association of Victoria's (MAV) submission to the Victoria Flood Review, MAV recommends that the role of municipal councils during emergencies be reviewed so that the current capacity of the municipalities is reflected (MAV 2011). This underscores inadequacies in the communication and expectations of policy implementation and planning strategy between agencies and governments which was discussed in the panel discussion.

Sandbags on the road, Kerang, Jan 2011. Credit: Sandra Neivandt

Community frustrations

The panel discussion highlighted some key community frustrations such as not having disaster control in the region but based from Melbourne, lack of information on water flow, or the repeated 'floods make enemies, fires make friends' which reflected how annoyed the community was with not only the length of the event but the need for them to take actions themselves.

These frustrations were not just felt in Kerang, but according to the Victoria Flood Review many of these issues were felt state-wide (2011). In particular, the review notes that communities felt an absence of Vic SES presence and many had to rely on Country Fire Authority Services which was not ideal. Other themes emerging at the think tank that were also raised in the Interim Report included:

- Lack of clarity of roles and responsibilities among different agencies (such as BoM, the CMA, DSE, SES, CFA, State Police and local governments) for warning and response.
- Lack of appropriate river gauges.
- Concern over confusing terminology used in floods to describe the dimensions (river height/volume) of floods.
- Incident control apparently ignoring, discounting or not using local knowledge (Comrie 2011).

A Kerang house surrounded by floodwaters, Jan 2011. Credit: Sam Mowat

References

Comrie, N. 2011, 'Review of the 2010-11 flood warnings & response,' *Interim Report*, June 2011, Victorian Government.

Gannawarra Shire Council 2011, 'Submission on the Victorian Floods Review', May 2011.

Municipal Association of Victoria 2011, 'Submission to the Review of 2010-11 Flood Warnings and Response', May 2011.

Worn, S. 2011, 'PIA Victorian division submissions into the Parliamentary Inquiry into flood mitigation infrastructure in Victoria,' August 2011, Planning Institute of Australia.

Credit: Sam Mowat

Appendix 1: Participant evaluation of the think tank

Fifteen participants filled out an evaluation of the event (Table 1.1). Many people cited Rob Wilby's talk as one of the most useful aspects of the think tank. They particularly were interested in taking his 'global lessons' and turning them into 'local solutions;' examining more closely flood planning and preparedness; and connecting the variability in the climate with climate change.

There were also several comments made expressing appreciation towards the variety of organisations, government departments and academics that were involved in the discussion.

Suggested improvements were to have more academic researchers representing universities present, that there was a bit of a divide about what some of the community thought the workshop was about and what the desired outcomes were, and that more input from the speakers, Rob Wilby in particular, would have been educational.

Other comments were that local media should have been invited along, as they are a key component in educating and communicating with the community. There were also a few comments on what was going to happen next, what was going to be done with the information gathered from this workshop and how was it going to be communicated back to the community.

When asked to rate the workshop from very poor to excellent, none of participants picked 'very poor' or 'poor.' The majority of people agreed that the workshop improved their knowledge of climate change adaptation and that the topics and the scope of the workshop were relevant.

Kerang house ready for water, Jan 2011. Credit: Sandra Neivandt

Table 1.1: Think tank evaluation questionnaire and participant responses

Questions	Tally	Comments
Question 1: Which of the following best describes your affiliation?		
Government (Federal)	2	
Government (State)	6	
Government (Local)	2	
Industry	1	
University	2	
Other	2	Flood Warden Local resident
Question 2: Why did you attend the *Floodplain Management Think Tank?*		
To present	3	
To network	4	
To represent a workplace	7	
For personal interest	2	
Other	2	Work reporting Take information to Flood Warden meetings Community Interest
Question 3: Did the *Floodplain Management Think Tank* improve your understanding of climate change adaptation?		
Strongly Disagree		
Disagree		
Neither Agree or Disagree	3	
Agree	12	
Strongly Agree	2	
Question 4: Were there any climate change impacts or issues for your region that you felt should have been included/given more attention by the *Floodplain Management Think Tank?*		
Yes	3	- Tools that allow for consideration of climate change - Real time access to data and data sharing - Better understanding of high volume rain/variation within catchment.
No	12	

Question 5: Were you introduced to any people organisations or projects at the *Floodplain Management Think Tank* that may assist you to improve you/your organisation's response to climate change? Yes No	 15 1	
Question 6: How would you rate the scope and relevance of the issues discussed at the *Floodplain Management Think Tank*? Very poor Poor Neither good or poor Good Excellent	 3 10 3	
Question 7: Which Aspects of the *Floodplain Management Think Tank* did you find most useful?		- Hearing about the 'lessons learned' from organisations - Rob Wilby's presentation - Hearing about a range of issues and perspectives from around the region - Open forum - Roger Jones and Rosanne Kava's presentations. - Brendan Christy's presentation - Identification of tools and planning - DSE flood plan mapping
Question 8: Which aspects of the *Floodplain Management Think Tank* did you find least useful?		- Some presentations didn't link very well into the discussion (BoM). - Possible formation of floodplain mapping for use by EM response agencies
Question 9: How would you rate the level of discussion and input from participants of the *Floodplain Management Think Tank*? Poor Undecided Fair Good Excellent	 3 9 6	

Question 10: How would you rate the level of opportunity that you had to contribute to the *Floodplain Management Think Tank?* Poor Undecided Fair Good Excellent	 1 11 4	
Question 11: Did you think the number and mix of participants and presenters was appropriate? Yes No	 14 2	- Need more local content, local VicSES needed
Question 12: How could the *Floodplain Management Think Tank* have been improved?		- More researchers from Universities - Complete proposal put up to be exposed to full road test. - If it had been longer it could have incorporated role plays of flood situations - Drop the C.C. components - Greater input from Rob Wilby during discussions - The community representatives didn't seem aware that the day was about developing research topics; needed better defined outcomes and expectations.
Question 13: Overall, how would you assess the value and importance of the *Floodplain Management Think Tank* as an event to discuss state and regional climate change adaptation issues and solutions. Poor Undecided Fair Good Excellent	 1 4 10 2	 - Issues highlighted not solved - Negativity from locals could be a barrier to on-going work
Question 14: Do you have any other comments/suggestions regarding the *Floodplain Management Think Tank* that may assist with planning future VCCCAR events?		- Not sure who the event was aimed at. - Invite local media to better educate community - Planning through presenters to check presentation content. - Community representatives need to have a better understanding of what the event is about. - Need more cohesive summary as to what will happen next with this information - Another workshop in 12 months to determine progress

Appendix 2: Roger Jones' submission to the Victorian Floods Review

Victorian Floods Review: Reflection and analysis

Roger Jones, Centre for Strategic Economic Analysis, Victoria University, PO Box 14428 Melbourne 8001.
roger.jones@vu.edu.au

This review submission is in three parts. Part I reviews the run-up to the floods and personal experience in dealing with flooding on the Model Farm Kerang. Part II reviews the hydrology and changing nature of floods on the Loddon River. Part III reviews the climate influences on the flooding. Finally, some recommendations are made.

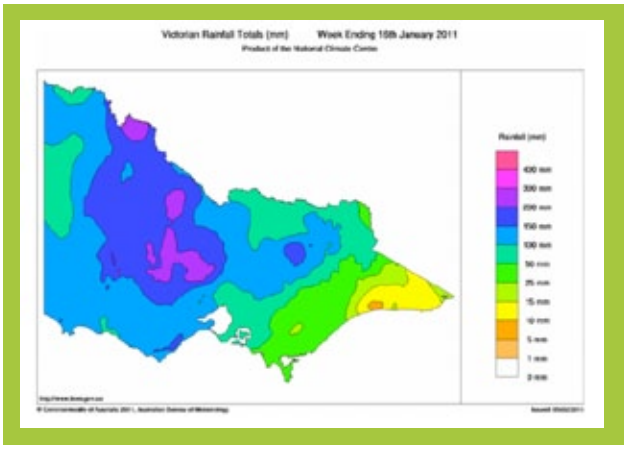
Part I: Run-up to the floods

Drought conditions eased during 2010 as a la Niña delivered old-fashioned average rains. This rain felt like wet weather to most people, because it had been so dry. In August conditions became wetter with decent falls. Large rains in September caused a moderate flood and the Kerang back swamp filled for the first time in years. At this stage, it was all good news – water was flooding into parched wetlands and spring temperatures were fuelling huge amounts of growth.

Kerang flood wardens met in September with local government and catchment representatives to update people on the flood situation, one technical and one more public. My mother, Elaine Jones of the Model Farm, Kerang, is a local flood warden. She and I had discussed the situation, she warned the meeting that more floods might be on the way, using past experience as an example. I remember thinking maybe a 25 per cent chance of a big one at that stage (that turned out to be very conservative). Some of the older heads in the district also felt the spring would be a wet one. We were going on previous years' experience, particularly November 1975, where the water reached the top of the levee bank. The farm levee bank was the town bank at that stage and we ended up with people from Kerang building up the bank with shovels full of dirt as the water lapped over. Town and property both saved. The latest record of a big flood in any year was December 1933.

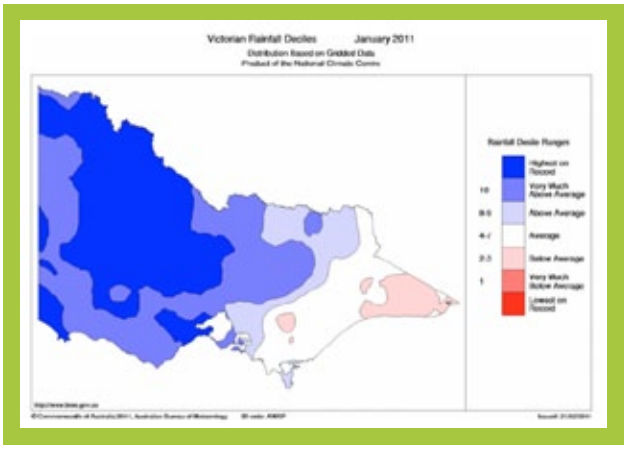
Because the drought had emptied storages and led to severe declines in the ecological condition of wetlands, all the local storages had been filled. The Kerang lakes, which can take water in a flood, and many other storages had been filled. Full storages provide insurance if it's been dry. These lakes supply irrigation water during the irrigation season, so are usually full in spring and summer, supply permitting. But full lakes also cut flood mitigation capacity. So at that stage, the odds between flood vs drought management were probably sitting on a knife's edge.

The local flood wardens didn't hear back from regional authorities again in 2010 after the September meeting. There was another big flood in December. It approached the top of the levee bank, nearing the 1975 level, but didn't go over. Perhaps at that stage everyone thought that they'd dodged a bullet and flood season was over. That's what history would suggest. But the northern catchments were very wet, with full mid and lower catchment storages, soil moisture capacity was full and only the rivers had emptied. Irrigation water was still being delivered, so the channel system was running at delivery capacity. Not full, but not empty, either.



Total rain Jan 9–16 2011 Victoria. Courtesy BoM.

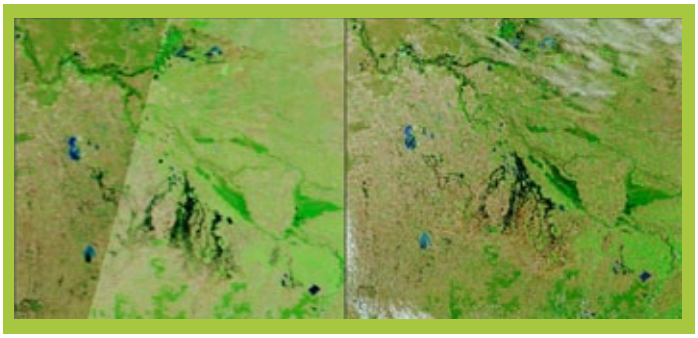
In January this year, central northern Victoria got some of its largest falls ever. Falls in the week to January 16 exceeded 200mm. Large parts of Victoria received their wettest January falls ever.



Rain percentiles for Victoria Jan 2011. Courtesy BoM

All that water had to go somewhere. The northern flowing rivers from the Kiewa to the Wimmera were bank-full or over-bank. The Murray had a flood peak from the Kiewa, King, Ovens and Upper Murray Rovers. The Goulburn and Campaspe arrived in Echuca, flooding out housing estates, and adding to Murray flows. The Loddon had a big slow-moving peak bearing down on Kerang. The Avoca was shooting through Boort and wanted to spread out over the floodplain between Kangaroo Lake, the Marshes and Benjeroop, joining the lower Loddon. The Wimmera flowed through Horsham, inundating houses, then north to Lake Hindmarsh, eventually with small amounts of water flowing into Lake Albacutya, last flooded in the 1970s. Swan Hill was threatened by the potential for Murray and Loddon-Avoca flows to join and flood the town.

Satellite photos of the floods are below, six days apart. The large black flows are on the Avoca, Loddon and Pyramid Creek systems, including anabranches and prior streams. Floodwaters in the Gunbower Forest along the Murray can be seen on January 26. The rivers joining to the north are the Murray and Murrumbidgee. The large lakes to the west are Lakes Buloke and Tyrell.



Satellite photos for northern Victoria Jan 20 and 26 2011 (MODIS Terra, courtesy NASA)

In Victoria's recent history, these were big floods affecting many people. Valiant community efforts managed to save some areas and salvage others. But circumstances have changed from those in the past. In old days, a solid timber house would dry out. Many older houses have since been condemned because the timber was no longer sound. Composite materials cannot take any soaking at all, so newer doors and furniture all have to be replaced. Patterns of land-use have also changed. Many newer property owners had never before experienced major floods and didn't know what to expect or where floodwaters were likely to go. Many properties have absentee landlords, so the old days of expecting that next door's levee bank will be maintained and monitored have passed. Many banks have weakened due to drought and rabbits. Landforms have been modified by dozer operators who don't know too much about local flood-ways and drainage lines.

Changes in the water management cycle over the past few decades have let certain elements – aspects of flood management being one – fall through the gaps.

Water management has become much more centralised. The last time major floods occurred, State Rivers offices were in most regional centres. Government amalgamations have merged organisations and corporatised parts of the water management cycle. Irrigation and supply are managed by corporations such as Goulburn Murray Water. Catchments are managed by catchment management authorities. They have responsibility for catchment management, particularly those relating to long-term condition, such as maintaining environmental flow targets.

The Bureau of Meteorlogy is responsible for flood hydrology and manage hydrometeorological data as well. They're very good at estimating how much rainfall is likely to turn into runoff. Recent changes to the BoM's website where real-time monitoring gives rainfall, flood status and river levels in some places is really useful. The biggest gap is when the water gets onto the floodplain and is moving downstream. Understanding how high peaks are likely to get and exactly where the water will go is a guessing game. There isn't a good flood modelling capacity in Victoria; consequently flood management is based mainly on the statistics of past floods. The January rains delivered record volumes of water to the Loddon and Avoca, therefore there was no precedent in terms of past floods (the one they used in 1909, is faulty as detailed in Part II).

Emergency management has also changed. It's much more centralised, so the flood is being managed from remote locations. Emergency management operates local hubs but may be controlled by people who work in general emergency management rather than flood management. Individuals may not have experience with flooding let alone local flooding. When floodwaters were rising, if we wanted sand-bags to build up weak spots in the levees we'd have to call a central number. The legitimacy of the request would be checked against a database to ensure against needless waste. And they'd get back to us. At some stage.

