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Communication and dissemination of probabilistic flood warnings

Science project SC070060/SR4

Flood and Coastal Erosion Risk Management Research and Development Programme

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It's our job to make sure that air, land and water are looked after by everyone in today's society, so that tomorrow's generations inherit a cleaner, healthier world.

Our work includes tackling flooding and pollution incidents, reducing industry's impacts on the environment, cleaning up rivers, coastal waters, contaminated land and improving wildlife habitats.

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Steve Killeen

Head of Science

Executive summary

This research fills a gap in the current knowledge regarding the potential users and uses of probabilistic flood warnings. The overall goal of the research was to establish the comprehension, requirements and mechanisms of communicating probability and uncertainty for different potential end users within flood forecasts and warnings, using information from relevant sources, consultations and other appropriate research methodologies. The findings of review of literature indicated that:

- No information on what probabilistic flood warnings look like is currently available. No probabilistic flood warnings have been developed as part of previous research.
- Limited end-user surveys of different examples of communicating probabilistic information suggest that end users prefer probabilistic information displayed graphically, as symbols or in the form of a map together with text.
- There is limited research to suggest that probabilities expressed in percentage terms are more readily understood than other formats.
- When communicating probabilistic warnings, putting the forecast event in context with a recent event can aid comprehension.
- Different end users have different requirements in terms of probabilistic flood warnings.
- There is limited research on how the public and professional partners understand probabilistic information related to imminent natural hazards. There is some limited research to suggest that decision-makers make better decisions when presented with probabilistic information related to hazards.

Four focus groups each comprising eight people were held in Fleetwood, Oxford, Kinmel Bay and Purley near Reading. These were used to gain an insight into the public's understanding of probabilistic warning information and its communication. Two workshops were held with professional partners in London and Leeds to obtain their views on probabilistic flood warnings.

The Environment Agency staff's understanding of probabilistic information, its communication and their requirements was gained via a series of workshops and a survey of Flood Warning Duty Officers.

Interviews were conducted with businesses to gather information on how they use flood warnings and how the provision of probabilistic information might change that use.

The 'public', 'business', 'professional partners' and Environment Agency staff are not homogeneous groups. A 'one size fits all' approach to probabilistic warnings will not be successful. From the research it was clear that all of the groups wanted to have more certainty about flooding in terms of when, where and how it was going to happen, something which they hoped could be delivered by a probabilistic flood warning. **There is an appetite among professional partners and the public to receive probabilistic flood warnings if an improvement in warning lead times and accuracy can be achieved**.

The research recommends the following:

REC 4 Further work is required to establish:
- What people think a probabilistic warning is going to deliver (e.g. longer lead times).
- The most appropriate way of warning those people to give them improved certainty?
- What role does probabilistic information of the sort that the Environment Agency is developing play in providing flood warnings that meet the needs of the Environment Agency customers (i.e. professional partners and members of the public)?

REC 6 The information content of the 'Flood Watch' and 'Flood Warning' codes should be revisited and possibly redefined if probabilistic flood warnings are to be introduced.

REC 8 The Environment Agency should address concerns about how its staff will cope effectively with the additional information that will be generated by probabilistic flood forecasts and warnings.

REC 9 The introduction of probabilistic flood forecasts should complement ongoing improvements to the hydrometric and flood forecasting networks.

REC 10 The Environment Agency should encourage staff to be open about the uncertainties inherent in flood forecasting and warning in their engagement with professional partners, businesses and members of the community.

REC 12 The Environment Agency should work with staff to ensure there is understanding and clarity around the potential use of probabilistic information in order to build internal 'buy in' to probabilistic forecasts and warnings.

REC 13 The Environment Agency should provide further professional development to enable its staff to make better sense of probabilistic forecasts, in terms of what they mean and the way in which they can be communicated.

REC 14 There is a clear opportunity for the Environment Agency to use professional partners' experience and goodwill to develop probabilistic warnings collaboratively. A forum should be set up with professional partners to work together on further developing probabilistic flood warnings.

REC 15 The lessons learnt from Environment Agency Area Offices that have a close working relationship with professional partners should be shared nationally as this will greatly assist the successful uptake of probabilistic warnings by professional partners.

REC 17 Different forms of probabilistic warnings should be developed by experts in communication and graphic design, in conjunction with the Environment Agency and the public. Comprehensive research will need to be carried out with the public to gain an understanding of their interpretation of these warnings.

REC 18 The research indicates that there is an appetite for probabilistic warnings among members of the public who have experience flooding. However, the Environment Agency should carry out 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 those who have not, in order to see how their responses differ.

REC 19 Further work needs to be carried out with the public to assess the most effective media via which probabilistic flood warnings can be disseminated to them.

REC 20 Further work needs to be carried out to understand how the public perceive ‘false’ warnings in probabilistic terms and what effect this may have on their response.

REC 21 The Environment Agency should consider the technical and operational impacts of providing a more localised probabilistic flood warning service than is currently technically possible to make available to the public.

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1 Introduction

1.1 Background

While it is widely acknowledged that probability and uncertainty are key issues related to flood forecasting, how to communicate and disseminate probabilistic flood forecasts and warnings presents further challenges. The draft Environment Agency Strategy poses the question as to how the Environment Agency can use probabilistic forecasts and warnings and also how other stakeholders can make use of them. The Pitt review of the June 2007 floods has also stated that in future probabilistic flooding warnings should be provided to professional partners (Pitt 2008).

The Pitt review states that 'Many stakeholders, for example, emergency responders and owners of critical infrastructure, have expressed a requirement for longer lead times for flooding events. Developments in technology could enhance the capability to produce earlier probabilistic forecasts' and 'if new forecasting tools and techniques are to be effective, the professional partners utilising them will need to be educated in their use. This is especially the case with probabilistic forecasting as there will need to be guidance on how to react to such warnings' (Pitt 2008). Pitt also recommended that the Met Office and the Environment Agency should issue warnings against a lower threshold of probability to increase preparation lead times for emergency responders (Pitt 2008).

This research fills a gap in the current knowledge regarding the potential users and uses of probabilistic flood forecasts and how these might be communicated and disseminated. In acknowledging the inherent uncertainties associated with flood forecasts, which arise from data and model uncertainties, the Environment Agency is moving towards probabilistic flood forecasting. However, the challenges and obstacles that may arise owing to the inclusion of uncertainty in internal and external communications of flood warnings for different users need to be researched, as does how these challenges could be mitigated.

The primary drivers for this research were:

(i) Introduction of probabilistic flood forecasting and link to flood incident management policy

Flood forecasts by their nature are uncertain. It is desirable that decisions made in relation to flood warnings are precautionary, proportionate and robust. Historically, however, the Environment Agency flood forecasting system has adopted a deterministic approach, which implies warnings and forecasts are precise and accurate and does not allow uncertain outcomes to be properly accounted for. Probabilistic forecasts, on the other hand, are characterised as being more scientifically honest and allow a more probability-based decision-making approach to be adopted. The introduction of probabilistic fluvial and coastal flood forecasting systems is currently being piloted by the Environment Agency.

(ii) Providing early warning in rapid response catchments

Flood warning in rapidly responding catchments is particularly challenging because lead times are short and forecasting is technically difficult, but the consequences of flooding can be severe. The use of probabilistic flood forecasting has the potential to

extend flood forecast lead times to provide early warnings of possible flooding in these catchments if the message can be communicated effectively.

(iii) Expanding flood warnings

The July 2007 floods affected many small communities in the north-east and Oxfordshire that were not in areas that received a flood warning service, typically because they were located on small watercourses in catchments where the Environment Agency has recently taken over the responsibility of Critical Ordinary Watercourses (COWS) and/or in small catchments where flood forecasting is difficult. In order to reduce flood risk nationally, there is a need to expand the flood warning service to the communities, and probabilistic forecasting may play an important role in this expansion of the service. The extent to which probabilistic information might be helpful with respect to different sources of flooding is an issue that needs to be considered.

1.2 Goal of the research

The overall goal of the research was to establish the comprehension, requirements and mechanisms of communicating probability and uncertainty for different potential end users within flood forecasts and warnings, using information from relevant sources, consultations and other appropriate research methodologies. A number of specific objectives were identified to meet this goal, and these are described below.

1.3 Specific objectives of the research

The research had the following specific objectives:

1. To determine how public and professional partners make sense of information about probability and uncertainty from literature and other relevant sources of information.
2. To review the outputs from parallel projects on flood warning communications to establish what personal or cultural factors require consideration for the communication of probability and uncertainty.
3. To establish how information about probability and uncertainty is used and communicated internationally.
4. To establish what professional partners, businesses and the general public understand about probability and uncertainty and how they would use this information if it was incorporated in flood warnings.
5. To establish what Environment Agency flood risk management teams and incident response duty officers require, and how they would use information about probability and uncertainty within flood warnings.
6. To use the outcomes from the research to determine the potential advantages and disadvantages related to probabilistic flood forecasting and warning.
7. To use the results from the research to inform a policy decision on whether the Environment Agency communicates uncertainty and probabilistic information externally in the future.

1.4 Structure of the report

This report has been structured as follows:

- Chapter 1 details the background, goal and objectives of the research.
- Chapter 2 covers the three literature reviews that were undertaken to inform the first three objectives of the project.
- Chapter 3 provides background to the mocking-up of probabilistic flood warnings for use in the research.
- Chapter 4 provides a summary of the public's understanding of probabilistic warning information and its communication based on the information gathered from four focus groups.
- Chapter 5 outlines professional partners' understanding of probabilistic warning information and its communication.
- Chapter 6 covers the Environment Agency staff's understanding of probabilistic information, its communication and their requirements.
- Chapter 7 provides business understanding of probabilistic information, its communication and their requirements.
- Chapter 8 provides recommendations.

2 Review of literature on the communication of probabilistic and uncertainty information

2.1 Introduction

This chapter provides a summary of three literature reviews that were undertaken as part of the research. The three literature reviews covered the following:

1. How the public and professional partners make sense of information about probability and uncertainty.
2. Defra/Environment Agency flood and coastal erosion risk management literature relevant to communicating probability and uncertainty in flood warnings.
3. A review of methods used internationally in the fields of natural hazards, climate change and weather forecasting to communicate and disseminate probability and uncertainty in warnings.

The full literature reviews are available as stand-alone reports. To gain a full appreciation of the work carried out it is recommended that these reports are consulted. The sections below provide a summary of the main findings of the three literature reviews.

It is important to note that the *Probabilistic Flood Forecasting Scoping Study* (Defra/ Environment Agency 2007b) was used as an important reference for the three literature reviews carried out as part of the research. It was also used as one of the sources to inform the team on likely developments to the Environment Agency's National Flood Forecasting System in terms of probabilistic flood forecasts.

2.2 A review of how the public and professional partners make sense of information about probability and uncertainty

The objective of this review was to determine how the public and professional partners make sense of information about probability and uncertainty, drawing from literature and other relevant sources of information. The literature review covered four specific tasks:

- to review existing knowledge and evidence of how the public understand information about probability and uncertainty;

- to review existing knowledge and evidence of how professional partners understand information about probability and uncertainty;
- to review existing knowledge and evidence of how the public use information about probability and uncertainty;
- to review existing knowledge and evidence of how professional partners use information about probability and uncertainty.

The review focused on the understanding and use of information about likelihood, chance or probability. The review was not restricted to the UK as the need to review initiatives and experiences used in other countries was important. However, it is important to note that caution does need to be exercised in making use of research undertaken in sometimes very different risk, cultural and political contexts. The key findings of this report are summarised below.

Broad societal debates about public understanding of probability and uncertainty have moved in the direction of arguing that it is a good thing that government institutions are more explicit and open about probability and uncertainty, promoting greater social trust and understanding. Counterarguments, however, point to the misunderstandings and undermining of expertise which might arise.

'The public' and 'professional partners' are not a homogeneous group. For example, it is important to note that there are a large number of the public who may have issues with literacy and numeracy. Age, gender, ethnic, cultural and socio-economic differences can all also be important in how information is received and interpreted. Various professional partners also might have quite different information needs (Environment Agency 2008d).

Research does not point to one single effective means of communicating probabilistic and uncertainty information. It is clear that communications are interpreted within personal, social or institutional contexts, and according to individual personality predispositions. Providing additional information may not lead to different decisions, as new information is merely one factor in the process of decision-making in the real world. Trust in the source of information can be particularly important (Environment Agency 2008d).

There is limited research to draw on to understand how probabilistic information on the likelihood of imminent hazard events is understood and used. This is the case for 'the public' and even more so for professional partners where there is very little work on the communication of probabilistic information in general. Research on probabilistic information in hurricane warnings provides the only limited examples.

There is a more substantial body of research on the use of probabilistic information in the fields of health and medicine and weather forecasting and these can both provide some useful insights. It is important though to remember the differences between these communication contexts. These differences include the types of information involved, who is communicating, the context of communication and implications of actions taken (Environment Agency 2008d).

Literature from health and medicine suggests that how people assess and process risk information, (e.g. related to the risks of adverse outcomes from surgery or medication) depends on their circumstances, medical condition at the time and their emotional response. Research has tested many different formats for presenting probabilistic information. Numerical formats such as percentages can suggest precision but are in practice interpreted in different ways. Expressing probabilities in terms of relative risk

and using reference classes have been recommended as more effective in some circumstances. Verbal qualitative formats might be easy to understand and suggest uncertainty. Guidelines have been developed, but some studies urge caution with assuming that these are clearly understood. Visual methods can hold peoples attention and communicate summaries of data. The exact formats used appear important to understanding but it is not necessarily the case that formats that are better understood lead to a greater degree of desired behaviour change (Environment Agency 2008d).

Research on weather forecasts tends to suggest that the public do understand basic probability information when it is clearly presented (e.g. there is a 30% chance of rain tomorrow). One source of confusion seems to be because forecasters have not been clear about what the percentage probability refers to (i.e. the reference class). Forecasters themselves have been found to be confused about the meaning of both quantitative indicators and qualitative descriptors such as 'fine'. People seem to infer uncertainty into forecasts, so would rather receive forecasts with additional uncertainty data (e.g. on average the temperature will fall within this range 5 out of 10 times) (Environment Agency 2008d).

Experimental research on public responses to probabilistic information in hurricane warnings in the USA, found that residents had a good understanding of the probability information, but that this was not influential in decisions over evacuation as the specific advice or orders of local officials were most important. Other research on public understandings of a visual representation of probability during a hurricane season found consistent misinterpretation and reading of uncertainty information as deterministic (Environment Agency 2008d).

Very limited laboratory based research seems to suggest that when decision-makers, such as professional partners, are presented with uncertainty information as part of weather and hazard scenarios, they may make better decisions.

Instead of trying to educate the public about the exact meanings of forecasts and probabilistic information, it may be more important and useful to first understand how the public use the information. Developing an iterative process in collaboration with end users would be a useful way of taking the development of probabilistic hazard warnings forward.

2.3 Review of relevant Defra and Environment Agency projects

A review of Defra and Environment Agency research relevant to the use of probabilistic information in flood warnings highlighted a number of issues that need to be explored:

- There is little available information about differences within the groups that were looked at (i.e. members of the public, professional partners, businesses) in terms of their perception of probability and uncertainty in flood warnings. While understanding differences in perceptions of probability and uncertainty was one of the objectives of the review, we have come to feel that differences in perception are likely to be less important than differences in the response to flooding. For example, the use of probabilistic information to provide an early alert to disabled or elderly people and their carers may greatly increase their ability to take action.

- One of the potential benefits of probabilistic flood warnings perceived by Environment Agency staff and professional partners is the possibility of giving earlier warnings. This could be of particular benefit to certain groups of people who may need more time to make preparations for flooding (e.g. the elderly or disabled people) or to emergency responders which need a longer lead-in period to put systems into operation such as the water companies.
- There are a range of variables which together determine flood warning response either by inhibiting or enabling response by individuals and organisations. The provision of information is only one of these variables and the way that information is understood and acted on is often influenced by other variables such as trust in the source of the information or warning. More information will not necessarily improve responses to flooding.
- No information on what probabilistic flood warnings would look like was found. No probabilistic warnings have been developed as part of previous research.
- There is a lack of information about the way that professional partners use warning information to inform their response to flooding.
- Little relevant information was found on how businesses use flood warning information, their perceptions of probability and uncertainty in relation to flooding or the significant differences in response between businesses of different sizes and characteristics.

(Source: Environment Agency 2008e)

2.4 Review of international literature on the communication of probabilistic forecasts and warnings for natural hazards

The objective of this review was to establish how information about probability is communicated internationally for different natural hazards, weather forecasts and climate change predictions by carrying out a review of the available international literature. The review provided the following:

- a list of examples where probability is communicated in the predictions of a range of environmental hazard forecasts internationally;
- details of different dissemination methods, including the type of technology used for such forecast communications;
- an overview of the type of language and images used to communicate probability in forecasts;
- strengths and weaknesses of the language and images used for the communication of probability in the forecast of hazards.

The review covered a number of natural hazards including floods, hurricanes, tornadoes, avalanches and earthquakes. The review also considered how probabilistic

information for climate change predictions and weather forecasts is communicated to end users.

Methods used to communicate probabilistic information include:

- a variety of messages either with qualitative or quantitative probabilities;
- graphs, icons and maps including: fan/plume charts, bar charts, pie charts, icons, coloured maps, track forecast maps, cumulative distribution functions (CDF) graphs, three-dimensional geographical information system (GIS) maps;
- a combination of icons/graphs/maps and messages.

(Environment Agency 2008f)

From the limited research that has been carried out it would appear that some methods are more successful than others in putting their message across. However, it is important to note that there are few examples where probabilistic or uncertainty information is included explicitly in warning messages. There are several key findings that have come out of this review and these are summarised below:

- No examples were readily available from the international literature illustrating probabilistic flood warnings and indicating how stakeholders would respond to them.
- Expressing probabilistic forecasts using language such as ‘possible’, ‘extremely likely’ or ‘unlikely’ is highly subjective. Limited research shows that when using this type of language the message that the forecaster intends to relay to the end user often does not match what the recipient understands. It is important to use consistent terminology to express probability and uncertainty.
- Expressing forecast probabilities is becoming a more common way of expressing uncertainty especially in the field of meteorological forecasts. However, it is important that probabilities are based on objective scientific techniques and that they are reliable, trustworthy and well-calibrated to the true probability distribution of the phenomena in question.
- Probabilities can be expressed in different ways. For example: ‘There is a 20 per cent chance of a flood tomorrow’; ‘The odds of a flood tomorrow are 4 to 1 against’; ‘There is a 1 in 5 chance of a flood tomorrow’; ‘There is a small chance of a flood tomorrow’. The limited research that has been carried out into end users understanding of probabilities indicates that using percentages or frequencies transmits the forecaster’s message most effectively.
- Limited surveys related to weather forecasts show that probabilistic information does not undermine people’s confidence in a forecasting service. On the contrary, it reassures people that they are being dealt with honestly, and gives them confidence that the service is being provided objectively and scientifically.
- Different users will have different requirements for probabilistic information, as well as different levels of understanding. For some (e.g. those involved in emergency response) detailed quantitative estimates of probability may be required. More ‘sophisticated’ users of probabilistic information are often

aware of the underpinning reasons for uncertainty and the forecaster can use technical language and speak in some detail. The engagement of specific user communities is important to define their needs and presentation preference with regards to probabilistic warnings.

- Limited end-user surveys have shown that end users prefer probabilistic information to be displayed graphically or in the form of a map with an accompanying text-based explanation.
- The choice of colours used to convey realistic information for forecast maps is critical to the use and interpretation of the probabilistic information. User surveys need to be undertaken to identify suitable colour scales and accompanying explanations.
- It is important to understand the roles and responsibilities for decision-makers. Limited surveys have indicated that improvements in decision-making can be made using probabilistic forecast information.
- A clear understanding of the roles and responsibilities of forecasters and decision-makers is essential for an effective communication process. Forecasters need to convey full information to the decision-makers. Maintaining the credibility of the science for the decision-maker is essential.
- It would appear that when communicating probabilistic warnings to the public, putting the forecast event in context to a recently experienced event may help with the public's understanding of the message.
- Experiences from both hurricane and weather forecasting indicate that educational programmes and materials are needed, both for decision makers and the public to ensure proper interpretation and usage of probabilistic methods in hazard situations.

(Environment Agency 2008f)

2.5 Overview of the findings

The key findings of the three reviews can be summarised as follows:

- No information on what probabilistic flood warnings look like was found. No probabilistic flood warnings have been developed as part of previous research.
- Limited end-user surveys of different examples of communicating probabilistic information suggest that end users prefer probabilistic information displayed graphically, as symbols or in the form of a map together with text. But such conclusions may be dependent on the context in which surveys were undertaken and related to the type of information.
- Probabilities can be expressed in many different ways. Qualitative expressions of probability (e.g. 'very likely', 'possibly') are interpreted in different ways by different people and can be confusing. There is limited research to suggest that probabilities expressed in percentage terms are more readily understood than other formats.

- When communicating probabilistic warnings, putting the forecast event in context with a recent event can aid comprehension.
- Different end users have different requirements in terms of probabilistic flood warnings.
- There is limited research on how the public and professional partners understand probabilistic information related to imminent natural hazards. There is some limited research to suggest that decision-makers make better decisions when presented with probabilistic information related to hazards.
- There is limited research to indicate that the public often has a greater understanding of probabilistic information than they are given credit for.
- Formats expressing the probability of an imminent hazard that are better understood may not necessarily lead to the desired change in behaviour.
- There is little information on how businesses use flood warnings or their perception of probabilities and uncertainties related to floods.

3 Development of mock-up probabilistic flood warnings for use in the research

3.1 Introduction

As outlined in Chapters 1 and 2, developing methods for communicating probability and uncertainty as part of flood warnings are in their infancy. The literature reviews carried out as part of the research found no examples of where information on probability and/or uncertainty was incorporated in the flood warnings. This chapter provides some background as to how the current Environment Agency flood warning codes were developed and details of the mock-up probabilistic flood warnings that were used as a tool in the research.

3.2 Background to the current flood warning codes

Until the year 2000 flood warnings issued by the Environment Agency and its predecessors were based around a three-phase colour-coded system, YELLOW, AMBER and RED, that was designed to indicate the likely severity of the flood in a simple form. The definitions of these warning codes are given in Table 3.1. Consumer research indicated that these codes caused confusion among the recipients of the warnings (Haggett 2000).

Table 3.1 Environment Agency flood warning codes prior to the year 2000 (Haggett 2000).

Warning code	Definition
YELLOW	A warning of flooding of some low-lying farmland and roads near rivers and the sea
AMBER	A warning of flooding to isolated properties, roads and large areas of farmlands near rivers and the sea
RED	A warning of serious flooding affecting many properties, roads and large areas of farmland

The Independent Review (the Bye Report) commissioned by the Environment Agency into the Easter 1998 floods concluded that the public was not well served by the system, and that an alternative more customer focused approach was required. The Bye Report stated the following:

> *Colour-coded warnings appear to be misunderstood by nearly all who receive them. This is because the colours are spontaneously linked with the escalating probability of flooding actually occurring and not with the extent definitions to which the colours relate. The interests of the public are not well served by warnings given on a colour-coded basis*.

(Bye and Horner 1998)

The Bye Report recommended that the Environment Agency should carry out the following changes to its flood warning procedures (Bye and Horner 1998):

- establish an alternative to the present system of colour-coded warning;
- give greater attention to the human and social aspects of warning message construction and dissemination, and encourage effective responses.

Following consultation with key stakeholders it was concluded that a three-staged warning system was most appropriate and this is supported by 'best practice' overseas. It was also recognised that a fourth stage that is described as the 'all clear' when all warnings have been cancelled for a particular locality was required (Haggett 2000). A series of symbols were also developed to accompany the new warning system. The design of the warning codes stipulated:

- that the codes are clear, intuitive and authoritative;
- that they communicate:
  - water as a danger;
  - threat to properties and human life;
  - level of danger;
- that they work across all visual media (screen and print) in both English and Welsh;
- that they are easy to understand for those who do not speak English as a first language.

(Khatibi 2005)

The current system of Environment Agency flood warnings with their respective symbols is detailed in Figure 3.1.

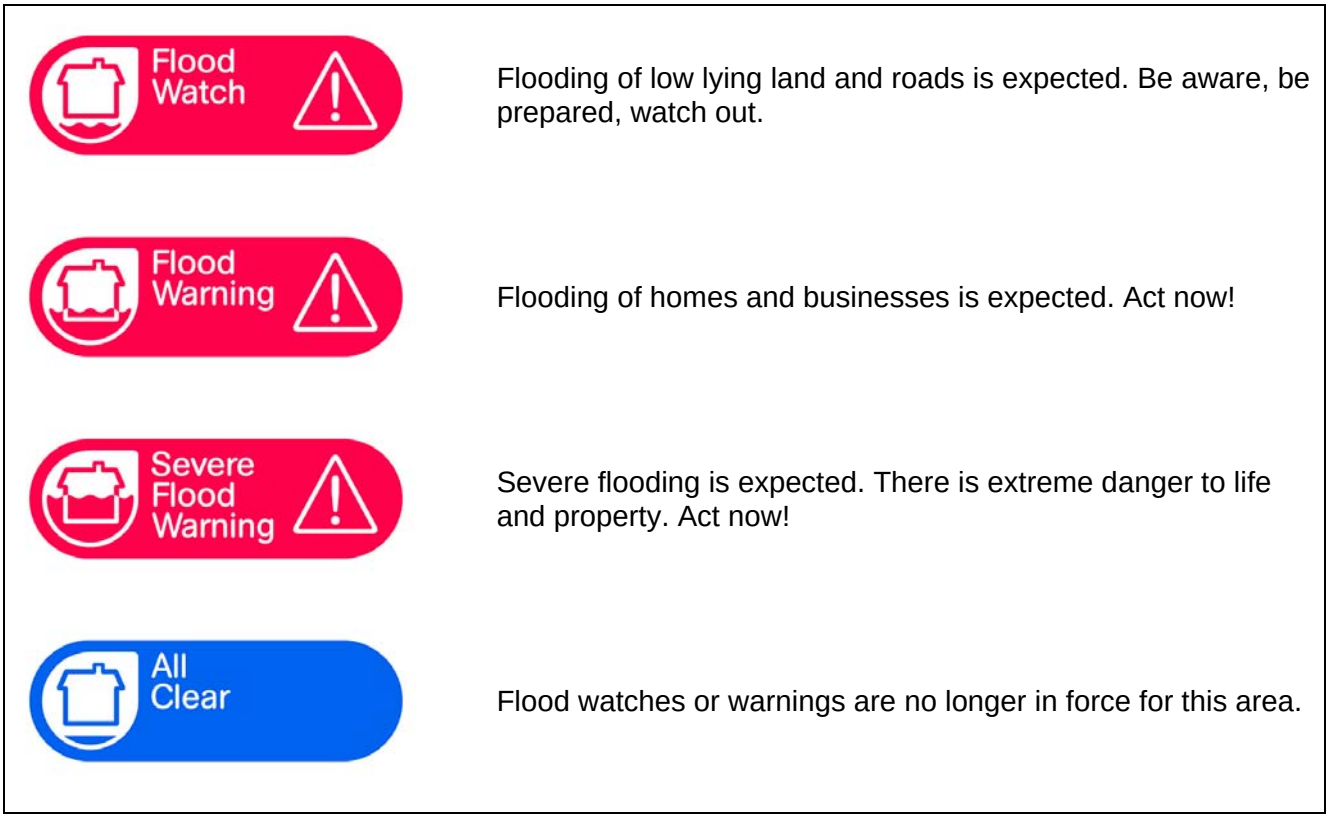


Figure 3.1 Current Environment Agency flood warning symbols and their meanings (Source: Environment Agency 2008g).

3.3 Development of mock-up flood warnings incorporating probability and uncertainty

The literature reviews carried out on the communication of probabilistic and uncertainty information indicated that there are no examples of such information being incorporated into flood warnings. As a result it was necessary to mock-up flood warnings that incorporated probabilistic information in different formats, so that these could act as a focus for surveys, workshops, focus groups and discussions. The mock-up probabilistic flood warnings are shown in Figures 3.2 to 3.6. A brief description of each flood warning is given below.

Figure 3.2 represents a five-day warning indicating in a qualitative manner, ranging from 'very unlikely' to 'very likely, the probability of a severe flood warning occurring on a certain day. The qualitative probabilities have also been colour coded as follows:

- Green = 'Very unlikely'
- Yellow = 'Unlikely'
- Orange = 'Probable'
- Red = 'Very likely'

The warning shown in Figure 3.3 is similar to Figure 3.2 except that the probability of a severe flood warning is represented in a quantitative manner by percentages. The

percentages are also colour coded, with low probabilities being represented by green and high probabilities represented by red.

Figure 3.4 shows the probability of each of the four Environment Agency warnings occurring on a certain day in the form of a bar chart. This example shows that on Friday 29 September there is a 9% chance of a Severe Flood Warning, a 25% chance of a Flood Warning, a 25% chance of a Flood Watch and a 41% of an All Clear. The bars on the chart have been colour coded as follows:

- Green = ‘All Clear’
- Yellow = ‘Flood Watch’
- Orange = ‘Flood Warning’
- Red = ‘Severe Flood Warning’

Figure 3.5 shows an example of a flood warning using a probabilistic map showing forecast flood extent in the next 24 hours. The map was based on outputs from the US National Weather Service. The white areas on the map have less than a 25% chance of flooding in the next 24 hours; the yellow areas have a probability of between 25% and 50% of flooding in the next 24 hours; and the light blue areas have a greater than 50% chance of flooding in the next 24 hours

Figure 3.6 is an example of a flood warning showing the uncertainty band around the five-day forecast river flows together with flood threshold levels. The black line on the graph shows the five-day forecast of river flows. There is a band of uncertainty either side of this line. The dark blue area indicates that the forecast flow will fall in this range 5 out of 10 times and the light blue area indicates that the forecast flow will be in this range 8 out of 10 times. The graph also shows flood thresholds as follows:

- Orange = ‘Minor flooding’
- Red = ‘Moderate flooding’
- Purple = ‘Major flooding’

It is important to note that it was not the purpose of this research to develop new flood warning codes. However, it was necessary to produce warnings incorporating probability in different ways to use in the research, in order to answer the question ‘what could a probabilistic flood warning look like?’ The technical feasibility of implementing these developed mock-ups was outside the scope of work of this project. However, it is envisaged that probabilistic flood warning maps are unlikely to be currently feasible to implement for large areas of England and Wales.

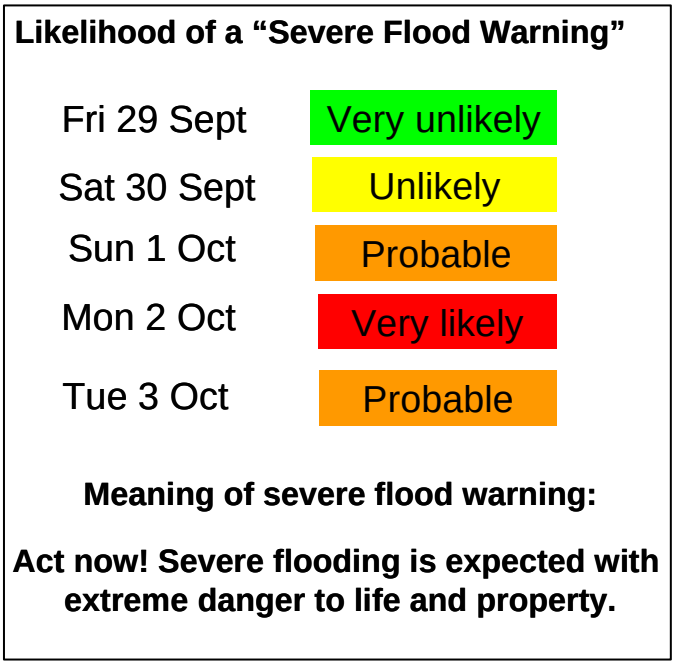


Figure 3.2 Example of a flood warning including qualitative probabilistic information.

