



**WATER SECURITY**  
Knowledge Exchange Programme



## Specific Priority Subject 2.4 Summary Report

### Supporting sustainable and resilient management of extreme rainfall

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<b>Lead Author</b>	Peter Woodward
<b>Contributors</b>	All those who attended the Workshop
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## Acronyms

WSKEP      Water Security Knowledge Exchange Programme

## Acknowledgement

HR Wallingford organised the event.

## Summary

This report is the Summary Outcomes Report of the WSKEP Specific Priority Subject Workshop 2.4 on '**Supporting sustainable and resilient management of extreme rainfall**'. It includes an introduction reporting the key recommendations resulting from the Workshop. This document will be made available on the Programme website [www.wskep.net](http://www.wskep.net). The full Participants Outcomes report was distributed to all participants at the Workshop.

## Disclaimer

This document reflects only the combined views of the Workshop participants.

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# 1. Overview

## 1.1. Introduction

As pointed out in the Pitt Review (2008), flooding is the most costly natural hazard in the UK. The Workshop's focus of "supporting sustainable and resilient management of extreme rainfall" was interpreted to mean the development of flood risk management in the UK to better handle the challenge of intense rainfall experienced at susceptible locations. The large number of recent events, notably including Boscastle, North Yorkshire, 2007 floods, Cockermouth, etc, indicate that the UK seems to be increasingly subject to intense rainfall events. This is likely to increase in the future due to climate change.

The result of initiatives such as the Pitt Review and the introduction of statutory requirements for risk assessment and risk management has been that flood risk management has increased in priority. This is not just for government, but also for industry and 3rd sector organisations.

## 1.2. What is the big science issue / challenge

The major challenges in managing flood risk - for the various responsible authorities and organisations – lie within a broad range of interacting issues. The spectrum of issues extends from prediction of near future extreme events to the performance of flood defence measures.

The Workshop identified the following issues as requiring immediate attention:

- Enhanced use of natural flood alleviation,
- Management of surface waters to enable flood control
- Emergency management planning
- Improving the resilience of building and communities against flooding.

However other issues also require attention. The role of major research programmes in contributing to the responsive improvements was a key area of review and discussion during the workshop proceedings.

At the government/regulatory level, one of the key organisations involved in research and science development relating to flood risk management is the Environment Agency. They have a key role in translating research into practice, and their emerging priorities include:

- Evidence-based decision-making regarding flood risk management investment
- Transitioning from awareness of problems to facilitating action
- Vulnerability of flood defences to projected climate change
- Sensitivity of coastal erosion to projected sea-level rise.

The LWEC UK Flooding Research Strategy covers these issues along with some longer-term priorities, such as investment in partnerships with: NERC, EPSRC and the EC. EA's priorities also include: (i) Natural flood management - including catchment scale monitoring, green design, and biodiversity management (using river restoration and Water Framework Directive guidance); (ii) Surface water management - involving numerical modelling and assessing the performance of drainage infrastructure [assets], through for instance retrofitting SUDS to manage surface water; (iii) Emergency planning – focusing on improved rainfall forecast accuracy and on managing emergency and recovery responses, through for instance FIM-frame and CRUE ERAnet initiatives; (iv) Property protection – through developing products and protocols for protection of vulnerable property.

An example of how local authorities are dealing with the need to improve flood risk management is given by the Greater London Authority's multi-tiered Drain London initiative. This focuses resources on improving management response across London Boroughs since various boroughs are ranked highly susceptible to surface water flooding. The programme has comprised data-gathering and awareness-building across all 33 boroughs and has completed surface water management plans as well as preliminary flood risk assessments for them all. This has led to detailed investigations and implementation of risk reduction projects. These projects have included modern approaches such as: flood storage in parks, increasing infiltration in road verges, deculverting of watercourses, and implementing of "green-street" interventions. The approach enables interventions to be introduced on a strategic basis rather than on local initiative.