When the floodwaters were overtopping the farm banks, this system was still in place. Which is no good if you want access to critical resources immediately. Because there was no flood modelling capacity, we had no information on how high the peak was likely to get, so it wasn't clear as to how much needed to be done. In the end, we lost it and the flood peak exceeded the previous peak by at least 10 cm. And then sat there for over a day.

Water level, Murray Valley Highway, Kerang, Jan 17-21 2011 (m AHD)

After the flood peak passed Kerang, people on the lower Loddon felt they'd been given up, because the town had been saved and those downstream faced record inundation with limited resources. A few people took it upon themselves to do all they could, clocking up $1000 mobile phone bills as they coordinated evacuation, bank works and general community support. In the face of these and other great acts, the review will be asking, could the whole situation have been better managed, and what are the lessons for the future? The short answers are 'Yes', and 'There are many lessons to be learnt'. Even if average conditions remain dry, there will be more big floods. Not a question of if, but when.

Part II: Flood hydrology of the Loddon River

Part II examines the hydrological influences on past and present flooding leading to the January 2011 floods in northern Victoria. Local data used are daily flows at Laanecoorie Reservoir on the mid Loddon River, and daily rainfall from the Newstead and Cairn Curran rain gauges upstream. Hydrological issues concern long-term catchment change and flow data. These affect the assessment of historical floods on the Loddon River.

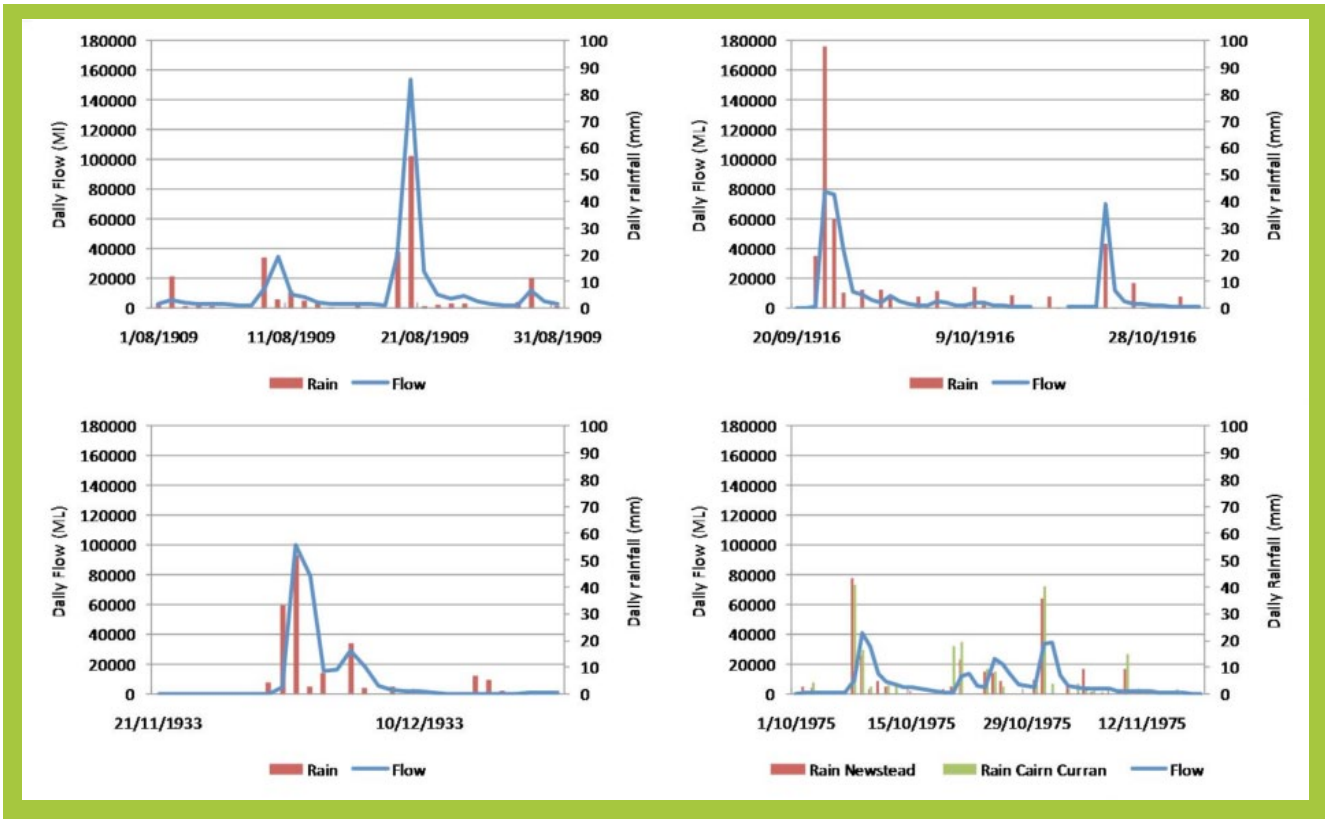
If there is no real ability to model the likely affect of floodwaters on a floodplain, planning will focus on past floods. This is problematic because catchments have been modified over time for flood mitigation, irrigation management, drainage and the protection of property. The following affects the Loddon River in particular but will be relevant to all the rivers affected by flooding last summer.

The flood of record on the Loddon River is August 1909. A flash flood led to the dam at Laanecoorie giving way, washing out the gauge, so the level and peak flow was estimated. The peak downstream at Kerang was higher than the second largest flood on record in spring 1975 – reflecting the amount of water coming from the dam failure. The flood hydrograph is dominated by this peak but the preceding rainfall is unexceptional. Twenty years ago I made a submission to the Kerang flood study suggesting that the runoff co-efficient assumed for the 1909 flood was unrealistic, its peak was influenced not by rainfall but by dam failure and that 1975 should be used as the flood of record as is the case for most other rivers in the region. This advice was ignored.

The catchment has also changed over time. In the past, the catchment was flashier than it is today. That is, rainfall very quickly became runoff and the resulting floodwater travelled very quickly down the river in high peaks that passed very quickly. This is due to two factors: gold mining, and water storages and river management. Gold mining led to many of the upper catchments in central Victoria being cleared for firewood to run stamping mills to crush the gold ore. Firewood collection for towns and bakeries especially was also a factor. These led to many of the box-ironbark and wetter forests in the upper catchments being cleared. Subsequent recovery after gold mining declined and electricity replaced wood fuel, which led to the forest recovery. Catchment management to prevent erosion via the Soil Conservation Authority also slowed runoff from cleared slopes in the mid catchment.

Water storages have allowed flow regulation; full-scale flooding does not occur until the storages are full and subsequent runoff has to be released. Even then, storages do slow down floodwaters. There are two reservoirs of significance on the Loddon: Cairn Curran and Laanecoorie. Farm dams on small tributaries in the mid catchments will also slow down runoff, preventing levels of low flow that would otherwise occur.

These changes over time can be illustrated by the August 1909, September–October 1916, December 1933, and October 1975 floods. Shown are daily flows at Laanecoorie and rainfall at Newstead. Using a single station provides a guide rather than full analysis, which would require total rainfall on the upper catchment. The 1909 floods clearly stand out as having a peak on the two vertical scales: flow on the left and rainfall on the right. 1916 has a greater rainfall event with lower flows. 1933 was a big flood occurring on a wet catchment. The 1975 event is the largest modern flood and was the best guide to what could happen in terms of flood behaviour. Later, lesser floods such as those in 1981 and 1993 also provided experience for locals and professional managers. These graphs also show that rainfall and flow occurred on the same day in the earlier floods but by 1975 there was a day's delay between rain events and peak flow. This is evidence of a healthier catchment but greater regulation will also be having an effect.



Rainfall (mm) and daily flow in megalitres at Laanecoorie Reservoir in 1909, 1916, 1933 and 1975.

Floods further downstream have become even less peaked than at Laanecoorie in the mid catchment. Big floods are now large slow-moving bodies of water that move down the main trunk stream. The catchments have different flood behaviour in their upper-mid and lower reaches. Under natural conditions when water reached the floodplains it would move into prior (ancient) streamlines and anabranches (stream that flow out and back into a river) across the plains. The whole mid Murray River system in northern Victoria and southern NSW behaves like this. In Victoria this behaviour can be seen in a whole system of surface- and groundwater-controlled stream and lakes. In NSW, large wetlands have been formed along major rivers such as the Lachlan and Murrumbidgee.

In the modern systems, most of the floodplain away from the main streams is now farmland protected from flooding. In NSW, many of the elongated wetlands are farmed and cropped. Much of the recent expansion in these wetlands has taken place since the 1970s using low security irrigation water and is one reason why the Murray Darling Basin is over-allocated and unsustainable. This expansion is still taking place further north on the Darling River.

This pattern of understanding then suggests we have a typology of floods along the river systems of the Murray Basin:

1. Small floods within single streamlines that are largely beneficial.
2. Moderate floods in single streamlines that require some level of protection for adjoining property (if that is current policy).
3. Large floods that affect multiple rivers and want to join across the floodplain utilising prior streams, anabranches and lakes.

The floods in January 2011 were clearly of type 3. Type 3 floods though, are largely being managed within single river systems and are informed by past records of flood heights. These, as I have already pointed out, are suspect for the first half of the 20th century. We can learn a lot from rainfall events during those periods, but less from the flooding behaviour. While the response to the recent floods was massive they could have been better managed. Understanding the climatic influences on major floods is a key part of this better management.

Part III: Climatic influences on the January 2011 floods

Northern Victoria's rainfall is influenced by the El Niño – Southern Oscillation (ENSO; spring–summer), Indian Ocean Dipole (IOD; winter–spring) and Southern Annular Mode (SAM; winter). Correlations of northern Victorian rainfall with simple indices are -0.51 for SOI May–Jan, 0.48 and -0.45 for two IOD indices May–Jan, and -0.25 for SAM for winter rainfall.

Recent research has linked exceptionally wet conditions in south-eastern Australia with the combination of La Niña and a negative Indian Ocean Dipole (-IOD) (Ummenhofer et al., 2009; Ummenhofer et al., 2011). The -IOD is associated with exceptionally warm waters off north-western Australia resulting in 'north-west' cloud bands that bring flooding rains into northern Victoria. The recent extended drought in Victoria has been characterised by an absence of these weather patterns. While central and north-western Australia have become wetter, this rainfall source has been conspicuously absent from south-eastern Australia.

Ummenhofer et al. (2009; UEA) nominate the following years as combined La Niña-negative IOD years: 1906, 1909, 1916, 1917, 1933, 1942 and 1975. These dates are based on (Meyers et al., 2007) classification of IOD that includes upwelling and/or strong winds near Java (MEA). MEA also included 1910, 1928, 1950 and 1981. Based on a more straightforward use of the Indian Ocean Dipole Mode Index, the Bureau of Meteorology's they nominate the years 1964, 1971, 1974 and 1975 as La Niña – negative IOD years since 1958 (http://www.bom.gov.au/climate/IOD/negative/) (BoM). However, if the simple Dipole Mode Index (DMI) is used, there are a good many false positives, so the accompanying climatological analysis by UEA and MEA nominating positive and negative IOD years is vital for assessing the statistics.

The figure above shows the status of La Niña conditions through the NINA3 index and the departure of the IOD index into a negative state in August, continuing through to October.

NINA3 and Indian Ocean Dipole Index Winter-Spring 2010.

When flood years are ranked according to the highest 40 monthly flows at Laanecoorie Reservoir in Victoria since 1900, of the 31 years represented, 11 (15) are combined La Niña -IOD years, 5 (8) are La Niña years, 11 (13) are neutral years, one is an El Niño year, one a -IOD year and one a +IOD year (numbers in brackets are occurrences). All seven of UEA's dates for La Niña –IOD register, one of four extra MEA dates, two of BoM's three dates and 2010 as yet not analysed. These add up to the at least 11 La Niña-IOD flood years estimated to have occurred in the past 110 years. Over the same period 29 La Niña years with neutral IOD occurred and one La Niña coinciding with a +IOD (UEA 2009, 2011).

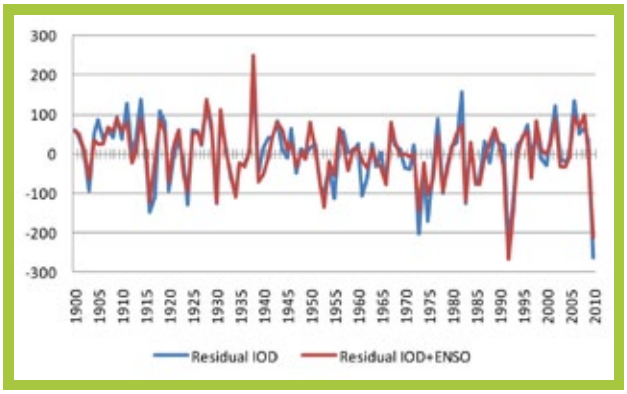
Most La Niña -IOD years have produced a major flow at Laanecoorie and about half have been major floods in northern Victoria: 1909, 1933, 1974, 1975 and 2010–11. La Niña years with major floods are 1956 and 1973, but the statistics for major monthly flows and La Niña years are not as high – they occur at a frequency slightly higher than La Niña years coinciding with neutral IODs. Neutral conditions (No ENSO or IOD event) occur about 50 per cent of the time, but are associated with about one-third of major flow years. Therefore there is about a 20 per cent chance of getting a high monthly flow in a neutral year. El Niño and +IOD events occurring with high flow events are rare but not unprecedented.

The lesson from this is clear. La Niña-IOD years are highly likely to have moderate or major flooding. La Niña years have a slightly higher probability of having high flow events. However, because La Niña years are on the whole wetter than normal, regional catchments are likely to be wetter – they are preconditioned to flood. Negative IOD conditions usually only occur after a La Niña is in place – in 2010, negative IOD conditions arose halfway through August (see Figure). Flooding followed immediately. La Niña conditions and/or catchment wetness should be used to establish flood readiness – these are conditions when heavy rain, if it occurs, is likely to cause flooding.

Table 1. Timing and monthly flow volume at Laanecoorie Reservoir on the Loddon River combined with La Niña, negative IOD (-IOD), and other climate status. Dates marked are repeat events in a single year. La Niña -IOD years are classified as a) Ummenhoffer et al., 2009, b) Meyer et al., 2007 and c) Bureau of Meteorology.