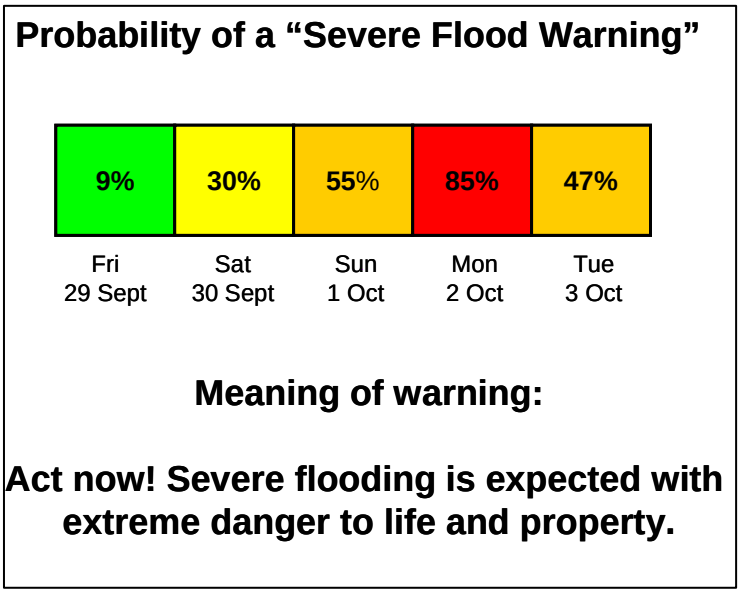


Figure 3.3 Example of a flood warning including quantitative probabilistic information.

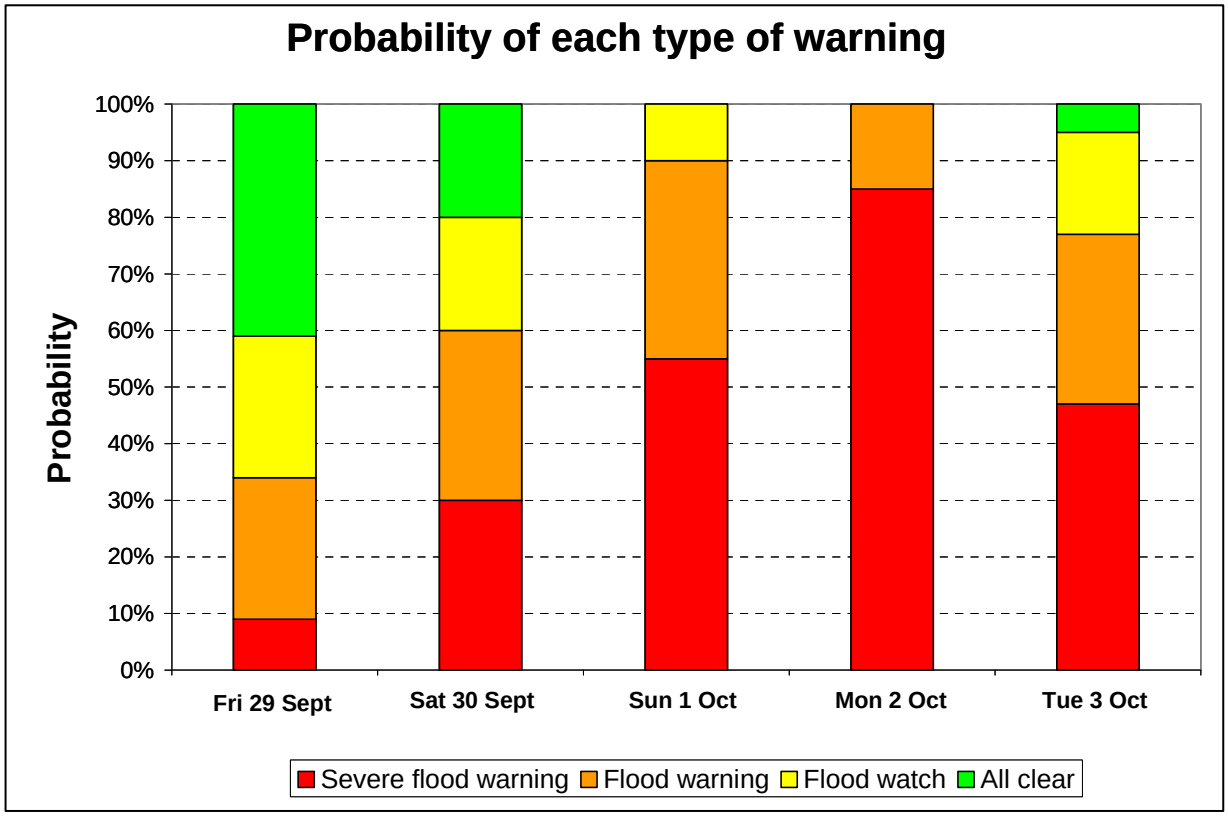
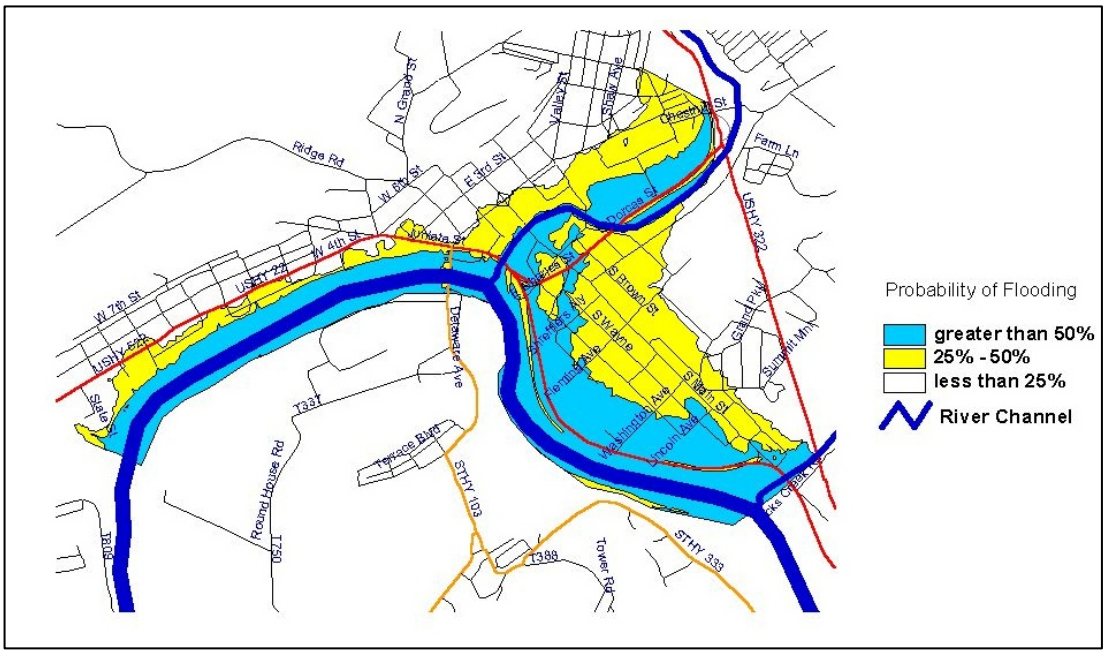


Figure 3.4 Example of a flood warning incorporating information in a bar chart format.



(Source: NOAA 2008).

Figure 3.5 Example of a flood warning utilising a probabilistic map showing forecast flood extent in the next 24 hours.

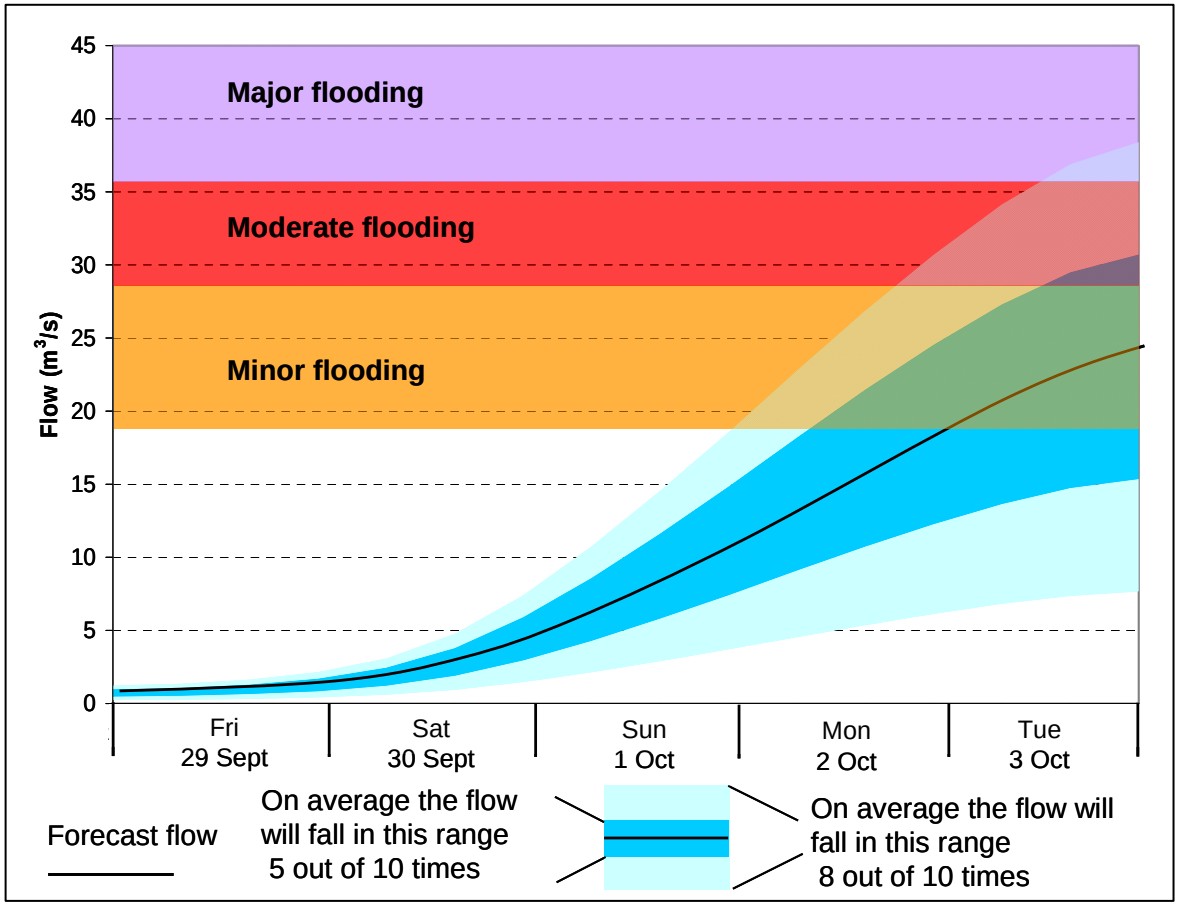


Figure 3.6 Example of a flood warning showing the uncertainty bands around the five-day forecast river flows together with flood threshold levels.

4 The public's understanding of probabilistic warning information and its communication

4.1 Introduction

One of the aims of this project was to establish what the public understand about probability and uncertainty in the context of flood warnings. The remit for the research included the following two tasks:

- Task 1 Collecting empirical data on what the public understand about probability and uncertainty.
- Task 2 Collecting empirical data on how or if the public would want to use probability and uncertainty if provided as part of flood warning.

The research team chose to use focus groups as a method to enable dialogue with members of the public regarding risk and uncertainty. Focus groups enable the type of two-way dialogue and interaction which is necessary to explore carefully and sensitively what may be rather involved and unfamiliar ideas for participants. Enabling discussion between participants was also designed to reveal the type of debate and deliberation that would be generated by the introduction of probabilistic information into hazard warnings and the processes through which different formats and delivery methods would be evaluated.

4.2 Setting up and running focus groups

4.2.1 Focus group locations

Four focus groups were carried out in Oxford, Purley near Reading, Fleetwood, and Kinmel Bay in Wales. The locations of the focus groups are shown in Figure 4.1. These locations were chosen using guidance from the Environment Agency regional staff and the project steering group. Oxford and Purley in Reading have experienced fluvial flooding from the River Thames in the past three years and Fleetwood and Kinmel Bay are coastal areas that had experienced flooding at some point in the past.

Oxford was flooded from the River Thames in 2000, 2003 and 2007. Over 1,600 homes were flooded across West Oxfordshire, with many more having damage to garages and sheds (West Oxfordshire District Council 2008). In Oxford itself, 169 properties were flooded in 2007 (Environment Agency 2008a).

In **Reading** we focused on flooding experiences of those living in the parish of Purley on Thames, an outlying village which has a residential population of about 1,500 households (Purley on Thames Parish Council 2004). Over 40 properties were flooded here in 2003 and over 10 properties in 2007 from the River Thames (Thames Flood Incident Management team 2008c.

In the urban areas to the west of London and in Reading and Oxford, approximately 40,000 properties are currently thought to be at risk of flooding. This risk is managed by maintaining the capacity of the river channels which 'provides protection against a flood that would be expected to occur on average every 10 to 20 years' (Environment Agency 2007).

Fleetwood, a fishing port on the Fylde peninsula, last suffered a major flood event in November 1977 when 1,800 homes were flooded, some up to one metre in depth (Wyre Borough Council 2004). The sea defences date back to the nineteenth century and are reaching the end of their design life. The River Wyre also flows through Fleetwood. Currently, there are 414 properties in Fleetwood at risk from the 1% annual probability (i.e. 1 in 100 year) flood (Environment Agency 2007b).

Kinmel Bay and Towyn, on the north-east Wales coastline, have a combined population of about 8,000 people (Conwy Borough Council 2003). The sea defences here also date back to the nineteenth century when the wall was built to protect the Chester to Holyhead railway line. In 1990, a storm-force wind, high tide and extreme wave conditions caused a breach of the Network Rail defences. Around 2,800 properties were flooded over 4 square miles (about 10 km^2) of land (Conwy County Borough Council 2008).

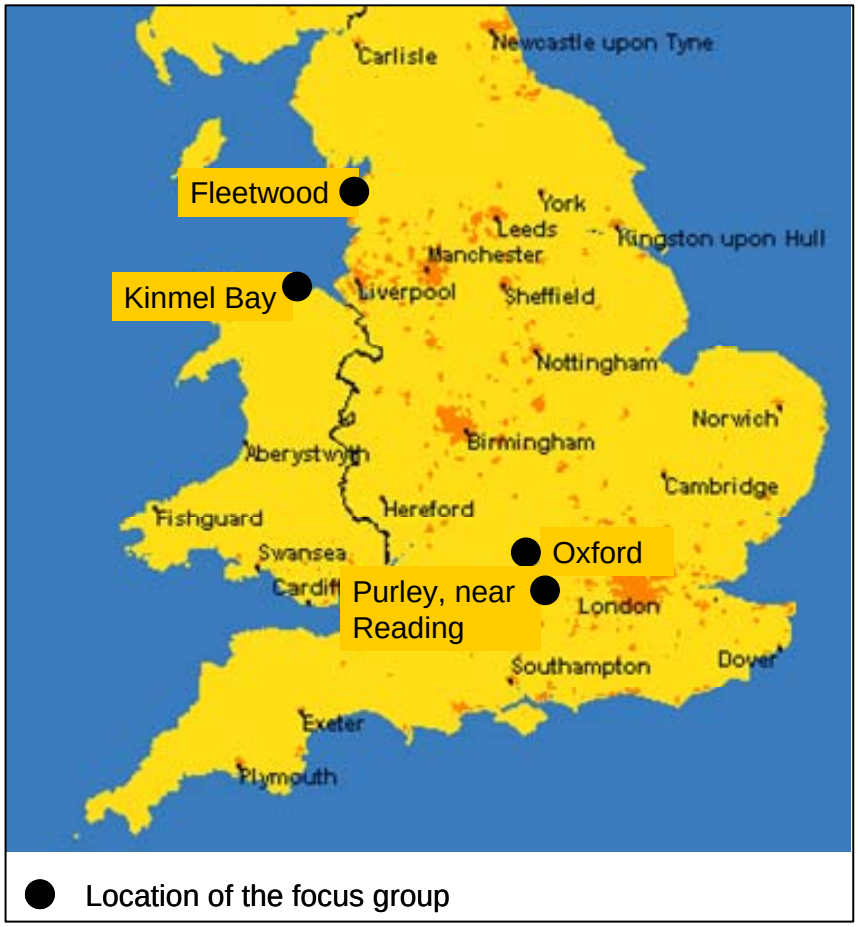


Figure 4.1 Locations of the focus groups.

4.2.2 Recruitment and profiles of the focus groups

The research team drew up a recruitment profile for each of the four areas, taking note of discussions with Environment Agency regional staff and the project steering group. This profile was then given to a professional recruiter who visited each area and recruited as close to the profile as was practicable. Factors specified in the profile were a balance of male/female participants, ages, type of housing (e.g. such as detached/terraced housing, rented accommodation/owner-occupier), socio-economic status and flood experience. Where possible, the recruiter was also asked to recruit across various parts of the area rather than from one or two streets.

In Oxford and Reading, the Thames Flood Incident Management team provided us with specific street names that were known to have flooded. In Fleetwood and Kinmel Bay where the flood events were a long time ago, the recruiter talked with local people to ascertain which streets had experienced flooding and where to recruit from. Table 4.1 provides details of the profile of the focus group participants.

Table 4.1 Profile of the focus group participants.

Location	Gender	Type of housing	Age range	Number who had been flooded in the past
Oxford	3 women 6 men	6 owner-occupiers 3 in rented accommodation	34 to 65	8 (8 in 2007 and some in previous years too)
Reading	4 women 4 men	All owner-occupiers	32 to 70	5 (1 in 2008, 1 in 2007 and 3 in 2003)
Fleetwood	3 men 5 women	All owner-occupiers	56 to 83	All in 1977
Kinmel Bay	2 women 6 men	All owner-occupiers	44 to 80	All in 1990

4.2.3 Focus group schedule

The focus group schedule was drawn up by the research team taking cognisance of the findings from the literature reviews. There were three sections to the discussions. The theme for the first part of the discussion was uncertainty and reliability, using weather forecasts as a means of discussing how uncertainty information is interpreted and used. Attempts to get the participants to talk about probability and uncertainty more generally or in relation to other types of issues did not meet with much success. This may have been because participants were recruited to discuss flood warnings and therefore interpreted all our questions in that context. It may have been because it was useful for them to have an opportunity to talk about flood risk and their experiences. It may have been because our questions were not properly phrased to encourage broader thinking, or it may be an illustration of the fact that people think about probability and uncertainty in a contextualised framework rather than in general or abstract terms.

The next theme that was introduced was experiences of receiving flood warnings, how these warnings may have been interpreted and used, and whether participants had used the Floodline Warnings Direct service. The team then circulated copies of current warning codes with accompanying text and asked participants to discuss the strengths and weaknesses of the codes and how they interpreted them.

The final set of questions related to information on risk and uncertainty in flood warnings. Five examples of probabilistic warnings that had been drawn up by the research team were circulated among the group, and each was discussed in turn. Participants were asked to discuss what the information meant to them, how they interpreted the graphics or the text, how much trust in the source affected how they would be used, and whether they were helpful in communicating risk. The final question asked participants to discuss whether they would prefer to have information on probability/likelihood added to hazard warnings or to leave them as they are.

4.3 Experience of flooding and flood risk perceptions

In this section, we summarise background information on how focus group participants experienced the most recent flood event in their locality. We also report on their expectations of future flooding and the degree of preparation for such an event. A longer account for each area, including quotes from the focus group discussion, is provided in Appendix A.

Participants in Oxford and Purley near Reading had experience of fluvial and groundwater flooding. The general sense from participants in both areas was that flooding, and the threat of it, were very much part of their lives. In Oxford some participants had been recently flooded several times in their homes and expected to be flooded again. They described different flooding experiences within a very small geographical space, some times even within the same street. In Purley flooding of gardens and surrounding land was an expected event every winter. Living with water was simply part of living in this area and people reported adaptations to homes to cope with this.

Participants in Fleetwood and Kinmel Bay had been flooded through seawater, groundwater and water contaminated with sewage. However the frequency of occurrence of significant flooding had been much lower. In Fleetwood all the participants remembered the last major flood from 30 years ago and could recount what happened very vividly. There was consensus among the group that the cause of flooding had been lack of maintenance of the lagoon on the shore. In Kinmel Bay participants had last experienced flooding in 1990. Participants talked about the flood as a one-off event that had been caused by a combination of high winds, high tide and an accidental breach of the sea defences. Because of this, some of them did not feel at risk of flooding again. Others did report feeling at risk of flooding and said they watched the weather forecast closely.

Although the exact experience of flooding is different and shows the importance of local context across the four locations, one common feature is the variety of flooding experiences within very small geographical areas.

4.4 Flood warnings, trust and uncertainty

In this section, we focused on flood warnings as they are at present. We asked participants to talk about how they receive warnings at present, if at all, and what their experience of such warnings had been. We presented participants with the current warning codes (i.e. Flood Watch, Flood Warning, Severe Flood Warning and All Clear) and asked them to discuss the graphics as well as the content of the warning codes. We were interested to find out if people were familiar with the codes and, if so, how they were used. We discussed other, more informal, ways of having flood warnings. We also talked about use of weather forecasts and how participants may use uncertainty information from forecasts in their every day lives. There were some general findings from the focus groups regarding flood warnings, trust and uncertainty. These are detailed below.

The focus groups clearly identified that warnings are understood, interpreted and acted on in different ways by different people depending on a variety of individual and social contexts. This is a crucial point to consider for flood forecasters and communicators who are keen to alert the public to imminent flood risk in their locality. Factors which may influence the way a piece of information is understood, interpreted and acted on may relate to people's individual characteristics, where they live, the networks they are connected to and what information is forthcoming from them, their past experiences of flooding, past experiences of people they know and so on. A flood warning will always be received through this contextual and mediated process.

Most participants already understood that there is an inherent level of uncertainty with official flood forecasts and that a flood may not necessarily happen because a warning has been issued. Conveying this uncertainty was generally seen by focus group participants as a potentially useful piece of information that could inform their individual decision-making processes.

The uncertainties that are already familiar in weather forecasts, that is with less certainty expected from day 5 of a five-day forecast compared to day 1, provide a commonly understood parallel to how longer range flood forecasts would be understood.

The focus groups illustrate a highly proactive process of information gathering and forecasting by some members of the public living in flood-prone areas and challenge the divide between expert/lay knowledge. Some participants felt confident in their expertise in forecasting floods *in their localities* and did not rely on the Environment Agency's flood warning service. Furthermore, rather than merely accepting official flood warnings as fact, the focus groups show that such information may be mediated by knowledge and experience of how water is known to behave at the local level. The Environment Agency's flood warnings are one piece of information that may be used to determine action, but other factors also have an influence on this process.

Perception of being at risk of flooding may be the major factor in determining the level of engagement with flood risk information. This may be of particular significance in coastal communities who may have been flooded once but who believe they are no longer at risk of flooding. Where previous flooding has been rationalised as a result of extremely rare weather conditions and/or an unusual breach of sea defences, residents may not view themselves as being at risk, even if the Environment Agency has designated their locality as being at risk.

The source of warning information and level of trust in the source is highly influential in determining action, but so is the level of trust in the spatial precision of the information being offered. It is the perception of the spatial precision, or the confidence in its geographical accuracy in relation to where they live, that affects residents' decision-making and ensuing action. Flood warning information must be seen to be relevant to residents for it to have any effect on behaviour. Focus group participants repeatedly stressed the importance of having flood warning information that made sense to them *at the local level* (i.e. that they could trust was relevant to them in their streets).

Communication strategies must take note of the existence of 'publics' rather than 'the public'. Flood warning information must continue to be communicated in different ways and at different levels in order for it to reach the many different layers of publics (e.g. to take account of age and related cultural differences, or whether people are home-owners or in the rental sector). Appendix B provides further details of the experience of the focus groups' participants related to flood warning and also of issues related to trust and uncertainty in the warnings.

4.5 Mock-up probabilistic flood warnings

The mock-up probabilistic flood warning options detailed in Chapter 3 were shown to focus group participants. A brief summary of some of the comments and observations of the participants related to each specific mock-up warning is given in the sections below. Section 4.5.6 provides a summary of the focus group reactions to the mock-up probabilistic flood warnings.

4.5.1 Five-day flood warning including qualitative probabilistic information

Figure 4.2 (example A) shows a five-day flood warning including qualitative probabilistic flood warning information. The following summarise the comments related to example A:

There was some confusion over the terminology used in this forecast

> *It says probable, I'm getting confused now. Is very likely more than probable or is probable more than very likely?* (Len, Fleetwood)

There was also some confusion about what the dates denoted. The five-day forecast element was not immediately obvious to some participants.

Participants questioned the need to be warned if flooding was very unlikely or unlikely.

One participant believed that the warning statement at the bottom (i.e. 'Act Now!') was the most important part of the warning, whatever format the warning was in. His view was that if the Environment Agency were warning people to take action immediately then it must be taken seriously.

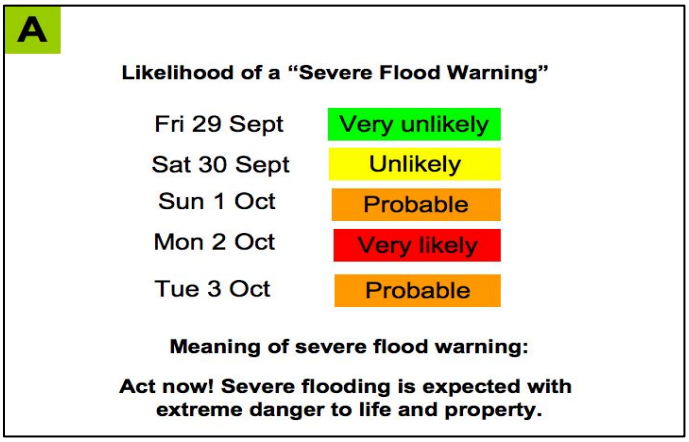


Figure 4.2 Example A – A five-day flood warning including qualitative probabilistic information.

4.5.2 Five-day probability flood forecast using probabilistic representation in terms of percentages

Figure 4.3 (example B) shows a five-day flood warning including qualitative probabilistic flood warning information.

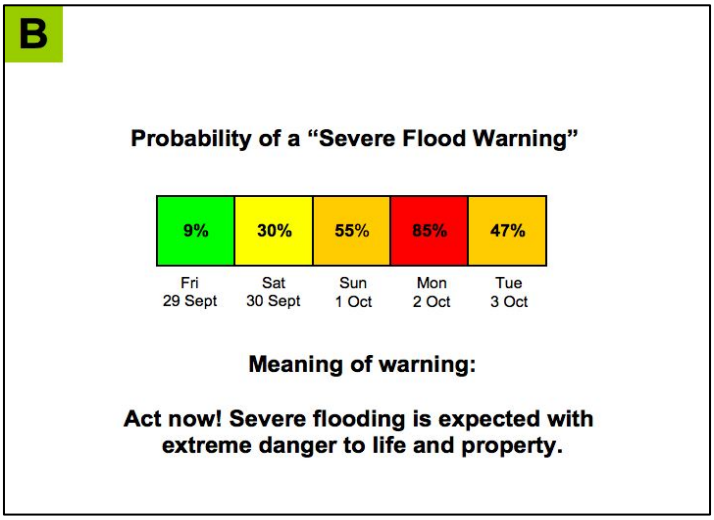


Figure 4.3 Example B – A five-day flood warning including quantitative probabilistic information.

There was a lot of support for this representation in preference to the previous one because it was seen to be a clearer indication of probability and trend. One suggestion was to combine the two in order to have a more precise tool for communicating probability.

Furthermore, having precise numbers meant that some people felt able to make more of their own judgements about what to do as a result. Words such as 'likely' and 'probable' were felt to be too value-laden to have meaning, whereas numbers were seen to be less open to interpretation Participants also believed that percentages had more impact than words by themselves. For example, 30% seemed more alarming than 'unlikely'.

The colours accompanying the numbers were felt to be important in determining response (i.e. regardless of the percentage, if a particular day was highlighted red then it would be interpreted as danger). This point was particularly emphasised by older participants.

There was some concern that if one time an 85% probability of a flood event was not followed by a flood, then next time a 65% probability may induce complacency or a false sense of security.

4.5.3 Five-day probability flood warning incorporating information in a bar chart format

Figure 4.4 (example C) shows a five-day flood warning incorporating information in a bar chart format.

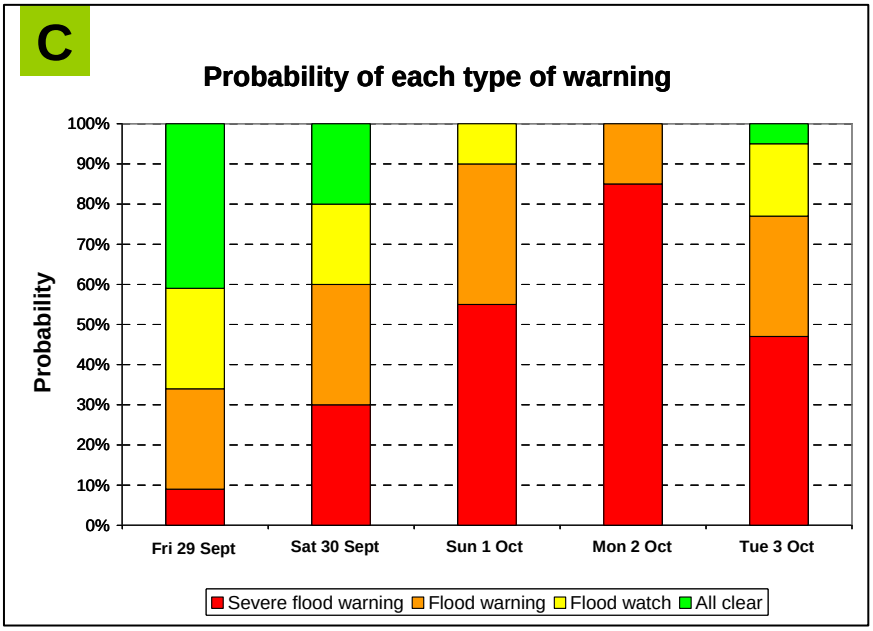


Figure 4.4 Example C – A five-day flood warning incorporating information in a bar chart format.

The general consensus across the groups was that example C was 'a very bad communication job'. Participants did not want to discuss this option. This representation was not at all popular with participants in the Oxford group, mainly because they felt it was too complicated to work out. If a warning had to be worked out then it was not an effective communication tool.