### 1.3. Networks and alliances

Flood risk management has a good history of cooperation between researchers, regulators and practitioners. Examples of recent relevant collaborative programmes include

- FREE, Flood Risk from Extreme Events integrated research programme (NERC) has researched the causes and mechanisms of floods, to help forecast and quantify flood risk, and inform society about the likely effects of climate change.
- CWC, Changing Water Cycle programme (NERC) is developing integrated, quantitative understanding of changes in the global water cycle, and improving predictions of regional hydrological factors.
- PURE, The Probability, Uncertainty and Risk in the Environment programme (NERC) has two elements: a natural hazards research programme, and a research and knowledge exchange network on how uncertainty and risk are assessed and quantified.
- SRM, Storm Risk Mitigation Programme (NERC) aims to improve short and longer term forecasting of storms and their impacts on catchments and coasts. The programme has three interconnected projects: (1) DIAMET Numerical weather prediction for increased understanding of, and capability to predict, meso-scale structures in extra-tropical

cyclones. (2) TEMPEST Climate science for improved understanding of how climate change and natural variability will affect the generation/ evolution of extra-tropical cyclones. (3) DEMON Improved ability to quantify storm impacts over both the short and long term by better characterising and correcting uncertainties in rainfall predictions, using remote sensed data to improve flood forecasts, and modelling urban flooding at small resolution.

- Flooding from Intense Rainfall programme (NERC) that will focus on understanding of the risks associated with flooding from high-intensity rainfall events.
- FRMRC the Flood Risk Management Research Consortium (EPSRC) has involved:
  - FRMRC/1 addressed key issues in flood science including: tools/techniques for more accurate flood forecasting and warning, improvements to flood management infrastructure, and reduction of flood risk;
  - FRMRC/2 the 2nd phase focused on coastal and urban flooding, focusing on Land Use Management relevant to flooding from extreme rainfall.
- Innovation in FRM Flood Risk Management (EPSRC).

#### 1.4. The Water Security KE Programme

Participants at this one-day WSKEP workshop examined how research should be specified to inform approaches to future flood risk management. They reviewed present knowledge and research, and discussed how to prioritise future initiatives. The scope of the workshop covered approaches to mitigating the impacts of extreme rainfall and current developments in emergency planning. It considered expert contributions from the wide range of participants who included: (i) Practitioners (including Local Lead Flood Authorities, Sewerage Undertakers and consultants); (ii) Academics with a research interest in flood risk management; (iii) Regulators and third sector organisations with responsibility for (or interest in) flood management.

The outcomes of the workshop were: a prioritised list of future research actions in the flood risk management sector, an informal review of research currently in progress, and of research gaps, and some reassurance about the relevance of planned future research programmes and research networks.

This workshop was one of a series of events funded by NERC as part of its long-term Water Security Knowledge Exchange Programme (WSKEP) initiative. The aim is to accelerate the uptake of research and help inform the direction of future science to ensure sustainable use of water in the future. For more information see: [www.wskep.net](http://www.wskep.net)

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## 2. The workshop and report

This workshop was the ninth in a series run for the Water Security Knowledge Exchange Programme (WSKEP) with funding from NERC, and was organized by HR Wallingford.

Nine Priority Subjects were identified at a national consultation event held in June 2011. The theme of this workshop was **‘Supporting sustainable and resilient management of extreme rainfall’**.

The workshop was designed to support the following key aims:

- increase awareness and uptake of research outputs in the focus area of ‘approaches to mitigating the impacts of extreme rainfall and current developments in emergency planning’;
- identify user needs and potential future research projects;
- strengthen research/user group collaboration and networks.

The workshop comprised 4 sessions with initial presentations (available online) as follows:

**Session 1      Setting the scene and making connections**  
*Introduction:* Graham Leeks, CEH Wallingford

**Towards a shared understanding of Priority Subject Area**

*Regulator’s Point of View:*

Dr Sean Longfield, Environment Agency (Delivered by Geoff Baxter)

*Practitioner’s Point of View:*

Kevin Reid, Greater London Authority

**Session 2      Making the most of current research activity**

*Researcher’s Point of View:*

Prof Slobodan Djordjevic, Centre for Water Systems, Exeter University

*Applying FRM Research:*

Andy Tagg, Manager, Floods, HR Wallingford

**Session 3      Identify areas for future research activity/collaborations**

*Introduction*

Dominique Butt, Science Manager (Terrestrial & Freshwater), NERC

**Session 4      Alliances, networks and advice to the WSKEP**

*Introduction:*

Prof Gareth Pender, Built Environment School, Heriot Watt University

The heart of the workshop time was devoted to opportunities for participative working among the 38 delegates. This report features the outcomes from those interactions as written up by delegates during the sessions. As such this report is primarily aimed as an ‘aide memoire’ for participants.

Elements from this report will be used to inform further development of NERC's Water Security Knowledge Exchange Programme.

