Department for Environment Food & Rural Affairs

Llywodraeth Cymru Welsh Government

Cyfoeth Naturiol Cymru Natural Resources Wales

Environment Agency

# delivering benefits through evidence


## Real-time flood impacts mapping

## Appendix 1: User requirements summary

SC120023/A1

Flood and Coastal Erosion Risk Management Research and Development Programme

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**Published by:**
Environment Agency, Horizon House, Deanery Road, Bristol, BS1 5AH

http://www.gov.uk/government/organisations/environment-agency

**ISBN:** 978-1-84911-440-0



Email: fcerm.evidence@environment-agency.gov.uk

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**Dissemination Status:**
Publicly available

**Keywords:**
Flood, impacts, inundation, mapping, real-time, forecasting

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**Project Number:**
SC120023/A1

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This report is the result of research commissioned and funded by the Joint Flood and Coastal Erosion Risk Management Research and Development Programme. The Joint Programme is jointly overseen by Defra, the Environment Agency, Natural Resources Wales and the Welsh Government on behalf of all Risk Management Authorities in England and Wales: http://evidence.environment-agency.gov.uk/FCERM/en/Default/FCRM.aspx.

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If you have any comments or questions about this report or the Environment Agency's other scientific work, please contact research@environment-agency.gov.uk.

Professor Doug Wilson
**Director, Research, Analysis and Evaluation**

# Note to readers

The User Requirements Summary report was produced following the user consultation. It documents user needs and provides a draft framework for developing technical options.

However, the information contained herein has been superseded by the final project report. The reader should consult the final report for the full and final details of the study.

# Contents



## List of figures

# 1 Wider context

A number of recent studies have involved consultation exercises that have shed light on the user requirements for future flood forecasting and warning services provided by the Environment Agency. A high-level summary of the requirements relevant to this project are provided below.

Note that some requirements are beyond the current remit of the Environment Agency and are included here for completeness only.

## 1.1 Flood Forecasting Service development roadmap 2015 to 2020

Key aspirations and commitments (extracted from on June 2014 draft).

- Put more emphasis on providing flood warnings to people rather than properties.
- Make flood forecasts and warnings more visual, probabilistic and impact-based.
- Develop real-time flood modelling and mapping capability for fluvial and coastal areas where appropriate.
- Communicate forecast uncertainty in flood warnings using a consistent, easily understood approach across the country.
- Develop more ways of sharing data and information openly and effectively with the public and professional partners.
- Invest in significant upgrades to the national flood detection (that is, telemetry), forecasting and warning systems to enable these changes to be implemented.
- Enable professional partners to take a lead on providing forecasting and warning services for other flood sources.
- Use consistent language and terminology throughout flood incident management and be clear in all communications.

## 1.2 ABC1 – scoping a new national flood risk assessment

**Key requirements**

- Capability to provide more precise and accurate flood forecasts with longer lead times
- Real-time, event-based flood modelling driven by prevailing hydrometeorological conditions
- Forecasts of detailed hazard information at the property scale (for example, flood onset time, maximum depth/level and duration)

- Provision of probabilistic flood warnings
- Approaches for consistent communication of confidence and uncertainty in forecast information
- Capability to redefine Flood Warning Areas in real time and so better target flood warning efforts on an event-by-event basis
- Extension of flood forecasts to receptors other than properties (for example, transport networks, critical infrastructure, agricultural areas)
- Data outputs should be freely available to all without requirement for upfront licensing agreements
- Provide forecasting and warning services for all sources of flooding

## 1.3 Flood risk communications public dialogue

**Key findings (extracted from Stage 1 report – draft 4)**

- The public struggle with concepts of likelihood and probability, but this may be less of an issue when forecasting imminent events.
- The challenge is to make flood risk information available for different needs and interests while avoiding information overload and consequent confusion.