> *Well that's double Dutch to me.* (Helen, Oxford)
>
> *I mean exactly what you've just said, if I've got to sit down there and work that out, then it's no good to me.* (May, Oxford)
>
> *My grand-daughter can colour better than that!* (Helen, Oxford)
>
> *It's just too much information.* (James, Oxford)

4.5.4 Real-time internet-based localised flood map

Figure 4.5 (example D) shows a probabilistic flood map indicating the probability of certain areas flooding within the following 24 hours. The representation in Figure 4.5 elicited different responses depending on location and type of flooding risk.

Those living in Purley near Reading and Oxford saw this option as the most useful one for them. Some participants felt the real-time map providing localised information was the best option for them.

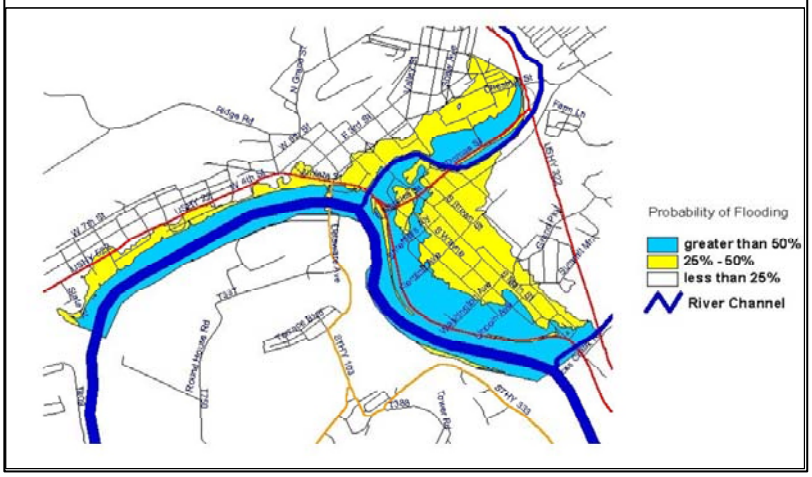
> *That's the most useful thing I think I've seen so far.* (Alan, Oxford)

> *If it was available on the Internet, I probably would go and look at it because you would imagine that from that you could put in your postcode just like you would do in Google Maps or something like that and you would get an immediate local picture and showing the area and the risk. But that's starting to become interesting and useful.* (Mathew, Oxford)

There was a suggestion to have the colours used in examples A, B and C superimposed on a map such as this one.

D

Map of probability of flooding in next 24 hours



(Source: NOAA 2008).

Figure 4.5 Example D – A flood warning utilising a probabilistic map showing forecast flood extent in the next 24 hours.

One participant made the point that it was already difficult to find relevant information on the Environment Agency website. A particular criticism was that it was difficult to search for flood warnings of rivers upstream from your own location because to do that requires knowing the names of lengths or segments by lock (e.g. looking between Whitchurch Lock and Caversham Lock) and also whether the tributaries come in above or below your own location. It would be more helpful to have a diagrammatic representation of the state of the rivers in the area.

Consequently, participants wanted to see this map on the internet in the same way as Multimap, capable of being viewed at different scales, in order to get a broader picture of the state of the rivers in the region.

One participant asked ‘obviously it hasn’t got a red colour in it, so it’s not actually flooding this area, is it?’ So despite having a legend that explains the colours, attention was being paid to the colours as understood by participants (i.e. red is danger).

The older participants from the coastal town of Fleetwood felt the design of the map was too complicated and not useful for them as a warning tool.

Participants in Fleetwood and Kinmel Bay both questioned whether this type of representation would be at all relevant in coastal areas because coastal flooding was seen as not being capable of prediction with such accuracy.

Those who used the Internet said that the map would be useful as a further source of information to seek out, but it was not seen as a general warning.

The view was expressed that houses on the borders between the blue/yellow and yellow/white areas would not know what to do because of the unpredictability of water. Also, there was a danger that people would see their house was in the white zone and be complacent about the threat of flooding to their properties.

4.5.5 Five-day probability flood forecast with uncertainty information

Figure 4.6 (example E) shows a probabilistic flood map indicating the probability of certain areas flooding within the following 24 hours.

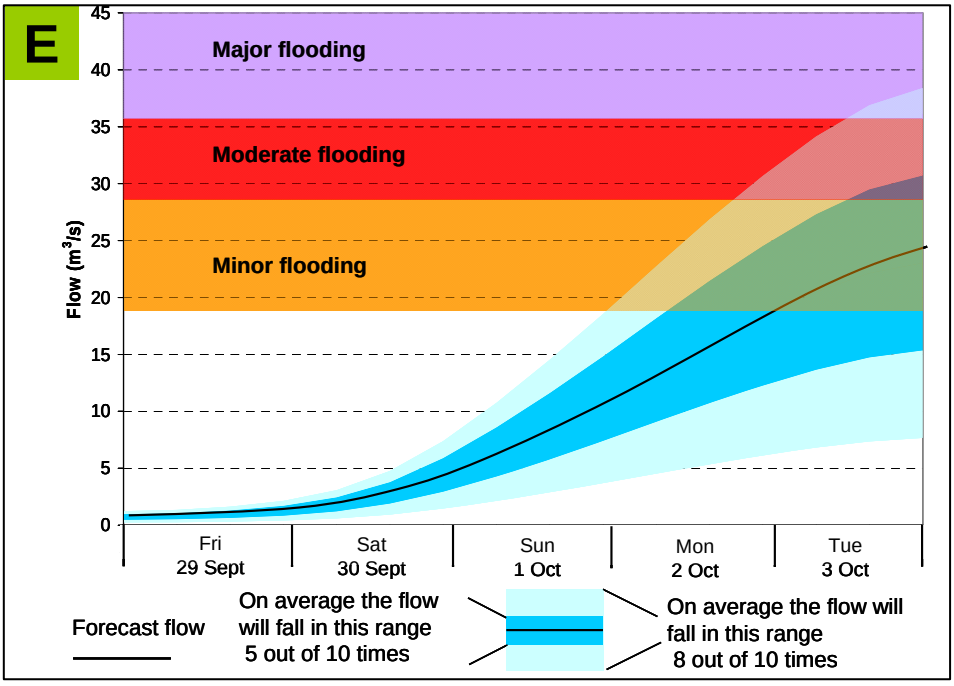


Figure 4.6 Example E – A flood warning showing the uncertainty bands around the five-day forecast river flows together with flood threshold levels.

All the participants unanimously rejected this representation for the general public, as it was too complicated. One participant interpreted the uncertainty as 'between a lot and nothing', which in the end was not seen to be useful to anyone.

One participant made an interesting observation about the uncertainty information contained here.

> *I think you could put any dates on this, you could just say today, tomorrow, three days hence, four days hence, five days hence, six days hence. And it would always look the same because you are just getting a greater degree of uncertainty the further ahead you are looking.* (Mathew, Oxford)

One participant who was unique in her degree of confidence in using technical data felt that it would be more useful to know the height of the river and whether it is rising or falling rather than its flow per second.

> *What I actually think would be more useful is to know whether it was rising or falling at those points because that's really the key thing. And what happens when we go on flood watch, you know I talked about, I look at all sorts of sources of information and so do lots of other people. We go down to the river and we start taking river levels and we do that twice a day and when it gets deeper we do it more often. I mean if you live on the river it's easier. But we actually go down to the lock at Mapledurham and I have my chest high waders for wading through because it actually gets deep on the way down and it's not passable in just ordinary wellies. And we go down and take our levels and we record them and we put them on a little spreadsheet on the computer and we are watching ourselves.* (Jo, Reading)

The older residents in Fleetwood did not like this option as a flood warning communication tool.

Len	*Well it would be useless for the old residents anyway, there's no chance that they could understand that.*
Gwen	*I can't understand it.*
Sue	*I can't even be bothered to understand it!*

4.5.6 Summary of the focus group reactions to the mock-up probabilistic flood warnings

Across the four groups participants in principle welcomed the opportunity of having access to probabilistic flood forecasts if it could provide them with advance warning days ahead of a probable flood. Furthermore, receiving some form of indicator of probabilities would allow householders to make their own judgements about appropriate courses of action to take.

Arguably the most important issue raised by participants was how much they could trust the accuracy of the forecasts. Regardless of the format the forecasts were presented in, participants commented that a flood warning would not be acted on unless they had confidence in its accuracy specifically in relation to where they lived. Trust depends on a complex interrelationship between different factors, and the focus groups began to explore what these factors may be. For example, participants expressed the importance of trusting that a flood forecast has geographical accuracy

and applies to their specific location. Flood forecasts that were seen to apply to too broad an area were viewed as irrelevant and unhelpful.

Another factor was whether it would be possible to develop such accurate predictions as outlined in the examples they were shown (such as ‘an 80% chance of a severe flood warning’). Most participants expressed an awareness of some factors that lead to uncertainty in flood forecasting. Those living in coastal areas doubted such forecasts could ever be accurate for their localities due to the factors involved in coastal flood events (e.g. unpredicted breaches in sea defences, change in wind speed or direction). Those in fluvial flood zones commented on the unpredictable nature of water in their areas.

> *We were saying earlier on that the situations were changing so quickly and the predictions that they made at the last flood here, initially it was going to peak on Saturday afternoon and then evening and then Sunday, means that I wouldn’t trust anything like this because certainly as far as we are concerned here at Oxford, I don’t think that they are ever going to be able to predict those with that sort of degree of conviction.* (Mathew, Oxford)

While most participants acknowledged the complexities of flood prediction and understood the uncertainties involved, they also believed that too many ‘false alarms’ could eventually mean loss of trust in the accuracy of the forecasts. On the other hand, the view was expressed that if uncertainty information was openly discussed, the public may still retain their trust in the Environment Agency and understand why warnings had to be issued.

> *Well I’ve got to say with all these things I think that somebody should come along and say, ‘I got it wrong but if I had got it right you’d all be thanking me now’. And somebody, when they don’t get it right, maybe somebody should come along on the television, the spokesman for the Environment Agency, ‘Well we did get it wrong but it was a near thing and I’m glad I was wrong’.* (Paul, Fleetwood)

The mode of flood warning communication was also mentioned in relation to trust. Many participants said they preferred to be alerted to flood risk through door knocking, the media and Floodline Warnings Direct but were not sure if these were the most appropriate means for providing probabilistic information. Receiving warning leaflets through the door was also not seen as a viable option for the simple reason that forecasts would need to be updated regularly in order for them to be trusted and acted upon.

Regardless of the format, participants from each group commented that if the meaning of a flood warning was not *immediately* obvious then it was not an effective communication tool. A format that was complex and needed interpreting was not favoured as a tool for flood warnings. There were some participants who wanted to engage with more complex and technical information but these were in a distinct minority.

Some participants commented that flood warnings need to be seen to be part of a bigger civil contingency plan for them to be trusted and have an impact on the public. Such warnings would be seen to have credibility. As probabilistic forecasts would be issued days in advance of a probable flood, it would provide the local authority with some time to communicate its contingency plan to householders along with the flood warning. Rather than issuing a warning that says ‘Act now!’, it was suggested that the warning should state what evacuation plans may have been put in place, where

residents could head to, or where the nearest emergency shelter would be and what they would be allowed to take.

> *The big issue really is, is the consequences of it … that you are actually going to be part of a process, a well-oiled machine … so as a result of getting to this stage three or four days before, contingency Plan B is now being mobilised, you know, coaches are being put to a certain place and ready to take people into schools etc. etc., should this happen. So I don't think it's really going to be particularly helpful to say on Thursday you are going to be flooded out of your house, good luck. It's got to be associated with a contingency plan.* (Ron, Kinmel Bay)

Participants commented that a probabilistic flood forecast would be one piece of information that they would use alongside other information (e.g. such as media reports, what friends or neighbours may think, personal judgement of the weather and how it may have affected the river). Flood warnings would not be acted on unless they could be corroborated with other information that they sought themselves. This was partly because of the issue of localised flooding (that the warning might be relevant for other people in the wider area but not for them), and partly because of the changeability of local weather patterns (referring to the unreliability of five-day weather forecasts).

> *Well I'd move stuff out of the way and I'd make sure just how high the tide was, whether it was a low tide of the month or a high tide of the month… and if there was a forecast of gales. And then I'd know with this [warning] there was a probability of flooding you see.* (Alfred, Kinmel Bay)

A further issue raised by participants related to marketing and communication of any new flood warning system. In order for the public to trust the forecasts, they need to be informed of why the system may be changing and how the new information could be used.

> *They don't tell people about it, they don't actually do the marketing around it. And they're in danger, if they don't do it properly, of coming out with a new scheme here and then in two years' time when that hasn't worked another new scheme and lots of new schemes and we never get to hear about it and we never know what's going on and we have patchy information and we don't trust any of them. So, if they are going to do it, whatever it is, they need to do it very carefully and properly promote it. Because if they don't do that we'll never believe it.* (Margaret, Reading)

Some participants expressed the view that the current system of warnings through Floodline Warnings Direct could be left as it is but that probabilistic information (such as the map shown in Figure 4.5) could be made available on the Environment Agency website for those who sought more detailed information.

There was no clear consensus as to how probability information should best be conveyed but some general patterns in the groups' discussions can be identified. Simple qualitative terms alone were not generally welcomed (example A shown in Figure 4.2) but when combined with a simple quantitative percentage indicator this was seen as more useful and convincing (example B, shown in Figure 4.3). Some participants particularly liked the idea of communication via a map with the spatial precision this enabled (example D, shown in Figure 4.5). Only a small minority found the more technical content of graphs useful or understandable (example E, shown in Figure 4.6).

4.5.7 Other comments

Besides talking about the topics that we introduced in the focus groups, the same issue was raised in three of the four groups. In these groups participants expressed their wish to see more action by the authorities to *prevent* further flooding than research on new ways of being warned about the probability of flooding. Appendix C provides further details of these comments.

4.6 Summary of the key findings

The key findings from the focus group work can be divided into two themes: the social context for flood warnings and the public's views on the inclusions of probabilistic information in flood warnings. These findings are detailed below.

The social context for flood warnings

- Perception of being at risk of flooding is a major factor in determining the level of engagement with flood risk information.
- Those who lived with and perceived the most immediate and frequent threat of flooding had greater knowledge and expertise and were highly proactive in gathering information relating to their local area. Many of these used their own methods to monitor the potential for flooding, rather than only relying on the Environment Agency to provide them with warnings. When they receive an official warning they assessed its relevance to their specific local area in the context of all the other pieces of information they had gathered.
- In contrast, those who had experienced flooding many years ago, but did not perceive themselves to be at significant risk, had little or no engagement with flooding issues. There was still some anxiety about the possibility of flooding but there was no proactive information gathering or direct engagement with flooding issues.
- Regardless of type or format of a warning, there is not necessarily a direct link between receiving a flood warning and taking action. Warnings are variably interpreted and understood by different people within different personal and social contexts.
- Trust plays a major role in how warnings are responded to, regardless of the format or type of warning and underlying this trust is the *perception* of accuracy that the public may have of the warning, specifically in relation to how it applies to their streets and their homes.
- There is an existing understanding about uncertainty and probability; uncertainty is inferred into flood forecasts, as research has shown is also the case in relation to weather forecasts. The focus groups showed that some people have a clear sense of the uncertainty and make sophisticated judgements with regard to uncertainties between weather forecasts, rain and how water is known to behave in their locality.

Public's views on the inclusion of probabilistic information in flood warnings

- Participants generally welcomed the possibility of receiving probabilistic warnings *if* it would enable them to receive advance warning and, therefore, make more informed choices. Advance warning was seen to be of particular benefit for vulnerable people in the community, such as those needing regular medicine or those with babies or young children.
- Being provided with simple probability information was thought to be a useful means of communicating uncertainty. Since uncertainty is inferred anyway, being informed of the levels of uncertainty and forecasted probabilities was seen as potentially useful additional information.
- Participants who were not actively engaged with flooding issues on a regular basis still expressed a need for clear guidance as to what action they should take as a result of a probabilistic warning.
- There was much discussion of what information would be most useful to have in probabilistic warnings, the scale of area that such information should relate to, in what format it should be and how it should be communicated to or made accessible to the public. These are *key factors* to take into account in any future development of probabilistic warnings for the public, and it is crucial to remember that not all people have the same information needs.
- Most participants felt that it would be useful to be alerted to the threat of flooding through present means (e.g. the media, Floodline Warnings Direct, door knocking), and have probabilistic information provided on the Environment Agency's website for those who wished to seek further information.
- Participants were very clear that there was a need to identify vulnerable people and those who did not have access to the internet or telephones, in order for them to be alerted to the threat of flooding. This issue was raised in *every* focus group, and is possibly one of the most strongly felt recommendations by participants.
- There were varying views as to the amount of information suitable for public dissemination. Some participants were interested in and able to utilise detailed technical information produced by forecast models, but many others wanted information to be presented in very simple ways that were easy to understand and did not require interpretation.
- There was no clear consensus as to how probability information should best be conveyed but some general patterns in the groups' discussions can be identified. Simple qualitative terms alone (such as 'likely', or 'probable') were not generally welcomed as they were seen to be too open to interpretation, but when combined with percentage indicators this was seen as more convincing. Participants at risk of fluvial flooding particularly liked the idea of being able to access a map that could provide them with regularly updated forecast information for their houses. Only a very small minority found the more technical content of graphs useful or understandable.

- The use of colour accompanying information about probabilities was seen to be significant, as the Environment Agency's value judgements about the probabilities were inferred by these. The older participants, in particular, said they would rely on the colours to decide what action they should take, regardless of what the percentage was.
- There would appear to be a tension between warning people early enough so that they can take appropriate action, but not so early that the forecasts keep changing, because then, future forecasts might be perceived as not being accurate or reliable. However, it is a feature of probabilistic forecasts and indeed flood forecasts in general that they will often change on a day-to-day, or an hour-to-hour basis, depending on the size of the catchment. It is possible that engaging in dialogue about levels of uncertainty in forecasts may provide better public understanding and acceptance of what may otherwise be perceived as forecasting errors rather than uncertainty. It is important to note that participants felt that too many 'false alarms' could eventually mean a loss of trust in the accuracy of the forecasts. However, it is unclear how the participant's perceive false alarms. For example, if a 'Severe Flood Warning' was issued with a 75% probability attached to it and then a flood did not occur, would the participants classify this as a 'false alarm'?

5 Professional partners' understanding of probabilistic warning information and its communication

5.1 Introduction

Under the Civil Contingencies Act 2004, emergency responders are categorised into Category 1 and 2 responders. Category 1 (core) responders are those organisations at the core of emergency response. For flooding the key Category 1 responders are:

- Ambulance services
- Environment Agency
- Fire and rescue services
- Local authorities
- National Health Service and Health Protection Agency
- Police forces.

Category 2 responders are 'co-operating' bodies who, while less likely to be involved in the heart of planning work, will be heavily involved in incidents that affect their sector. For flooding the key Category 2 responders are:

- Highways Agency
- Gas and electricity distributors and transmitters
- Railway operators
- Strategic Health Authorities
- Telephone service providers, fixed and mobile
- Water and sewerage undertakers.

As part of this project, two workshops were held with professional partners in autumn 2008, one in London and one in Leeds.

The purpose of these workshops was to determine the most appropriate and effective way that the Environment Agency can use information on probability and uncertainty within its flood warning communications with its professional partners. It is essential that the Environment Agency does not make any major changes to current services before talking to partner organisations. The workshops were one of a number of methods the Environment Agency is using to get input from emergency responders.

Another is the Extreme Rainfall Alert Service pilot, which is currently being conducted in conjunction with the Met Office.

The specific objectives of the workshops were to:

- Provide emergency responders with information about the Environment Agency's thinking so far in relation to probabilistic flood warnings.
- Explore with representatives of the Environment Agency's partner organisations:
  - How they currently use probabilistic information in analogous situations.
  - How they currently apply their understanding of probabilistic information to flood situations.
  - How they might respond to changes in probabilistic information and warnings that the Environment Agency might propose.
- Gather views about how the Environment Agency might take this idea forward.

The programme for each workshop included presentations, facilitated small group discussions and facilitated plenary sessions. The main points from the discussions for the London and Leeds professional partners workshops are summarised in Appendix D.

5.2 Understanding of probabilities and uncertainty

Emergency responders are engaged in risk assessment on a daily basis whether at operational or strategic level. For example this could be deciding when to grit roads, how to respond to water quality issues, how to respond to a criminal incident, whether to evacuate an area or when to close down schools due to a hazard. One emergency responder summed up their work by saying 'an awful lot of what we do is maybes, ifs and possiblys'.

As a result, professional partners are used to making risk-based decisions, involving judgements on the likelihood of a hazardous event occurring plus the likely consequences it may have and the timescale in which it may occur. For example, a low impact event that has a high probability of occurring may not necessarily require a response, whereas a low probability event with a high impact may. Such assessments often have to be made in the face of uncertainty owing to changing circumstances (e.g. how a change in wind direction may change the consequences of a fire, how many employees may be needed to staff call centres).

Hazard warnings merely act as a trigger to gather more information about the event to build up a picture of likely consequences. In making such assessments, emergency responders look for verification from colleagues and other organisations and interpret risk and probabilistic data using their own personal and professional judgement and experience. Personal judgement is particularly important in unexpected situations where responders need to draw on past experience.

A key factor in developing a reliable picture of events is having trust in the source of information. Often this trust is built up through developing relationships with key personnel in forecasting agencies. In the course of the research many participants

emphasised the importance of being able to make personal contact with relevant advisors when warnings are issued (e.g. with public weather advisors in the Met Office or flood forecasting and warning staff in the Environment Agency). The ability of professional partners to talk directly to those involved in issuing warnings increases their confidence because they can discuss the grounds upon which the warning is based.

In general risk assessments carried out by professional partners have to consider the financial implications of taking action, and the impact it may have on the organisation (e.g. in the case of a warning being received during the night). There are times when, even if a response is required, lack of funds or personnel may prevent effective action being taken. A judgement has to be made about the consequences of non-action versus the potential impact of the event on the population at risk.

5.3 Decision-making in emergency situations

In certain respects the assessment of risk by professional partners can be a highly subjective process that relies on judgement and experience as well as many other factors. Probability-based information is just one factor that is taken into account. The professional partners involved in the research highlighted factors that affect their decision-making processes which are not necessarily related to the probability and impact of an event. Examples were:

- Utility companies often need to consider the impact of non-action on the company's public relations, and the likely damage to the company brand and image.
- Statutory sector agencies mentioned the threat of public inquiries as some times affecting their decisions whether to take action or not.
- In some cases action is taken even when professional opinion does not warrant it, because of public demand for protection: a case of this is putting up storm boards on the seafront. Media interpretations of risk may play a part in stimulating demand.

The issue of false alarms was raised by many participants in the research, as too many false alarms can result in a lack of trust in the source of the information, as well as in the accuracy of future warnings. False alarms can also have knock-on effects for the internal operation of an organisation, such as staff refusing to come in outside the working day or to do extra hours because they may think the event is not going to happen anyway.

5.4 Current use of flood warnings

Professional partners taking part in the research reported currently receiving warnings at the same time as the public. The 'Flood Watch' level of warning was perceived as a trigger to seek extra information rather than a trigger for action. Professional partners are highly unlikely to act on the basis of a single piece of information from a single source.

On the whole, the Environment Agency's flood warning areas were considered too large to provide accurate information at the local level. Knowledge of how water behaves in each locality is crucial in making decisions and many agencies mentioned the importance of having access to people on the ground with such information (e.g. engineers, beach patrols, lifeboat stations, or community flood wardens).

Information that was currently perceived to be missing from the Environment Agency's flood warnings relates to what has been happening in the run-up to the warning and what is happening at that moment upstream. This missing information is gathered through personal contact with colleagues in other areas and with Environment Agency Flood Incident Management staff.

5.5 Potential for the use of probability and uncertainty information in flood warnings

During the workshops, professional partners were shown the five examples of possible probabilistic flood warnings that are detailed in Chapter 3. In general they felt that having this kind of information in a graphic representation would be very beneficial because it would allow organisations to focus their resources and determine what resources are required. They would be able to warn people downstream while mobilising resources upstream.

In terms of format, there were quite distinct preferences. Example D (a flood warning utilising a probabilistic map showing forecast flood extent in the next 24 hours) was seen as very useful but recognised as more of a longer term aspiration, because neither the Environment Agency nor the Met Office are able to provide such localised information at present. An advantage of this presentation that was highlighted was that the bands/thresholds represented could be linked to the current Flood Watch/Warning/Severe Warning categories. This would provide decision-makers with a single visual guide to refer to. Improving flood warnings was felt to be as much about integrating the different sources of current information as it is about providing new probability-based information.

Thinking about formats that could be provided in the short or medium term, some professional partners strongly favoured a version of Example B (a five-day probability flood forecast using probabilistic representation in terms of percentages), which they saw as being simple to understand because it uses recognisable 'traffic lights' colour coding, combined with percentages. Two participants in the London workshop proposed their own version of this format, and this is shown in Figure 5.1.

Others, however, expressed a preference for Example E, shown in Figure 4.6, a flood warning showing the uncertainty bands around the five-day forecast river flows together with flood threshold levels. It was also suggested that additional information could be incorporated within this example, such as wind speed and direction, or tides.

In general, professional partners welcomed probabilistic warnings if they allow them extra time for planning and preparation. Earlier warnings would also enable more effective multi-agency coordination and better decisions. However, probabilistic warnings would still just be one piece of information that emergency responders would use in their decision-making. The earlier warning would merely give them more time to gather other information they require within their own organisations. Such information

was also seen to be useful for explaining decisions to senior management or as a way of justifying decisions in audit trails or in the event of an inquiry.
It would be important for the Environment Agency to develop probabilistic flood warnings in collaboration with its professional partners. Those involved in the development process could then usefully act as advocates within their own organisations. The Environment Agency would also need to develop a means of continually updating probabilistic information for responders to be able to rely on them as a basis for action.

Participants in the research acknowledged that different organisations will have different rules and protocols for responding to warnings and that each will have differing trigger levels for action. For example, a local utility company may use 80% chance of flooding as a trigger for action whereas the local authority may set their trigger level at a lower rate. Many professional partners felt that responders would need training and education in order to be able to interpret probabilistic information with any confidence.

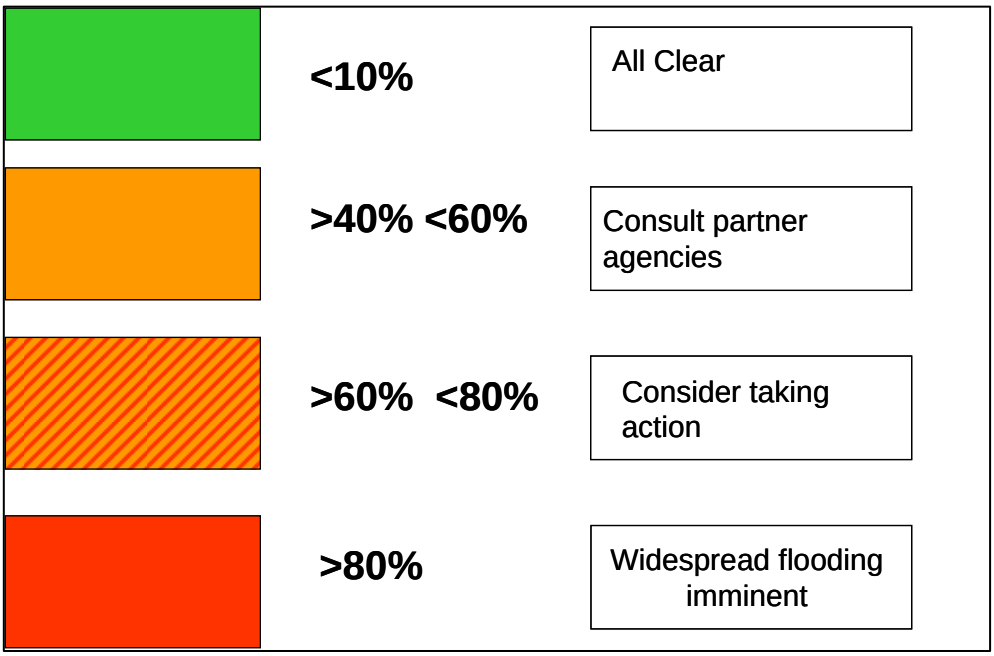


Figure 5.1 Probabilistic flood warning codes suggested by some professional partners.

5.6 Conclusions

- Professional partners seem to use the current 'Flood Watch' and 'Flood Warning' codes as a trigger to seek extra information, rather than a trigger for action.

The research suggested that often the Environment Agency Areas where professional partners have taken the most notice of flood warnings is where they have strong working relationships with the Flood Warning Duty Officers. The Environment Agency needs to generate and maintain trust with professional partners if probabilistic warnings

are to lead to effective responses. This means ensuring that if key members of staff change there are other members of the team who also have a relationship with the professional partners.

Professional partners and other end users would like the Environment Agency's flood warning service to be better tailored to the needs of users as well as responding to the Environment Agency's own priorities. Making qualitative and/or quantitative assessments of probability and uncertainty is part of the everyday work of emergency responders. This research indicates that professional partners would be very interested in being involved in developing a 'fit for purpose' probabilistic warning system. There is a clear opportunity for the Environment Agency to use partners' experience and goodwill to develop probabilistic warnings collaboratively.

One source of difficulty in relation to probabilistic information is that there appear to be inconsistencies in the way terminology is used by the Environment Agency, the Met Office and different professional partners. Agreement on the terminology to be used for probabilistic flood warnings will lead to greater consistency in the way that information about uncertainty is communicated to professional partners and members of the public, and will help to avoid situations where inconsistencies lead to confusion and lack of or ineffective response.

6 Environment Agency staff's understanding of probabilistic information, its communication and their requirements

6.1 Introduction

In order to establish what Environment Agency flood risk management teams and incident response duty officers need from, and how they would use, information about probability and uncertainty within flood warnings, research was carried out into:

- The perceived internal barriers to the communication of probability and uncertainty as part of the flood incident management process (i.e. in real time).
- How flood forecasting and warning practitioners (i.e. duty officers and flood risk management teams) would use probabilistic and uncertainty information in flood warnings and forecasts if such information was made available to them.
- How Environment Agency flood forecasting and warning practitioners understand probability and uncertainty, as used within flood warnings and flood forecasts.

6.2 Methodology

The following methods were used:

Telephone interviews with two senior Environment Agency staff: a regional flood forecaster and an area manager recently responsible for leading the Environment Agency's review of the 2007 floods. The focus of these interviews was to gain an initial understanding of the technical and managerial aspects of communicating probabilistic flood information.

An initial workshop with Environment Agency flood forecasting and warning staff, focusing on the current management of risk and uncertainty within flood warnings, the role of information and the opportunities and risks associated with the use of probabilistic forecasting and warning information. The findings can be found in Appendix E.

A self-completion questionnaire sent to Environment Agency flood forecasting and warning staff. The aim of the survey was to gather views on probabilistic information

and its use. The questionnaire is included in Appendix F. Seventy-one completed questionnaires were received and analysed. A summary of the analysis is given in Appendix G.

A final workshop held with Environment Agency flood forecasting and warning staff. The purpose of the workshop was to provide an opportunity for staff to develop ideas about what the Environment Agency could do to realise the potential benefits of using probabilistic information in flood warnings, and how it could address some concerns raised. A summary of discussions that took place at the workshop is provided in Appendix H.