Month	Flow (ML)	La Niña-IOD	La Niña only	Other
Aug-1909	375490	Yes (a,b)		
Aug-1981	292149	Yes (b)		
Dec-1933	280034	Yes (a,b)		
Oct-1975	279720	Yes (a,b,c)		
Jul-1923	260239			Neutral ENSO +IOD
Sep-1916	246963	Yes (a,b)		
Aug-1955	246886		Yes	
Sep-1993	213692			Neutral
Jul-1956	198211		Yes	
Sep-1917	191455	Yes (a,b)		
Sep-1960	185493			Neutral
Sep-1906	168059	Yes (a,b)		
Oct-1964	161189	Yes (c)		
Aug-1920	160766			Neutral
Jun-1931	154443			Neutral
Aug-1917	153875	Yes (a,b)		
Oct-1979	152308			Neutral
Jul-1951	143829			Neutral
Sep-1973	142411		Yes	
Sep-1921	140227			Neutral
*Oct-1916	139376	Yes (a,b)		
Sep-2010	137741	Yes		
Aug-1939	132528			Neutral
Sep-1983	131189			Neutral
Jul-1918	128845			El Niño
Aug-1974	126726	Yes (c)		
*Aug-1973	125526		Yes	
Aug-1932	125459			Neutral
Oct-1992	121268			-IOD
*Oct-1973	116880		Yes	
Aug-1942	116598	Yes (a,b)		
Oct-1996	112869		Yes	
*Sep-1920	112238			Neutral
*Aug-1996	111688		Yes	
Jul-1936	110116			Neutral
Oct-1906	104902	Yes (a,b)		
Sep-1988	103832		Yes	
Nov-1924	103066		Yes	
*Sep-1974	102235	Yes (c)		
*Aug-1921	101228			Neutral

There are several Dipole Mode Indices measuring the IOD. The straight index does not serve as a diagnostic for flood conditions. An attempt was made to see if the relationship between northern Victorian rainfall ENSO index and IOD index has changed over the past century. This created a regression relationship between Northern Victorian rainfall and the ENSO and IOD indices.
No evidence of change was found, whereas eastern Australian rainfall has increased relative to ENSO. However, the model does seriously underpredict the last two -IOD related flood events on the Loddon in 1992 and 2010. The figure below shows that the model estimates are out by a couple of hundred mm. Adding ENSO and IOD give better estimates than using only one predictor. Are extreme rainfall events getting wetter? This provides some evidence that it may be the case, but it's not very compelling evidnce. Further research is required to build a better model for diagnosis and prediction that develops MEA and UEA's work further.



Simple regression model predicting northern Victorian rainfall from the ENSO and IOD index. Note the large errors in 1992 and 2010. If the model under-predicts, are extremes getting wetter?

Lastly, a great deal of research has been carried out to investigate the cause of the recent extended drought (Timbal et al., 2010). An anthropogenic component is likely, and has been linked to the strengthening of the sub-tropical ridge, linked to less storm generation over the mid latitudes and strengthening of the circum-polar vortex, pushing the rain-bearing frontal systems south. Therefore, dry conditions are likely to continue but do not rule out large floods occurring.

Recommendations for future management

1. Build flood modelling capacity to estimate flood volume, speed, location and peaks. This can also be used for mitigation before events by using past floods with current storage and soil moisture and also to run scenarios.

2. When negative IOD conditions, accompanied by phenomena such as a shallow thermocline and upwelling in the Java-Sumatra region, are sustained for more than two weeks during a La Niña event, the northern catchments of Victoria should be placed on full flood alert.

3. A wet catchment with full storages, La Nina conditions or a negative IOD should place the catchments on flood watch. This is time to look at potential mitigation, review flood plans and ensure that flood mitigation capacity is in good shape.

4. During full flood alert any temporary works limiting flood mitigation capacity should either be completed urgently, or mothballed if that is not possible, to make that capacity available. Storages such as the Kerang Lakes that can be partially emptied should be partially emptied. Modelling should be used to set the limits for reducing storage levels that best allow trade-offs between meeting environmental flow targets and flood mitigation. Agreements between the states at the scale of the Murray Darling Basin are also required. Major anabranches should not be closed when such conditions occur, and seldom filled wetlands can be earmarked and flooded opportunistically.

5. During floods the local situation should be managed by local flood wardens with outside assistance operating under their guidance. It is not possible to import instant experts who know enough about what they are doing. This will require some training.

6. Further research to develop a better climate based prediction system that can reliably pinpoint likely conditions for extreme rainfall needs to be undertaken. Built into a warning and flood mitigation system, such research has the potential to save millions of dollars damage into the future.

7. Northern Victoria is a water-sensitive landscape. Floods larger than the January 2011 are possible, if the indications provided by the simple model are correct (although this is low confidence). A drying climate with wetter extremes seems the most plausible climate outcome for coming decades given the current scientific state of knowledge. Long-term planning is required to adapt to these and other plausible changes that also take into accounting changing environmental, social and economic conditions.

References

Meyers, G., McIntosh, P., Pigot, L. and Pook, M. (2007) The years of El Niño, La Niña and interactions with the tropical Indian Ocean. *Journal of Climate*, 20, 2872-2880.

Timbal, B., Arblaster, J., Braganza, K., Fernandez, E., Hendon, H., Murphy, B., Raupach, M., Rakich, C., Smith, I., Whan, K. and Wheeler, M. (2010) Understanding the anthropogenic nature of the observed rainfall decline across south-eastern Australia, The Centre for Australian Weather and Climate Research, Melbourne.

Ummenhofer, C.C., England, M.H., McIntosh, P.C., Meyers, G.A., Pook, M.J., Risbey, J.S., Gupta, A.S. and Taschetto, A.S. (2009) What causes southeast Australia's worst droughts? *Geophysical Research Letters*, 36, L04706.

Ummenhofer, C.C., Sen Gupta, A., Briggs, P.R., England, M.H., McIntosh, P.C., Meyers, G.A., Pook, M.J., Raupach, M.R. and Risbey, J.S. (2011) Indian and Pacific Ocean influences on southeast Australian drought and soil moisture. *Journal of Climate,* 24, 1313-1336

A boatman ferrying people out of Kerang, Jan 2011. Credit: Sandra Neivandt

Appendix 3: Rob Wilby's think tank presentation

Flood risk management in a changing climate: Global lessons and local solutions

Kerang, Victoria January 2011
Source: http://www.uhavta1.ausequine.com/kerang_floods_2011.htm

Walham, Gloucester July 2007
Source: Pitt Review

Rob Wilby (r.l.wilby@lboro.ac.uk)
Department of Geography, Loughborough University, LE11 3TU, UK

Loughborough University

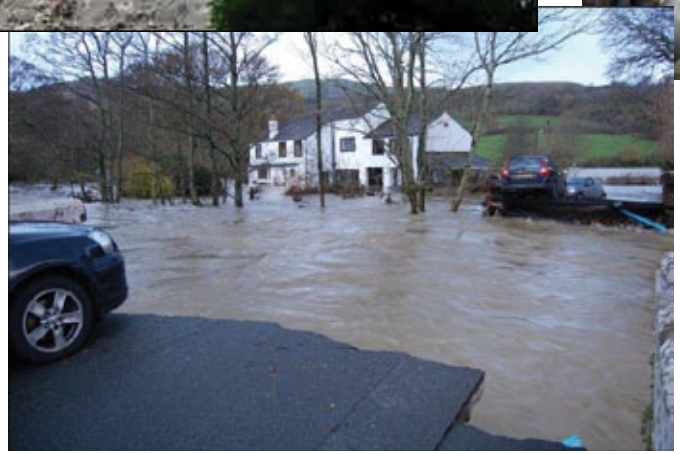
Hard lessons from notable UK floods

Autumn/winter 2000/1

Boscastle 2004

Carlisle 2005

Summer 2007



Cumbria 2009

National survey of water-related concerns

www.defra.gov.uk

Summary of Responses to the Water White Paper Online Survey

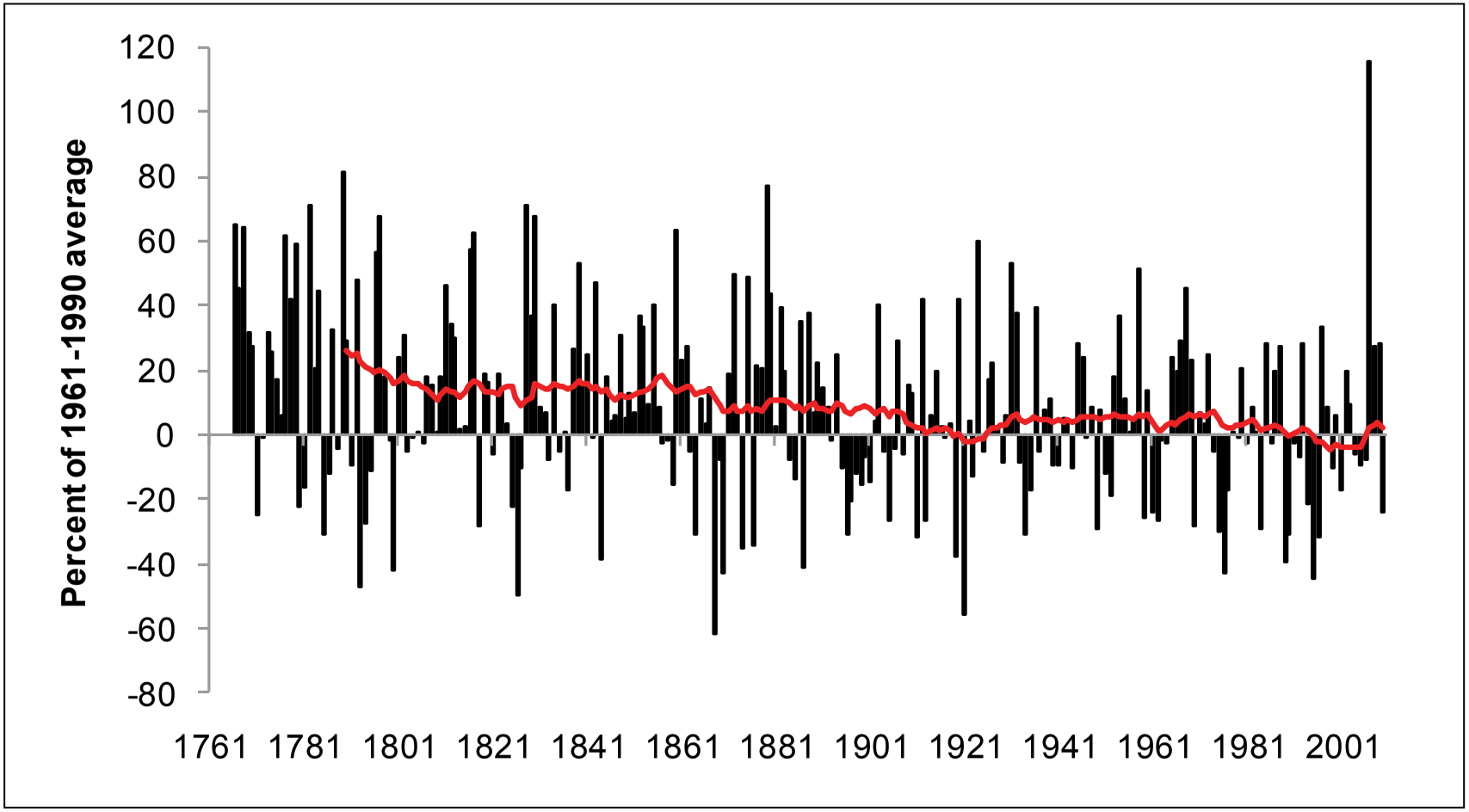
April 2011

defra

3. Question one: what do you see as the main issues around water that you or your community face? And how would you address them?

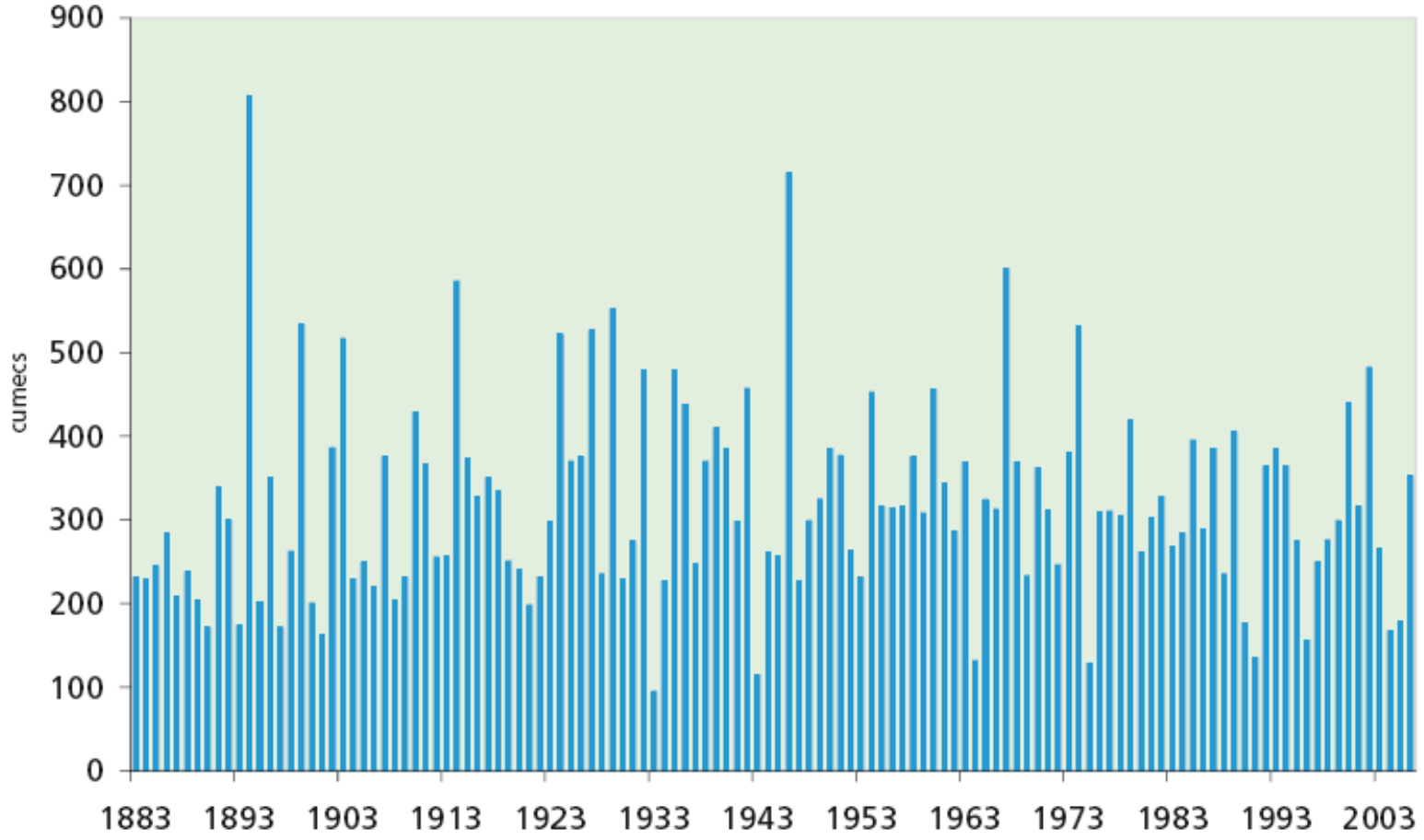
Source:
http://www.askderbyshire.gov.uk/neddc/water/files/waterwhitepapersurveyresponses110405.pdf