  The research indicates that there is an appetite for probabilistic warnings among members of the public who have experienced flooding. However, there is a need for further research with a broad range of the public to test probabilistic flood warning materials once these have been developed. The research should include both people who have experienced flooding and others who have not to see how their responses differ. The development work should be carried out by experts in communication and graphic design in conjunction with the Environment Agency and the public.
- Flood warning should make use of more visual methods where possible (for example, virtual landscape with water, a dynamic flood map).
- Any system should provide information on what specific actions need to be taken and not just what the forecast risk is.
- Any data/tools/materials developed need a simple/layman and detailed/expert user version.
- Flood warning services cannot solely be internet based.

## 1.4 Emergency responder survey 2013

**Key requirements**

- Undertake a more comprehensive consideration of all sources of flooding.
- Provide more geographically targeted or localised flood warnings.
- Provide information on flood depths and/or how much higher the river level will get.

- Tailor flood warning information to specific services and their roles and responsibilities rather than the general information provided to all. It is acknowledged that this would require an in-depth assessment of what each agency/service requires to make their role easier.
- Manage the trade-off between timeliness and certainty of flood warnings. This is acknowledged as a very difficult task as early action means less certainty of information but waiting then gives less time to act.

# 2 Internal user requirements

## 2.1 Incident responders questionnaires

The Project Team developed a short questionnaire to help identify existing practices and techniques for assessing and communicating the predicted impact of flooding within Environment Agency Area incident rooms and also at Gold/Silver Command. It also sought suggestions on how these approaches could be developed further to better support Gold/Silver Command staff in the future.

The questionnaire was circulated to:

- Area management teams
- regional incident and emergency managers
- modelling and forecasting managers within the Environment Agency and Natural Resources Wales

A total of 26 responses were received. A summary of the responses is provided below.

### 2.1.1 Key requirements (flood event description/mapping)

- Better information to plug the gaps where information from offline local detailed flood modelling does not exist
- Real-time, event-based flood modelling driven by prevailing hydrometeorological conditions. A simple(r) first step would be to develop methods and tools for deriving flood extents (either through real-time modelling or selecting pre-computed look-ups) for actual or forecast water level at the nearest gauging station.
- Availability of real-time flood modelling for localised breaching and/or overtopping situations, particularly where assets have been damaged during an event
- Tools to compare current/future water levels against bank/defence levels
- Functionality to allow (and provide an audit trail) for local manipulation of forecast information by experts
- Any flood mapping produced or reused would ideally contain information on flood depths, velocities, hazard ratings and timings (‘extents don’t tell the full story’). Animations can also be very useful for describing the spatiotemporal evolution of flooding to professional partners.
- Use of ensembles within the flood forecasting models to better understand the potential range of forecast values (rather than attempting to predict a single value more accurately) and support the production of ‘most likely’ and ‘worst case’ flood scenarios

### 2.1.2 Key requirements (flood impact description/mapping)

- Any real-time flood inundation modelling should be linked to real-time impact assessments.
- Impact forecasts (including some appropriate consideration of uncertainty) are needed with at least 3–5 days lead time to inform the strategic positioning of Category 1 responder resources.
- Provide a more comprehensive assessment of flood impacts, tailored where possible to meet the needs of individual professional partners.
- The most important information for Gold/Silver Command is a high-level overview of:
  - the worst affected communities
  - the number of properties flooded
  - where there is likely to be a significant risk to life and/or important infrastructure

### 2.1.3 Key requirements (communication/visualisation/decision support tools)

- Any data/tools developed must be quick and simple to use, and the outputs easy to communicate to non-technical decision-makers ('the 4am test'). However, more technical details should be readily available on request.
- All partners need access to 'one version of the truth', but this information should be tailored for different end users.
- Common visualisation tools across Environment Agency flood incident rooms should be able to be shared with Gold/Silver Command if necessary. Tools should work on tablets/smart phones and also in offline mode where internet connections are poor/non-existent.
- Want the functionality to capture, store and interrogate 'on the ground' intelligence during an incident alongside telemetry, forecast and map data.
- Develop forecast data (ideally maps) that can be used directly within IM Map Viewer, EasiMap 2 and Resilience Direct (or other systems used by professional partners).
- Must be easy to save the current layouts and print/export images from visualisation tools.
- Need to avoid the 'illusion of accuracy' (that is, ensure that detail at which information is used/displayed is supported by the underlying methods/data).
- Need tools and training to help professional partners understand the uncertainty in flood forecasts.