Follow-up interviews. In order to clarify some of the issues raised during the research, interviews were held with a cross-section of Environment Agency forecasting and warning staff as follows:

- Faye Burrows a Flood Warning Duty Officer (FWDO) in South West Region.
- Guy Boswell a FWDO in Environment Agency Wales.
- Peter Fox a Flood and Coastal Erosion Risk (FCER) Manager in North West Region.
- Mark Fuller an Operations Duty Officer (ODO) in North East Region.

The findings of all the research activities described above were analysed and inform the discussion below.

6.3 Probability and uncertainty in the flood incident management process

As part of this task it was important to have an agreed picture of the Flood Incident Management (FIM) process in order to understand the roles involved. We obtained feedback on the diagram presented in Figure 6.1 on the different roles during a major flooding incident, from the participants at the initial workshop (see Appendix E for details of attendees), and the respondents to the survey (see Appendix G).

The diagram of the Flood Forecasting and Warning System was generally felt by the respondents to be a good representation of what happens on the ground. The majority of responses indicated that the diagram reflected the system ‘Absolutely’ or ‘Overall’. Discussion and feedback on the diagram highlighted a number of issues around current communication during major flood incidents.

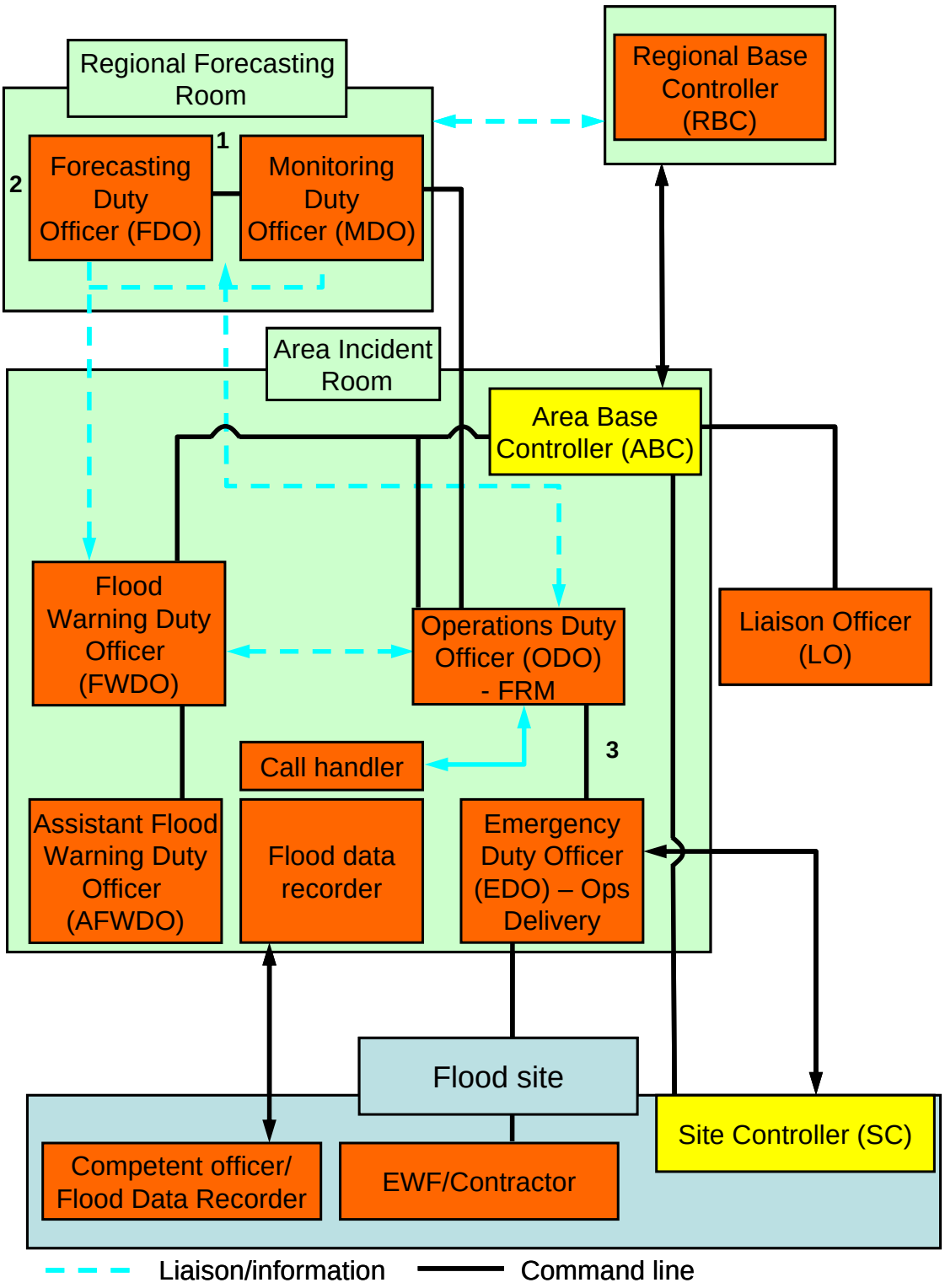
1. Information given by Monitoring and Forecasting Duty Officers (MFDOs) to area FWDOs was regarded as advisory. It was felt that the relationship between regional-level forecasters and area-level FWDOs should not be described as a command line.

2. Generally, although there was evidence of some regional variations (e.g. Wales), the link between forecasters and the ODOs was considered to be advisory, with there often being little or no direct liaison between those staff.

3. The diagram does not provide much information on the Regional Incident Room and its relationship with the other actors, but the relationship between the regional and area levels was considered not to be one of command.

4. It was suggested that there is a need for clarification of the roles of Call Handler, Communications Officer and Flood Data Recorder (FDR) in the Area Incident Room (AIR) as some respondents were not familiar with these roles. In particular it was felt that AIR box did not reflect the Call Handler's further liaison with the FDR or new role of Communications Officer (not shown in diagram).

5. There is regional variation in the monitoring and forecasting roles. For example, in South East Wales there is no forecasting, and monitoring is carried out by the FWDO. The boxes below give two examples of regional variation.



Notes:
1. Regional MDO and FDO is often a single role and will shortly be merged to MFDO.
2. In Wales the MDO role is located in the Area Incident Room, not at a regional level.
3. ODO and EDO posts will shortly be merged as Flood Incident Duty Officer (FIDO).

Figure 6.1 Diagram of the regional and area flood forecasting and warning process.

South-East Wales

- *We don't have forecasting so don't have any interaction with a Regional Forecasting Room or the Forecasting Duty Officer.*
- *We don't have a Monitoring Duty Officer. All monitoring is carried out by the Flood Warning Duty Officer.*
- *We don't have Call Handlers or Flood Data Recorders.*
- *We don't have an Emergency Duty Officer in South East Wales. The Operations Delivery Teams are managed via the EDO in South West Wales.*
- *We do have Field Duty Officers managed by the Operations Duty Officer.*
- *RBC has direct control over FDO and other Regional Incident staff (we have combined Regional Incident & Forecasting room plus RBC is the duty line manager for FDOs and other Regional incident staff) – hence should show as a command line. We also have Welsh Floodline translator duty officer (Regional incident role) to record Welsh RMS messages for Floodline. We also may send a LO to WAG Government equivalent of COBRA in Cardiff.*

Thames Barrier

Thames Barrier/Tidal Thames operates 24/7 with a Forecasting and Warning Officer always on duty in the Control Room. All forecasting and warning including message handling is carried out by the single officer. Only in the event of an overtopping event (this would be an 1:1000 year event) or a breach or flood defence failure, either of which would almost certainly have given rise to the need to issue a Severe Flood Warning, would additional resources be required. Thames Barrier Flood Defence Operations (i.e. Thames Barrier and its associated gates closed for flood defence purposes) are covered by purposely designed procedures with roles specific to these operations.

Overall the main themes that came out of the feedback on the flood warning and forecasting process were:

- There were a number of staff who said that they make judgement calls and make judgements based on an understanding of probability and uncertainty. Certainly, the impression was given that the FIM is a 'messy' system; that is, decisions are made based on the best available scientific information, conversations and also 'gut feelings'. This is discussed more in the next section but is a key theme that runs through the research.
- There appear to be marked differences in the role of different staff within the FIM process but also a sense that roles are changing, for example from ODO/EDO to FIDO, and from Forecasting Officers to Monitoring and Forecasting Officers. The data were collected on this project with a

backdrop of change within the FIM teams, a situation not unusual for any large organisation.

- There are marked differences between regions/areas which seem to be a combination of the type of catchment (e.g. tidal Thames, flashy catchments in Wales), the amount of expertise within the teams, the number and types of staff, the amount of forecasting/modelling that is available (e.g. in Wales there is no modelling), together with the nature of the consequences of each flood (e.g. if it impacts on large numbers, or specific land – for example many Welsh farmers need to move livestock).

6.4 Flood warning and forecasting practitioners' understanding of probabilities and uncertainty within flood warnings and flood forecasts

The following section summarises how flood warning and forecasting practitioners currently take uncertainty into account. In terms of what 'taking uncertainty into account' meant, from the answers it would seem that respondents were considering how they manage and reduce uncertainty within flood warning and forecasting. Further, they discussed both scientific uncertainty (associated, for example, with the degree of reliability of data, uncertainties inherent in the use of models, etc.) and decision uncertainty, which relates to the whole range of factors that affect decisions, including political pressures, business management considerations and others.

Overall, it was clear from respondents that many are making judgements based on a number of aspects, using each bit of information to piece together a picture clear enough for them to be confident to act upon, to manage decision uncertainty.

> *You can not always be certain when you issue a level of warning, you have to take best judgement…either your own judgement or talk it through with other people. It is nearly always better to play safe. If there is uncertainty with something we issue, we always try and make this clear internally and externally i.e. really good information on floodline.*

Beyond this overall approach four themes around uncertainty emerged from the analysis of the data.

1. **Using different forecasting techniques and tools to confirm results.**

Staff do not rely on a single set of readings or a single model in forecasting flooding. They recognise that individual pieces of information or data sets cannot give a complete picture of either the causes or consequences of flooding, and where possible use different sources of information to check results.

> *Some locations are forecast with a number of models/tools. If the majority of these show an exceedance then I would be more confident in the forecast. We also create ensembles and what-if scenarios using different rainfall inputs in our real-time models, which again are used to show the range of uncertainty*.

2. **Using local knowledge and experience,** e.g. knowledge of the catchment and how it behaves and of where the vulnerable locations are located.

Environment Agency FIM teams build up a reserve of knowledge and experience of the catchments they work in. They described how this is used in making sense of information from modelling and flood forecasts:

> *Any uncertainty has to be accounted for by antecedent conditions, past history/knowledge of area, conditions prevailing at other local sites etc.*

Linked to this is the understanding of the current conditions (e.g. rainfall, catchment conditions), telemetry and monitoring.

3. **Assessing the confidence in the information** that is being passed on, which could either be an assessment of the information itself or an assessment of the confidence of the person who is passing on the information.

While staff tend to emphasise the need to understand and take account of the technical uncertainties associated with the data and information they are using, in practice they build up a good understanding of the wider pressures and 'decision uncertainties' that also have to be built into flood risk management. This enables them to apply judgement and expertise in decision-making.

> *Assess how confident the MFDO is in the forecast. Look at the lead time of the forecast (higher the confidence nearer to the event).*

4. **Issues of time**, having to take into account, for example, how long is needed to take action, how long to wait before the forecasts are accurate.

Timing is one of the major considerations in decision-making: the nearer the possible event, the more pressure there is likely to be to take action.

> *Take into account probability, time and level. If the certainty is high with a short time frame then act on it.*

It is worth noting that despite this ample evidence of the way that Environment Agency staff take uncertainty into account, there was some discrepancy between practitioners about how much uncertainty is currently communicated, both within the Environment Agency itself and to professional partners. It may be that this reflects differences in practices between regions, or that it is more about differences between individuals' understanding of uncertainty or readiness to communicate it. We were unable to come to a definite conclusion about this on the basis of the evidence available.

6.5 Potential for the use of probability and uncertainty information in flood forecasts and warnings by duty officers and flood risk management teams

Over 80% of staff responding to the questionnaire said that they took probability and uncertainty into account, at least to some extent. The types of uncertainty taken into account vary, with some staff making their own assessment of the uncertainty in forecasting techniques:

> *I use a subjective assessment of likelihood based on the uncertainty further up the chain (e.g. weather forecast uncertainty), the uncertainty of the forecasts I produce and experience/local knowledge.*

Others recognise that there is uncertainty in the forecasts they receive, and seek further information:

> *Certain forecasts are inaccurate, especially if they are too far in advance, so I usually discuss with the FDO and wait for a more accurate one.*

The use of information about probabilities and uncertainty was therefore not seen as something completely novel. However, many staff struggled to imagine what probabilistic information would look like, both in their own work and in information passed on to others (professional partners or members of the public).

The Environment Agency has trialled presentations of probabilistic flood forecast information (e.g. work on coastal flood forecasting, see Flowerdew *et al*. 2007), but there has been no similar development and testing of probabilistic flood warnings. In the course of the present research it became clear that providing probabilistic information to support flood warnings could mean different things. In particular, there would be a considerable difference between, on the one hand, *providing a probabilistic warning product* and, on the other, *attaching a probability to a forecast.* In the first case, there would be an implicit or explicit link between the likelihood of flooding and the expected response: warnings are provided to prompt action. In the second case, probabilistic information would be provided alongside forecasts, as an additional source of information.

As this distinction emerged as a conclusion of our discussions with Environment Agency staff, there was not the opportunity to ask them directly about the relative benefits and disadvantages of these two types of probabilistic information. The following sections therefore explore members of staff's views on the general implications of introducing probabilistic information. We have only sometimes been able to make an assumption about the kind of probabilistic information staff are referring to. This is an area that will need further examination in taking forward work on probabilistic flood warnings.

6.5.1 Factors influencing attitudes to the potential use of probabilistic information

A number of different factors affect staff attitudes to the potential value of using probabilistic information in flood warnings. This reflects the complexity of the subject, the range of staff who contributed to the research and the difference in the way that staff work across the country, as well as personal characteristics (e.g. whether they are risk averse or not) and institutional culture. The most important of these factors are described below.

Role in flood incident management

The introduction of probabilistic information has very different implications for staff in different roles in flood incident management. For forecasters, this is almost inevitably seen as a positive development, which will provide a wider range of options and better information about the uncertainty expressed in different forecasts. Most forecasters run

'what if' scenarios. Additional probabilistic information will help them to test and check their models and forecasts:

> *MFDOs will find probabilistic forecasting useful to at least inform the confidence on any deterministic flood forecast.* (Flood Forecaster)

Staff in other roles in the flood incident management system are in a different situation: they have to translate forecasts into warnings, decide how to respond (e.g. by activating defences) or communicate warnings to other organisations and members of the public to ensure that they respond effectively. These staff seemed less sure that the introduction of probabilistic flood warnings would make their work easier:

> *…on a personal level, I just feel that this is actually placing more of a burden onto the staff at the sharp end, to be seen to meet with the demand for information from higher management, and outside parties. In times of heavy workload, such as in a flood event, flood warning duty staff need to know which levels are going to reach certain triggers and when, not complex graphs.* (FWDO)

A number of staff felt that it is the Environment Agency's responsibility to make decisions about the likelihood of flooding and the appropriate response. Several commented that by passing on information about uncertainty in predictions, the Environment Agency could, in some sense, be seen as abdicating its responsibility:

> *It is our business to forecast and warn. We shouldn't contemplate pushing the responsibilities on to others.* (Technical Officer)

This view was expressed by staff across the flood forecasting and warning system.

Use of judgement in interpreting forecast and warning information

Over 80% of staff said that they used judgement in interpreting and using information about the likelihood of flooding. In the final workshop, some flood forecasters expressed concern at this:

I felt uncomfortable at the idea of my forecasts being weighted by other EA staff. (Forecaster)

However, most staff felt it was part of their job to make judgement calls about when and how to apply the information they receive. Given the lack of clarity about what form probabilistic flood warnings would take and what status they would have (e.g. would staff be expected to use them as a trigger for action or as information to contribute to their understanding or decision-making?), it was no surprise that staff had quite different views about the impact probabilistic information would have on the degree to which they would use their own judgement in interpreting information or responding to a warning. Many felt that having more information would help duty officers to make decisions:

> *It is a good opportunity for more detailed and realistic information to be used as a decision making tool, as to whether to issue a flood warning or not.*

Spaghetti plots or graphs showing extreme cases would mean that duty officers would have earlier information on worst case scenarios.

Some staff thought that thresholds would be aligned to probabilities, which would limit the duty officer's use of his or her own knowledge and experience.

Some staff saw this as a positive development:

> *Set triggers on probability and when to issue warnings will decrease the stress on FWDO and they will have more information to communicate with all.*

It was generally felt that the use of probabilistic information would have a knock-on effect throughout the flood warning system, particularly in terms of where thresholds are currently set. However it was recognised that a rule-bound use of probabilistic information could have disadvantages: 'you could be crying wolf a lot and stop people listening'.
Several people suggested that senior managers might take probabilistic warnings at face value and put pressure on duty officers to take action, even when they did not believe that it was warranted:

> *I have big concerns that the MFDO and FWDO will be unable to use their own judgement and experience to decide whether a warning will be issued. Instead I envisage the possibility of a percentage probability that will be set by senior managers to when we have to issue. This will inevitably lead to very high false alarm rates.*

When asked what difference it would make if Environment Agency senior managers received probabilistic information about flooding, one member of staff said,

> *It would make our work much harder. Senior Managers don't want to know probabilities: they want to know what needs to be done, in terms of authorisations, etc. It is difficult to imagine how it would work: I would hope that if senior managers received probabilistic information on flooding that they would ask for our advice. But this won't necessarily be the case.* (FWDO)

It is possible that this kind of attitude comes from a lack of trust in senior management or from the experience of members of staff having their views over-ruled by managers. It is not a view that is universally held. When asked directly whether they had any concerns about the way probabilistic information might affect their relations with managers, one ODO responded: 'I don't see it as a problem – I would try to argue my point'.

Significance of regional differences

The ability to forecast flooding varies significantly between different parts of the country. While there are sophisticated models of water flows for many areas, in the case of others, particularly where catchments are short and steep, models are inadequate or simply do not exist. Without adequate modelling, staff cannot provide probabilities for rivers overflowing or overtopping flood defences.

> *Everything depends on accuracy, issuing information that turns out to be inaccurate in either direction results in distrust or complacency. The survey identifies the need*

for regional variations, I would say this needs to go further down to area variations due to the wide range in geography. (FIDO)

There is a gulf between staff in different regions in terms of their understanding of and engagement with probabilistic forecasting information. Staff in some areas are using the Met Office's Extreme Rainfall Alert Service (ERA):

... ERAS probabilistic warnings have already made it easier for me to plan and prioritise my time when faced with heavy rainfall in the next 24 hours. I'm less likely to be 'taken by surprise' with this information at my fingertips. (FWDO)

In Thames Region West Area the Environment Agency is providing professional partners with an interpretation of what the Met Office's probabilistic alerts mean in terms of the likelihood of flooding. However, staff in other parts of the country are either unfamiliar with the concept of probabilistic forecasting or feel that the probabilistic forecasts being provided by the Met Office are irrelevant to their localities:

The ERAs frequently cover such huge areas, I doubt that any truly operational decisions are made on them unless they cover very small areas with high degrees of probability. Even then they will be quickly discredited if little of consequence occurs.

Experience of changing weather events

One of the drivers for improving flood warnings is the more frequent occurrence of extremely heavy rainfall with sometimes devastating effects, for example in Boscastle (2004) or the North East (2007). Where staff and emergency responders have had experience of this kind of extreme rainfall, they tend to be more enthusiastic about probabilistic information, which is seen as providing advance notice and making it possible to take preparatory action.

Earlier detection of high impact flood events allows better preparation of duty teams and shift rotas etc. It is much easier to stand down duty teams than to organize them at short notice. (FDO)

Different forms of uncertainty

The factors contributing to flooding are complex. Probabilistic information about rainfall should allow greater clarity about the uncertainties in both the forecast of the event and in the chances that the event could lead to flooding. However, there is concern that this narrow approach risks increasing confusion rather than clarifying it, for example:

- By focusing on only one source of uncertainty (i.e. rainfall forecasts) the Environment Agency could divert attention from other uncertainties (e.g. in models, measuring equipment, etc).
- By presenting probabilistic information as a way of dealing with the problem of uncertainty, the Environment Agency risks 'papering over' other complex issues in forecasting and warning and so making them less transparent.
- The emphasis on resolving the problem of technical or scientific uncertainty in relation to rainfall may play down the equally difficult problem of decision uncertainty, which is about weighing up the multiple potential effects of a particular decision.

Certainty over rainfall forecast variables

The impact of rainfall depends on three main variables: time, location and intensity. In some regions (especially Wales and the North West) there was a sense that the degree of uncertainty associated with each of these variables is so great that forecasts of rain events are virtually useless.

Currently, experienced staff use their professional judgement to take account of the different contexts which affect the probability and likely impact of flooding:

- **Time:** the likelihood of rainfall causing flooding will depend on conditions at the time when it falls (e.g. if ground is waterlogged); its impact will vary according to the time of day and the season.
- **Location:** the smaller the area covered by the information, the less uncertainty. Where rivers are short, a difference of only a couple of miles in where heavy rain falls can mean that a totally different area is affected. Furthermore, the impact of flooding increases in relation to the amount of people and property affected.
- **Intensity:** 30 mm of rain falling over a 3 hour period may have little effect, while the same amount of rain falling as a 15 minute cloudburst can be devastating.

6.5.2 Alternatives for introducing probabilistic information into flood warnings: potential strengths and weaknesses

- Three simple alternatives for using probabilistic information in flood warnings were developed for the final staff workshop, as a means of exploring the strengths and weaknesses of different approaches. These are:

(i) Use of probabilistic flood warnings internally within the Environment Agency only.

(ii) Use of probabilistic flood warnings within the Environment Agency and also by professional partners.

(iii) Use of probabilistic flood warnings within the Environment Agency, by professional partners and also the public.

While none of these alternatives has been tested in practice, the Extreme Rainfall Alert (ERA) service pilot being trialled by the Met Office and the Environment Agency is something like Alternative 2, as is the Environment Agency Thames Region West Area's initiative of providing an interpretation of Met Office severe weather alerts to professional partners.

The implications of making probabilistic information available to different audiences was further explored in in-depth interviews with a small number of FCERM staff.

The following section summarises staff feedback on the alternatives.

Alternative (i): Environment Agency uses probabilistic flood warnings (but these are not provided to professional partners or the public)

Staff identified a number of potential strengths associated with this alternative. The key strength was seen as the increase in lead times, allowing advance planning or scenario testing.

The approach would involve no change in communications with external stakeholders and would give time for Environment Agency staff, including FWDOs, to adjust to and gain confidence in a new system. It was also seen as the most cost-effective option.

It would give the Environment Agency the opportunity to develop a common language with the Met Office which could lead to better communication between the two organisations. Keeping probabilistic forecasts and warnings within the Environment Agency only was also seen by some participants as a strength because it keeps the information in 'expert hands'.

Some participants felt that the Environment Agency already 'always gets the blame' for flooding because staff have to make yes or no decisions about whether to issue a flood warning. If probabilistic information were available but was not disseminated with flood warnings, the Environment Agency could also be accused of withholding information. If probabilistic forecasts and warnings are kept within the Environment Agency it may be that some senior managers make the assumption that professional partners and the public have access to the same information. There was a general sense that, even if the Environment Agency tried to contain probabilistic forecasts, these might 'leak' out anyway.

Alternative (ii): Environment Agency and professional partners use probabilistic flood warnings

The key strength of this alternative was seen by those involved in the research as giving professional partners a direct link to Environment Agency flood forecasters. This would demonstrate transparency but also give a better understanding of the complexity of the forecasting system. Disseminating probabilistic warnings to the professional partners would enable them to be better prepared for imminent floods (e.g. by putting staff and resources on standby). It would also create the opportunity for some professional partners who have the technical capacity (e.g. water and electrical utilities) to carry out cost–loss analysis of decisions as to whether implement mitigation measures. It was suggested that if probabilistic forecasts had been available to water utilities in June 2007 and a cost–loss decision-making approach had been followed, measures could have been taken to prevent 300,000 people in the south-west of England losing their potable water supply for two weeks. Disseminating probabilistic forecasts and warnings to professional partners would also provide an opportunity to educate them, manage their expectations and heighten their awareness of the uncertainty in flood forecasts.

Environment Agency staff expressed the concern that disseminating probabilistic warnings to professional partners could lead to 'information overload' and extra work for flood forecasters in processing more information. Environment Agency senior management may underestimate the amount of resources that are required to implement the new approach. It could also put more pressure on flood warning duty staff, partly as a result of the possibility of more 'false alarms'. Disseminating probabilistic warnings to professional partners could create confusion if this information

was not consistent with warnings going out to the public. If the media also received probabilistic warnings, they might pick up on forecast events with a low probability of occurring: if this information were misinterpreted, that could impact on the Environment Agency's reputation and force it to dedicate greater resources to dealing with media enquiries. Finally, if all the sources of uncertainty (e.g. rainfall, river flows, ground conditions) are not included in the forecast and warning this could lead to confusion.

Alternative (iii): Environment Agency, professional partners and members of the public get a developed probabilistic flood warning

The key strengths of this approach were seen by Environment Agency participants in the research as being a sharing of the risk and responsibility in a transparent manner. It would help to increase lead times for preparation for all stakeholders. It could also act as part of a long-term programme to improve awareness among professional partners and the public.

With regards to the weaknesses in this approach it was felt that there could be too much information being disseminated and that not all the stakeholders would understand the information. Implementing such an approach could detract from or reduce investment in other critical components of the flood forecasting system (e.g. improvements in the monitoring network, improved hydrological and hydraulic models). There was a concern that the approach would raise the expectations of professional partners and the public beyond the capability of the Environment Agency.

6.6 Perceived internal barriers to the communication of probabilistic information as part of the flood incident management process

In this section we review briefly the institutional and cultural factors that Environment Agency staff mentioned as potential barriers to the effective introduction of probabilistic flood warnings.

6.6.1 Technical expertise

A common theme running through the majority of the feedback received from Environment Agency staff was the importance of experience and technical expertise in making sense of or knowing who to go to in order to get a good interpretation of information about the likelihood and potential impact of flooding. Staff felt strongly that their work was both complex and important and that they had a responsibility to do it to their best of their ability.

This shared ethos of expert responsibility probably helps staff to cope with the pressures of managing flood incidents. However, there is a risk that a focus on the Environment Agency's internal competencies and responsibility can induce a degree of blindness to the role and capabilities of others. So, in discussing the alternatives for rolling out probabilistic flood warnings, many staff expressed the view that the Environment Agency should establish the system internally before taking it out to partners. They failed to see that it will be hard to get probabilistic information 'right'

without involving the audience for that information. There is also a danger of missing an opportunity here, as professional partners are very willing to get involved in this (see Section 5).

Not all staff agreed with the proposal to roll out probabilistic warnings as a 'two-tier' system and argued that the value of this information could only be realised if it were passed on to professional partners and the public ('If we don't progress it to professional partners and public then the service won't go any further – just tweaking around edges') and others thought that it could be illegal: 'We could be seen to be withholding information if it's not in the public domain'. However, the majority of participants at the final workshop seemed to support the proposal that, at least for an initial period, probabilistic information should only be provided to staff, allowing for the system to be tested internally before being used externally.

6.6.2 Training and capacity building

The use of probabilistic information is expected by many duty officers to increase their workload. This was partly seen as a temporary process of getting to know the new system ('ODOs will have to respond to more warnings until the system beds in'), but also a change in ways of working that would involve more conversations between people at different levels ('With probabilistic flood warnings there would be more information to discuss with the forecaster').

Passing this type of information on to the Environment Agency Areas will need local knowledge and professional judgement which Areas do not yet have. There was little clarity about how this capability would be developed and what kind of training staff would get before the system was rolled out.

6.6.3 National consistency versus local flexibility

The introduction of probabilistic information should take account of local and regional differences, as otherwise Areas where the information necessary for developing probabilistic forecasts is not available might be put at a disadvantage. 'It makes it harder for Areas which don't have this information, if this is how 'we' do it'.

6.6.4 Risk adverse culture

- Having more information about the likelihood of flooding could make decisions harder. This depends partly on staff personalities and how risk averse or not they might be. There is a concern that introducing probabilistic information could have negative impact on consistency. Warnings are currently determined by thresholds, so it is clear why and when they are issued.

6.7 Conclusions

- There is still debate within the Environment Agency about what kind of 'probabilistic warnings' are being proposed and how they would be used. As a result staff in different roles tend to make different interpretations. FWDOs and Operations staff tend to be less clear than flood forecasting

staff about how probabilistic information would be used and the potential impact on their work.

- Most staff recognise that probabilistic information could provide greater certainty about when flooding might happen. However, they feel that probabilistic information is only one way of improving the flood warning system. Some staff were concerned that the implementation of probabilistic flood warnings could divert resources away from other investments such as improving the monitoring, hydrological and hydraulic models that support the flood forecasting systems.
- Staff expressed concerns that the Environment Agency's computing systems, hydraulic models and communication systems might not be able to cope with the additional information generated by probabilistic forecasts and warnings.
- Given the variable coverage of forecasting models, staff felt that introducing probabilistic forecasting and warnings in parts but not all of England and Wales could have negative consequences such as different services generating conflicting warnings, difficulties in joining up warning information for professional partners or businesses who operate in different Environment Agency Areas and, ultimately, loss of trust.
- Environment Agency Area Offices take different approaches in deciding whether to issue warnings and interact with the end users (e.g. professional partners). While these are sometimes influenced by the use of telemetry and the forecasting data available, they often reflect the application of professional judgement, knowledge and experience to the interpretation of uncertainty in different geographical and social contexts.
- Some staff felt that it would be unhelpful to expose the level of uncertainty in the current forecasts externally and that the Environment Agency could be seen as not being able to meet its responsibilities or to be trying to offload these responsibilities on others.
- Not all Environment Agency flood incident management operational staff are confident that they have a full understanding of probabilistic forecasting.

7 Business understanding of probabilistic information, its communication and their requirements

7.1 Background

This chapter discusses the way that businesses use flood warnings and how the provision of probabilistic information might change that use.

Businesses are significant customers for Environment Agency flood warnings. Flooding can cause major damage to business premises, equipment and stocks, as well as threatening continuity if companies are not able to quickly restore production or services. It therefore seemed important to look at the needs of businesses as an additional strand of the research.

7.2 Objectives

The research with businesses had the following specific objectives:

1. To establish what private sector managers and business continuity planners understand about probability and uncertainty and how they would use this information if it was incorporated in flood warnings.
2. To use the outcomes from the research to determine the potential advantages and disadvantages related to probabilistic flood forecasting and warning.
3. To use the results from the research to inform a policy decision on whether and how the Environment Agency should communicate uncertainty and probabilistic information externally in the future.

It was agreed that the focus of the research should be on small and medium enterprises, because smaller businesses tend to be less resilient to flooding, have fewer resources and less capacity to recover quickly.

7.3 Methodology

The research involved collecting empirical data on what businesses understand about probability and uncertainty, and finding out how or if businesses would want to use probability and uncertainty data as part of flood warnings.

Individual telephone interviews were held with people who have responsibilities for emergency planning and management, business continuity planning or facilities

management. This provided an opportunity to understand the context in which the flood warnings were received and used, and to explore how the provision of probabilistic information could change the way they prepare for and deal with flooding.