### 3. Towards a shared understanding of the Priority Subject Area

Table groups discussed the contextual presentations by Geoff Baxter (EA) and Kevin Reid (GLA Drain London) and noted key insights and issues, supported by a brief narrative, that enriched the Priority Subject Area. These were roughly grouped into common theme areas by the delegates as follows:

3.1	Extreme rainfall has different meanings for different locations
3.2	Rural is important
3.3	Passive measures needed where forecasting is difficult (urban areas)
3.4	Urban design
3.5	Impacts of flooding on health and mental health (also socio impacts)
3.6	Improve access to observational data, eg sewer blockages
3.7	Improve implementation of research
3.8	Competing objectives of flood management in different parts of catchment
3.9	Extreme flooding tackled with short term solutions (community resilience etc) and long term solutions (roads as flood corridors, retrofits SUDS etc)
3.10	Rural management can affect urban flooding
3.11	Evidence base required for local mitigation measures
3.12	Public understanding of flood risk – expectation – action
3.13	Water quality impacts of water storage
3.14	Data issues – evidence base; more high quality; management/archive
3.15	Benefits of integrated water management and governance
3.16	State of system – real time info; maintenance; funding
3.17	Need for better understanding of FULL (ie intangible and non-monetized) costs and benefits of plans, policies and interventions over full life time
3.18	Reconciling time scales and other governance imperatives of different SUDS partners/stakeholders

## 4. Making the most of current research activity

This session gave participants the opportunity to learn more about current research programmes and to make new connections to add value to research taking place. Prof Slobodan Djordjevic introduced the range of current research activity and outlined some relevant research projects. The state-of-the-art research work currently in progress covers planning tools and probabilistic forecasting, and includes:

- Small-scale 3D gully modelling
- Medium-scale 2D modelling
- Cost effectiveness of resilience measures in urban growth areas involving multi-physics modelling, taking into account the beneficial effects of SUDS in reducing imperviousness
- Large-scale modelling
- Impact assessment tools to calculate expected annual damage (EAD) from depth analysis, depth-damage curves, from large data-sets.
- Health impact assessment from exposure to pathogens in flood distributions.

An evaluation of the application of research currently carried out on the major issues relevant to extreme rainfall, was provided by Andy Tagg. With reference to assessment and prediction of extreme rainfall, the main needs are: real-time forecasting, real-time prediction of floodwater extent, depth, velocity, real-time warnings, and mechanisms for information transfer. The key question is whether current models provide a good enough representation of the surface water flooding. To this end a recently developed model, RFSM, is being assessed for the accuracy of its fast-processed predictions.

The key areas of extreme rainfall impacts for consideration are:-

### 1. Natural flood alleviation

There is a need for improved design and understanding of systems to manage extreme rainfall. These systems provide benefits at local scale (not at catchment-level) and avoid unsustainable upgrading of underground assets. A recent example of such design was at the London 2012 Olympic Park.

### 2. Surface water management

The major issue at present is the development and uptake of SuDS. SuDS potentially combines: (i) rainwater harvesting with stormwater control, (ii) stormwater control with environmental protection, (iii) stormwater control with green infrastructure. Present R&D for SuDS includes: (i) Hydraulic and water quality performance, (ii) Liabilities due to environmental risks, costs, maintenance, etc., (iii) Constraints and opportunities for high

density development, and (iv) Design strategies for rainwater harvesting and stormwater control. In terms of management, guidance on SuDS is available from CIRIA, BSI and Defra.

### **3. Emergency management planning**

The main issues relevant to emergency management planning for extreme rainfall and flooding are: (i) Timeliness of warning (ii) Number/location of rescue resources, (iii) Adequacy of flood emergency plans, (iv) Communication of plans to the public, (v) Tools to inform the emergency response/plan. An example of such a tool is the Life Safety Model (LSM). This is a micro-scale evacuation model in which each person and building are modelled individually. The model computes evacuation times for different individuals and predicts potential loss of life. The use of such models enables different evacuation strategies to be evaluated at a detailed level (such as preparation of road closure plans and Warning Centre strategies).

### **4. Building and community resilience**

R&D work is currently underway utilising “flooding” test rigs, flood protection products, testing of materials & methods, and the development of new guidance and tools (such as the Building Resilience Tool).

#### **Research Needs**

Possible SuDS research needs include: (i) monitoring, (ii) performance of SuDS structures under extreme rainfall, and design for adaptability. There is also a need to improve the understanding of flood defence asset performance.

Various Workshop participants gave a short introduction to research work they were involved with. Other participants had the opportunity to connect with programmes that interested them. Comments were captured, and participants logged their interest. 10 connections were identified across 7 research programmes.