## 2.2 Views of emergency responders involved in the winter 2013 to 2014 flood event

The following key requirements were extracted through targeted consultation with 22 Environment Agency staff involved in the winter 2013 to 2014 flood response.

### 2.2.1 Key requirements (flood event description/mapping)

- Many Environment Agency staff rely on model outputs, pre-computed for a range for standard design return periods, to understand the potential flood extent and/or impact for a given event. There is currently no guidance on how to select the most appropriate pre-computed scenario or options for real-time flood modelling using observed data as boundary conditions.
- Information is needed on the temporal and spatial evolution of flooding over the course of the event (that is, not just the maximum extent). Information on the rising limb is required for flood warning and proactive incident management, whereas information on the falling limb is useful for prioritising the recovery effort (that is, which areas will dry first).
- The Environment Agency must be able to provide the best information available at a given time so that operational decisions can be linked to specific reference points. Information can be reissued/updated at regular intervals appropriate to the event at hand, but rapidly and unpredictably changing information does not help responders.
- Tools are needed to:
  - convert forecast levels into flood extents
  - provide onset, depth/level and duration of flooding at specific locations
  - determine the arrival time of flood peaks through the catchment
- Tools should allow event-specific ‘what if’ scenarios to be investigated.
- Methods that recognise and are tailored to the specific challenges of forecasting flooding from different sources (for example, fluvial, coastal, estuarine, rapid response catchments) are needed.
- A clear audit trail of the methods, models and data used in the forecasting process must be maintained.

### 2.2.2 Key requirements (flood impact description/mapping)

- Professional partners expect the Environment Agency to be able to provide accurate and precise information on affected receptors at the property scale.
- More effective sharing of information on critical infrastructure and assets is vital.
- Tools should be able to identify properties, assets and so on that are protected from flooding, and not just those at risk.

- Need to be able to assimilate ‘on the ground’ information provided during an event by broadcast and social media.
- Tools that can identify agricultural land flooded are needed.

### 2.2.3 Key requirements (communication/visualisation/decision support tools)

- The impact forecasts must be very simple and easy to use during an incident, particularly if they are to be shared directly with the public.
- Tools should be integrated into the day job where possible (that is, not just used in emergencies).
- Information should be provided in a form that allows professional partners to plan their operational response efficiently. Hard copy maps provide a very useful focal point for developing a multi-agency response.
- Detailed information on depth, velocity and hazard rating is unlikely to be required by Gold/Silver Command. Their requirements are more binary – is there a risk to life or not?
- Uncertainty in the forecasts is useful but must be clearly communicated (for example, as minimum and maximum flood envelopes or a range of forecast water levels).
- Keep technical details and caveats to a minimum. This information is best communicated verbally by the local Environment Agency liaison staff.
- Information should be packaged in a size and format that can be emailed to enable easy printing, sharing and onward distribution (for example, PDF documents) as some professional partners do not/cannot attend Gold/Silver Commands in person.
- Communication and visualisation tools should utilise non-proprietary/open software and data formats. Clear specifications should be provided for all data products that would allow them to be used within the widest possible range of incident management IT systems.
- Any web-based solutions must recognise the wide range of connection speeds and reliability across incident responders.
- Standardised pro-formas for reporting flood impacts, such as the Flood Guidance Statement, should be used.
- Where map information is provided, the symbology and data classifications should be customisable by the end user.

# 3 External user requirements

The following were determined through targeted consultation with 7 Local Resilience Forums.