An interview schedule was designed and used in all the interviews. This covered the following main points:

- Understandings of probability and uncertainty
- Experience of flooding and of flood warnings
- Options for the introduction of information on risk and uncertainty in flood warnings

The full interview schedule can be seen in Appendix A.

7.3.1 Identification and recruitment of participants

Recruiting businesses to take part in the telephone interviews proved to be a difficult process. Businesses that have not been flooded appear to feel that this is not a relevant subject and they are not prepared to spend time discussing it. Businesses that have been flooded may already have been contacted for other market research purposes and be unwilling to participate in further surveys. Three different contact lists were consulted in order to recruit a sample of ten businesses:

- Market research list of 230 SMEs in the South East. This list was provided by a market research company that had recently carried out a survey for the Environment Agency. 100 companies were contacted by email. One agreed to be interviewed. The rest of those who responded indicated that as they had recently participated in an interview on flooding, they weren't willing to do another.
- List of 100 SMEs in the East of England provided by Business Link. The companies were selected by size (2- 99 employees) and location in areas where there has been flooding. However, it was not possible to identify companies that had been affected by flooding. One company, with no experience of flooding, was recruited from this list.
- Environment Agency database of businesses in the Midlands. The companies in this database have been in contact with the Environment Agency about flooding, and there was a much higher rate of response to emails. Nine companies were recruited on the basis of 50 emails. The database does not provide details of company size. Of those recruited, three were not SMEs.

As the sample size was very small, it was decided to prioritise companies with activities which were likely to be particularly disrupted by flooding or which might suffer significant losses as a result of flooding. Recruitment therefore focused on the following business categories:

- Manufacturing
- Distribution

- Services involving use of the premises by members of the public (e.g. health, education, financial services)

Table 2.1 provides an overview of the characteristics of the companies interviewed.

TYPE OF BUSINESS	COMPANY SCALE	NUMBER	PREMISES FLOODED	NO DIRECT EXPERIENCE OF FLOODING
Education and culture venue	SME	2	1	1
Private hospital	SME	1		1
Financial Services	Local office of national company	2		2
Manufacturing and distribution	Local office of national company SME	1 1	1	 1
Manufacturing	SME	1	1	
Distribution	SME	2		2
TOTAL	**Local office of national company** **SME**	**3** **7**	**1** **2**	**2** **5**

Table 7.1 Overview of companies interviewed.

7.3.2 Interview format and materials

Each telephone interview lasted between half an hour to an hour. Prior to the interview, the participant was sent a set of sample warnings including probabilistic information (see Appendix B).

The first examples used were warnings shown on the Met Office's website before a major snow incident in February 2009. All interviewees remembered the snow, so this allowed them to talk about a real situation.

The rest of the examples were the same as the examples used in the focus groups with members of the public and in the workshops with Environment Agency staff and professional partners. Using the same materials makes it possible to compare the responses of the different groups and gives consistency to the analysis.

7.4 Experience of flood events and flood warnings

Of the businesses interviewed, three had experienced flooding of their premises, four had seen the local area and access routes to their sites affected by flood waters, one had received and acted on a flood warning but had not actually experienced flooding, while only two had no experience of flooding.

Of those that had been flooded, two businesses had experienced significant damage. In one case, a retail outlet was flooded; this was subsequently closed for seven months, with an adverse impact on turnover for the year. The other business suffered losses of over £500k. The third company that had experienced flooding said that they were able to get back to work soon after. All three companies had insurance cover.

Four businesses had experienced local flooding of roads and properties near to their premises. These caused problems of access so did have an impact on their business activities, as well as making them more aware of the risk of flooding.

All but one of those interviewed were signed up to FWD, although their experience of receiving and using warnings varied considerably. Several companies receive warnings and have procedures in place to respond, including sandbagging the premises and lifting equipment off the ground to avoid flood damage. Other companies were signed up but hadn't received any warnings. Warnings are mainly received by text message and email.

Being signed up enables businesses to take proactive action in advance of being flooded. None of the interviewees mentioned any disadvantages in being signed up. There was some concern about how early the Environment Agency could warn businesses (would it be early enough to give them time to take action?), and how geographically specific the warnings could be (would they be specific enough to base business decisions on?)

Even though businesses are signed up to FWD, their own assessment of risk is still as important.

> *I would say as much as anything, we use our own experience to cover it rather than relying purely on some body else. We have a standing order with the shop manager on site that if the weather looks a bit dodgy and it has been raining heavily, when you shut up shop at half past 5, you put the flood barriers up. Yes it takes 10 minutes to do it and it's a pain in the backside and all the rest of it, but it's a lot less hassle than clearing up the mess after. So that's a standing instruction. If it's dodgy, or looks dodgy, do this as a precaution.*

Few of those interviewed were very familiar with the different EA flood warning codes and symbols. Those who were receiving warnings by text did not realise that there were symbols that accompanied the text for each level.

7.5 Understandings of probability and uncertainty

The businesses interviewed cover very different types of activity, so inevitably the types of situation in which they look at risk and probability vary:

- One business interviewed is a private hospital, where the management has to consider the risks of patients causing harm to themselves, to others or to the wider community. They also need to be prepared for the possibility of supplies being cut off, particularly food supplies.
- The managers of two centres that run classes for adults were concerned about the business risks of cancelling classes due to severe weather events.

- Manufacturers, distributors and retailers were concerned about the risk of disruption to their factories and damage to goods in their warehouses, as well as delays in getting supplies to retail outlets and other customers. For one national company, the risk of disruption at their headquarters was perhaps the most worrying issue.

7.5.1 Understandings of probability

Many interviewees were comfortable with the concept of risk and probability, as working with probability is seen as part of their normal routine: '*We use risk and probability regularly*'. The larger organisations had business recovery or continuity planning embedded into their work culture, and risk assessment was very much part of their everyday activity. Additionally, business managers may be dealing with information about probabilities related, for example, to sales projections and variability of stock supplies.

At the other extreme, one interviewee reported not using probability or likelihood information at all in everyday activities. In a few other cases, interviewees found it hard to think of situations apart from flooding where they would consider probability.

In general interviewees focused on probabilities of flooding or weather-related risks (e.g. heavy snow). Some general risks such as environmental risks and the risk of fire were also mentioned. One interviewee said that his company had specialist contractors to carry out risk assessments: this was the only case in which it was suggested that risk assessment was a specialist role.

7.5.2 Making sense of information on uncertainty

The interviewees were asked what they understood when they heard or read that a piece of information is uncertain. Specifically, they were asked whether knowing that information is uncertain would change the way that they responded to it: would they have less trust in it and would they find it harder to use uncertain information?

Several interviewees reported that if they were told the information is not certain they would trust it less. One of these interviewees equated uncertainty with inaccuracy and said that if the EA were issuing serious warnings, he expected them to be accurate. Another wondered why the EA would be issuing warnings if they weren't certain.

> *It would just confuse the issue further. If it's only 50% accurate or not correct, then you'd think, well which way do I go? Is it going to be wet or isn't it? So that again, linked in to the very localised nature of our climate in this country confuses us further.*

Other interviewees felt that it was important for businesses to have as much information as possible in order to make their own decisions. One interviewee said he would trust the warning less but preferred to know about levels of certainty in any event.

> *As long as they quantify it in some way it's fine. If they said we're not certain but we're 80% convinced this will happen, then whoosh, we'd do something straight away!*

Several argued that knowing the levels of confidence in a piece of information would aid decision-making and would ensure that flooding would not be a total surprise.

> *I'd much prefer the fact that I've prepared for it and if it happens I'm better off for it and if it doesn't happen, then fine, we live to fight another day.*

However, if warnings were issued and there were no flood events nearby then perhaps trust in the warnings may be compromised.

> *First time you might be likely to respond. If you find it's consistently wrong, it's like crying wolf isn't it? If you get a flood warning and some areas locally get flooded and you escape, I think you think it wasn't as bad as they anticipated but I'm grateful for the warning because it could have gone either way. I think if they're suggesting you'll have flooding and nothing happens at all, anywhere in the area, then I think that's where there would be more trouble around the trust element.*

The level of confidence the businesses have in the information they receive will influence the measures they take. Several pointed out that taking action to prepare for flood warning is difficult.

> *The more certainty there is, the more helpful the information is, because it's hard work to take action to prepare*.

Two interviewees who said they had some knowledge of statistics didn't expect predictions necessarily to be borne out in practice. One commented that *'all data is subjective anyway'* and said that his approach was to 'cut through' the problem of uncertainty by setting a threshold for action at 50% probability.

Several of the interviewees said that it would make no difference to their confidence if they were told that a piece of information was uncertain. These people found it difficult to talk about uncertainty in the abstract and preferred to talk about specific risk situations. In relation to flood warnings, one manager argued that their business was so vulnerable to flooding that they would want to take action even if there were only a small likelihood of flooding.

Some of these interviewees further suggested that the source of the information would make little difference to how seriously they took the warning. When pressed, one did agree that he might take account of whether the source had been right on previous occasions.

7.6 Response to probabilistic information in warnings

7.6.1 Met Office severe weather warnings

The Met Office issues daily advisories which indicate confidence of expected severe or extreme weather. Early Warnings and Flash Warnings supersede advisories when confidence levels are 60% or greater. Examples of an Early Warning and an Advisory

issued by the Met Office prior to a snow incident in February 2009 were shown to interviewees[1].

There was a mixed response to the Met Office Early Warnings. Many interviewees felt that the large geographical area covered by the warning made the warning seem general rather than specific to their locality. This might deter them from action.

Many said that if the warning came during the working day, they would warn staff and maybe offer more flexible working hours. Others suggested that they might prepare for snow by actions like gritting. The action that could be taken would depend on how much warning there was and on the time of day it was received: if the warning came at night, there would be no way of contacting staff or customers.

For those involved in distribution or businesses depending on regular deliveries (such as the hospital), receiving a severe weather warning would be a useful prompt to contact customers about alternative arrangements or to make back up plans.

> *It would tell me that goods coming in and going out are going to be delayed.*

For others, a snow event was not seen as serious enough to take action on, as it would not disrupt their business. Taking preventive action has costs for companies, so they may be wary of doing things that have a financial impact:

> *We avoid cancelling lessons because we lose money, but sometimes we can move classes.*

One interviewee said that rather than take action to prepare for the snow event, their company would tend to carry on as usual for as long as they could.

> *If you told me in the afternoon for the following day, we'd talk about it but we'd tend to soldier on. We'd see it as interesting information rather than as causing disruption.*

When the information in the Early Warning was compared with the Advisory (which does not show percentage probabilities), the majority felt that the wording (e.g. 'moderate risk') gave too much uncertainty to warrant action. However, one interviewee disagreed and felt that taking out the percentage probabilities made the warning more to the point and easier to understand.

7.6.2 Possible presentations of information on risk and uncertainty in flood warnings.

Interviewees provided the following feedback on the examples of possible presentations of information on risk and uncertainty in flood warnings.

Example A

Most of the interviewees thought that this warning was clear and easy to understand. The use of 'traffic light' colours was mentioned as aiding understanding. But several interviewees were not sure about how they would use this information.

[1] The examples are provided in Appendix B.

- Some felt that while the information was worrying, they wouldn't know what to do about it. One argued that their business would expect to be told explicitly when to take action.
- Several people felt that the terms used to describe likelihood were open to misinterpretation. For one interviewee, 'unlikely' and 'probable' meant the same thing. Another felt that 'probable' was a borderline term, and that they would not be sure in that case whether to take action.

Example B

Most interviewees responded positively to this warning and felt that the percentages, accompanied with colours, provided a clear indication of risk. One person commented that having two different percentages in amber demonstrated to him that a high degree of calculation had gone into the warning. Another comment was that numbers allow the recipient of the warning to perceive the relationship between the risk of flooding on different days, and to take appropriate action accordingly.

However, a few interviewees said that including percentages made the message more confusing. The main reasons for this were that they would equate 'Probable' with at least a 50% chance of flooding, whereas in the warning, a 47% chance of a Severe Flood Warning is 'probable'.

Several interviewees commented that this warning would still only be useful if it was geographically specific enough for businesses to be able to rely on its accuracy.

Example C

All but one of the businesses felt that this presentation had too much information. So while the users could make sense of it, this would demand too much effort as the information doesn't stand out at all. The presentation hasn't got as much impact as the two previous ones.

> *I would totally ignore it I think. It isn't clear. It doesn't jump out at me. It doesn't say you're going to get under water in 2 days time. I would just ignore that. I'd think it was a load of government agency rubbish and it's just totally useless.*

One manager pointed out that the information about probabilities of flooding would need to be shared with others in their company and that it therefore needed to be as simple as possible.

Example D

All but one of the interviewees liked the map format, because it shows graphically where you might get flooding. In general, however, they seemed to think that the map would be better used in conjunction with one of the other warnings, rather than on its own. One reason why people may like the map is that it appears to cover quite a small area, and it may be difficult to provide this level of detail in practice.

> *D I liked because it actually shows me where I live as it were and it's telling me which areas around that river are at highest risk. If I was in blue, I would be definitely watching this but it still says greater than 50. Well how much greater than 50? I would want to use D in conjunction with B. The map would help me understand the accessibility as well. If all routes to you are not fine, you're going to have trouble the following day. I like the fact that it's within the next 24 hours which is a good time window to have, but for me the downside*

is, the banding is too simplistic. There's actually a long way between 50 and 100. I'd want a 4th banding in there which said 50-75%.

There was a mixed response to the implications of the various colours on this map. For some, being in the white zone meant they did not need to take any action, being in the yellow zone meant keeping an eye on the river, and being in the blue zone meant flooding was possible. However, the percentages of the blue zone were not high enough for all interviewees to wish to take action. One person commented that the colours were not traffic light, and said that they missed the red.

Another comment was that a map such as this would help businesses consider their routes in and out of their premises in terms of staff safety arriving or leaving work.

Example E

No-one liked this presentation, which was felt to be hard to understand, 'too fussy' and complicated. One person commented that the colours were too calm and wouldn't worry them at all.

7.7 Conclusions

Recognising that the interviews covered only a very small sample of businesses at risk of flooding, some initial conclusions can be drawn from the comments received:

- **Trust in information on flood risk:** several business users indicated that they would not to rely on a single source of information when deciding how to respond to a flood warning: a number of the interviewees talked about looking at the weather or the level of water in the river to confirm the risk. However, in other cases interviewees suggested that they would expect to be able to 'rely on the experts' and not need to verify information received in warnings. It is not immediately clear whether the different stances reflected in the interviews are associated with factors such as losses due to flooding or size and nature of the company: further research would be needed to explore the reasons for these attitudes.
- **Spatial scale:** many interviewees were sceptical about the value of probabilistic information covering a large area (for example, at the scale used in the two example Met Office Warnings). In particular, companies with activities across the UK or across several regions had experience of wide differences in weather conditions occurring at the same time. A number of people noted that the spatial scale at which information was provided would affect their trust in the information and their willingness to act on it.
- **Earlier information on flood risks:** most interviewees agreed that it would be useful to have earlier information about the likelihood of flooding. This would enable them to take low-cost preventive actions such as advising staff about alternative routes to or from work, advising customers about potential delays to services or deliveries; re-programming activities, etc.
- **Costs of actions to prepare for the risk of flooding:** businesses that have flood plans or protocols in place pointed out that taking action to prepare for the risk of flooding has costs: this may be because staff have to spend time taking physical measures such as laying down sandbags or

moving equipment, or it may be because services are re-scheduled or reduced. One company that had suffered extensive losses as a result of flooding now insists that employees take preventive measures when there is even a small risk of flooding. However, most interviewees were concerned at the prospect of getting numerous flood warnings without an increase in flood incidents.

- **Presentation of probabilistic information:**
  - There was widespread agreement that percentages provide more precise information about probability than words such as 'likely' or 'probable' which were interpreted differently by interviewees.
  - The use of colour in flood warnings can reinforce information about probability; traffic light colour systems were felt to be particularly effective in differentiating between degrees of risk.
  - Map-based presentations were felt to be useful because they specify the area covered and enable users to visualise problems spatially, for example in terms of to access routes to premises. However, several interviewees felt that the map lacked information about changes in probability over time and felt that the map would be best used in conjunction with the percentage tables.

8 Recommendations

The following points summarise generic issues coming out of the research and the key policy recommendations related to the adoption of probabilistic flood warnings in practice.

8.1 Introduction

The research raised a number of issues that are general to flood warning, and which have been raised in other pieces of research (e.g. Improving Institutional and Social Responses to Flooding). These issues shape the context in which any probabilistic flood warning will be experienced and therefore need to be addressed, alongside the more specific issues around probabilistic flood warnings.

This research represents the first step in developing probabilistic flood warnings. When the decision was made to change the Environment Agency flood warning codes in 1998, there were two years of research and consultation to enable the move from colour-coded warnings to the current symbols with associated messages. A similar process, involving target audiences in the development of the warning service, will be needed this time.

The text below provides recommendations that have come about as a result of the research.

8.2 Generic flood warning issues

Members of the public interviewed for this research were interested in how flood warnings are disseminated (e.g. via the web, telephone, etc.), as well as what they say and the format in which information is presented. Some communications channels are inappropriate for use in certain situations or with particular sectors of the population (e.g. internet connections may be cut off during floods and some people do not have access to the internet at any time).

REC 1 It is recommended that the Environment Agency continue to explore how to provide warnings through different channels to reach people in different situations or with specific needs.

Flood warnings can be disseminated through direct links with local agencies, organisations and groups (e.g. such as tenants' or residents' associations, credit unions, community centres, schools, health centres, sports associations, faith groups, voluntary organisations, etc.). This approach would not only provide an opening for a large number of people to become aware of the risk and have the opportunity to discuss it in a social context, but it would also ensure the message is heard in a diverse range of settings, reaching people from different backgrounds, many of whom may otherwise not hear it.

REC 2 It is recommended that the Environment Agency develop means of communicating risk horizontally, in a way that encourages discussion between people through their networks and groups.

There is an aspiration from end users for an externally directed warning service, tailored first and foremost to meet the needs of the users as well as responding to the Environment Agency's own priorities. This means moving from an emphasis on awareness raising and providing one-way information to the co-production of flood warning services, including probabilistic information, tailored to the needs of a diverse audience. In some areas there will be end users (e.g. residents, professional partners) who have extensive knowledge and expertise about how floodwater behaves in their locality.

REC 3 It is recommended that the Environment Agency engage with professional partners, businesses and members of the public during the development of any changes in the flood warning service and consider how end users' local knowledge can be best used to improve flood warnings.

8.3 Issues related to probabilistic flood warnings

8.3.1 General

As much previous research has highlighted, the 'public', 'business', 'professional partners' and Environment Agency staff are not homogeneous groups. A 'one size fits all' approach to probabilistic warnings will not be successful. From the research it was clear that all groups wanted to have more certainty about flooding in terms of when, where and how it was going to happen, something which they hoped could be delivered by a probabilistic flood warning. However, the form of probabilistic information provided to them is only one way of improving confidence in making appropriate and timely decisions. It should also be noted that at present providing probabilistic forecasting information for rivers is not open to all Environment Agency areas.

REC 4 It is recommended that further work should be undertaken to establish:

- What people think a probabilistic warning is going to deliver (e.g. longer lead times).
- The most appropriate way of warning people to give them greater certainty.
- What role does probabilistic information of the sort that the Environment Agency is developing play in developing flood warnings that meet the needs of the Environment Agency customers (i.e. professional partners and members of the public)?

The current flood forecasting service is highly variable in terms of the coverage of forecasting models. The Environment Agency estimates that at present only 40% of fluvial flood warning areas (Andrews 2009) are in a position to use forecasting techniques that could generate a probabilistic flood forecast at a local level. Some possible impacts that should be explored include: potential for different services to generate conflicting warnings, loss of trust, and difficulties in joining up warning information for professional partners or businesses whose areas cover different Environment Agency warning systems.

REC 5 It is recommended that the Environment Agency needs to do further research on the potential impact on different users (e.g. members of the public, professional partners, businesses and Environment Agency staff) of having a probabilistic warning service in areas that have/have not the models to generate and process this information.

The research indicated that the ‘Flood Watch’ and ‘Flood Warning’ codes seem to be used by professional partners and some members of the public as a trigger to seek extra information, rather than a trigger for action.

REC 6 It is recommended that the information content of the ‘Flood Watch’ and ‘Flood Warning’ codes should be revisited and possibly redefined if probabilistic flood warnings are to be introduced.

8.3.2 Environment Agency staff

The research showed that different Environment Agency Area Offices take different approaches in deciding whether to issue warnings and interact with the end users (e.g. professional partners). While these are sometimes influenced by the use of telemetry and the forecasting data available, they often reflect the application of professional judgement to the interpretation of uncertainty in different geographical and social contexts.

REC 7 It is recommended that the use of professional expertise, within the framework of agreed approaches to the interpretation of uncertainty, should be recognised and supported internally through appropriate training and less emphasis on prescriptive processes.

Staff expressed concerns that the Environment Agency’s computing systems, hydraulic models and communication systems would not be able to cope with the additional information generated by probabilistic forecasts and warnings.

REC 8 It is recommended that the Environment Agency should address concerns about how its staff will cope effectively with the additional information that will be generated by probabilistic flood forecasts and warnings.

The introduction of probabilistic flood warnings will need to be part of an ongoing process of improving monitoring, hydrological and hydraulic models that support the flood forecasting systems to ensure that the whole system of flood forecasting and warning is developing and progressing. There has been a concern expressed among some Environment Agency staff that the implementation of probabilistic flood warnings could divert resources away from these improvements.

REC 9 It is recommended that the introduction of probabilistic flood forecasts should complement ongoing improvements to the hydrometric and flood forecasting networks.

There were concerns among staff about exposing the level of uncertainty in the current forecasts externally. This seemed to be reflected in a difference in attitudes about the usefulness of probabilistic information between Environment Agency staff and external audiences.

REC 10 It is recommended that the Environment Agency should encourage staff to be open about the uncertainties inherent in flood forecasting and warning in their engagement with professional partners, businesses and members of the community.

REC 11 It is recommended that flood risk and other Environment Agency managers need to challenge the organisation’s culture of ‘expertise’, which may cause some staff to feel uncomfortable saying that they do not have all the answers.

This research has shown within the Environment Agency there is still debate about what kind of a 'probabilistic warning' is being proposed and how it would be used. Furthermore, the terms 'probabilistic forecasts' and 'probabilistic warning' meant different things to staff in different jobs.

REC 12 It is recommended that the Environment Agency should work with staff to ensure there is understanding and clarity around the potential use of probabilistic information in order to build internal 'buy in' to probabilistic forecasts and warnings.

Not all Environment Agency flood incident management operational staff are confident that they have a full understanding of probabilistic forecasting.

REC 13 It is recommended that the Environment Agency should provide further professional development to enable its staff to make better sense of probabilistic forecasts, in terms of what they mean and the way in which they can be communicated.

8.3.3 Professional partners

Making qualitative and/or quantitative assessments of probability and uncertainty is part of the everyday work of emergency responders. This research indicates that professional partners would be very interested in being involved in developing a 'fit for purpose' probabilistic warning system. There is a clear opportunity for the Environment Agency to use professional partners' experience and goodwill to develop probabilistic warnings collaboratively.

REC 14 It is recommended that the Environment Agency should set up a forum with professional partners to work together on further developing probabilistic flood warnings.

The Environment Agency needs to generate and maintain trust with professional partners if probabilistic warnings are to lead to effective responses. This requires succession planning so that if key members of staff change their post or leave there is another member of the team who has also developed a relationship with the professional partners. The research suggested that often the Environment Agency Areas where professional partners have taken the most notice of flood warnings is where they have strong working relationships with the FWDOs.

REC 15 It is recommended that lessons learnt from Area Offices that have a close working relationship with professional partners are disseminated nationally as good relations will greatly assist the successful uptake of probabilistic warnings by professional partners.

The terminology related to probabilistic flood warnings should be consistent between the Environment Agency, the Met Office and different professional partners. This will lead to greater consistency in the way that information about uncertainty is communicated to professional partners and members of the public, and will help to avoid situations where inconsistencies lead to confusion and lack of or ineffective response.

REC 16 It is recommended that a working group comprising key Environment Agency, Met Office and professional partner staff is set up so that the

terminology to be used for probabilistic flood warnings for these organisations can be agreed.

8.3.4 Members of the public and business

There were four public focus groups undertaken as part of the research comprising 33 people, 29 of whom had at some point in their lifetime experienced flooding. Ten business interviews were undertaken, 9 of whom had been in contact with the Environment Agency previously about flooding. For these groups mock-up probabilistic flood warnings were produced by the project team because the research found that there were no readily available examples of probabilistic flood warnings.

REC 17 It is recommended that different forms of probabilistic warnings are developed by experts in communication and graphic design, in conjunction with the Environment Agency, business users and the public, and that comprehensive research is carried out to gain an understanding of their interpretation of these warnings.

REC 18 It is recommended that the Environment Agency should carry out further research with a broad range of businesses and members of the public to test probabilistic flood warning materials once these have been developed. The research should include both companies and individuals who have experienced flooding and others who have not, in order to see how their responses differ.

Participants in the public focus groups who had experience of being flooded were interested in receiving probabilistic information that they could use with other local information and indicators to assist them with preparing for floods. However, their interest in the content of the information and its perceived usefulness was linked to the medium by which it would be delivered.

REC 19 It is recommended that further work is carried out with the public to assess the most effective media via which probabilistic flood warnings can be disseminated to them.

If probabilistic warnings are introduced it will be important for the Environment Agency to manage the perception of stakeholders of ‘false alarms’. There is literature that describes a ‘false alarm hypothesis’ whereby experience of cancelled or ‘false’ warnings diminishes the belief and response to any warning messages (Atwood *et al*. 1998). However, there has been recent research by the Environment Agency that indicates some members of the public would prefer ‘false alarms’ to no warnings at all (Defra/Environment Agency 2007a).

REC 20 It is recommended that further work is carried out to understand how the public and business users perceive ‘false’ warnings in probabilistic terms and what effect this may have on their response.

The research indicated that flood warnings are too large in spatial scale for members of the public and business users. They would like information related to precisely where they live or run their businesses, with a degree of uncertainty/percentage probability attached to the warning.

REC 21 It is recommended that the Environment Agency should consider the technical and operational impacts of providing a more localised probabilistic flood warning service than it is currently technically possible to make available to the public and businesses.

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List of abbreviations

AIR	Area Incident Room
ABC	Area Base Controller
COBRA	Cabinet Office Briefing Rooms
Defra	Department for Environment, Food and Rural Affairs
EA	Environment Agency
EDO	Emergency Duty Officer
ERA	Extreme Rainfall Alert
FCER	Flood and Coastal Erosion Risk
FCERM	Flood and Coastal Erosion Risk Management
FDO	Forecasting Duty Officer
FDR	Flood Data Recorder
FIDO	Flood Incident Duty Officer
FIM	Flood Incident Management
FWDO	Flood Warning Duty Officer
IDB	Internal Drainage Board
MDO	Monitoring Duty Officer
MFDO	Monitoring and Forecasting Duty Officer
NFFS	National Flood Forecasting System
ODO	Operations Duty Officer
PP	Professional partner
RMS	Recorded Message Service (i.e. Floodline messages)
SMS	Short Message Service, i.e. a text message
WRVS	Women's Royal Voluntary Service

Appendix A Participants' experience of flooding at the focus group locations

A1 Oxford

The general sense from participants in Oxford was that flooding and the threat of it were very much part of their lives. Some participants had been flooded several times in their homes and expected to be flooded again.

> *I've been flooded three times, in 2000, 2003 and 2007 and almost in 2008 in January. And each time has been worse than the one before. In 2000 it was a couple of inches, in 2003 it was about four or five inches, in 2007 it was about eighteen to twenty inches, which is a completely different ball game.* (Alan, Oxford)

> *When you move somewhere which is close to a river then you accept that you are putting yourself at risk.* (Derek, Oxford)

Participants described different flooding experiences within a very small geographical space, some times even within the same street. For example, one participant described being flooded through the door, another a few doors down was flooded through the floorboards, furthermore, during the same episode flooding occurred on various days within a very small area. One participant was flooded on Sunday; another who lived minutes away was flooded on Wednesday.

The speed of incoming water in 2007 had surprised both those who had not been flooded before and those who had.

> *… it just appeared. I mean my partner went to work at 10 o'clock Sunday morning and by half past ten I was phoning him up to come home because we'd been flooded, within half an hour.* (Helen, Oxford)

> *… in two hours it had gone up the best part of two foot* (Mathew, Oxford)

> *From nothing to becoming almost a tributary of the Thames. It just shot across our streets.* (Alan, Oxford)

Some participants had detailed accounts of what they perceived to have caused the flooding.

> *This was caused, I believe, by a surge, which came down from the tributary rivers into the Thames and we were warned that this surge would come. That's why it happened so suddenly because it was water that built up higher up and as somebody said earlier that water would perhaps, in the past, have gone into Port*

Meadow, which is north, on the northwest side of the city and into the Hinksey floodplain but they couldn't contain the amount of water. (Anne, Oxford)

The problem isn't so much the river breaking its banks. It's the problem of rising groundwater… we are trying to make sure that the various agencies involved are looking at all the pinch points and the blockages that are stopping the flow of water southward and if we can allow the water to continue on its way, then it will do just that. But when it gets up against a blockage south of us, we just live in a basin, it just fills up. (Alan, Oxford)

Several participants believed they may be flooded again and had adapted their homes to cope with this possibility to a greater or lesser extent. Adaptations that were mentioned were raised sockets and meters, replacement of carpets or wooden floors with ceramic or stone flooring, and putting plastic bases on kitchen units. One person had commissioned a new kitchen made entirely from plastic.

Yet some others felt it was the job of the local authority and other services to protect them from being flooded again and felt let down that 'nothing had been done' since the last floods. For example, residents had been promised that a stream nearby would be dredged but as far as they were concerned it had not been done; 'their promises are full of hot air' (Helen, Oxford).

A2 Purley near Reading

The situation for those living in Purley near Reading was slightly different to that for those in Oxford in that flooding of gardens and surrounding land was an expected event every winter. Living with water was simply part of living in this area.

I've lived down here thirty years and you do occasionally go a few winters when the water table doesn't come up in the back garden but you expect it to come up. (Mary, Reading)

Some people lived in houses that had been adapted to cope with flooding. For example, one person mentioned that they had moved their living space upstairs and the ground floor was being used as storage and office space. These rooms had been especially designed to cope with water. For example, they had ceramic floors, all the electricity points had been raised and all the equipment was stored above ground level. Being flooded was not a major catastrophe for them. On the other hand, one participant lived in a bungalow and had endured severe damage to her property and had lost her belongings.

Perhaps even more so than in Oxford, there was a very localised picture of flooding here; houses on the same street had different experiences, varying from not being flooded at all, to flooding in the garden only and being flooded several inches inside the house. These two experiences are from neighbours who live two doors from each other.

Our house wasn't flooded, although it was very close, it was on the damp proof course. I live in a dormer bungalow, so there's bedroom space upstairs. It's much bigger downstairs than upstairs; you can't fit everything from downstairs upstairs. Our garage flooded which is attached to the house and our garage had been converted to a room and the water ran up the walls in that room, even

though the floor level was at the same level as the house. And it was sitting under our floorboards; the joists that support our floorboards were sat in the water for three days or whatever. (Jo, Reading)

I live in a bungalow so had no option when the Environment Agency tell you to move everything upstairs. I was severely flooded, my property had to be gutted internally. It was just brick walls left, and the roof that was left. All the plaster came off, all the wiring had to come off and I was out of my property for eight months. (Mary, Reading)

It was mentioned here also that even though they were close to the river, the threat of flooding often came from the water table rising rather than the river breaking its banks. Measures often cited in defending homes against flooding (e.g. flood defence walls, sandbags) would have no effect in such cases.