Decadal variability and extremes



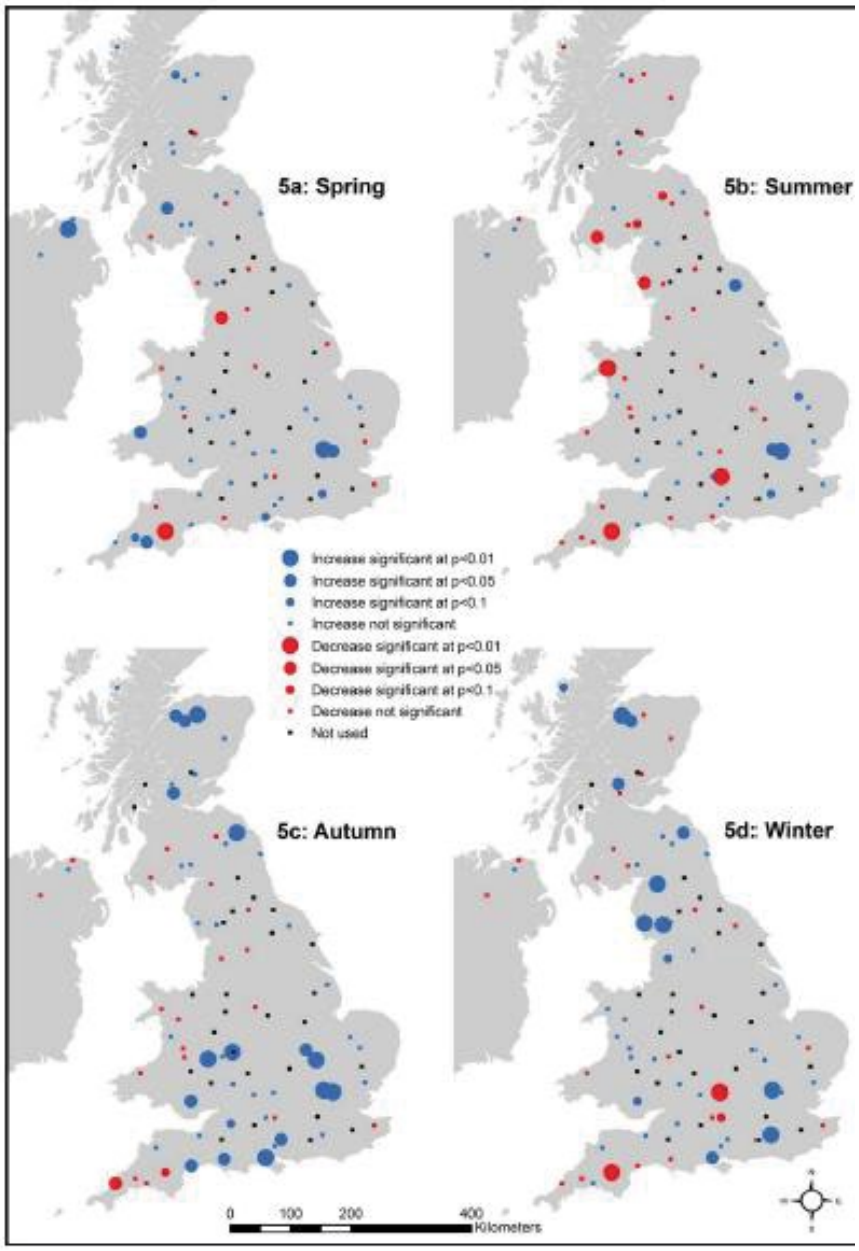
England and Wales May-June-July rainfall anomalies 1766-2010. The thick red line shows the 30-year moving average. Data source: UKHC

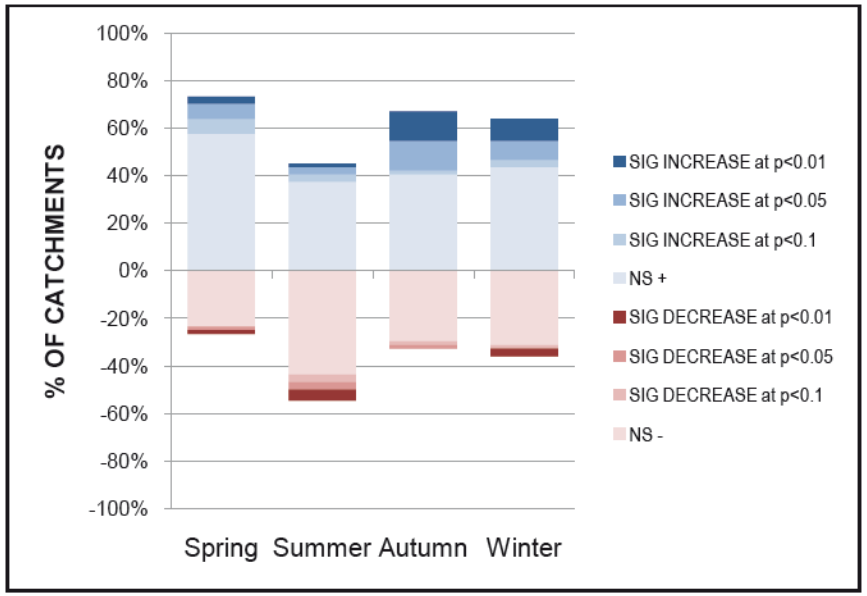
Annual maximum flows in the River Thames



Source: Marsh & Hannaford (2008)

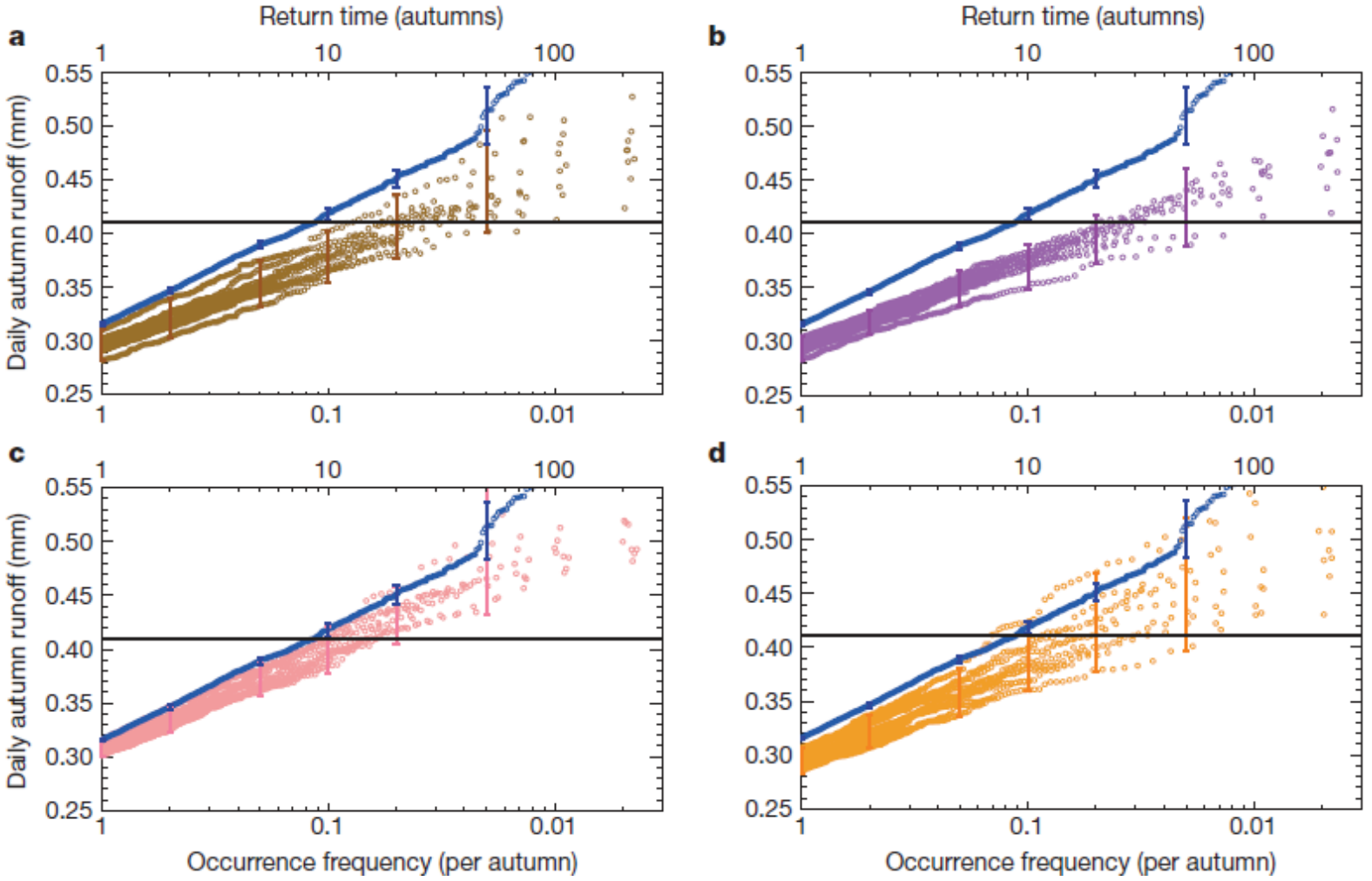
Flashiness of river flow





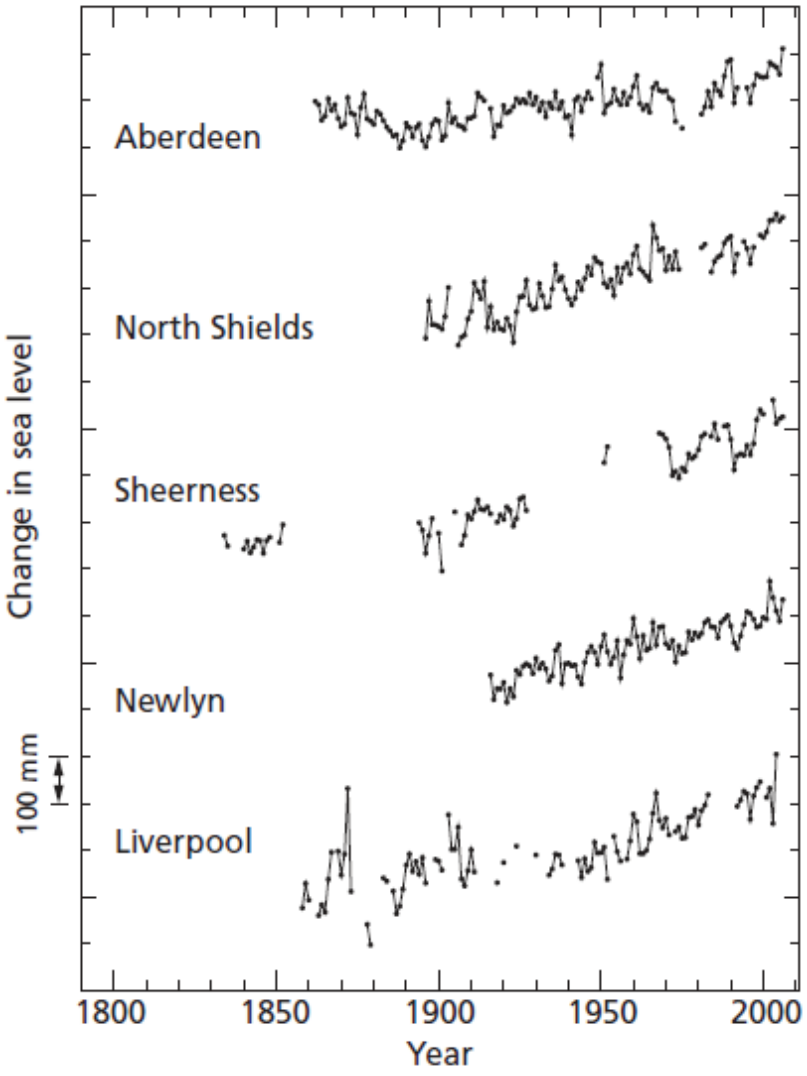
Trends in the Richards-Baker (R-B) flashiness index over the 44 years to 2008. Source: Quinn (2010)

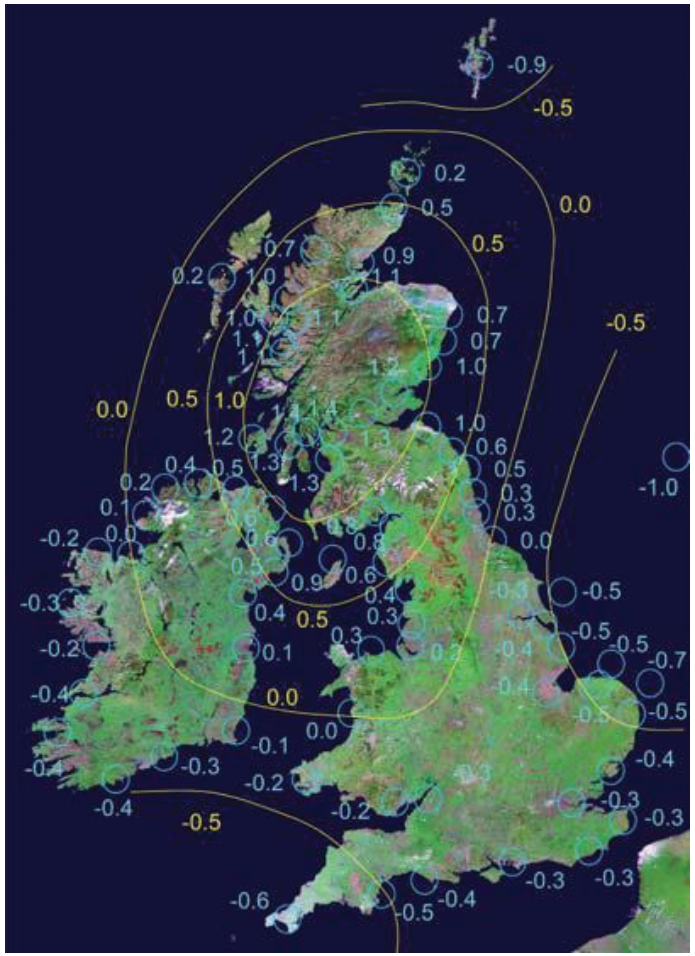
It's official: Human fingerprint found



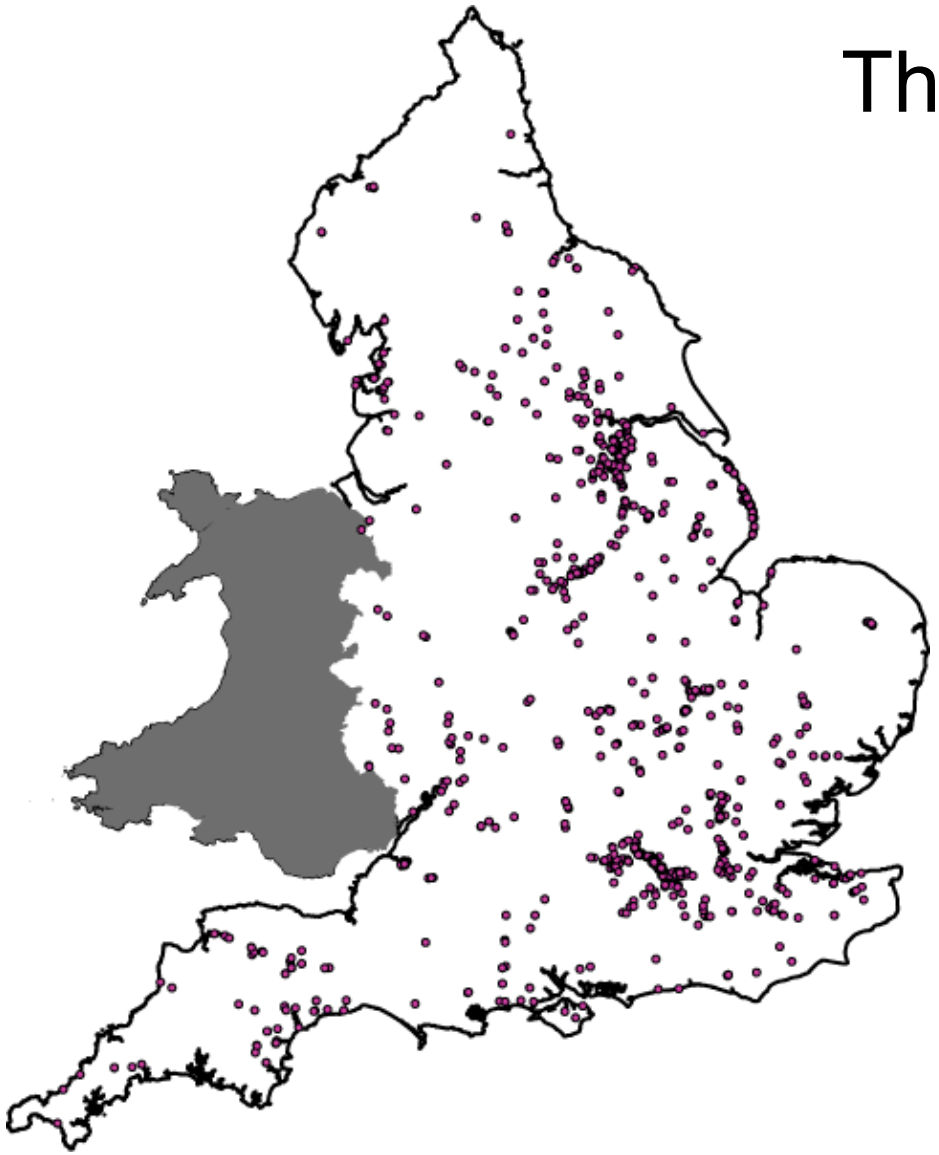
Change in occurrence frequency of daily river runoff for England and Wales autumn 2000 with GHGs (blue dots) and without GHG emissions (coloured dots, four GCMs). Source: Pall et al. (2011)