## 3.1 Key requirements (flood event description/ mapping)

- Improve the accuracy of forecasting information and the provision of bespoke forecasts for particular areas.
- Flood mapping that is accurate at the street level is most useful for ‘on the ground’ flood incident response.
- Contextualise forecasted flooding in the context of previous events rather than design return periods. Improvements in local historical data may be required to achieve this.
- Extend telemetry, forecasting and warning systems to non-Main Rivers and ordinary watercourses.
- Real-time information on catchment response is wanted based on forecast meteorological and observed antecedent conditions, in particular downstream lead times for peak flood flows and levels.
- Forecasting and warning systems for both surface and groundwater flooding are required.
- Collect, assimilate and disseminate information on actual flooding during an event. Ideally this information would be collated and published centrally based on ‘on the ground’ intelligence from multiple organisations collected using simple, standardised reporting formats.

## 3.2 Key requirements (flood impact description/ mapping)

- Recognise that different flood incident responders have different priorities during an event (for example, public safety versus continued operation of critical infrastructure and/or transport networks). Responders therefore have different requirements for information on flood impacts.
- Information is wanted on specific flood levels/depths at specific times, coupled with knowledge of the consequences at the specific levels, depths and times (such as the Environment Agency Midlands Region’s gauge board charts).
- Flood impact modelling and data handling tools that can be run in real time are wanted.
- Improve the quality of non-property related information in the National Receptor Dataset, particularly for critical infrastructure.

- Better understanding of the secondary impacts of flooding was wanted, although it was recognised that this is primarily the responsibility of Local Resilience Forum members rather than the Environment Agency.
- Extend application of the Environment Agency's Flood Visualisation Tool to other, smaller communities at risk (that is, those with fewer than 100 properties at risk).
- Collect, assimilate and disseminate information on actual impacts during an event. Ideally this information would be collated and published centrally from 'on the ground' intelligence from multiple organisations collected using simple, standardised reporting formats.

## 3.3 Key requirements (communication/ visualisation/ decision support tools)

- Any system and data that are developed should be simple to use and in a format that can be used efficiently in the operational response.
- (Ideally simple) statements of uncertainty/confidence should be attached to all forecasts.
- Remove/reduce barriers to sharing data between different systems (GIS most commonly cited).
- One web-based system or platform is needed, accessible to all members of the Local Resilience Forum and compatible with all IT/GIS systems. All partners need access to the 'same version of the truth'. Such a system would display real-time/pre-computed flood mapping, receptor data and feeds from the Environment Agency's telemetry network. Several Local Resilience Forums commented that Resilience Direct already provided this type of functionality and that there was 'no need to reinvent the wheel'.
- Present forecasts alongside information from previous events (for example, meteorological drivers, antecedent conditions, flood impacts, incident management actions) to better understand the potential consequences of the current event.
- Present forecasts alongside known locations of flood alleviation schemes, local community initiatives and property level protection/independent flood protection measures and predetermine their effectiveness for mitigating particular types of flooding.
- Any visualisation tools or pages from web-based systems must be easily printable and results useable from both black and white and colour printers.
- Recognise that different Local Resilience Forums, and even professional partners within them, have different appetites for risk and any data/tools should be flexible and locally customisable.
- Standardise the use of incident management tools and the forecast information available across Environment Agency Areas.
- Recognise the different levels of internet connectivity in Gold/Silver Commands and that any data/tools developed may need an 'offline' mode.

- Staff resources required to utilise and maintain any data/tools developed should minimised.
- Expensive new technology should be avoided and any data/tools developed should work within existing systems wherever possible. The costs and timescales associated with implementation should be considered very carefully, as should potential sources of funding.
- Any new data/tools must be supported by appropriate training and/or briefing materials. They must also recognise the technical limits of most Local Resilience Forums.

# 4 Conceptual framework for technical option development

Figure 4.1 shows a conceptual framework that identifies the sub-components of a real-time flood impact mapping system. It is hoped that this framework will make the task of initial option development more manageable and also recognises that individual sub-component options may not be mutually exclusive in practice.

A flood forecasting system for any given flood source is likely to utilise a combination of pre-computed data, forecast products and recent observations (for example, from a telemetry network). From this forecasting system, it is assumed that one or more event-specific descriptions of the future flood hazard (for example, 1D water levels or 2D maps of flood depth/extent) can be produced in real time. These hazard descriptions may be useful in their own right and can be shared within the Environment Agency and beyond. However, more importantly, they can also be combined with information on the receptors of flooding to understand the impacts of the forecast flooding in any given location. The impact forecasts can be shared in their 'raw' state or be consumed within a range of visualisation and/or decision support tools used by the flood incident management community.