A3 Fleetwood

All the participants remembered the flood in Fleetwood very vividly, even though it had occurred over 30 years ago, with one person saying that she still felt traumatised by the event.

You never forget something like that. (Paul, Fleetwood)

For those who lived near the sea, the speed with which the water came into their homes had prevented them from taking any action, and in some instances, the water had left their property as quickly as it came.

So I rung my mother in law, she said, 'Get a taxi down here'. Well the toilet was overflowing and then my front door broke in and I looked and the phone went and it just came in like a river, just coming right through. (Gwen, Fleetwood)

I seem to remember, sort of between ten and eleven looking out of the window and I'm at the bottom of a little cul-de-sac and seeing a wall of water like the Severn Bore, coming along the top of the road and turning round. And I phoned the police and they said, 'Well when it comes up to your knees we'll come and take you out'! I was in a bungalow. So I put the babies on the top bunk, with a record player between them and then the water just came straight down, just like the Severn Bore. And you know, I thought right, I phoned the police again and of course by then there was no phones and you could see that night, the lights going out up the road, starting at the top and then gradually, and I thought right, that's the electricity going… So the next morning the bungalow, the floor looked like the bottom of the sea and there was seaweed and little jellies all over the place. And the water had gone out of the bungalow but the roads were still flooded all around me. So I had a little boat and I put the children in the boat and floated them out and went to a friend who had an upstairs. (Sue, Fleetwood)

Those who lived a little further in had had a different flood experience, as blocked drains had been the cause of their flooding.

It was sewage that came into our house. My wife was, she'd had a stroke and she was sleeping downstairs and I had to carry her upstairs… I've got a bad back so it was difficult for us at the time … about eleven or after eleven we were wakened up by somebody hammering on the door shouting to us that, 'Did you know you are flooded?' And the water was coming into the house by this time and as I say, we'd been asleep. So it was all panics downstairs and we had a kitten and we had to rescue the kitten out of the water because it went up to three steps of the stairs and we were watching the electrics, it went to the electric meter, we watched all that blow and everything. (Lenny, Fleetwood)

Participants reported localised flooding here too. Neighbours had had different experiences, with one being flooded up to the stairs, the other not having any flooding in their home at all.

There was consensus among the group that the cause of flooding in 1977 had been lack of maintenance of the lagoon on the shore, and this had led to the sea defences being overtopped. Participants living close to the sea reported that they remained vigilant of the state of the lagoon and contacted the local authority when they felt it was too full again.

Although there had been no major flooding event since 1977, many participants still reported watching the weather closely and even taking preventive action.

The last time I got worried I think was last winter when there was one day when it was really wild ... There was high tide; there was a lot of spray coming in and I just automatically went round and picked everything up. You know, just lifted everything out of the, tried to lift everything out of reach. (Sue, Fleetwood)

Even today [I] keep stuff at a height, higher than what the water came to previously. I'm probably over the top because I've actually built an embankment at the back of my house to stop the water coming in because it came round the back. (Paul, Fleetwood)

A4 Kinmel Bay

Participants here had experienced flooding in 1990. Here, again, the speed of the water is what many commented on.

The water just seemed to come from nowhere, it came in and it was quite high, about three steps up. (Paula, Kinmel Bay)

No it just came, we actually watched it coming across the field about three foot deep sweeping all the rubbish in front of it. And then it hit the patio door, we were watching the patio door, it hit the patio door and it just bowed it and then the water was outside about that depth and we were sort of obviously inside. I ran into the bathroom and got a towel and put it in front of the patio door, to stop the water from coming in! (Bob, Kinmel Bay)

> *If you've never been flooded, you look at that [TV] and you think those poor people. I tell you, until it actually happens to you you've no conception of what it's really like. And it really is upsetting.* (Neil, Kinmel Bay)

Localised flooding had also been a feature of this flood event.

> *The thing is it's so localised isn't it? We were flooded out, walked over the bridge and my wife's sister was sitting there doing her knitting and didn't know anything about it!* (Ron, Kinmel Bay)

> *The house opposite me, the first day that it flooded, which was 26th for us, I got it about two or three foot in the house, they hadn't even got it over the doorstep because mine dips a bit, so it just came in like that.* (Paula, Kinmel Bay)

Participants were surprised at how people living near the sea had not been flooded but houses much further away had. Participants talked about the flood as a one-off event that had been caused by a combination of high winds, high tide and an accidental breach of the sea defences. Because of this, some people did not feel at risk of flooding again. Others did report feeling at risk of flooding and said they watched the weather forecast closely. None of the participants reported having made any adaptations or preparations for another flood event.

Appendix B Participants' experience of flood warnings, and trust and uncertainty issues at the focus group locations

B1 Oxford

Some participants had received a flood warning from the police who had gone round and knocked on doors to advise them about flooding and also to see if there were any vulnerable people who needed to be evacuated to safety. For some people, this warning had been taken seriously because it was a police officer.

> *… it was definitely a wake-up call. If policemen are going round knocking on every door, then you know, they don't do that unless things are pretty close to being a disaster. So you know, we reacted and reacted quickly to that*. (May, Oxford)

For others, the police warning was not taken seriously but this may have had more to do with not having experienced a flood before, and not appreciating the different types of flooding that may occur.

> *It was my first time of being flooded so when the policewoman knocked on the door on the Saturday evening, I just laughed because I thought; well it's sunny all day. I'd never experienced it, so I thought yes, whatever, and just shut the door. So now I would listen but at the time no I didn't, because you just don't think it would flood that quick.* (Helen, Oxford)

This comment emphasises the point that flood warnings are received in an already established individual or social context, and warnings will be interpreted and made sense of by people in many different ways. The same statement will lead to different reactions by different people.

Some participants had had a general warning from the police officer (e.g. 'you have a good chance of being flooded in the next 24 hours'); others had been given more definite warnings (e.g. 'you've got three hours before the river bursts its banks'). Being given a more definite warning had prompted participants to take preventive action in their homes.

However, some were not flooded within the three hours, or the next day, or the day after, by which time they were beginning to ignore the warning.

> May: *We had that, you know, a long time, by which time you were beginning to ignore it.*

Derek: *Well it did seem as if it wasn't going to happen by then because you know, they kept telling us it was going to peak and it didn't and you know, you just kept thinking, oh well it's just a bad dream you know.*

The changing advice also seemed to make some participants lose trust in the warnings.

> *You lose faith in people because you don't know what's going on. That's your life in your flat or your house. And people are telling you different things. Plus you have to go to work and try to carry on a normal life while you are waiting to be flooded. And you just walk around not sleeping; not eating and you just wish someone would come up to you and say, look sit down, you've got 4 hours, you are going to flood, pack up what you can now. But no, everyone tells you different.* (Helen, Oxford)

There is, then, a need to strike a balance between warning people with enough time for them to do something and not so early that the situation keeps changing and the advice is perceived as not being accurate. Being explicit about the level of uncertainty in a forecast and engaging in dialogue about this *may* potentially be one way of increasing public understanding and acceptance of what may otherwise be perceived as forecasting errors.

Some participants expressed an understanding of the difficulties involved in providing effective flood warnings in a place like Oxford, not only because of the difficulties of forecasting the weather accurately, but also because of the amount of water that surrounds the city.

> *When the river hits Oxford it hits a big bed of shale and splits into seven streams… So there are lots of series of weirs, which they can control for day-to-day use and they try and keep the level on the navigable part of the river more or less steady and so they adjust the flow on the other streams … it just is a place where there's an awful lot of water. And when it's coming at you from all directions it must be a nightmare trying to work out when it's going to hit and where. I had a lot of sympathy for people who were trying to give accurate information … the situation was changing a lot and there was so much water.* (Mathew, Oxford)

Others were more cynical in that they believed the flooding was partly as a result of decisions made by the Environment Agency with regards to the locks along the Thames.

> *Sometimes I think that they have to make decisions, which they know if they made a different decision perhaps you wouldn't flood but then your neighbour or downstream might flood even worse. So they are having to sort of juggle.* (Derek, Oxford)

Almost all participants were signed up with Floodline Warnings Direct and were already familiar with the codes. Many believed the words 'watch' and 'warning', and the graphics associated with the words, were too similar to each other. One suggestion was to use colours as a means of distinguishing between 'watch' and 'warning' (e.g. as amber for watch and red for warning).

There was consensus among the group that the new catchment areas for the flood warning system would help them receive more accurate warnings in future.

One participant felt very strongly that provision should be made for older people, in particular, who do not have access to the internet or even telephones sometimes.

> *And I think, already in West Oxford … we are trying to set up a system in our area so we have somebody in each street who is on the Internet and on the phone who can receive the warnings and then go round and tell people. For example, we know we have two partially sighted and three blind people living in our area … We are hoping that if we can set up a system of flood warnings, although we are trying not to use that word, that people will know enough about the people in their street or their section of the street, to know who they should go to and offer help to early enough, soon enough.* (Anne, Oxford)

Many participants reported that because of its geographical position, Oxford gets some advance warning of river levels by watching rivers in other places.

> *Remember that we always know it's going to happen in advance because we sort of get it 48 hours or 24 hours or 72 hours after it's happening everywhere else because of the way it happens here … But we don't get the water running down the street and through the doors normally … it's much slower here.* (Mathew, Oxford)

B2 Purley near Reading

Purley's geographical proximity to Oxford meant that residents expected 'whatever's coming down from Oxford' to reach the Thames near Purley in two to three days' time. Many people reported habitually using the weather forecast in conjunction with their own knowledge of the river.

> *The accuracy of what the normal weather forecast is on the television is not that important, it's the overall picture. I tend to look at it on the web and get the weather maps. You can see how long and how severe some of these storms are going to be and then we can make the right decisions.* (Steve, Reading)

Participants demonstrated a large amount of local knowledge that they had gathered over the years of living in the area regarding how the river was going to behave and/or whether they were at risk of flooding from rising groundwater. When the researchers commented on this, one participant replied, 'yes but it's a shame no one actually listens to us' (Paul, Reading). Some of the sources of knowledge were:

- watching the river fill using own markers;
- not being able to take the dogs for a walk by the river because the level's too high;
- colour of the river (e.g. brown means it's going very fast and will rise with a bit more rain);
- watching nextdoor's garden fill up;
- watching own back garden fill up;
- being mindful of rainfall levels;

- keeping an eye on the fields and gardens to see if they've dried out since the last flooding;
- gauging the potential severity and length of forecasted rain and how that might interact with the local situation;
- watching the field by the stile because it's the first place that floods.

> *That's where we judge it, we can see it from our bedroom window and when it starts to come up the field you know.* (Paul, Reading)

One participant mentioned that her neighbours keep an eye on the river level because in their experience that has a correlation with groundwater flooding. Knowing how much the river level is rising per hour allows them to make informed decisions about what course of action they should take to protect their property, and how long they have before they may be flooded.

All participants reported proactively seeking information in order to gauge whether they were likely to be flooded or not. Sources of information were the internet, the local radio, friends and family, and own knowledge as mentioned above. Although this may not have been a typical response, one participant summarised this process thus:

> *I mean I'll look at the weather forecast on the web … I'll look at the Met Office; when there's either been a lot of rainfall further up in the Thames Valley you know, say in Gloucestershire or Oxfordshire, I'll walk down to the river to have a look at the levels and to see how fast it's flowing and also to check whether they've got all the paddles out of the boats and all the gates up because that's a big concern. We have issues with that. And I'll also look at other sources of information you know, like if other places have flooded that are near. On the Environment Agency's website the river is all segmented up, but you know that if they've got flooding on the River Ray or somewhere in the Windrush or something like that, that there is a chance, if the river levels are rising there, when that gets into the Thames it's going to bring the Thames up by an amount. And you sort of have a picture in your mind that all of these different things can have an affect overall. So you look at all of them and when one of them happens you look at the other ones more frequently. So I probably would only listen to the weather forecast most of the time, not look on the Environment Agency website. But if there was a bad weather forecast you know, like there was torrential downpours or where they forecast two inches of rain for tomorrow, I won't just look at the weather forecast then. I'll start to look at all those other things as well, and try and get local information.* (Jo, Reading)

Everyone in the group was signed up with Floodline Warnings Direct. Some used the Flood Watch status as a trigger for further investigation of their own. However, not everyone felt the Environment Agency's warnings were timely or useful. Some had been flooded already when the Environment Agency's website reported only a Flood Watch, and this was attributed to the large Flood Watch areas which did not take into account local contexts.

> *It's usually too late, I don't believe it, I've already made my own assessment of what's happening ... I think it's a very blunt instrument.* (Margaret, Reading)

In January we got nothing, nothing at all. We knew we were going to flood by looking at the signs, my wife got told at a pre-school meeting 'oh we are on a flood warning'. We had no text, we had no calls and I think a lot of other people with gardens were in the same boat. We got no warnings. So we were on the phone to the Environment Agency, the Council, we want sandbags. 'Don't worry we're not going to flood'. 'We know we are going to flood, we want sandbags'. It was horrendous. We sort of found out that West Berkshire had put some flood warning in but the Environment Agency said no because they didn't want to panic Reading because Reading would worry that they were going to get flooded. So West Berkshire were doing one thing and the Environment Agency were doing another. (John, Reading)

One participant who had lived in the area for a long time commented that it was futile being registered for Flood Watch as the whole community is under Flood Watch most of winter every year. Some participants felt that flood warnings had wrongly been issued for their area in 2007, which in turn caused a lot of stress and disruption, particularly for those people who were asked to evacuate.

It was pointed out by one participant that those who had come to the focus group were not necessarily representative of everyone who lived in the area.

We've all, sitting round this table got a deal of experience between us in different ways about what is likely to happen, the patterns you've seen in the past and we are all sort of fairly up with it and all the rest of it. I just want to make the point that we are not necessarily totally representative of everybody that lives down here. There are different people, different age groups, different levels of understanding and I think that is something that needs to be very much borne in mind. I do understand myself why the Environment Agency only put out these levels because if you put out too many, we might like it, not everybody is going to understand it, cope with it, it might just switch them off… It's not a question of not being interested necessarily, it's you know, maybe they are incapacitated, maybe they are elderly, maybe they just haven't got the understanding. Some people are so frightened that they can't even cope with even thinking about it. There's all sorts of levels here. (Mary, Reading)

B3 Fleetwood

All the participants reported listening to the weather forecast with particular attention to wind speed and rainfall predictions but did not necessarily trust the long-range five-day forecasts.

I notice that the five-day forecast on the internet for sure changes that many times in the five days that you are looking at. You look one day and you think it's going to be nice on Wednesday and when you look on Monday it's already changed and when you look on Tuesday it's changed again. So it's not really a five-day forecast, it's not accurate. (Paul, Fleetwood)

Participants had some interesting means of predicting weather conditions for themselves.

In this area as well you will find that people that live here go and stand on the promenade and it's so clear that you can actually feel that you can actually touch Barrow that you know that the next day it's going to be raining. (Sue, Fleetwood)

We see the weather coming in. (Sue, Fleetwood)

Iceland's used to be a fishmeal place, a factory. And if the wind was in that direction they really used to get the real pong. And then you think that it's going to rain. (Gwen, Fleetwood)

Sometimes Mother Nature can give you indications … the trees are very heavily laden with berries at the moment, which always signifies to me that we are going to have a harsh winter, because Mother Nature is looking after the wildlife. And there are an awful lot of berries about this year. (Sue, Fleetwood)

One participant suggested that local weather forecasts should include tide information, as happens in the south lakes for Barrow and Walney Island. Having more information would enable residents to make their own preparations.

The authorities cannot protect all of us all of the time, they can only let us attempt to protect ourselves. (Paul, Fleetwood)

Participants reported the presence of sirens around Fleetwood that would be activated if there was probability of imminent flooding but none had heard them for many years. They recalled them being sounded during tests – there was a worry that if they heard them now people may think it was another test. There was concern that they would not be heard over the sound of rain and wind in any event.

At eleven o'clock on a windy blowing night I don't believe you'd hear the loudest siren in the world. I think the only thing, the only way you are going to get through to people is, the majority of us got warnings because other people came and knocked on your door or whatever. (Paul, Fleetwood)

In contrast to Oxford and Purley near Reading all but one participant had never heard of the Environment Agency's warning system but welcomed the possibility of receiving warnings. All participants took away details of this service and wanted to sign up. Participants expressed an interest in having a phone number to call that would give them accurate information about their local coastal area, although this would not be able to warn them of flooding caused by blocked drains or sewerage pipes.

On the other hand, they felt the warning codes as they stood were more relevant to fluvial flooding than to coastal areas. Some felt that coastal flooding was unpredictable and, therefore, not capable of being measured in the same way as river levels. Concern was also expressed about the unpredictability of global warming and rising sea levels.

There was some support for returning to red, amber and green warning signs rather than the graphics as they stand. The graphics did not communicate the difference between a watch and a warning.

While improvements in warning systems were welcomed, participants wanted the door-knocking tradition not to be forgotten, as, in their view, many people would not have access to the technology needed to receive these warnings or be able to understand what the warning codes mean. The suggestion was made for developing a phone/door knocking tree so that warnings would be passed on from one person to another at community level.

B4 Kinmel Bay

All participants reported listening to the weather forecast but with varying consequences. Some reported ignoring it completely, some said they would change the course of their day based on the forecasts, and others reported using forecasts along with other pieces of information they gather elsewhere. So, for example, one person said he looks at the pressure on the clock and puts that together with the forecast. Low pressure means a really bad day and that coupled with high winds off the sea and high tides could mean flooding. Another person said they would listen to the forecast and use their own judgement of looking at the sky to decide what they would do.

Most participants felt that the weather forecast was given for too broad an area to be helpful for where they live. Instead of being given a forecast for north-east Wales, they would prefer a forecast for their own town, because there are local climates in this region.

In complete contrast to those in the Reading and Oxford focus groups, participants here reported not having enough experience to be able to predict flooding with any accuracy and reported not knowing what warning signs to look out for. One participant reported that he'd seen the breach in the sea defences the week before but 'didn't even think it would happen because it had never happened before' (Ron, Kinmel Bay).

Furthermore, only one person had heard of Floodline Warnings Direct and believed he had signed up to receive flood warnings. The other participants did not know of the service and did not believe they were at risk of flooding.

One participant wondered if being signed up to a warning service might provide a false sense of security and felt that some people may interpret a lack of a warning as meaning that they were not going to get flooded.

Similar to residents in Fleetwood, participants in Kinmel Bay felt that the warning codes were more suitable to people at risk of regular fluvial flooding rather than coastal flooding. In particular, they felt that the warning system would not have helped them in the last flood event unless the warnings took into account breaches in sea defences.

One participant mentioned that residents would be more at risk of fluvial flooding if planning permission was granted in Rhyl to raise their side of the sea defences. In that case residents their side of the river would be more at risk and the flood warnings would be very useful then.

Appendix C Other comments made by participants at the focus groups related to the prevention of flooding

This appendix gives brief details of other comments made by the focus groups related to the prevention of flooding. In Fleetwood participants referred to maintenance of the lagoon. In Oxford and Reading, particular reference was made to the dredging of rivers and tributaries, which participants believed had not taken place.

> *At this stage I better be perfectly honest, this exercise that you are doing on behalf of the Environment Agency, these sort of documents that they provide, I'm not really interested in this. What is sadly lacking is any action and I think particularly on behalf of the Environment Agency and Thames Water, all these sorts of things are actually red herrings to make it look as though they are doing something. I know they are concerned, I take that for granted, but they'd rather do all this type of stuff than actually stick a dredger in the river and start doing some work, or digging a relief channel. Because these things are very easy to do and it makes it look as though you are doing something and that's my greatest criticism over their reactions of this whole flooding problem. I don't need information. I need action.* (Mathew, Oxford)

In Kinmel Bay, one participant referred to the huge difficulties faced by residents after the flooding in 1990. He felt strongly that the authorities should be working together to find effective ways of supporting people after they have been flooded, rather than spending money on researching new ways of warning people.

> *The big issue is after the flood – it's the consequence, it's the management of the consequences, that's the big thing. When you watch the TV in the evenings and you see the floods you think, my god these poor people. You see them sweeping up the floors and you think you've got the loss adjusters, you've got the homelessness, you know. I mean, I'm very similar to Dave; in that I was a young man at the time but I had shingles in my eye because of the stress of managing a business, managing a home, got two kids in this caravan, trying to manage an insurance deal. And they are all against you, you know, the whole system is against you, everywhere you go you are being tripped up by people that you expect to help you. And so I really wonder you know, is this sort of all sizzle and no sausage you know, it is a flood warning but really the things that cause family stress, the things that killed people, heart attacks and stress and things after the flood, was not the depth of the water in the kitchen, it was their ability to project manage complex rebuilding programmes, manage complex financial arrangement, manipulate their way through loss adjusters who were out to screw them. So that, in my view, if you were going to break the scale of help required it's like a 30% there, 70% here. You know, where was society during that period, they were nowhere to be seen.* (Ron, Kinmel Bay)

This participant suggested that flood warning leaflets should also contain phone numbers of voluntary sector organisations that can help people rebuild their lives in the aftermath of a flood, because that is where the help is needed.

Appendix D Notes from the professional partners workshops

D1 London workshop

D1.1 Participants

For the London workshop invitations were sent to the Environment Agency's Civil Contingencies Act partners, including both Category 1 and Category 2 responders. The organisations represented at the London workshop are summarised in Table D.1.

Table D.1 Organisations represented at the London professional partners workshop.

Responder category	Organisation
Local authority	Cherwell District Council Greenwich Borough Council London Borough of Bexley North Norfolk District Council Oxfordshire County Council
Emergency services	Sussex Police Thames Valley Police West Sussex Fire and Rescue Service
Health services	Health Protection Agency
Utilities companies	Severn Trent Water
National agencies	Highways Agency British Waterways

D1.2 Use of probabilistic information in non-flooding situations

The participants worked in three groups that were split along the following lines:

- local authorities;
- emergency responders (e.g. police, fire and rescue services and health authorities);
- other responders (i.e. national agencies and utilities companies).

Discussion focused on where participants come across information on likelihood, chance and probability, in both non-work and work situations.

Local authorities group

In this session participants talked about a number of issues related to information and the kinds of situations that they find themselves in.

- The impact of ‘weather’ situations was discussed, as was the fact that there was always uncertainty around those situations (unlike perhaps an incident at a major industrial site where they would be responding to something that had already happened).
- In all cases the first piece of information, be it a warning or about an incident, was discussed as the trigger for looking for more information to get a better picture and to assess the nature/extent of the incident.
- Although the focus was on probability for the responders, of course the issue is as much about consequence as probability: where is the incident, who is affected? That issue of consequence applies also to staff in the local authorities; that is, what is the consequence for the organisation if they have to mobilise (e.g. there will be a bigger consequence if they have to mobilise at the weekend or night time).
- The issue of technical knowledge was discussed with a sense that training is needed if technical inputs are to be interpreted adequately, but also that these inputs only represent one piece of information.

Emergency services group

Participants described the procedures they use to decide on how to respond to possible emergencies, focusing on the use of information in risk assessment.

- Risk assessment is part of the day-job. In making an assessment of immediate or pending risks, emergency responders:

- rely on trusted information sources;

- draw on their own experience of past events.

- Information about probability in percentages can give a strong indication (e.g. where probability is 80% and higher). Responders would like this information to be supported by information on the likely impact and the timescale for this impact.
- Responsive action (e.g. evacuation) can take a long time, so earlier warnings allow organisations to gear up, particularly in cases like hospital evacuations where patients have to be relocated.
- An additional advantage of early warnings is that it allows for coordination: when the decision is taken, it is a collective decision.
- Multi-agency coordination has been strengthened by the Civil Contingencies Act: generally using a traffic light system (i.e. red – amber – green) to grade risks.

National agencies and utilities group

Participants gave a number of examples where uncertainty and probability are used informally and more formally in their work.

- Probability-based information can be a useful aid to decision-making but is not always presented or used formally.
- The nature and size of the consequence of acting/not acting is critical, not just the probability of an event happening.
- Credibility and reliability of the information were seen as very important – both at an organisational and an individual level.
- Confidence in the reliability of information would be built up by gathering additional data and information, sometimes formally but often informally by talking to colleagues and contacts in other organisations.

D1.3 Different ways in which professional partners currently use probabilistic information

A plenary session was held to discuss ways in which the professional partners present currently make use of probabilistic information. The key points that came out of this session were as follows:

- Emergency responders are already using probabilistic information and information from the Environment Agency is another input.
- There was concern about using the 'traffic lights' approach to describe risks as there is a danger of people responding unquestioningly to a single source of information.
- The credibility of a source of information depends on a number of factors including:
  - the reliability and consistency of information;
  - the relationship formed by having worked with people over a period of time;
  - openness of the engagement on the part of both the organisation and the individual contact; willingness to share information;
  - an understanding of the implications of the information being provided.
- There is a need to have sources of reliable information from the Environment Agency. Certain key staff are relied on, but that raises the issue of what happens when they leave.
- Timing is an issue – if responders receive information several days in advance they can start to prepare; ability to respond also depends on whether information is received during the day or night.
- Training and interpretation will be key to success of implementing probabilistic flood warnings, otherwise this kind of warning could confuse the situation rather than improve it.

D1.4 Uncertainty and probability in relation to flood warnings

For this session, participants worked in locality-based groups as follows:

- Members of the Thames Valley Local Resilience Forum.
- Participants from London and Sussex.
- Representatives of national agencies and organisations in areas outside the Thames, London and Sussex.

Discussion focused on what happens currently in relation to flood warnings.

Thames Valley Local Resilience Forum (LRF)

The following key points came out of the Thames Valley Local Resilience Forum Group:

- Thames Valley (LRF) currently gets an extra service from the Environment Agency: they get an email written by an experienced Flood Warning Duty Officer summarising different bits of information and letting them know if they should be concerned.
- The sense from the group was that they have a lot of confidence and trust in the people that they work with that has been borne out in previous situations and that gives them the confidence to act on information.
- Where relationships are not so strong then there is much less confidence in the information and therefore it is less likely that they will take action until the information is clearly confirmed.
- The current warnings are felt to be too prescriptive and that is seen as a problem because it is not a system that can be managed without judgement and just using procedures.
- LRF members use the ‘Flood Watch’ as an opportunity to look for more information but do not really go further than that.
- The fact that the public get the warning at the same time as the professional partners was seen as a problem because if the professional partners do not feel a warning should be acted on, they may then find the public has already done so.

London and Sussex group

The following key points came out of the London and Sussex Group:

- Responders usually have rules and protocols for dealing with flood warnings, but different organisations respond to levels of warning in different ways.
- Many responders seek further information from the Environment Agency before acting on warnings. There is a concern that different Environment

Agency offices give different kinds of information. This is problematic where organisations deal with several Environment Agency offices.

- Responders interpret the information they receive. Some have had training, but generally new staff get advice from more experienced colleagues and refer to established procedures and action plans.
- The group felt that there was a more structured and formalised approach to flood planning than in the past. This gives greater confidence about taking action.
- The current warning system was seen as too prescriptive, obliging responders to take certain actions at different stages. 'Flood Watch' was seen as 'meaningless' by this group.
- Much of the Sussex coast is low-lying and vulnerable. Emergency services have taken action to improve the trigger levels and get their own information from local responders and organisations' on-the-ground people (e.g. beach patrols, lifeboat stations).
- Probabilistic information from the Environment Agency will support other information, not 'cut across it'.

National agencies and responders from outside the Thames and South East

The group discussed the variety of different arrangements for receiving and interpreting flood warnings that exist at the present time. 'Flood Watches' are seen as a useful 'heads up' for internal use but are not likely to result in any action being taken. Flood Warnings are essentially the trigger for staff to start gathering more information and assessing the situation. It was described as a 'give us a call' message rather than a direct instruction that would automatically invoke flood defence or other actions.

The actual interpretation of the information received is quite a varied and *ad hoc* process. It is not a formalised or particularly well-structured phase in the flood response. If action is taken, but a flood does not occur, then the organisation may be viewed unfavourably by the public. As such, they are constantly working to improve the reliability of the information so that they can act with confidence. They are unlikely to act on the basis of a single piece of information from a single source.

D1.5 Views of professional responders on different types of probabilistic flood warnings

For this session, participants worked in the same locality-based groups as before. Participants gave their views on a series of suggested probabilistic flood warnings and considered how this kind of change in warnings might affect their work.

Thames Valley Local Resilience Forum

The views of the Thames Valley Local Resilience Forum were summarised as follows:

- Overall, the group felt that there would be benefits to having the probabilistic information if it was able to give them more planning and preparation time.
- They felt having the information would help them explain decisions to senior management, which could be useful.
- They pointed out some negatives including the possibility of too many sources of information. The relationship between the new warnings and the current codes was seen as a real issue.
- They emphasised that there would need to be training, education and a change in the current codes for this to be implemented effectively. It was felt that the current flood warning codes are too prescriptive for the professional partners. This goes against the tone of providing this type of information which suggests the Environment Agency wants the professional partners to be weighing up different sorts of information.

London and Sussex group

The London and Sussex group made the following points:

- Probabilistic flood warnings are an additional tool to reinforce existing information.
- This will be a useful source of information if it is developed with practitioners, as this will save time and resources by allowing responders to make preparations for implementation of response and increasing the credibility of the warnings, as partners who are involved in developing it can act as advocates.
- The group stressed the importance of accuracy and of setting the thresholds at the right level to ensure credibility: there is a risk of the 'cry wolf' syndrome if there are more 'wrong' warnings – emergency responders may not take notice.
- It is important to provide background text to warnings, for instance picking up on Met Office good practice.
- Regardless of the type of flood warning used, there is a need to get the media much more involved, to educate the public better and to raise the profile of flood warnings.

National agencies and responders from outside the Thames Region and South East

The national agencies and responders from outside the Thames Region and South East made the following key points and observations:

- There was general support for the introduction of probability-based flood warnings in principle. The primary benefit was seen as earlier warning and therefore the potential to prepare for a flood more widely and effectively.

The updating of probability estimates would enable the response to be adapted as knowledge about the impending situation developed.

- There was some unease about how such warnings might be used for the public: participants felt the warnings should only be used for the organisations with civil contingency responsibilities.
- The interpretation of the probability estimate would occur at the strategic level and that information would not be shared with operational staff or the public.
- Probability-based warnings would not remove the need for some of the existing information sources. Participants thought it would provide an earlier opportunity to start gathering information from their networks of people in their own and other organisations. In other words, the warning would represent a starting point for two-way conversations.
- In terms of format, there was some preference for Example E, detailed in Figure 4.6, in the short and medium term. Example D, detailed in Figure 4.5, is more of a longer term aspiration. It was also suggested that additional information could be incorporated within Example E, such as wind speed and direction, tides, etc. The bands/thresholds represented in Example D could also correspond with the current Flood Watch/Warning/Severe Warning categories. This would provide decision-makers with a single visual guide to refer to. As such, it is as much about integrating the different sources of current information as it is about providing new probability-based information.
- There would be a significant training and education need so that staff in the relevant organisations are confident in the new system and capable of interpreting the information sent to them.