Changes in sea level





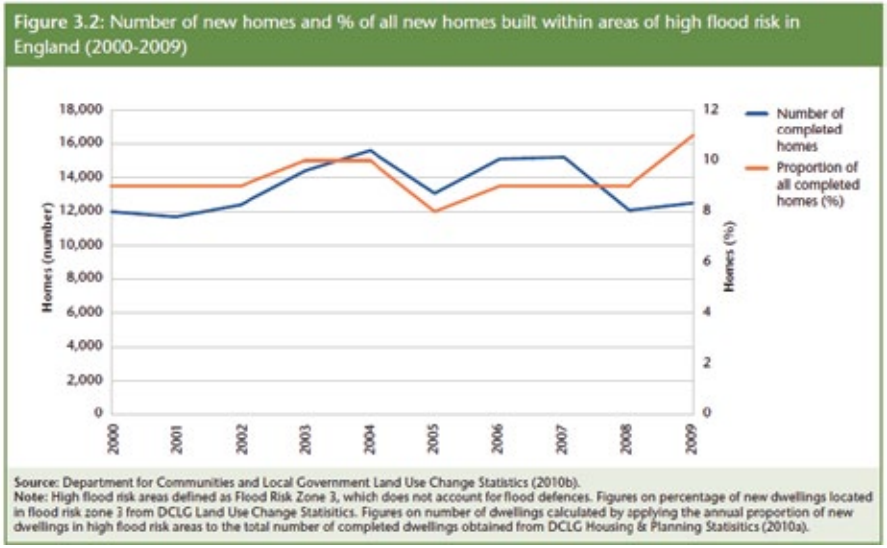
Current rate of relative land- and sea-level change in the British Isles in mm/y, showing relative land uplift as positive and relative subsidence as negative. Source : Shennan et al (2009)



The other side of the coin

Residential development since 2000 in areas that have flooded in the past. Source: ODPM and Environment Agency. No data for Wales

- Annual insured losses ~£1 billion/yr
- 5 million people live/work in flood risk areas
- 1 in 6 properties at risk from flooding
- Infrastructure costs ~£570 million 2009/10



In an ideal world – what can be done?

Tidal surge at Whitstable 1953

‘Enabling environment’ – policy and legislation

‘Enabling environment’ – risk maps

Map legend

- Flood Maps
- Flooding from rivers or sea without defences*
- Extent of extreme flood**
- Flood defences
- Areas benefiting from flood defences
- Main rivers

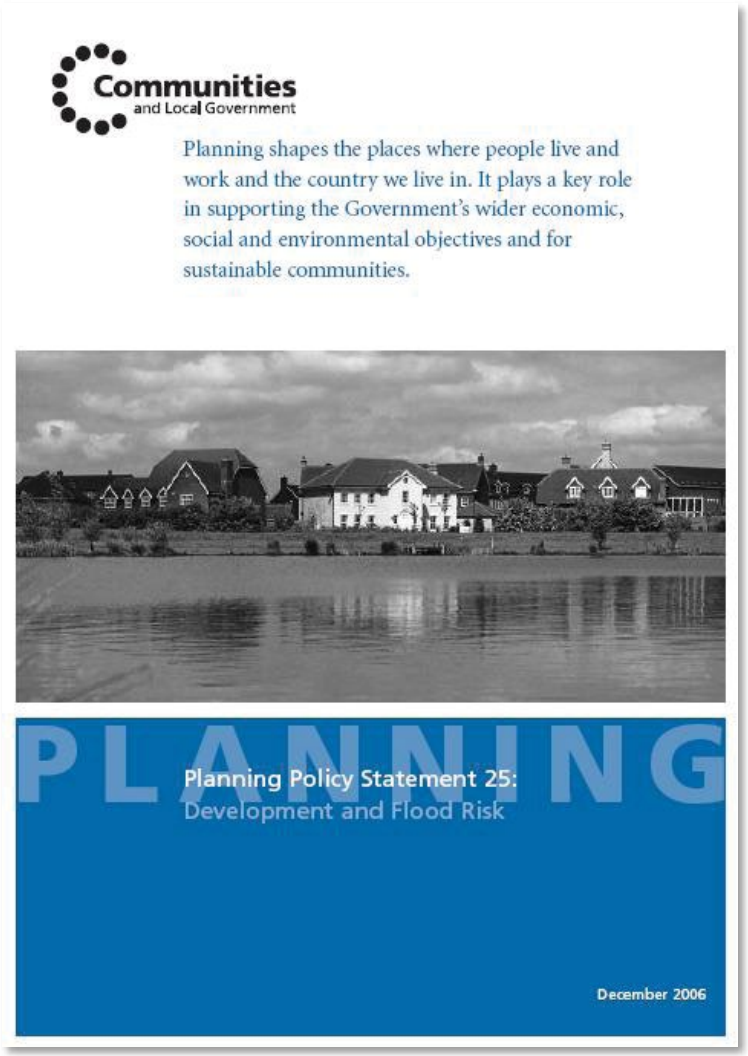
* 1 in 100 yr
** 1 in 1000 yr

Map of NG11 6PE at scale 1:40,000

Text only version

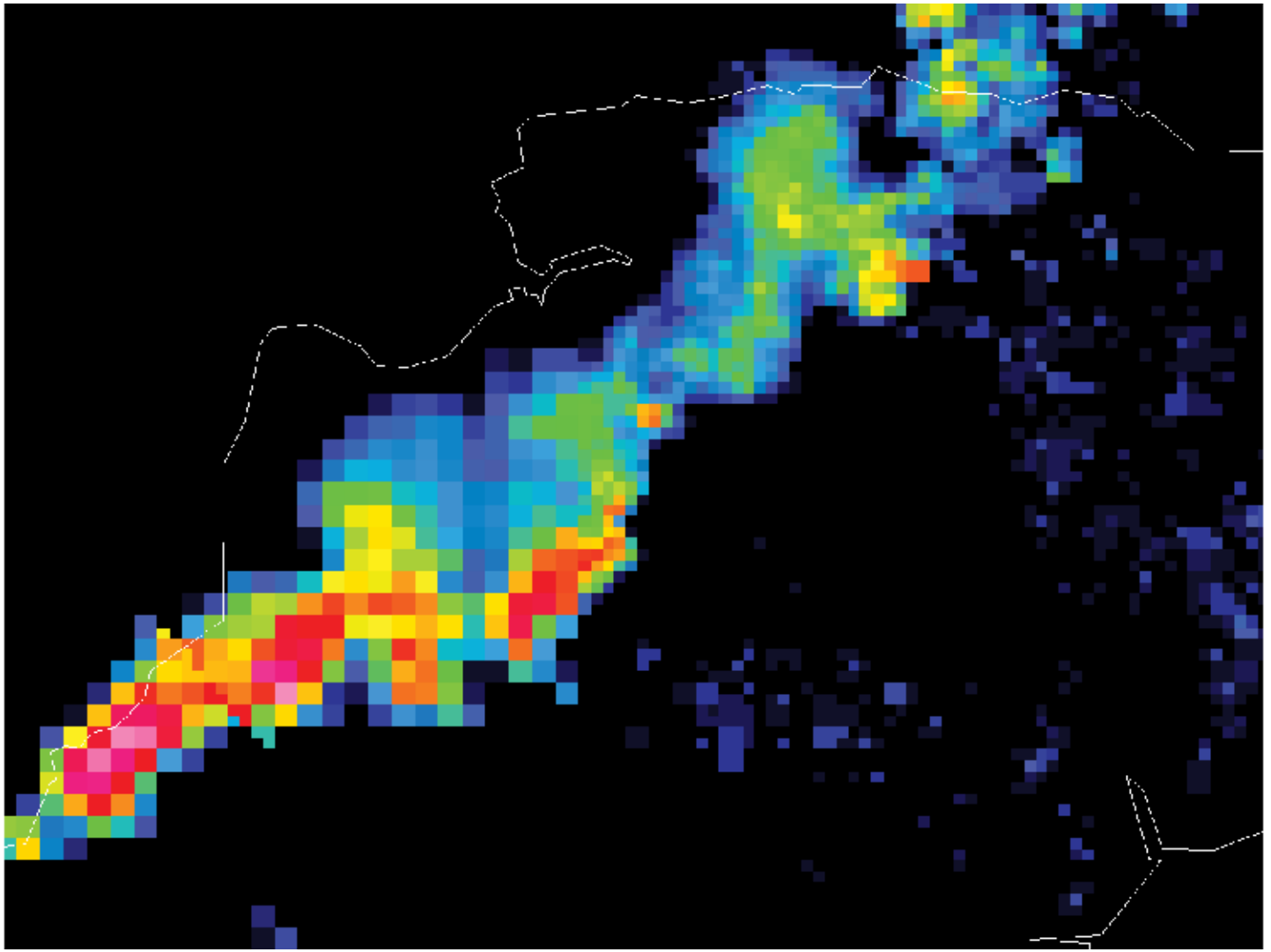
‘Enabling environment’ – planning control

Thames at Wallingford, January 2003. Source: Nick Reynard



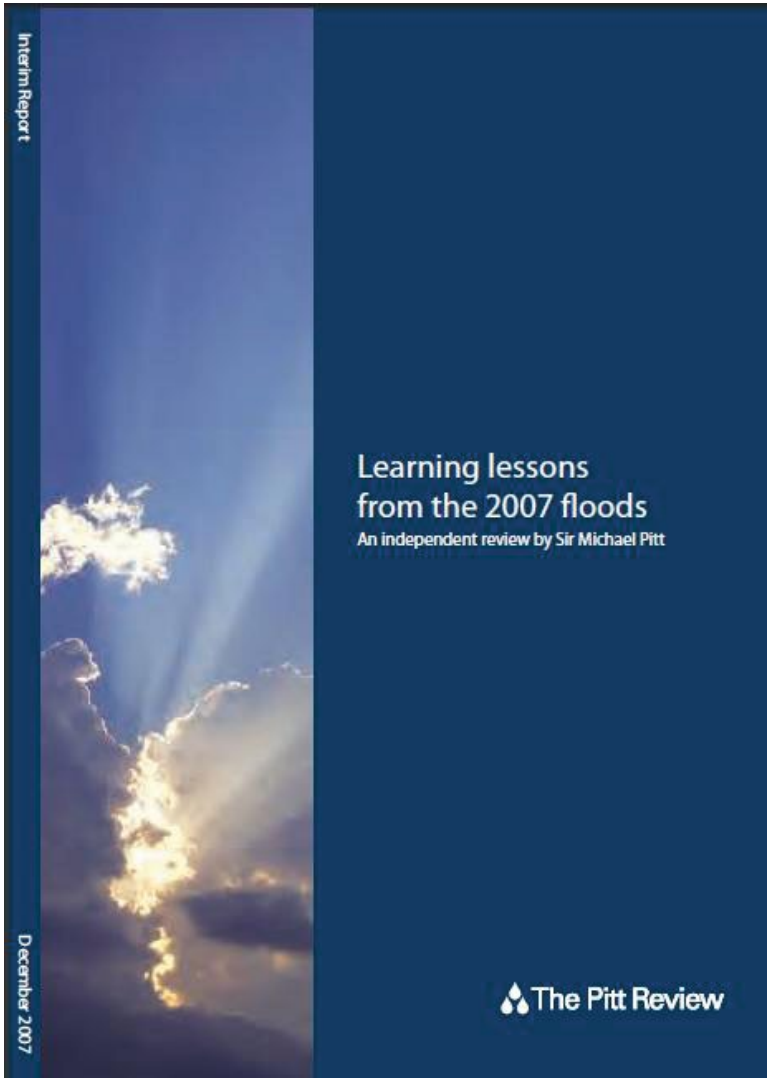
Source: DCLG (2006)

‘Enabling environment’ – monitoring systems



Boscastle flood radar image 16 August 2004

‘Enabling environment’ – hazard response



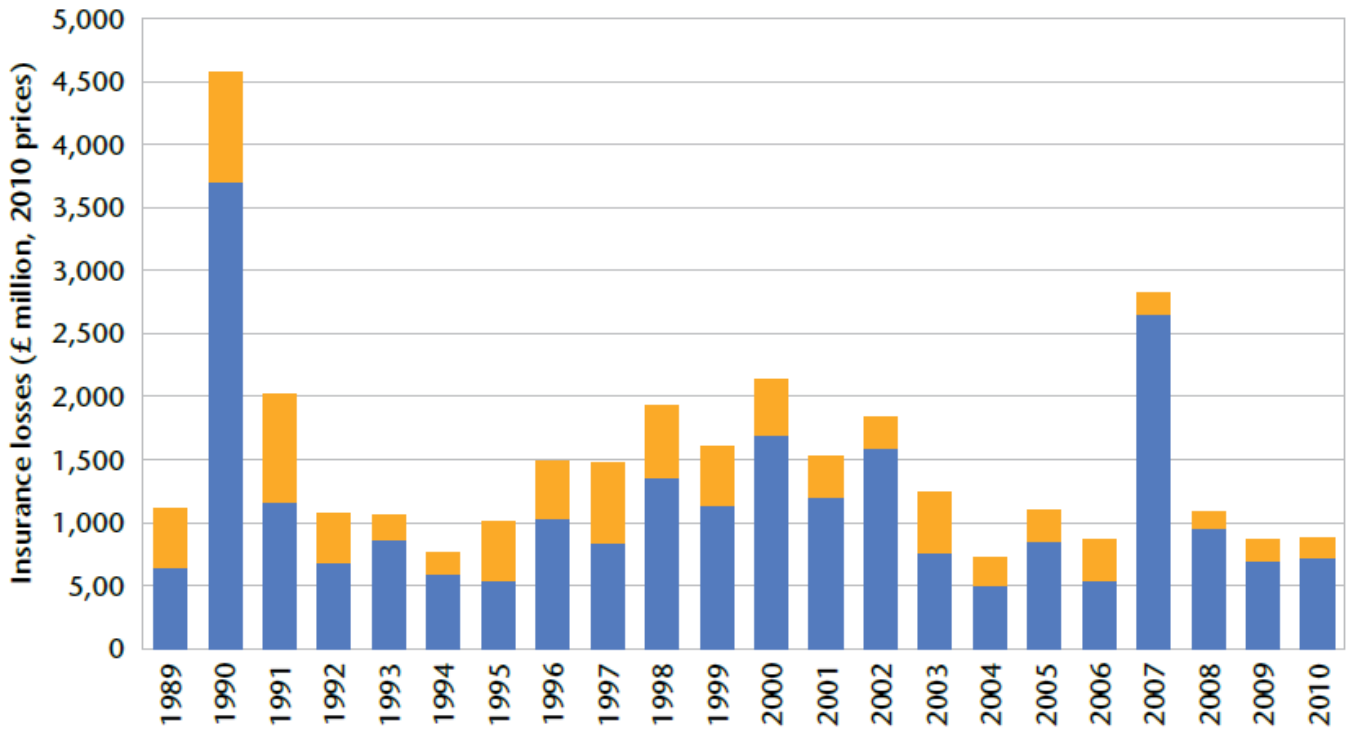
Pitt Review 15 urgent recommendations

1. Monitor groundwater levels systematically
2. Identify highest risk surface flood areas
3. Develop policy for demountable defences
4. Review local water rescue capabilities
5. Review adequacy of designated rest centres
6. Consider stockpiling equipment/consumables
7. Clarify role/ accountabilities (health guidance)
8. Identify and plan for most vulnerable people
9. Develop national flood emergency framework
10. List critical infrastructure
11. Extend telephone warning schemes
12. Enhance plans for ‘door knocking’
13. Involve local media in preparedness/ response
14. Encourage public to make flood kits
15. Persuade public to follow EA advice