Developing technical options that implement these concepts in practice is one of the key challenges for the remainder of this project.

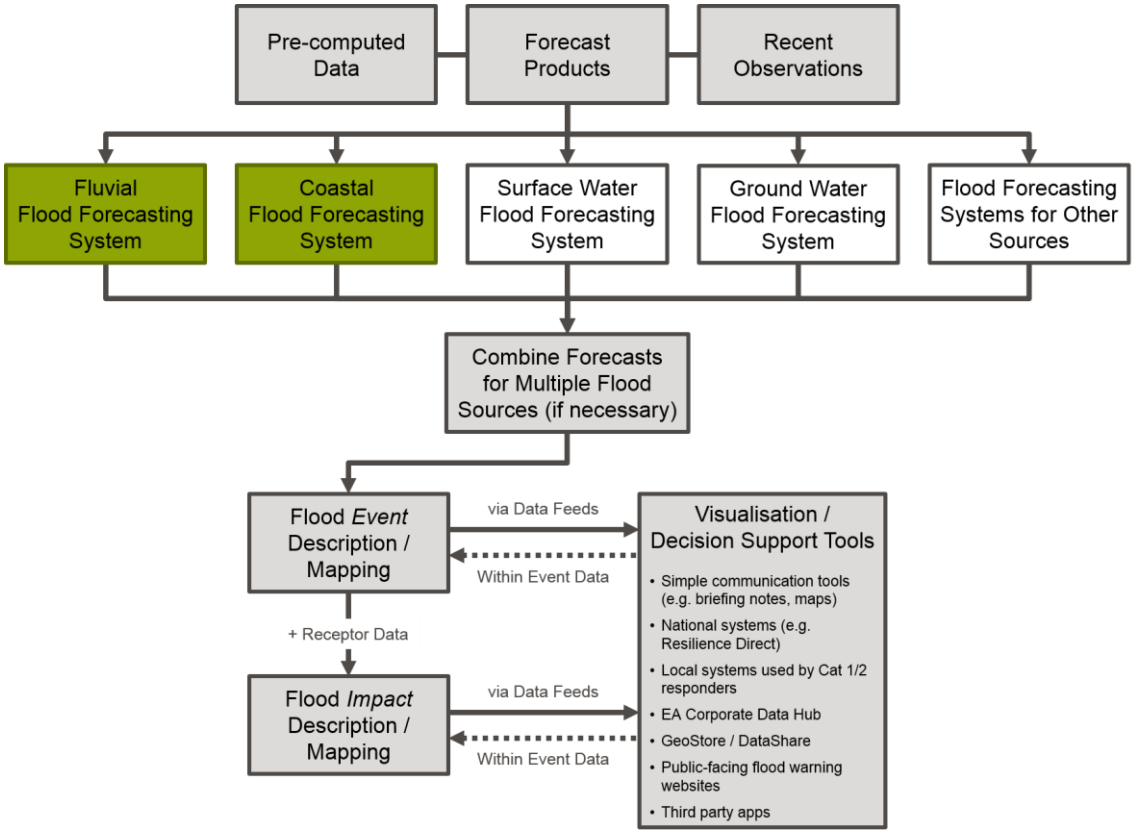


**Figure** 4.1 **Conceptual framework for technical option development**

# 5 Acceptability criteria for technical option evaluation

This section presents a simple approach for the appraisal of the high-level acceptability of different technical options developed at the workshop to be held in November 2014. It is envisaged that these initial acceptability criteria will be refined into a more detailed 'scorecard' for each option during the next stages of the project.

At the workshop, participants will be asked to provide a commentary against the following criteria for each option developed:

- Pros
- Cons (for example, in terms of not meeting key user requirements)
- Development route(s)
- Indicative development costs
- Development risks
- Implementation route(s)
- Indicative implementation costs
- Implementation risks

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