## **5. Identify areas for future research activity / collaborations**

Dominique Butt, from NERC’s Terrestrial and Freshwater Science/Innovation Team, gave an overview of the main components of the “Flooding from Intense Rainfall” Programme that NERC will call in the near future. The programme picks up on recommendations from: Pitt Review, LWEC partners, and FRMRC2. It has 3 principal work packages:– improved forecasting of storm intensities; flooding susceptibility of different catchment types to intense rainfall; and improved flood risk management.

Workshop participants, through table group discussions, identified key propositions where further research/activity could be of value in taking forward flood risk management. These took into account the introductory briefing provided by Dominique. The propositions were grouped into common themes by participants and discussed, as follows:

Ref	Propositions for further research / activity
5.1	SUDS impact on Water quality and quantity at local and catchment scale
5.2	Long term monitoring based case studies for sustainable drainage strategies
5.3	Natural and surface water management options – what should we be monitoring to help ensure we understand how our interventions perform?
5.4	Evidence base to support sustainability choices
5.5	Geographical spread of simultaneous rainfall
5.6	Identifying and supporting vulnerable people - integrating databases and identifying what does and doesn't work
5.7	Need for a full research gap analysis (including end user)
5.8	How can we make better use of existing research/knowledge?
5.9	Communities – How they function/human behaviour during extremity – Behaviour responses in floods (e.g. evacuation) vs approaches and current technology and future design.
5.10	Community resilience
5.11	Sediments/Pollution Surface Water and Water Course Floods ie muddy floods/Debris – Blockage of culverts Infrastructure; WFD compliance, building of Existing Knowledge
5.12	How do we adapt existing urban areas/buildings to best alleviate flood risk – both urban and rural?
5.13	Optimised urban design for integrated water management

## Prioritisation

Following the discussion, delegates were given 3 sticky dots to indicate the three propositions they believed should be given priority consideration.

The table below shows the results of this prioritisation:

Ref	Proposition	Dots	Position
5.4	Evidence base to support sustainability choices	9	1
5.2	Long term monitoring based case studies for sustainable drainage strategies	7	2
5.9	Communities – How they function/human behaviour during	6	3

5.10	Community resilience		
5.7	Need for a full research gap analysis (including end user)		
5.8	How can we make better use of existing research/knowledge?		
5.3	Natural and surface water management options	5	4
5.5	Geographical spread of simultaneous rainfall	4	5
5.11	Sediments/Pollution Surface Water and Water Course Floods	3	6
5.12	How do we adapt existing urban areas/buildings to best alleviate flood risk?	2	7
5.13	Optimised urban design for integrated water management		
5.1	SUDS impact on water quality and quantity at local and catchment scale	1	8
5.6	Identifying and supporting vulnerable people		

## 6. Improving alliances and networks

Prof Gary Pender, Head of School of Built Environment at Heriot-Watt University, gave an introduction to funding programmes in this area of work with particular focus on the initiatives that have been carried out so far by the FRMRC2 consortium of researchers, and also the research arrangements that have recently been put into progress by EPSRC following their recent “Sandpit on Innovative Solutions to Flood Risk Management”. He outlined the objectives of the three proposals that EPSRC are going to support:

1. Organisational Operational Response and Strategic Decision Making for Long Term Flood Preparedness in Urban Areas – (lead by Durham University).
2. Flood MEMORY: Multi-Event Modelling Of Risk & recoverY– (lead by Newcastle University).
3. Delivering and Evaluating Multiple Flood Risk Benefits in Blue-Green Cities – (lead by Nottingham University).

The proposals map to LWEC priorities, and it is expected that an EPSRC/EA supported Network is utilised to enable cross-fertilisation between projects.

Delegates, in table groups, made suggestions for steps to further improve communication and networking, as follows:

Ref	Suggestions to improve networks/communication
6.1	Review of IP consideration to enable sharing or outputs

6.2	Alliances and Networks are a useful resource but to communicate with them I need a contact name, not just a network name!
6.3	Need to have a purpose - example in LEA 'Flownet Community'
6.4	Getting people from different disciplines together to address multi-disciplinary challenges (via sponsorship encouragement etc).
6.5	Problem of engaging with local authorities. Find Key Personnel – what are their needs
6.6	Research Policy 'networking/ 'dating service' at research planning stage

## 7. How do we maximise the value of the Water Security KEP?

Table groups suggested the following as ways to maximise the value of the Water Security Knowledge Exchange programme:

Ref	Insights for WSKEP
7.1	Effective links with Business and local government
7.2	Research 'so what?' documents should be written at the end of research projects (as in EPSRC)