LOCAL RESILIENCE FORUMS

‘Enabling environment’ – insurance

Figure 2.2: UK insurance losses due to floods, storms and subsidence

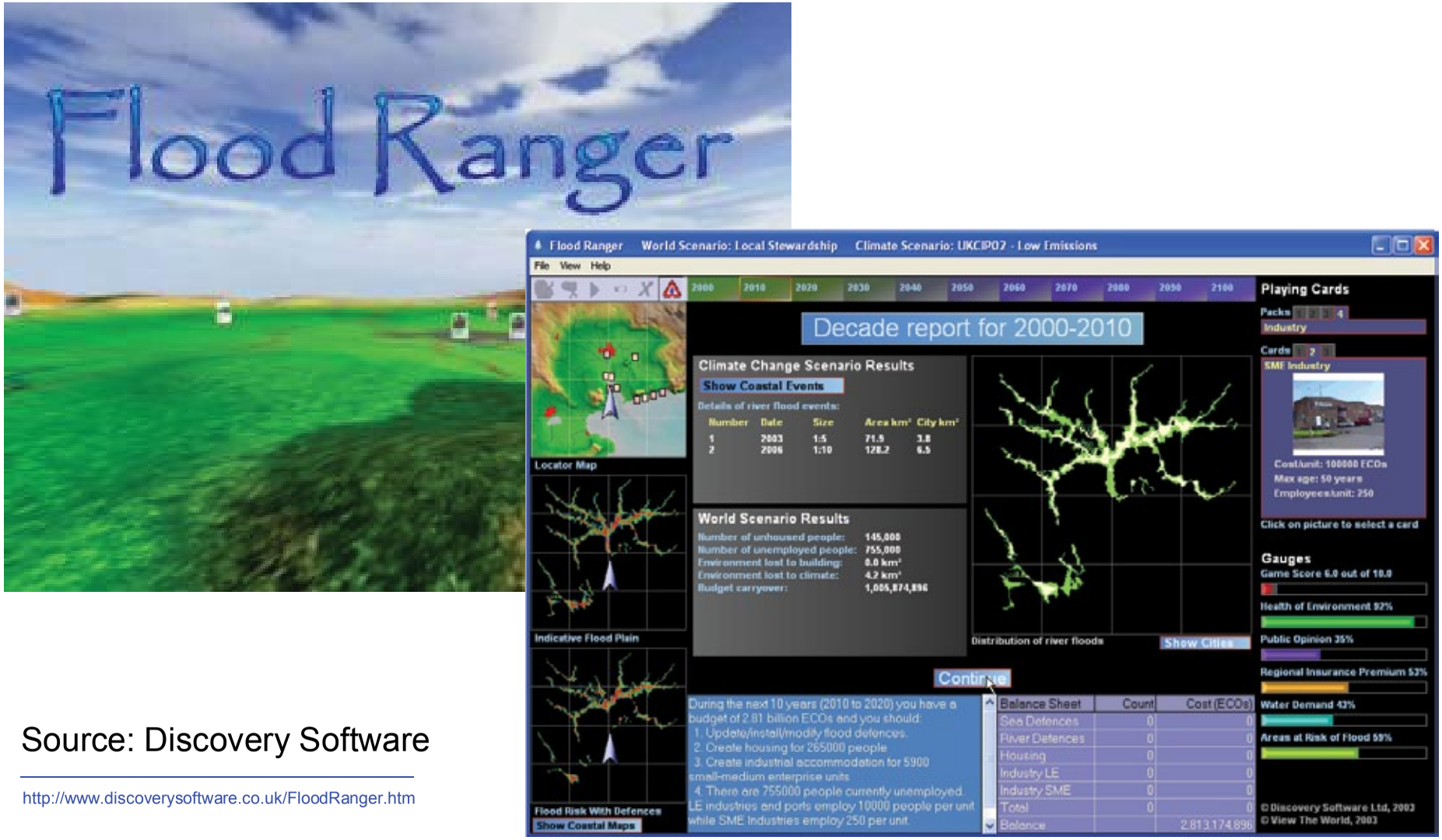


Issues:

- Incentives
- Gvt liabilities
- Solidarity

Source: Association of British Insurers.

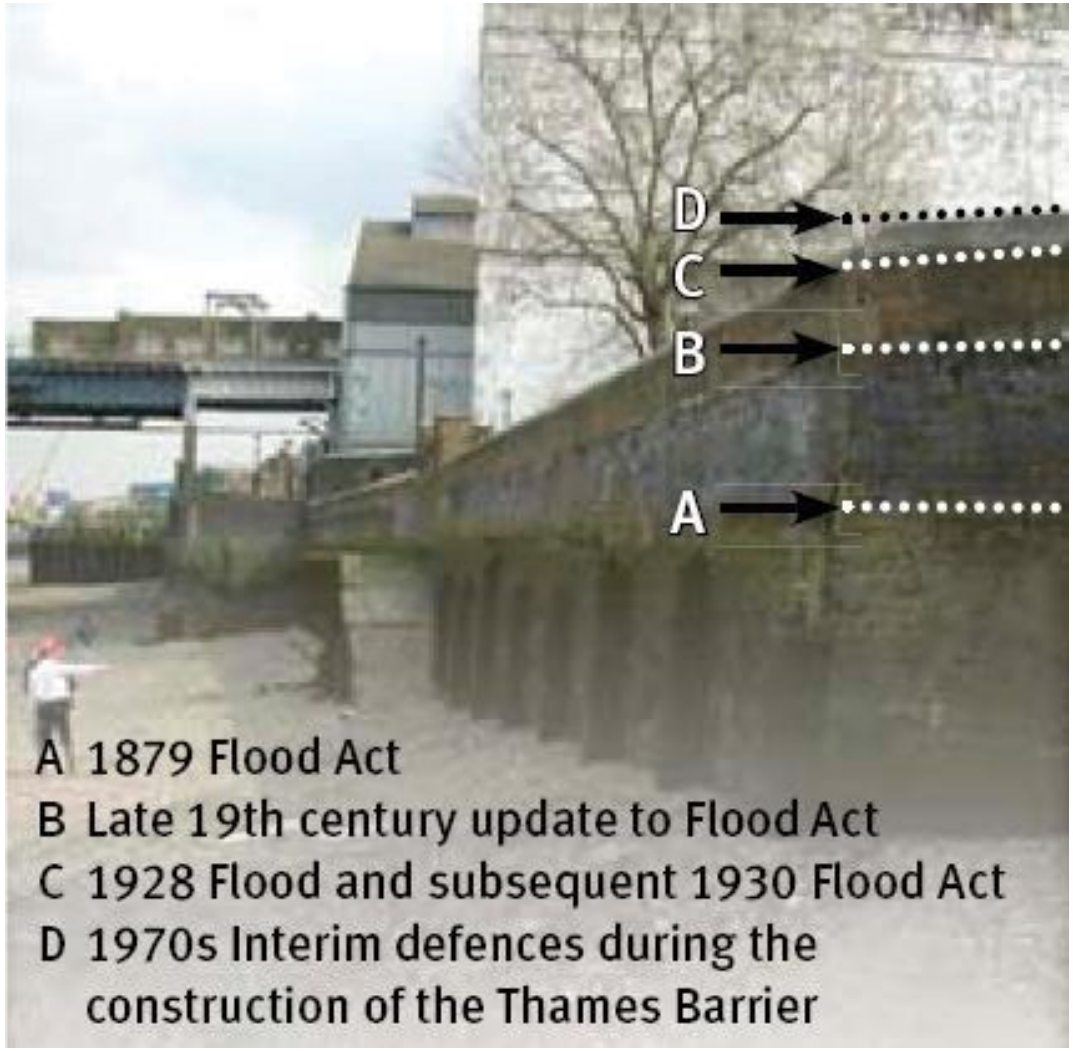
‘Enabling environment’ – education/role play

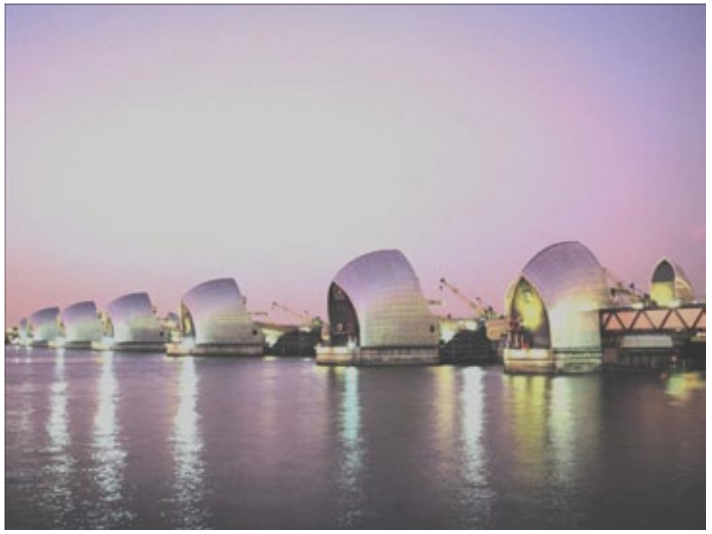


Source: Discovery Software

http://www.discoverysoftware.co.uk/FloodRanger.htm

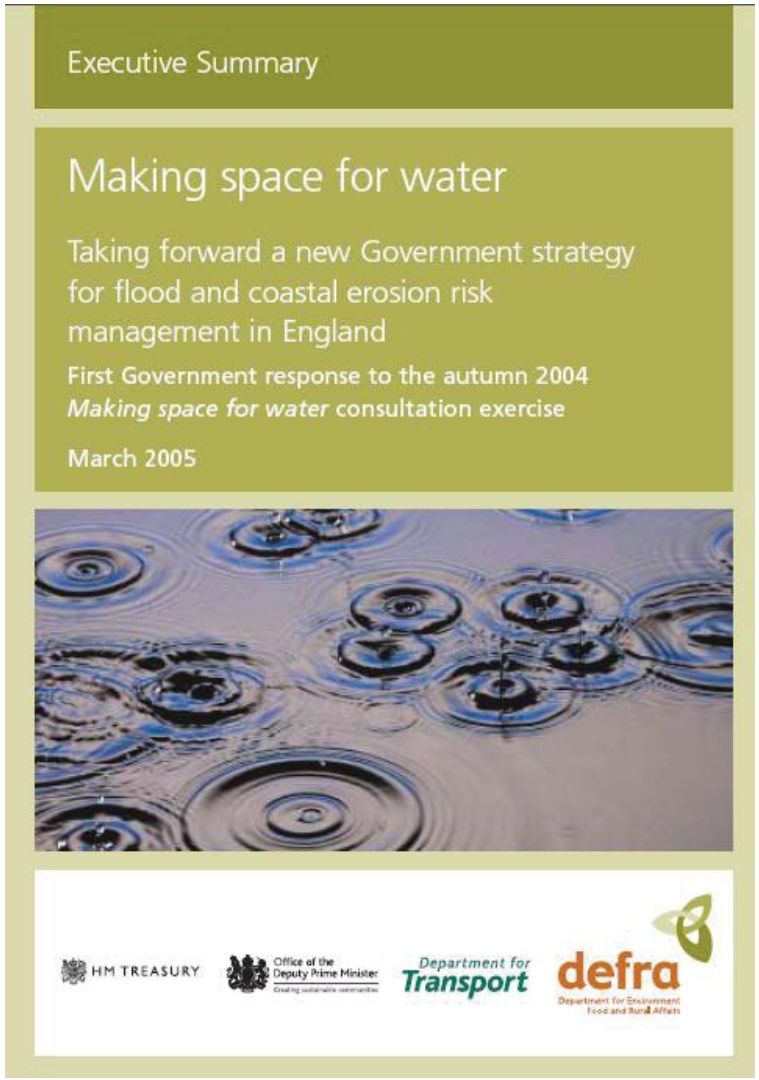
Reducing vulnerability – traditional





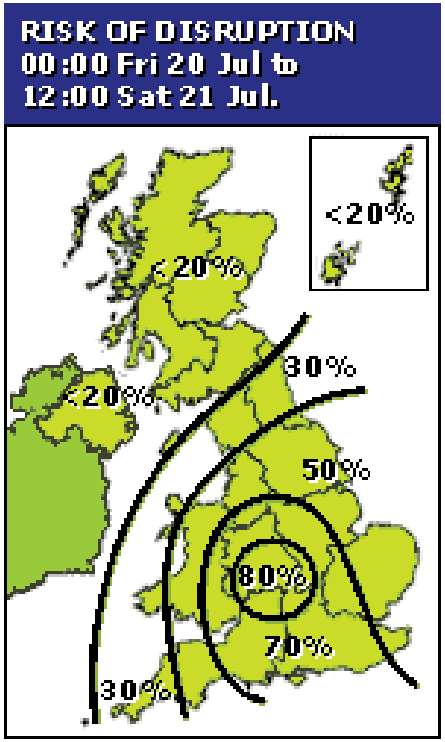
Responding to floods in Greenwich. Source: EA (2009).