D2 Leeds workshop

For the Leeds workshop invitations were sent to the Environment Agency's Civil Contingencies Act partners, including both Category 1 and Category 2 responders. Important voluntary organisations also attended the workshop. The organisations represented at the Leeds workshop are summarised in Table D.2.

Table D.2 Organisations represented at the Leeds professional partners workshop.

Responder category	Organisation
Local authority	Barnsley Metropolitan Borough Council Lancaster County Council
Emergency services	Gloucestershire Constabulary
Health services	Resilience Team, East Anglia Ambulance Service Chemical Hazards and Poisons Division, Health Protection Agency North East
Utilities companies	United Utilities Severn Trent Water Anglian Water
Voluntary organisations	Women's Royal Voluntary Service (WRVS) National Flood Forum British Red Cross

D2.1 Use of probabilistic information in non-flooding situations

The participants worked in three groups as follows:

- Civil Contingencies Act Category 1 responders (i.e. local authorities, police, fire and rescue services and health authorities).
- Utilities.
- Voluntary organisations.

Discussion focused on where participants come across information on likelihood, chance and probability, in both non-work and work situations, and how they use this information.

Civil Contingencies Act Category 1 responders group

The discussions of the Category 1 responders group yielded the following key points:

- Probability is used a lot:
  - assessments are mostly subjective, based on sound judgement, expertise or experience, not numerical;
  - assessment of risk looks at probability and at impact/costs.
- Response may be made regardless of costs but costs are counted afterwards.
- Proportionality is the goal in setting the level at which action is taken.
- In deciding when to respond, decisions may be taken by the following:
  - a single organisation (e.g. Police)
  - coordination between responders (e.g. Local Resilience Forum, LRF).

- There were benefits gained from coordination. These included:
  - reduced risks;
  - contribution to assessing risk of long-term events over wide area (e.g. health pandemic);
  - better understanding of different risks;
  - multi-agency training, building confidence and sharing experience.

Utilities group

Participants described when and how they use information about probabilities to prepare for possible emergencies. Key points that came out of the discussion were as follows:

- Probability-based information is most embedded within investment planning by the water utilities, partly because of the regulated nature of the sector.
- Probability is formally estimated and used in the context of staffing of call centres.
- The Millennium bug was a good example of risk-based decision-making where there was no prior experience to draw upon.
- All of the participants emphasised the importance of interpretation of risk data, drawing on past experience, professional judgement and other sources of information to build a more detailed and reliable picture of what is going on.
- There is concern about the consequences of inaccurate predictions as people and organisations may not respond as they should if there is a history of false alarms.

Voluntary organisations group

The key points that were made by the voluntary organisations group were as follows:

- Voluntary organisations respond and react to rather than prevent emergencies.
- It is difficult for organisations to have a variable response to incidents because they are made up purely of volunteers.
- Organisations have different roles in emergencies. For example:
  - the Red Cross might be asked to help with giving out sets of clothes and toiletries (e.g. they have a store full of clothing for this purpose);
  - the National Flood Forum works in communities in the aftermath of flooding to reassure people and help them in any way needed.

The group discussed whether it was useful to receive information about likelihood and uncertainty and concluded:

- It depends on the quality of the information and the source of information.
- The information could be useful in reducing unpredictability in the number of call-outs. This is a particular problem facing voluntary organisations in terms of planning, especially considering the entire team is made up of volunteers who may have other jobs as well.

It would be hugely beneficial, as they would be able to begin planning as soon as information is available. Voluntary organisations often do not receive information at the same time as the Category 1 responders. On the other hand, in some areas, statutory sector organisations do respect the support provided by voluntary organisations – for example, Lincolnshire Red Cross is thought by the fire and rescue service to be a seamless part of the fire service; WRVS works a lot with utilities and receives pre-warning from them regarding severe weather warnings.

There is difficulty in that there are very many different voluntary organisations nationally and locally, and every area has its own arrangements for working with Category 1 and 2 responders; for example, while in Lincolnshire the Fire Service may be working with the Red Cross, in other areas it may be the WRVS or Salvation Army or other voluntary organisation. There are no national standards or national arrangements. It all depends on the local situation. Hence for the Category 1 and 2 responders to inform all the voluntary sector organisations who might conceivably respond is very difficult.

In addition, partnerships can be variable because they are based on relationships between individual people.

Voluntary organisations are of different sizes. For example, WRVS only has 12 paid managers across the country, so for them it would be easy to email or text probability information. The Red Cross, on the other hand, has more staff in a county than WRVS has in the whole country, so the logistics of disseminating information down to the local level quickly would be entirely different.

D2.2 Different ways in which professional partners currently use probabilistic information

A plenary session was held to discuss ways in which the professional partners at the workshop currently make use of probabilistic information. Feedback from the sector groups showed that information about uncertainty is used in different ways:

- Probabilistic information (e.g. on chemical hazards) gives statutory responders early ‘heads up’ so that they can plan resources.
- Responders have to act on uncertainty (inaction is not an option). They have to make decisions about where to respond.
- Category 1 responders have to justify action after the event:
  - staff are aware that there could be a public enquiry;
  - a wrong call has long-term impact on credibility;
  - this puts a lot of pressure on staff.
- Utility companies use probabilities a lot to justify investment planning and spending public money. Some cover areas crossing many local and

regional authority boundaries, so they get information from multiple sources.

- Voluntary organisations are alerted nearer time and with greater certainty. However, volunteers do not necessarily mind being put on standby as it underlines their importance: voluntary organisations want to be called out.

The plenary expressed some concerns about the use of probabilistic information:

- How this might be used by the media: the media can have an influence in amplifying incidents.
- It could impact on the take up of flood warnings, which is low even after a flood incident (e.g. as seen in Carlisle).
- There is a risk of the 'cry wolf' syndrome.
- There was a concern that probabilistic warnings might be seen to take decisions out of professional partners' hands, obliging them to take action: there would be a sense of losing control.
- This is in the context of heightened public expectation of risk being prevented – members of the public tend to say, 'why didn't you do what it said on the tin?'

There was a discussion on the significance of experience in interpreting probabilistic information: experience was felt to be important but cannot always be relied on, especially in events which take place over an extended time period such as a few days (as people have to go off shift during the event). Some organisations, like the police, have better systems today for transferring experience.

D2.3 Uncertainty and probability in relation to flood warnings

For this session, participants worked in locality-based groups as follows:

- North of England
- Midlands and East Anglia.

North of England group

The group discussed the way in which warnings are currently received and the way that they respond to different types of warnings. Multi-agency response on the part of ambulance, police, local council emergency planning services, voluntary organisations and the health sector was seen as very important. Warnings are received by and action starts with key personnel. These then cascade down if necessary. The following points were made:

- The decision to cascade depends on probability (i.e. the information on likelihood from Environment Agency/Met Office and information on consequences from responders' own experience.
- Multi-agency coordination is often virtual (e.g. ringing around) before escalating to more formal response.

- Personal discretion on the level of action to take is important.

Some of the issues or difficulties raised by using information about uncertainty are:

- Whether to escalate the response because there is a fear of 'cry wolf'. Here the problem is not so much with other responders, but with the public. The responders felt that the people hate false alarms and have unrealistic expectations.
- Prioritising where to put efforts.
- Taking account of the possibility that action may have negative consequences. For example, in Morecambe storm boards have to be put up, but if no flooding occurs, the storm boards stop access to the beach.
- In Barnsley residents complained about the council mobilising resources when flooding did not occur: council resources were wasted.

Responders identified their priorities for action as follows:

- Minimising risk to life.
- Provision of essential services (e.g. water and electricity).
- Avoiding risks to services (e.g. reservoirs).
- It was agreed that a multi-agency team was in the best position to decide on action in case of severe flood warning (likely to affect a large number of properties as well as posing a risk to life/safety).

Midlands and East Anglia group

The group included utilities, local authorities, ambulance service and voluntary sector organisations.

As well as the Environment Agency warning, other sources of information are used to verify and build a more detailed picture of what is going to occur. Internet sources are important but may lag behind the most up-to-date information and also national web pages may convey a different message or level of information compared to regional or local pages. Responders also tended to rely on ground staff to check for evidence of actual or impending flooding to support their decision-making.

There was a lot of discussion about the role of interpretation of warnings. Often the warning contains very little information because it is simply based on a certain trigger level (e.g. water level) being reached. The responders need to know what has happened in the previous hours in the run-up to the flood and what is going on in real-time further upstream. Responders often use their local contacts to try to fill in the missing details. Often the main uncertainty concerns the period immediately after heavy rainfall and whether it is likely to result in flooding.

The importance of multiple information sources came out very clearly. Examples included the Maritime and Coastguard Agency for tidal surge information and local authority emergency planners, who themselves are receiving information from the Highways Agency, etc. If others are already responding, you are more likely to act! The Met Office may also be contacted for location-specific information not available from standard sources such as websites.

The situation is slightly different for the voluntary sector organisations. Warnings come via email and these will then be checked using the internet. Ultimately, the decision to act depends on what the Category 1 responders request them to do. If the Category 1 responders have more timely and accurate information, the voluntary organisations will be able to respond more readily.

For the water companies, trigger levels such as flood watches and even warnings are too low to act on. Such warnings are considered to be too frequent and often too inaccurate to rely upon on their own or to act upon. There was a real concern about getting it wrong and alarming people unnecessarily. The group also highlighted some uncertainty around what the wording of the warnings actually means to people.

D2.4 Views of professional responders on different types of probabilistic flood warnings

For this session, participants worked in the same locality-based groups as before. Participants gave their views on a series of suggested probabilistic flood warnings and considered how this kind of change in warnings might affect their work.

North of England group

The following summarise the comments made by the north of England group:

- There was a worry that probabilistic information could just appear to be more vague, rather than more useful. Probabilistic warnings will give an earlier warning but this may not be a good idea if it gets everybody up and running but then tails into nothing.
- The importance of the local level was emphasised. Any flood information ultimately has to be interpreted at the local level so it would make it a more effective tool for local responders if the information that the probabilistic warning is based on is sent along with it. Some rivers or parts of rivers may respond to rain very quickly, while others may take days to overflow. There will be a challenge to apply the probabilistic warning to the local situation.
- Having a graphic representation would be very beneficial because it would allow agencies to focus their resources and determine what resources are required. This could warn people downstream while mobilising resources upstream.
- Better flood prediction, however, could put local authorities under pressure because they may not always have the resources to act on the warnings.
- Probabilistic information may be useful for utilities to defend their actions in the aftermath of a flood.
- Each organisation will have its own level at which it will be prepared to act.
- It may be useful to have a transition period where both types of flood warning are made available concurrently so that local decision-makers can gauge how to use the probabilistic information.

- The map was seen to be very useful, especially if it could be scanned at regional level and local levels.
- If probabilistic information is to be sent out, it will be very important to have access to Environment Agency forecasting personnel.

Midlands and East Anglia group

The following summarise the comments made by the Midlands and East Anglia group:

- The current flood warning system is inadequate as it provides insufficient information and does not assist decision-making.
- There is confusion over what the trigger levels of issuing a warning of any given sort actually are.
- It is as much about working out the likely consequences of a flood as it is about estimating its probable occurrence.
- There needs to be a balance of information. There is not enough information at the moment but equally too much would be a problem as well.
- Warnings should be tailored to the needs and requirements of the different recipients.
- There is a need to boost overall confidence in the use of flood warnings by comparing predictions with actual flood events.
- There is a need for closer inter-agency working in the design and development of any new warning system.

D2.5 Concluding plenary session comments

Looking at how probabilistic flood warnings could be developed, participants felt that in part this is about generating a new kind of information on flood risk, but it is also about displaying and disseminating that information effectively.

The development of a new system is a big challenge and there needs to be a pilot scheme to test, prove and improve it before it is applied across the country. The system should be tailored to reflect the different information requirements of the various agencies and other users. In developing the system the Environment Agency needs to engage all users, including both emergency planners and those involved in managing flood incidents.

Appendix E Notes from the communicating and disseminating probabilistic flood warning workshop August 2008

E1 Communicating and disseminating probabilistic flood warnings

Workshop Write-up

Tuesday 5th August 2008

Facilitators: Paula Orr & Clare Twigger-Ross (CEP) and Darren Lumbroso (HR Wallingford)

Attendees:

1. Michelle Partridge, Flood Forecaster (Technical Specialist), Anglian
2. Louise Guy, Flood Warning Duty Officer (& FIM Team Leader), Thames/South East Area
3. Tim Preece, Flood Warning Duty Officer, Thames/South East Area
4. Emma Hoyle, Flood Warning Duty Officer, Thames/West Area
5. Nathan Fahy, Operations Duty Officer, Thames/South East Area
6. Dan Brown, Flood Warning Duty Officer, Wales
7. Caroline Watson, Flood Warning Duty Officer, Upper Trent, Midlands
8. Mike Anderson, Flood Warning Duty Officer/Operations Duty Officer/Emergency Duty Officer, North Area, NW

Expectations of workshop

- I would like to understand how accurate the forecasts and subsequent warnings will be. Especially for upper-catchment and pluvial flooding prone areas.
- To understand the difference between probabilistic forecasting and probabilistic warning.
- More clarity on potential uses of probabilistic flood warnings.
- Better understanding of how we will communicate warnings to professional partners and the public.

- A better understanding of how probabilistic flood warnings are issued and what they are based on. Does it increase the chance of not issuing a flood warning and then property flooding occurring?

Morning 1

Notes: Professional partners => Category 1 and Category 2, media, 3rd party operators for structures. Some flood wardens.

Morning exercise 2

- *Does the schematic diagram reflect reality?*
- *Differences between regions/areas.*
- *Points where personal judgement has to be used.*
- *How confident do attendees feel when giving a flood warning*
  - FFDO/FMDO would use trigger to issue information that threshold to be reached. Info to FWDO who makes decisions *either* on judgement *or* automatically; info goes to ODO and possibility to EDO.
  - ODOs notified when watch in place – ODO will discuss with FWDO – e.g. timing and actions required (e.g. FWDO/ODO may have to take actions).
  - Public receiving information automatically on thresholds reached:
    - trial in two places in Thames, currently in evaluation
    - Anglian – notification to caravan parks, therefore Flood Watch; also info to IDBs
    - Thames – warnings to contractors, for rostering
    - information to farmers.

Forecast and confidence on it

- (Forecasts raise) questions, e.g. do we need Incident Room? etc.
- Advises what we are operating (ODO => MDO & FWDO).
- Discuss impacts on the ground of Flood Watch/Warning – what would be needed
  - NB – no set procedure – depends on Duty Officer, relations with others – not much consistency.
- Sometimes discuss public relations (vexatious customers, MPs, etc.) Involving management can work both ways – decisions taken away from FWDO.

How are messages communicated:

Generally telephone

- Except Anglian (strict audit trail involving written warnings as well as recorded telephone communications).
- ODO – records what has been operated.

Contemporaneous log kept by Duty Officer – but should be following procedures (reduces pressure/stress)

- Difference between probabilistic flood warning and just following a trigger.

Points where personal judgement has to be used

Interpretation – difficulty in case of tidal information (South West)

- Low levels of confidence.

How confident do attendees feel when giving a flood warning

External partners

- Depends on level of flooding.
- External partners want information on extent, depth, etc. which FWDO may not have.
- Not all EPs respond to Flood Watch, whereas others want information
  - Think about message/way of communicating.
- Expectation often unrealistic
  - Want (accurate) detail at local, community level
  - 'Don't really know what to think'.

Afternoon 1

Q1. What difference would it make to how flood forecasting and warning staff communicate with each other?

- More information to discuss with forecaster
  - Especially 'worst case scenario' – see from outliers
  - Earlier information on worst case.
- More information to FWDO.

Q2. What difference would it make to how flood warning staff communicate with professional partners?

- Hydrographs – showing professional partners where it might flood and the probability.
- Talk to professional partners earlier – give them longer.
- Professional partners would have 'tools' to see why the Environment Agency has given information – the basis for the decision.

Afternoon 2

Q3. How could this information be put into a flood warning? (and should it?)

- Concern about impact on ground – likely to get more phone calls.
- Banded confidence levels as 1st step (low/medium/high), or likely/less likely (associated with a percentage), but a percentage might give a false sense of accuracy.
- Something similar to Met Office ERA – timing of alerts e.g. 12 hr – 8 hr…….
  - But some rivers react differently.
- What are you asking professional partners (and the public) to do?
  - Link to response.
- Does FLO have to go to Area or to catchment?
  - Could start at higher (Area) level and then down to catchment => community level?

    - But how would you choose the area? It would depend on where you had information.
- What service are we trying to provide? What can we provide? Manage expectations.
- Be careful about warnings with low levels of confidence – some ignoring of Met Office low confidence alerts.

Afternoon 3

Q4. Would workshop attendees need additional guidance to use probabilistic flood warnings effectively?

- Depends on factors.
- Some guidance is needed.

Q5. What are the implications for Operational Duty Officers (ODO and EDO)?

- Make it busier – ODOs will have to respond to more warnings until the system beds in.
- Knock-on effect throughout the system – thresholds.
- More work – if work is done and no event occurs. Knock-on correspondence.

Exercises

Opportunities

- More informed decision-making.
- Provide another decision-making tool for issuing warnings.
- Extra information which could help you make the decision to roster up over a weekend or to open the incident room.
- More information which would help duty officers to make a decision.
- Good opportunity for more detailed and realistic information to be used up as a decision-making tool, as to whether to issue a flood warning or not.
- Set triggers on probability and when to issue will decrease stress on FWDO and they will have more information to communicate with all (disadvantage is that you could be crying wolf a lot and stop people listening).
- The system implementation leads to an improved more automated service allowing duty staff to prepare for the event on the ground.
- Preparedness internal/external.
- Increased lead-time for professional partners to pull resources together.
- More responsibility on professional partners to take action sooner and be better prepared – will improve relationships/communications between responders.
- Hopefully the services will provide a warning service in areas that are prone to quick response rapid flooding, i.e. upper catchments (urban) and even pluvial flooding prone areas.
- It may help you issue general warnings for thunderstorms using just forecast rainfall data
- Useful for rapid responding catchments.

- More self confidence in information being given out, i.e. less subjective/opinion-based information.
- More information can be provided, i.e. different scenarios, both internal and external.
- More emphasis can be placed on professional partners to utilise probabilistic flood warning information……i.e. activate emergency response plans – which is all important flood incident management.
- Highlights the difficulty in providing 100% accurate warnings. This will help educate Professional partners/public and help manage their expectations.
- More information to be open and honest with professional partners.
- Service will help us meet requirements/outputs of Pitt Review and assist our professional partners with an improved service.
- Improved communication between MFDO and FWDO.
- Better understanding of flood risk in Flood Incident Management.
- To take a risk-based approach to Flood Incident Management.
- Understanding flood risk.

Threats

Information overload

- The warning or watch message becomes diluted or confusing for the public and professional partners to the detriment of the current Floodline/Warning service.
- Adding another level of uncertainty into decision-making process.
- Warning message is about getting public to take action. Bringing in probabilities could make this confused and people stop taking action.
- Increased confusion for professional partners and public about action they should take.
- There is a threat of confusing FWDOs over when and what to issue. The number of flood warnings we have to issue is going to treble in the next 2–3 years. Will this not mean even more work in deciding what to issue?

Mis-understanding

- More information could get confused/misinterpreted by professional partners and public.
- It could lead to confusion with members of the public as to what our warnings mean and what we expect them to do – Do I move my furniture if it's 30% confidence?
- Warnings/watches are not clear. They can be misinterpreted and wrong decisions made as a consequence. The system becomes too complicated to implement quickly.
- There is a risk that the work we have done to inform our partners and public of the meaning of a flood warning might be lost.
- There is the risk that people might just ignore a flood warning if the probability is not 100%. Would it be better to have people take action regardless of the probability?
- People's perception may change negatively, i.e. they may think we are guessing and not knowing what is happening.
- Risk people loose respect for Environment Agency and say we don't know what is happening, and stop listening.

- It may be seen by professional partners/media/public that we are wimping out of making a decision we should be best placed to make.

Warnings issued to be on safe side

- The role of duty staff is increased. Requirements to open air and respond out of hours calls impacts on the day to day business. Great expectation stress on personnel for rostered positions.
- Flood warning duty officers will end up turning a probabilistic forecast into a deterministic warning.
- It may be difficult to make the options a probabilistic forecast gives fit in to area warning procedures.
- Low confidence/probability may stop things being issued.

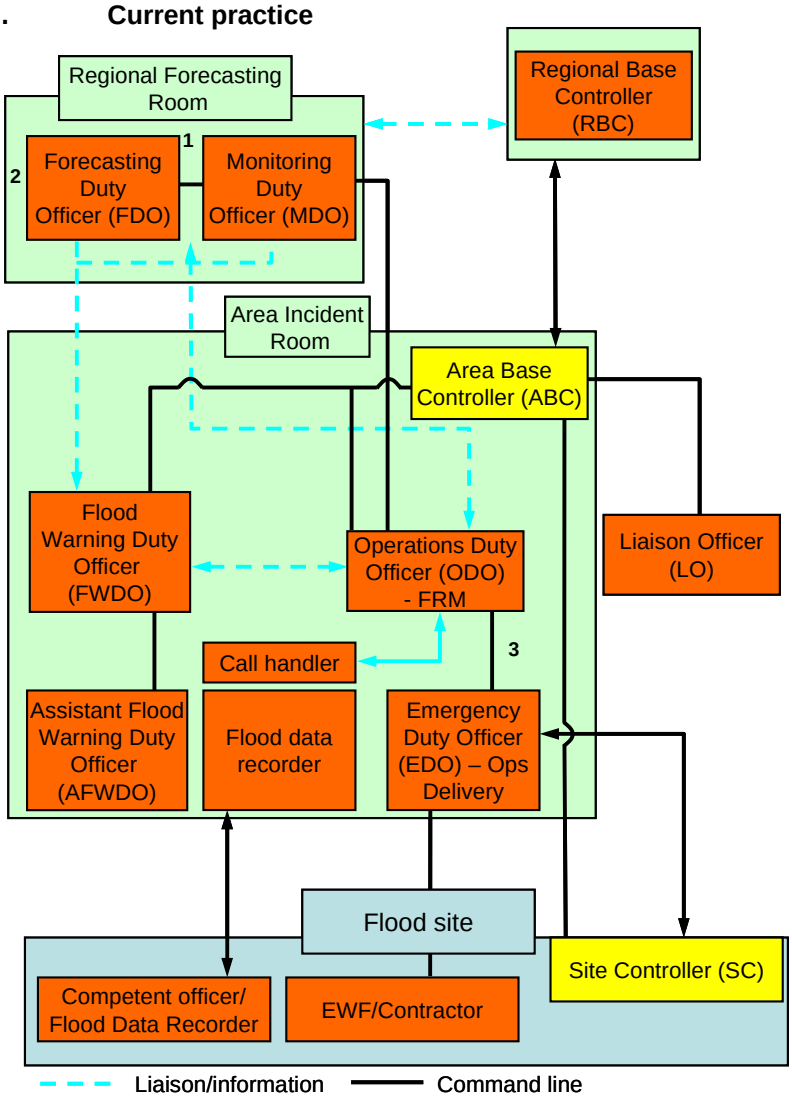
False alarms

- Probabilistic flood warnings could increase the amount of false alarms.
- Interpretation of data – how, internal/external.
- Use of data – will we have set criteria nationally as to when to issue watch/warning based on confidence levels?
- Will public and PPs disregard anything issued under X% confidence?
- More misses/false alarms.

Appendix F Survey of Environment Agency Area flood warning and forecasting staff

Thank you very much for taking the time to participate in this survey. Completing this questionnaire should be done individually and should take about 20 minutes. As it involves commenting on graphics shown in colour, we recommend that you complete the questionnaire online to get the best possible image.

I. Current practice



Notes: 1. Regional MDO and FDO is often a single role and will shortly be merged to M & FDO.
2. In Wales the MDO role is located in the Area Incident Room, not at a regional level.
3. ODO and EDO posts will shortly be merged as Flood Incident Duty Officer (FIDO).

Figure 1 Diagram of the regional and area flood forecasting and warning process.

1. Does Figure 1 reflect the way that you visualise the flood forecasting and warning system? (*Please highlight the appropriate option)*

   Yes, absolutely / Overall, Yes / Overall, No / No, not at all

2. If no, how does your picture of the flood forecasting and warning system differ from the diagram?
   (*Describe the main differences*)

3. What is your post in the Flood Forecasting and Warning process?
   Title (as shown in the diagram)……
   Title you use (if different) ……..
   Title of day job……

4. How long have you been in this post? …….. years
   How long have you been working on flood forecasting and/or warning in any part of the Environment Agency? …….. years

5. Does your post involve interpreting flood forecast information? (either to alert others or to take action yourself)
   (*Please highlight the appropriate option)*

   Yes / To some extent / No

If you answered No, please go to Question 7.

6. Do you currently take uncertainty into account in deciding what warning to issue *or* what operational response to action?
   (*Please highlight the appropriate option)*

   Y/To some extent/N

   If Yes, or To some extent, can you describe briefly how you take uncertainty into account?
7. Do you use any information – such as action thresholds or result thresholds[2] – to trigger flood warnings or action operational response?
   Y / N
   If Yes, how do you use them? (*Describe briefly*)

8. Are you aware of probabilistic flood forecasting? Y / N
   If Yes, describe what you know about probabilistic flood forecasting:

   What level of understanding would you say you have? (*Please highlight the appropriate option)*
   Little / Some / Full

II. PROBABILISTIC INFORMATION

In the next section you will see a series of figures for which there are similar questions.

[2] In the simplest terms a threshold is a pre-defined value that can be crossed. It can be a level or point at which something would start or cease to happen or come into effect. *Action thresholds:* Crossing these thresholds instigates some form of action. Can be either to take action or to consider taking action. *Result thresholds:* Any required action should have taken place by the time these thresholds are crossed in real-time. There is no in-built lead-time.

9. Looking at the information presented in Figure 2 below

(a) How useful would you find this information in a flood event? (*Please highlight the appropriate option*)
Very useful / Quite useful / Not very useful / Not at all useful

(b) How useful do you think professional partners would find this information in a flood event? (*Please highlight the appropriate option*)
Very useful / Quite useful / Not very useful / Not at all useful

(c) How useful do you think the public would find this information in a flood event? (*Please highlight the appropriate option*)
Very useful / Quite useful / Not very useful / Not at all useful

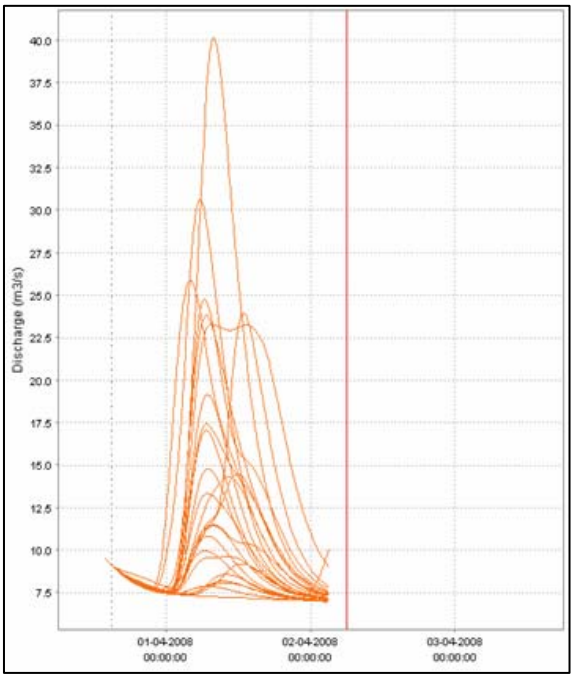


Figure 2 Possible representations of probabilistic flood hydrographs in the Environment Agency National Flood Forecasting System.
Version 1: Spaghetti plot.

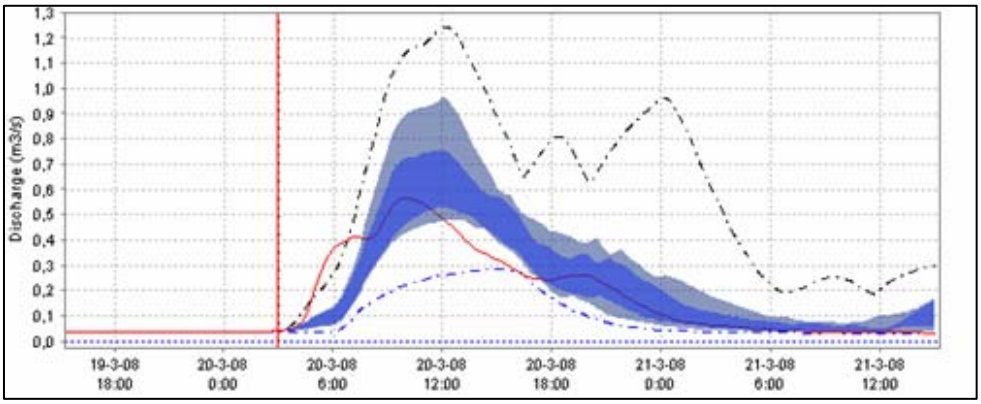


Figure 3 Possible representations of probabilistic flood hydrographs in the Environment Agency National Flood Forecasting System
Version 2: Probability plume

10. Looking at the information presented in Figure 3 above

(a) How useful would you find this information in a flood event? (*Please highlight the appropriate option*)
Very useful / Quite useful / Not very useful / Not at all useful

(b) How useful do you think professional partners would find this information in a flood event? (*Please highlight the appropriate option*)
Very useful / Quite useful / Not very useful / Not at all useful

(c) How useful do you think the public would find this information in a flood event? (*Please highlight the appropriate option*)
Very useful / Quite useful / Not very useful / Not at all useful

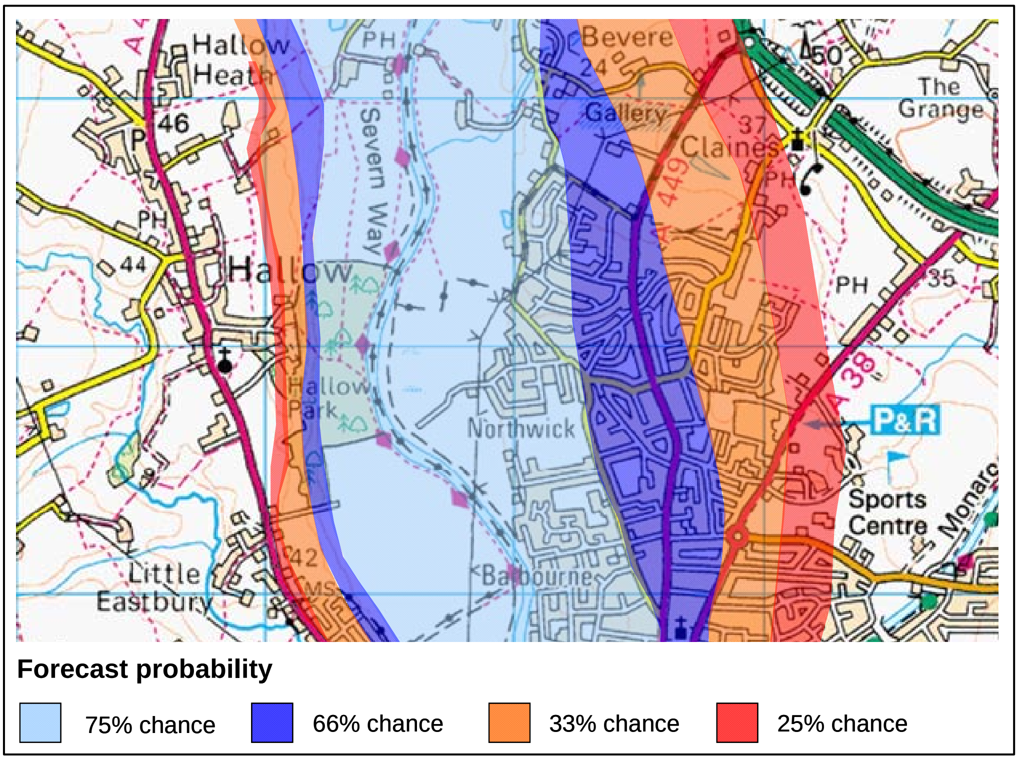


Figure 4 Probabilistic forecast extent map.