Reducing vulnerability – making space for water



Photos:
EA, WWF

Reducing vulnerability – forecasting



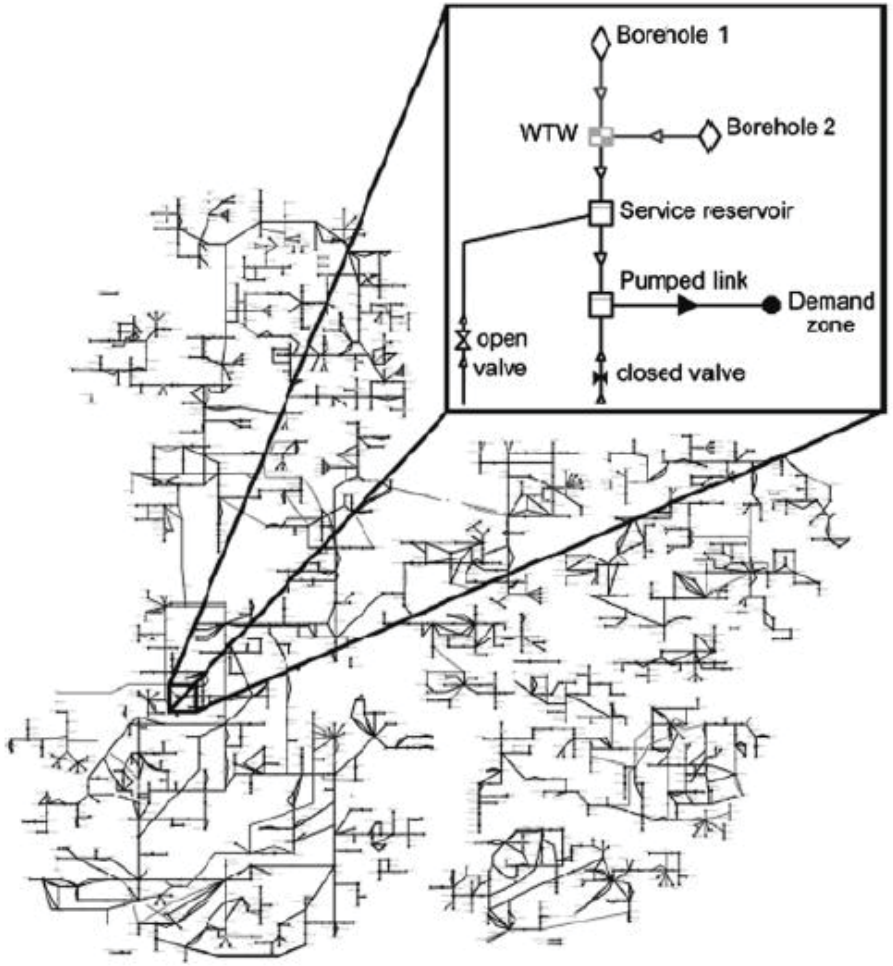
Map of the risk of disruption in July

Forecast timeline for July 2007	
Dates	**Actions**
16 July	Medium-range computer forecast suggests a vigorous weather system could move toward the UK and engage with relatively warm air over northern France.Met Office Executive Board briefed about the chances of this event.
18 July	Early Warning issued in the morning, central and eastern areas of England at risk of disruption from 60-90 mm of rain.
19 July	Risk areas narrowed to south-west Midlands, Gloucestershire and Oxfordshire. Possible rainfall total increased to 75-100 mm.
20 July	Flash warnings for southern and central England issued before 9 a.m.

Pitt Review led to the formation of the Met Office-Environment Agency Joint Forecasting Centre

Met Office forecast of the 20 July 2007 flooding
Source: http://www.metoffice.gov.uk/about-us/who/how/case-studies/summer-2007

Reducing vulnerability – asset/network resilience



Source: Henriques & Spraggs (2011)

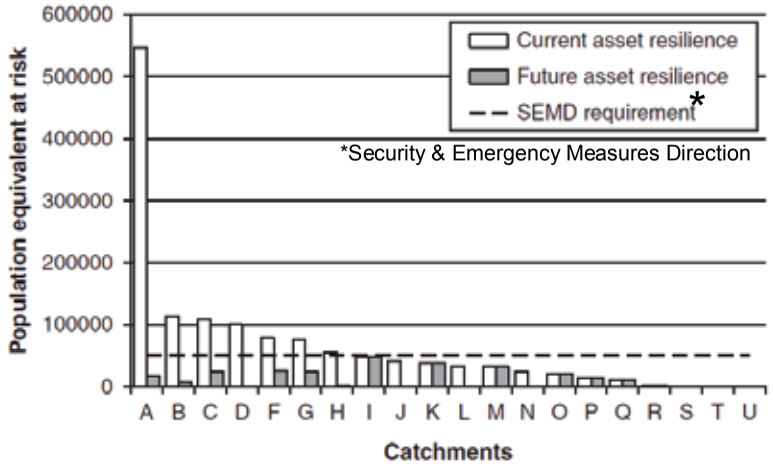


Figure 6 | Population equivalent at risk in case of widespread flooding. Results shown per catchment before and after implementation of flood mitigation options.

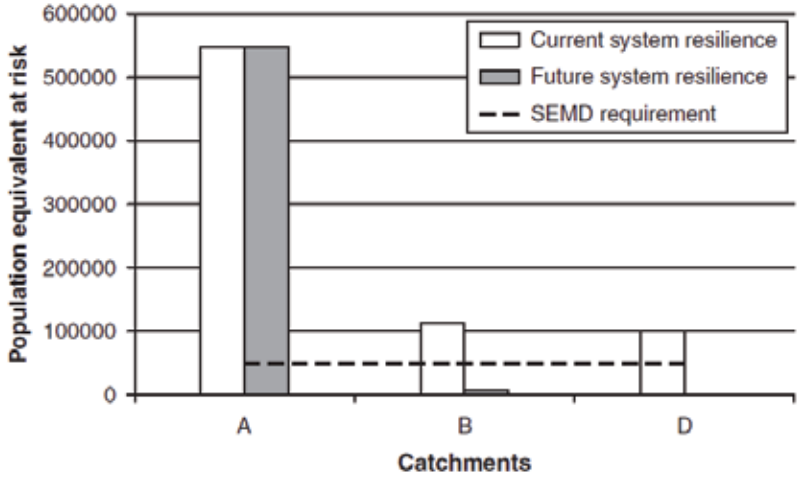
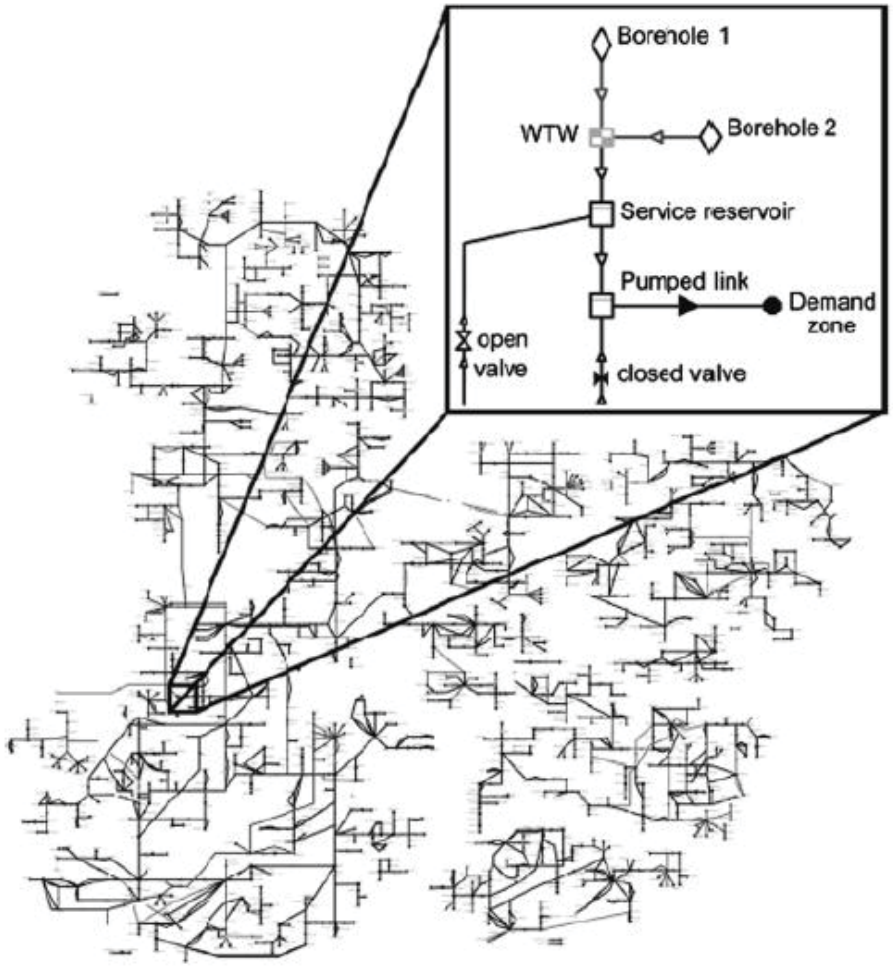


Figure 7 | Population equivalent at risk in case of widespread flooding for three example catchments before and after implementation of improved system resilience.

Reducing vulnerability – asset/network resilience



Source: Henriques & Spraggs (2011)

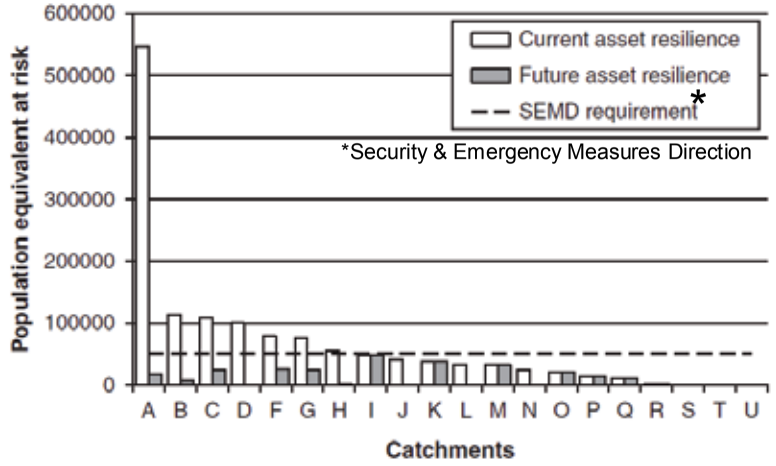


Figure 6 | Population equivalent at risk in case of widespread flooding. Results shown per catchment before and after implementation of flood mitigation options.

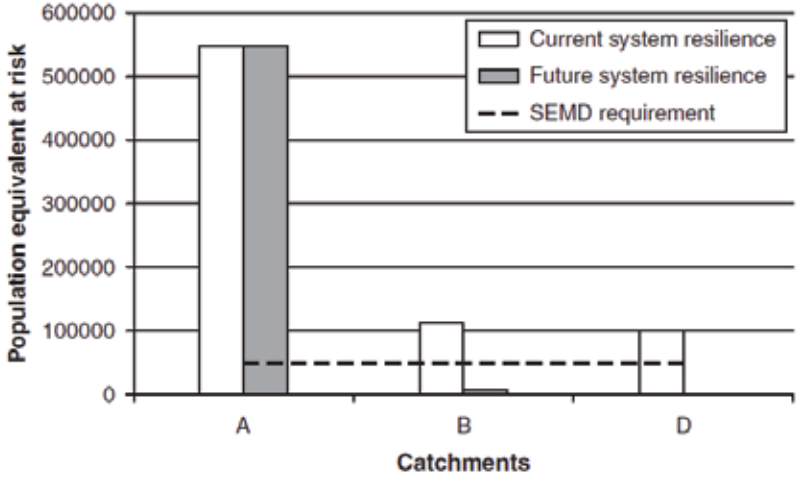
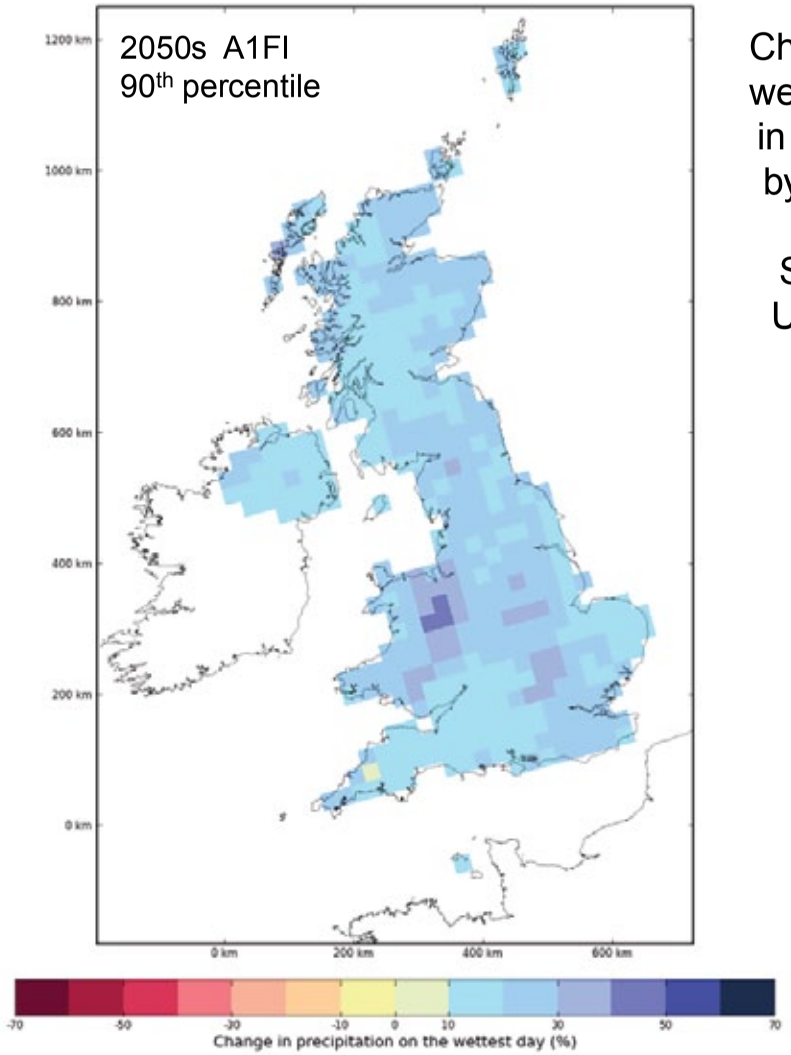


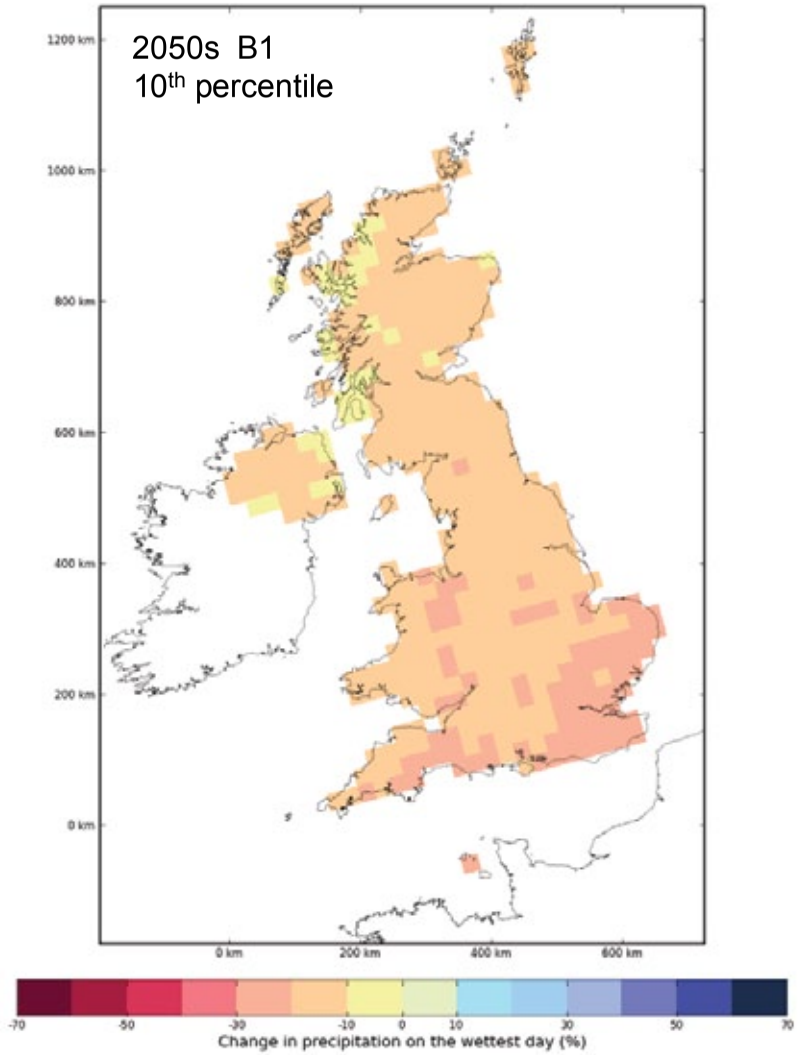
Figure 7 | Population equivalent at risk in case of widespread flooding for three example catchments before and after implementation of improved system resilience.

Adapting to an uncertain future climate



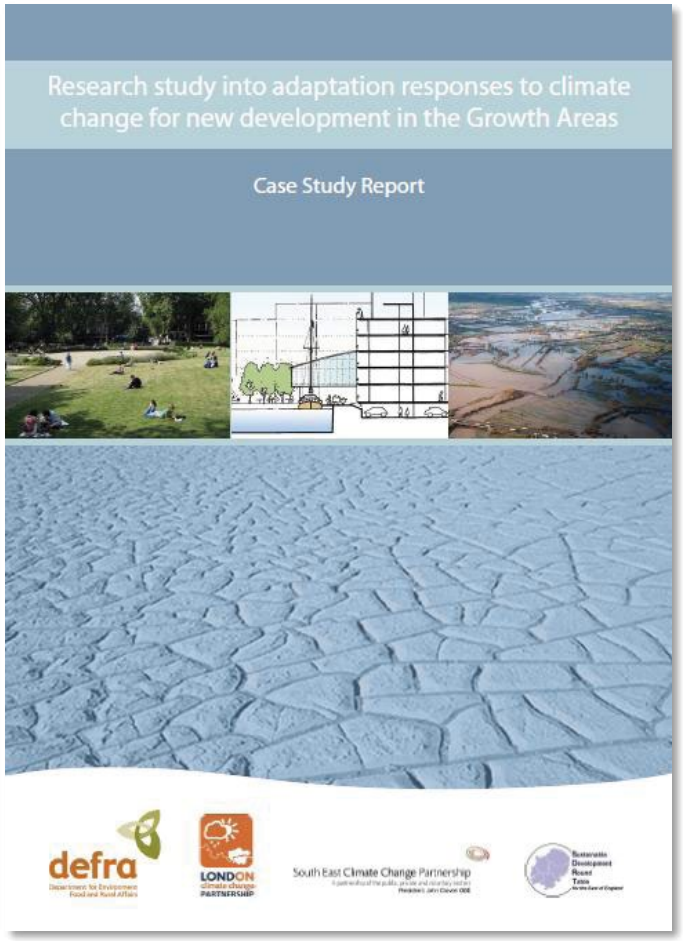
Changes in wettest day in summer by 2050s.

Source: UKCP09



‘Enabling environment’ – bridging agencies

Times 6 March 2011



Defra/UKCIP 2006

Reducing vulnerability – safety margins

Annex B: Climate Change

B1. There is an increasing body of scientific evidence that the global climate is changing as a result of human activity. Past, present and future emissions of greenhouse gases are expected to cause significant global climate change during this century. The nature of climate change at a regional level will vary: for the UK, projections of future climate change indicate that more frequent short-duration, high-intensity rainfall and more frequent periods of long-duration rainfall of the type responsible for the 2000 floods could be expected. Sea levels will continue to rise. These kinds of changes will have implications for river flooding and also for local flash flooding. There are several indications that the climate in the UK is already changing. Central England's temperature rose by almost 1°C during the twentieth century. Heat waves have become more frequent in summer and there are now fewer frosts and winter cold spells. Winters over the last 200 years have become wetter relative to summers; a larger proportion of winter precipitation in all regions now falls on heavy rainfall days than was the case 50 years ago.

B2. To help organisations (including local authorities and regional planning bodies) to assess their vulnerability to climate change and plan appropriate adaptation strategies, the Government established the UK Climate Impacts Programme (UKCIP).[13] Scenarios of future climate change in the UK[14] were produced for the UKCIP in 2002 and published by the Department for Environment, Food and Rural Affairs (Defra). Over the next 2-3 years, this climate change scenario information will be revised, expanded and developed to better meet stakeholder needs.

B3. The companion guide supporting the PPS *Planning and Climate Change*[15] will provide guidance on how planning should secure new development and shape places resilient to the effects of climate change.

B4. The Foresight project on future flood risk reported in April 2004.[16] The project found that, using the UKCIP02 climate change projections, together with scenarios of potential economic and social changes, annual damage from flooding may rise from around £100 million to between £460 million (under the community orientated *Local Stewardship scenario*) and £2,500 million (under the more consumerist *World Markets scenario*) by 2080.

B5. Global sea level will continue to rise, depending on greenhouse gas emissions and the sensitivity of the climate system. The relative sea level rise in England also depends on the local vertical movement of the land, which is generally falling in the south-east and rising in the north and west. Allowances for the regional rates of relative sea level rise shown in Table B.1 should be used as a starting point for considering flooding from the sea, along with the sensitivity ranges for wave height and wind speed in Table B.2, in preparing flood risk assessments.

[13] www.ukcip.org.uk

[14] Defra, 2002. *Scenarios of future climate change in the UK* http://www.ukcip.org.uk/scenarios/ukcip02/documentation/ukcip02_scientific_report.asp

[15] see footnote 1

[16] DTI, 2004. *The Foresight Future Flooding project* www.foresight.gov.uk/Previous_Projects/Flood_and_Coastal_Defence/Reports_and_Publications/Project_Outputs/Outputs.htm

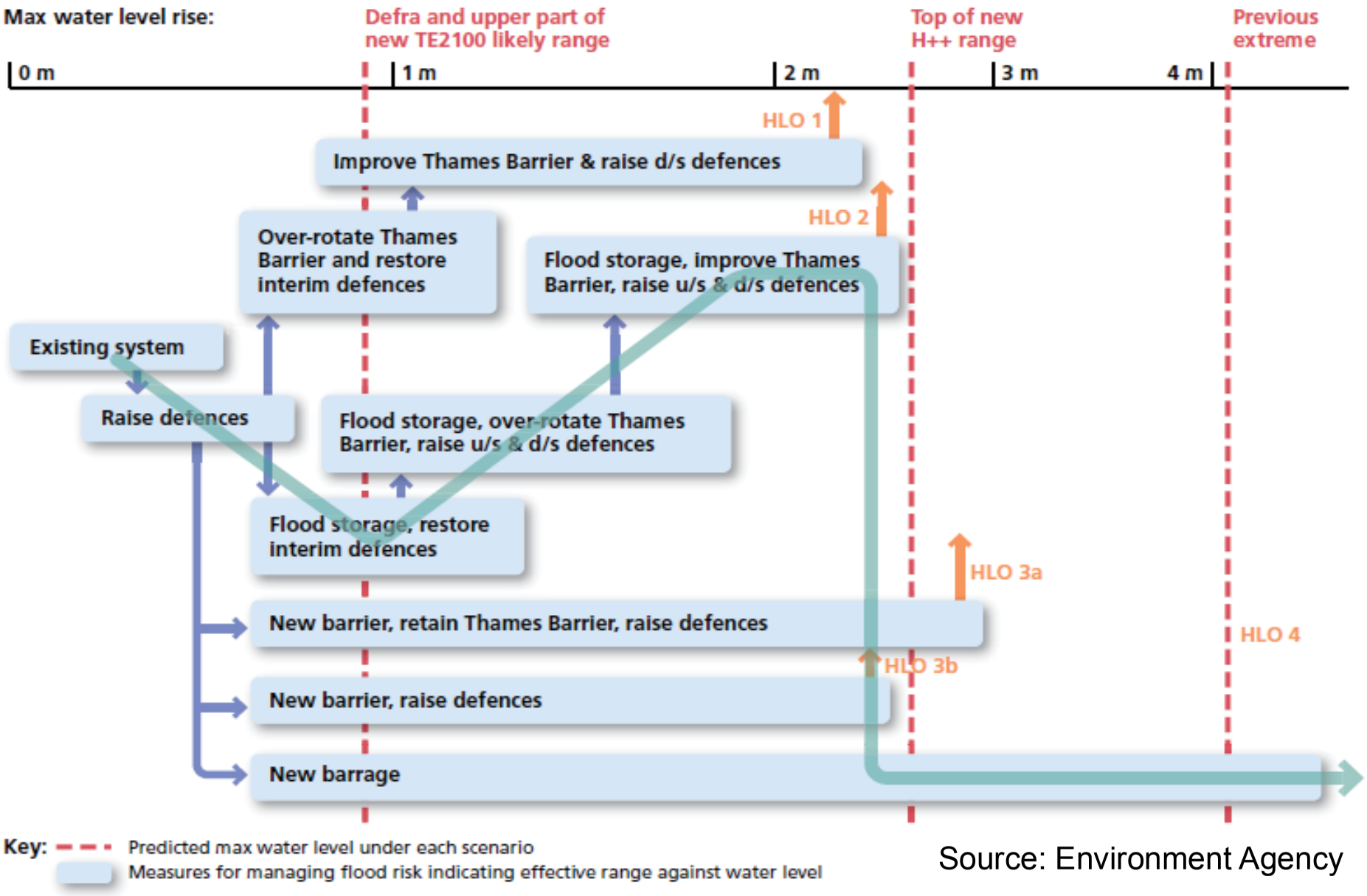
Table B.1 Recommended contingency allowances for net sea level rise

Administrative Region	Net Sea Level Rise (mm/yr) Relative to 1990			
	1990 to 2025	2025 to 2055	2055 to 2085	2085 to 2115
East of England, East Midlands, London, SE England (south of Flamborough Head)	4.0	8.5	12.0	15.0
South West	3.5	8.0	11.5	14.5
NW England, NE England (north of Flamborough Head)	2.5	7.0	10.0	13.0

Table B.2 Recommended national precautionary sensitivity ranges for peak rainfall intensities, peak river flows, offshore wind speeds and wave heights.

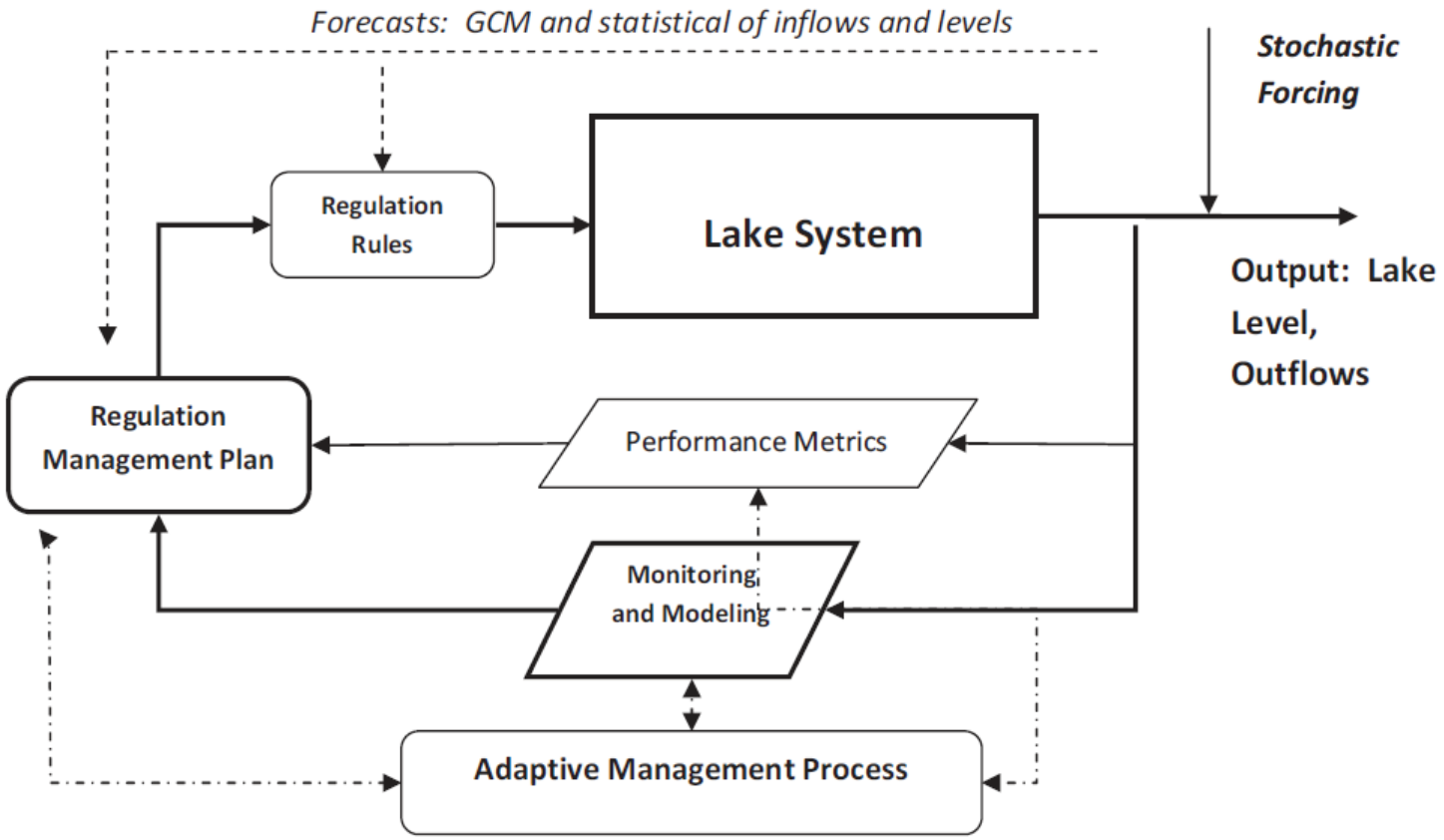
Parameter	1990 to 2025	2025 to 2055	2055 to 2085	2085 to 2115
Peak rainfall intensity	+5%	+10%	+20%	+30%
Peak river flow	+10%	+20%		
Offshore wind speed	+5%		+10%	
Extreme wave height	+5%		+10%	

Reducing vulnerability – 'options-centric'



Source: Environment Agency

Reducing vulnerability – control rules/monitoring



A dynamic regulation plan for Lake Superior that depends on the plan performance and observed climate conditions. Feedback is provided via a monitoring program and ongoing evaluation of performance metrics related to coping zone status. Source: Brown et al. (2011)

Concluding remarks

- Multiple drivers of flood risk (climate, socio-economic, demographic, land use)
- Climate science informs adaptation planning BUT is not enough
- Scenario-led approaches have limited utility
- Adaptive management embraces uncertainty
- Costs attached to the enabling environment

Any questions?

VCCCAR Publication 05/11 ISBN: 978 0 7340 4747 2.

Document available from VCCCAR website at:
www.vcccar.org.au/content/pages/vcccar-publications