11. Looking at the information presented in Figure 4

(a) How useful would you find this information in a flood event? (*Please highlight the appropriate option*)
Very useful / Quite useful / Not very useful / Not at all useful

(b) How useful do you think professional partners would find this information in a flood event? (*Please highlight the appropriate option*)
Very useful / Quite useful / Not very useful / Not at all useful

(c) How useful do you think the public would find this information in a flood event? (*Please highlight the appropriate option*)
Very useful / Quite useful / Not very useful / Not at all useful

12. How easy to understand do you think the different groups shown in the following table would find the information presented in each of the figures? (*Please highlight the appropriate option, where 1 = Very easy to understand 2 = Quite easy to understand 3 = Not easy to understand 4 = Not able to understand)*

	Figure 2				Figure 3				Figure 4			
Environment Agency staff	1	2	3	4	1	2	3	4	1	2	3	4
Professional partners	1	2	3	4	1	2	3	4	1	2	3	4
Members of the public	1	2	3	4	1	2	3	4	1	2	3	4

13. Have you come across other methods for communicating probabilistic information about flooding (or another hazard)?

    Please describe below:

14. Below is some text that has been used within the Extreme Rainfall Alert [3] project with professional partners

Early alert

Start of event: 19.30 local time on Monday 9 June 2008
End of event: 23.30 local time on Monday 9 June 2008

Rainfall amounts of over 50 millimetres in 6 hours are expected.
Event total accumulations of 90 millimetres are possible.

Extreme rainfall may lead to surface water flooding.
Consider activating your emergency procedures.

The thresholds for issuing Extreme Rainfall Alerts are:

[3] The ERA project is a joint partnership project between the Met Office and EA that is issuing warnings based on probabilities to opted-in Category 1 and 2 responders.

	Extreme Rainfall Alerts		
	Advisory	**Early Alert**	**Imminent Alert**
Probability of thresholds being exceeded. Either: • 30mm per hour, • 40mm in three hours or • 50mm in six hours	Very low >=10%	Low >=20% <40%	Moderate >=40%
Guidance to responders on receipt of an ERA	Extreme rainfall may lead to surface water flooding. **Be prepared should the situation worsen.**	Extreme rainfall may lead to surface water flooding. **Consider activating your emergency procedures**	Extreme rainfall may lead to surface water flooding. **Activate your emergency procedures**

Do you think that receiving this type of information about the probability of rainfall (*section underlined*) would improve your work? (*Please highlight the appropriate option*)

Yes/No

Please explain why….

III. OUTCOMES

15. Below is a list of some of the benefits which might be provided by probabilistic flood information. Please can you:
    - Read through them
    - Add any more that you are aware of
    - Indicate their importance **to you**, where 1 = very important 2 = quite important 3 = not very important 4 = unimportant

Benefits	Importance			
Show user the degree of uncertainty related to the meteorological inputs in the flood forecast	1	2	3	4
Provide extra information which could help to make the decision to issue a flood warning	1	2	3	4
Increase lead times giving Environment Agency staff more time to prepare and assist with issues such as resource planning and management	1	2	3	4
Increase lead times helping professional partners to plan the resources they need to address an incident more effectively	1	2	3	4
Enable the provision of a flood warning service in rapid response catchments	1	2	3	4
Provide more confidence for FWDOs in the information that judgments are based on	1	2	3	4
Make the flood forecasting process more transparent thus highlighting complexity to professional partners	1	2	3	4
Assist with the operation and deployment of demountable defences	1	2	3	4
Assist with the operation of flood barriers and gates	1	2	3	4

16. The following table lists some concerns that have been expressed about probabilistic flood warnings. How important are each of these concerns **to you**?
Please highlight as appropriate where 1 = very important 2 = quite important 3 = not very important 4 = unimportant
If you have any other concerns about probabilistic flood information then please add them to the table

Concerns	Importance			
The Environment Agency's computer systems will not be able to cope with the increased data and model run times	1	2	3	4
A single nationally-defined set of probabilistic products will not meet regional needs	1	2	3	4
There may be difficulties communicating probabilistic information internally within the Environment Agency	1	2	3	4
Professional partners will not understand probabilistic warning information	1	2	3	4
Members of the public will not understand probabilistic warning information	1	2	3	4
The introduction of probabilistic flood forecasting and warning will mean that Agency staff will no longer be able to use their own judgment	1	2	3	4
It will add another layer of uncertainty into the decision making process	1	2	3	4
Providing uncertainty information may suggest that the Environment Agency does not know what is happening and this may affect the Agency's reputation	1	2	3	4
Warning may be issued "just to be on the safe side" when probabilities are very low	1	2	3	4
There will be more false alarms	1	2	3	4
It is difficult to present probabilistic forecasting and warning information in a concise manner	1	2	3	4

17. Thinking about your area and how it functions during a flood event, who do you think would benefit from access to probabilistic information on flooding during a flood event? (*in each case, please highlight the appropriate option)*

Environment Agency flood warning duty officers
Yes, definitely / Yes, probably / Probably not / Definitely not

Environment Agency flood forecasting duty officers
Yes, definitely / Yes, probably / Probably not / Definitely not

Environment Agency operations duty officers
Yes, definitely / Yes, probably / Probably not / Definitely not

Environment Agency emergency duty officers
Yes, definitely / Yes, probably / Probably not / Definitely not

Environment Agency Senior Managers
Yes, definitely / Yes, probably / Probably not / Definitely not

Professional partners – Local Authority emergency planners
Yes, definitely / Yes, probably / Probably not / Definitely not

Professional partners – Emergency services, including the police
Yes, definitely / Yes, probably / Probably not / Definitely not

Professional partners – Category 2 responders
Yes, definitely / Yes, probably / Probably not / Definitely not

Business stakeholders
Yes, definitely / Yes, probably / Probably not / Definitely not

Members of the public
Yes, definitely / Yes, probably / Probably not / Definitely not

The media
Yes, definitely / Yes, probably / Probably not / Definitely not

IV ADDITIONAL COMMENTS

18. If you have any other comments or observations about probabilistic flood warnings, please include them here.

Please return to: p.orr@cep.co.uk
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Appendix G Overview of the survey results of the Environment Agency Area flood warning and forecasting staff

G1 Section I: Background and current practice

G1.1 Diagram of the flood forecasting and warning system

The diagram of the flood forecasting and warning system (Appendix F, Figure 1) was generally felt to be a good representation of what happens in practice, with just over 81% of responses indicating that the diagram reflected the system ‘Absolutely’ or ‘Overall’.

The main ways in which current practice was seen as differing from the figure are listed in Appendix E. These are summarised here:

- The relationship between regional-level forecasters and area-level Flood Warning Duty Officers (FWDOs) should not be described as a command line. Monitoring and Forecasting Duty Officers (MFDOs) see themselves as providing a service for FWDOs, which FWDOs can decide to use or not.
- FWDOs liaise with regional MFDOs and then pass information on to Operations Duty Officers (ODOs that are now becoming Flood Incident Duty Officers, FIDOs) and others. There is little or no direct liaison between ODO/FIDO and MFDO.
- The diagram does not provide much information on the Regional Incident Room and its relationship with the other actors. But the responses received suggest that the relationship between the regional and area levels is not one of command.
- There is a need for clarification of the roles of Call Handler, Communications Officer and Flood Data Recorder (FDR) in the Area Incident Room (AIR): some respondents were not familiar with these roles. In particular the AIR box does not reflect the Call Handler’s further liaison with the FDR or new role of Communications Officer. One respondent described the relationships between these officers in the North East: ‘The Communications Officer in NE liaises directly with FWDO, FDR, ODO & ABC and cascades information to the Call Handler and also ascends information back to the other duty roles.’
- The Emergency Duty Officer (EDO) and ODO roles are to be combined in the FIDO.

- Certain locations have slightly different systems: this was highlighted in the cases of Wales and the Thames Barrier.

G1.2 Profile of respondents

- There was a wide variation in the length of service of those responding to the questionnaire: while the average length of time respondents had worked on flood incidents was 5 years, this included people with up to 36 years of service and others who had only been in the Environment Agency for three months.

When asked whether their post involved interpreting flood forecast information, over two-thirds of people responded positively, and a further quarter said that this was involved to some extent.

Asked how they took uncertainty into account in deciding what warning to issue or what operational response to action, respondents mentioned a range of aspects including:

- Reliability of the information on which judgement is based.
- Developing Flood Warning Thresholds using a variety of tools including surveys and modelling.
- Use of subjective judgement based on experience: e.g. 'I use a subjective assessment of likelihood based on the uncertainty further up the chain (e.g. weather forecast uncertainty), the uncertainty of the forecasts I produce and experience/local knowledge.'
- Some responses pointed to a tension between professional judgement and the use of defined thresholds: 'Usually this would involve a judgement decision on issuing a warning; however, recent guidance means that we should issue warnings if a predicted threshold is reached, regardless of uncertainties.'
- Action to confirm forecast information or prepare for response.
- Use of 'What if' scenarios for planning.
- Looking at the confidence score issued with the warning is very useful when deciding whether to issue Flood Watch, and also deciding whether to wait for more detailed information closer to the event.
- The situation in Wales is different from England: rainfall forecast products are too uncertain for short-term forecasting model use for large parts of Wales so most forecasts are based on observed rainfall.

- The majority of respondents use thresholds (action thresholds or results thresholds) to trigger action.
-
- In relation to their awareness of probabilistic forecasting, most respondents said they had some understanding of probabilistic flood warnings, but only 25% felt confident enough to say that they had 'full' understanding.

G2 Section II: Probabilistic information

The tables below present respondents' opinions on the spaghetti plot presentation of probability (Appendix F, Figure 2).

G2.1 Presentation: Spaghetti plot 1

The majority of respondents felt that the spaghetti plot presentation was not very or not at all easy to understand for professional partners and members of the public; probably as a result, it was also felt that the presentation would be not at all or not very useful for these audiences. Respondents were more divided in their views of the usefulness of the presentation for Environment Agency staff, with 46% stating that it would be very or quite useful. Further analysis of the data showed that Operations Duty Officers (or Flood Incident Duty Officers) had expressed the strongest support for this presentation.

Table G.1 Ease of understanding of spaghetti plot presentation of probabilistic information.

	Ease of understanding for:		
	EA staff (%)	**Professional partners (%)**	**Public (%)**
Very easy to understand	11	0	0
Quite easy to understand	35	8	2
Not easy to understand	34	34	15
Not able to understand	18	54	80
Did not respond	1	0	3
TOTAL	100%	100%	100%

Table G.2 Usefulness of spaghetti plot presentation of probabilistic information.

	Usefulness for:		
	EA staff (%)	**Professional partners (%)**	**Public (%)**
Very useful	14	0	0
Quite useful	35	0	5
Not very useful	41	25	19
Not at all useful	8	75	76
Did not respond	1	0	0
TOTAL	100%	100%	100%

G2.2 Presentation: Probability plume

A large majority of respondents felt that the plume presentation (Appendix F, Figure 3) would be very or quite easily understood by Environment Agency staff and that the information would be useful for staff. Respondents were less sure that the presentation would be understood by professional partners and virtually none thought that it would be understood by members of the public. Associated with this, most respondents said that this presentation would not be useful for members of the public and few thought it would be useful for professional partners.

Table G.3 Ease of understanding of plume presentation of probabilistic information.

	EA staff (%)	Professional partners (%)	Public (%)
Very easy to understand	31	0	0
Quite easy to understand	44	30	4
Not easy to understand	20	51	21
Not able to understand	4	18	75
Did not respond	1	1	0
Total	100	100	100

Table G.4 Usefulness of plume presentation of probabilistic information.

	EA staff (%)	Professional partners (%)	Public (%)
Very useful	31	0	0
Quite useful	46	32	10
Not very useful	13	41	31
Not at all useful	6	21	56
Did not respond	4	6	3
Total	100	100	100

G2.3 Presentation: Map

The map presentation (Appendix F, Figure 4) was generally felt to be easy to understand and useful: over 85% of respondents said it would be very or quite useful for Environment Agency staff and professional partners, and 62% felt it would be easy for members of the public to understand. As a result, almost 90% of respondents said that the maps would be very or quite useful to Environment Agency staff and

professional partners, with 62% saying that they would be useful for members of the public.

Table G.5 Ease of understanding of map presentation of probabilistic information.

	EA staff (%)	Professional partners (%)	Public (%)
Very easy to understand	76	48	17
Quite easy to understand	18	39	45
Not easy to understand	1	8	28
Not able to understand	1	1	7
Did not respond	3	3	3
Total	100	100	100

Table G.6 Usefulness of map presentation of probabilistic information.

	EA staff (%)	Professional partners (%)	Public (%)
Very useful	49	54	23
Quite useful	39	35	42
Not very useful	6	6	18
Not at all useful	3	3	11
Did not respond	3	3	6
Total	100	100	100

G2.4 Early Rainfall Alert (ERA) project

When asked for their reactions to the way probabilistic information is presented in the Early Rainfall Alert (ERA) project communications, almost 75% of staff thought that receiving this type of information about the probability of rainfall would improve their work. Among the reasons given were:

- Provide an early ‘heads up’.
- Help resource planning, preparations and prioritising time.
- Make senior management aware of weather conditions.
- Give time to run ‘what if’ scenarios.
- Particularly useful for flashy catchments so that warnings can be issued in advance.

- However, not all respondents felt that this type of information would improve flood warnings and many of those who replied positively also had comments. Among the concerns mentioned were:

- Problems of levels of confidence and the impact of false alarms:
  - there is too much uncertainty to warrant action, both for Environment Agency staff and for professional partners;
  - risk of the 'cry wolf' syndrome, if warnings are repeatedly issued but no flooding occurs;
  - forecasts are not accurate enough;
  - risk that those receiving the information will misunderstand or misinterpret it.
- Inadequate information: some respondents felt that the information is not specific enough, in particular that the area covered is too large; others said that the alert duplicates information they already receive.
- There were conflicting views on whether receiving this kind of alert would change Environment Agency staff's work: several respondents said that they would not take any action on receiving information of this kind; others it would mean that they would run 'what if' scenarios and check catchment conditions. One respondent referred to the potential problem of information overload making decision-making more difficult.

G3 Outcomes

G3.1 Potential benefits of probabilistic flood warnings

The survey included a list of the potential benefits of probabilistic flood warnings, and respondents were invited to say how important each benefit is. Overall, the benefits considered to be most important were as listed below (percentages refer to the number of respondents saying the benefit was Very Important):

- Increase lead times giving Environment Agency staff more time to prepare and assist with issues such as resource planning and management (55%).
- Enable the provision of a flood warning service in rapid response catchments (55%).
- Show user the degree of uncertainty related to the meteorological inputs in the flood forecast (48%).
- Provide extra information which could help to make the decision to issue a flood warning (44%).
- Increase lead times helping professional partners to plan the resources they need to address an incident more effectively (44%).

The complete results are given in Table G.7.

Table G.7 Potential benefits of probabilistic flood forecasting and warning information.

Benefits	Importance (%)				
	1	2	3	4	No response
Show the user the degree of uncertainty related to the meteorological inputs in the flood forecast	47.9	36.6	12.7	2.8	0.0
Provide extra information which could help to make the decision to issue a flood warning	43.7	36.6	12.7	5.6	1.4
Increased lead times giving Environment Agency staff more time to prepare and assist with issues such as resource planning and management	54.9	32.4	7.0	4.2	1.4
Increased lead times helping professional partners to plan the resources they need to address an incident more effectively	43.7	31.0	12.7	11.3	1.4
Enabling the provision of a flood warning service in rapid response catchments	54.9	23.9	7.0	11.3	2.8
Providing more confidence for FWDOs in the information that judgements are based on	35.2	38.0	18.3	7.0	1.4
Making the flood forecasting process more transparent thus highlighting complexity to professional partners	19.7	39.4	23.9	15.5	1.4
Assisting with the operation and deployment of demountable defences	21.1	26.8	28.2	21.1	2.8
Assisting with the operation of flood barriers and gates	28.2	31.0	23.9	12.7	4.2

Note: 1 = very important; 2 = quite important; 3 = not very important; and 4 = unimportant.

G3.2 Concerns about probabilistic flood warnings

The following concerns were identified as 'Very Important' by over one-third of respondents (percentages refer to the number of respondents saying the benefit was Very Important):

- Members of the public will not understand probabilistic warning information (54%).
- The Environment Agency's computer systems will not be able to cope with the increased data and model run time (51%).
- Warning may be issued 'just to be on the safe side' when probabilities are very low (48%)
- There will be more false alarms (48%).
- A single nationally-defined set of probabilistic products will not meet regional needs (39%).
- Professional partners will not understand probabilistic warning information (40%).

The complete results are given in Table G.8.

Table G.8 Concerns expressed about probabilistic flood forecasting and warning information.

Benefits	Importance (%)				
	1	2	3	4	No response
The Environment Agency's computer systems will not be able to cope with the increased data and model run times	50.7	23.9	16.9	7.0	1.4
A single nationally-defined set of probabilistic products will not meet regional needs	40.0	34.3	20.0	4.3	1.4
There may be difficulties communicating probabilistic information internally within the Environment Agency	33.8	42.3	21.1	0.0	1.4
Professional partners will not understand probabilistic warning information	39.4	36.6	18.3	1.4	4.2
Members of the public will not understand probabilistic warning information	53.5	21.1	18.3	2.8	4.2
The introduction of probabilistic flood forecasting and warning will mean that Environment Agency staff will no longer be able to use their own judgement	26.8	23.9	35.2	12.7	1.4
It will add another layer of uncertainty into the decision-making process	25.4	26.8	31.0	12.7	4.2
Providing uncertainty information may suggest that the Environment Agency does not know what is happening and this may affect the Environment Agency's reputation	25.4	28.2	26.8	16.9	2.8
Warning may be issued 'just to be on the safe side' when probabilities are very low	47.9	25.4	16.9	5.6	4.2
There will be more false alarms	47.9	25.4	15.5	9.9	1.4
It is difficult to present probabilistic forecasting and warning information in a concise manner	31.0	46.5	19.7	0.0	2.8

Note: 1 = very important; 2 = quite important; 3 = not very important; and 4 = unimportant.

Appendix H Environment Agency workshop on probabilistic flood warning on 12 November 2008

H1.1 Introduction and workshop objectives

The Environment Agency is looking at ways of providing flood warnings and information about flooding issues with as much notice at possible, so that those involved can take the necessary actions. With such advanced notice, however, comes some uncertainty in predictions. The Environment Agency needs to understand how the introduction of this kind of information might affect its own staff as well as external stakeholders, to explore potential risks and benefits and to identify any conditions required to make this change effective. As part of a Defra/Environment Agency Science project on Communicating Probabilistic Flood Warnings, a series of activities were organised to get staff input, including a workshop and a survey.

The purpose of the 12 November workshop was to report back on the findings of the survey and other elements of the Science project and to provide an opportunity for staff to develop ideas about what the Environment Agency could do to realise the potential benefits of using probabilistic information in flood warnings, and how it could address some concerns that have been raised. The information generated will be fed into an appraisal of the options for introducing probabilistic flood warnings.

H1.2 Participants

Invitations were sent to the 71 members of staff who participated in the Environment Agency staff survey between August and September 2008 (see Appendices F and G)and to the eight who attended an initial workshop held in August (see Appendix E). Efforts were made to ensure a broad representation from across the Environment Agency's regions and flood warning staff. In the event, all regions were represented and participants included staff from:

- Flood Monitoring and Forecasting
- Flood Warning
- Flood Incident Duty Officers.

Table H.1 shows the range of participants.

Table H.1 Participants, by region and post.

Region	Post		
	Flood Warning Duty Officer	Monitoring and Forecasting Duty Officer	Flood Incident Duty Officer
Anglian	1	1	
Midlands	1	2	
North East	2	1	1
North West	1	-	-
Southern	1	1	-
South West	-	1	-
Thames	1	4	-
Wales	1	1	-
Unspecified	2	1	-
TOTAL	**10**	**12**	**1**

A full list of participants is provided below in Table H.2.

H1.3 Programme

The programme, given below, included presentations, facilitated group discussions and facilitated plenary sessions.

The main points from the discussions are summarised below.

Small group session 1: Discussion of the findings of the Environment Agency Staff Survey

Following a presentation on the findings of the survey of Environment Agency staff, participants broke into four small discussion groups.

Some participants expressed surprise at the number of staff who reported that they were involved in interpreting or making judgements on the basis of information about flooding. In discussion, it was felt that the kinds of interpretation or judgement would depend on the individual's role: for example, FWDOs know more about public understanding of information about flooding and will take this into account in passing on information. There were mixed reactions to the results of questions about the usefulness of a range of presentations of probabilistic information: while some participants were surprised that people had trouble understanding some of the plots, others were surprised at the numbers who said they did understand them.

Participants felt that more information was needed about the differences between the views of staff in different roles and about regional differences,

When asked what messages they would like to send to senior management about probabilistic flood warnings, the following topics were put forward:

- Rainfall is not the only form of uncertainty, and there may be other things that should be put in place first (e.g. telemetry and equipment such as laptops).
- The provision of probabilistic information or warnings would need to allow for local flexibility.

- There needs to be a discussion about what is an acceptable level of probability.

Plenary session 1: Environment Agency staff survey

In the discussion following the breakout groups, staff emphasised a number of the points made earlier:

- While probabilistic warnings might seem to be an attempt to 'solve complexity', there should not be any attempt to paper it over.
- Introducing probabilistic information into forecasting is a no brainer.
- There is a need for local flexibility, not a 'one size fits all' approach: think about where the product is going.
- Some concern was expressed about the risk of senior managers going over the head of flood warning and forecasting staff and making decisions before information had been interpreted.

Plenary session 2: Research on views of emergency responders and of members of the public

In the discussion following the presentation on the results of two workshops held with emergency responders, a number of points were raised:

- Emergency responders will need to be able to put probabilistic information into context.
- These results suggest there is a need for a two-tier service – one to emergency responders and one to public. This could be confusing.

There was then a presentation on the results of four focus groups with members of the public that had been held in different parts of the country. The subsequent discussion covered the following issues:

- The focus groups seem to be saying that the public is not ready for probabilistic warnings; they are ready for Yes/No information more locally. Emergency responders seem to be more ready for probabilistic warnings.
- Issues raised in the focus groups are similar to those being discussed internally
- The Pitt review seems to suggest that the Environment Agency should start again with flood warnings, but this indicates that there is still a way to go. Flood warning is like drink/driving – you need a long time to get change.
- Changing the codes again would be problematic. We already have problems getting the public aware so probabilistic information would only beuseful for emergency responders and the Environment Agency. Keep the codes and keep it simple.
- The Environment Agency needs to be realistic about what service can be provided.

Small group session 2: Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis of three options for taking forward probabilistic flood warnings

Working in small groups, participants assessed the strengths, weaknesses, opportunities and threats associated with one of three options for taking forward probabilistic flood warnings.

The tables below show the results of each group's analysis.[4]

Option 1 (Group 1)**: Environment Agency staff get probabilistic information (e.g. plume plots)**

Description of the option: The provision of probabilistic information runs in parallel with current warning system

Strengths	**Weaknesses**
• Cheap! • FWDOs get understanding of confidence in forecasts • Don't have to worry about communicating probability information to PP and public • Enables knowing where uncertainty is • Forecasters should have a better understanding of customer base than if they had to go outside organisation • Common language with Met Office • No external change and gives time for people to adjust – for learning and testing • Should be getting better lead time, longer to put things in place • Keeps information in 'expert' hands • Keep in house • Enables a focus on where it can be used to most effect • Simpler to adjust/correct forecast based on experience over deterministic forecast	• EA will always get the blame – because making Y/N decisions. Met Office can always say that EA knew • IF don't progress it to PP and public then service won't go any further – just tweaking around edges • Could be seen to be withholding information if not in public domain • Making a deterministic decision on basis of probability may not seem so 'rational' because does not show the range of possibilities • Without probabilistic information the different locations of people relative to the warning can't be taken into account (near river/not near river) • May know about this earlier but not be able to do anything about it and senior management may want to know why • Still have problem of same info going to PP from Met Office yet getting different forecasts from EA • Potential – expands amount of information to FWDOs to an unacceptable level • Makes it harder for areas which don't have this if this is how 'we' do it • If used to make decisions and give data, EA could spend a lot of time defending decisions

[4] Two groups looked at Option 2.

Opportunities	Threats
• Highlights where there is low confidence and identifies development opportunities • Highlights different types of uncertainty and allows for improvement e.g. models • Able to be ahead in planning responses • Enables scenario planning e.g. if 10% probability [in] 3 weeks [time] what does that mean? • Possibly save time in terms of running scenarios • Externalising expertise to support less experienced staff	• Could be seen to be talking in exactly same terms as Met Office but there is a difference in capability • People may think EA is Met Office • Could be seen to be just repeating Met Office forecasts • Draining to be on 'heads up' unnecessarily • Not enough staff in forecasting and other teams who understand the probabilistic forecasting • Senior management may assume that public and PP also have the same info • Losing sight of actual probability and spending time on very low scenarios • If EA tries to contain it, then info will spread by any means – need to develop a proper process to manage • May see it as at all levels of service BUT not possible to do probabilistic forecasting for all areas • Lack of clarity in terms of how it would use Met Office information. Is it adding to uncertainty? • If best guess of forecaster is outside of 75% of all the probabilities could be difficult: e.g. if EA knows model does not work well at certain levels of rain fall

Option 2 (Group 2**): Environment Agency staff and emergency responders get probabilistic information supported by expert explanation and advice**
Description: similar to the Extreme Rainfall Alert Service information
(**Bold** signifies point directly relevant to professional partners)

Strengths	**Weaknesses**
• **Direct link between forecasters and PP without any interpretation** • Less likely to miss low probability event • **Demonstrating transparency and complexity of system** • Improve EA resourcing • Adding value to forecasts • Forecasters will have more information • **PPs can be better prepared (e.g. put staff on standby)** • **Improve lead time**	• Extra work load for EA forecasters • More likely to have false alarms • **Information overload** • No uncertainty in forecasting models taken account of by National Flood Forecasting System => could remove professional judgement • Issuing of probabilistic flood warning could take the focus away from improving hydrological/hydraulic models
Opportunities	**Threats**
• **To improve PP's planning** • Improve communication at all levels • **Can improve response of PP, e.g. stepped response** • Formalising uncertainty: opportunity internally within EA • **Possibility of managing PPs' expectations** • Chance to invest in forecasting • **Opportunity for cost v loss analysis of decisions/decision-making**	• **[Lack of] equipment and manpower to inform PPs** • Taking away of judgement and local knowledge from forecasters and warners • **Threat of not enough training of PPs** • **Possible inconsistent response from PPs owing to introduction of probability** • Media may pick up on low probability events – more chance of misinterpretation => impact EA reputation and resources • **Formalising uncertainty could be a threat externally with PPs** • EA senior management underestimate resources required • Danger of implementing probabilistic forecasts and warning too early without enough piloting • Demand from senior management to implement too early.

Option 2 (Group 4): Environment Agency staff and emergency responders get probabilistic information supported by expert explanation and advice (like Extreme Rainfall Alert Service)

(Points underlined were considered most significant)

Strengths	**Weaknesses**

• Sharing information – transparent
• Regular provision – understood better by partners
• Education for partners – heightened awareness of uncertainty
  o Take on board language
  o Understanding of different uncertainties
  ▪ Event uncertainty
  ▪ System uncertainty
• Improve quality of uncertainty assessments
• Greater efficiency of assessment process – objective, streamlined
• Increased lead times – better for all, especially senior management
	• Not entirely clear what inputs are – how it would work in different situations, e.g. Wales?
	• Not well defined how uncertainties can be translated into decisions
	• System likely to mean no mitigating action taken in low probability high consequence situations
	• EA doesn't have power to make partners prepare major incident plans – these will be needed or will need to be adapted for probabilistic forecasting and warnings
	• 'one size fits all' approach – no clear advantages for some places, e.g. for Thames Barrier; currently there are regional differences.
	• added pressure on duty staff – need for core rota of trained staff

Opportunities	Threats
• Trial runs within EA using both existing and new systems • Review processes and systems – these will need to be adapted and changed • Feedback results to improve delivery and probabilistic results • Educate partners • Focus efforts to improve forecasts • Be honest with partners about the range of uncertainties • If lowest probability does occur there is evidence to 'cover backs' • Might be able to factor costs into decisions • Align info with other info sources • Take advantage of/modify current changes that are being made to the system	• Different info required at different points • Different audiences need specific information • Could become disinformation if users not prepared • If all sources of uncertainty not included will cause more confusion • Uncertainty about whether uncertainty bounds/range are right • Lowest probability occurs • System overload – computers and people • Creates confusion if information not aligned with other information sources • Warning system might produce contradictory information • Availability of resources – for EA and PPs • Impact on current change

Option 3 (Group 3): Environment Agency staff, emergency responders and members of the public get a developed probabilistic flood warning

Description: Warnings use presentations like percentages with traffic light system, or shading on a map.

(Points underlined were considered most significant)

Strengths	**Weaknesses**
• Transparency • Meeting all needs • Shared risk and responsibility • Keep Pitt happy • Justifies decisions • Increases lead times • Can consider timings (social time, weekends) • Heighten awareness • Good for PP resources • Honesty around risk level	• Shared risk and responsibility • Still based on high confidence so still need data • Do we all understand it? • Too much information going out • Wouldn't solve problem if still generic warnings • Very complex • Massive training need for warners, etc. • How is performance analysed? • When along a timeline are decisions/actions taken?
Opportunities	**Threats**
• Ultimate aim/goal • Could provide opportunity to provide a 'gradient' of actions • Chance to change language • More consistent way of using uncertainty • Plan internally further in advance • Part of long-term programme to build expertise and know-how • Run in parallel to see outcomes	• Would detract or reduce investment from other critical aspects of 'system' • Information demands will increase significantly – resources? • Reduce opportunity to provide 'action' advice (too much information) • Can actions be developed • Raise expectations beyond capability • Need to raise all data quality and availability to some level

Plenary session 3: Outcomes of SWOT analyses

Participants reviewed the main conclusions of each of the SWOT analyses. In general participants did not think that Option 3 (providing probabilistic flood warnings to Environment Agency staff, emergency responders and members of the public) was a good option. One of the groups that assessed Option 2 (providing probabilistic information with interpretation to emergency responders) argued that this option should be implemented by providing the information only to Environment Agency staff to begin with, in order to get the system right internally first.

In a general discussion on how probabilistic flood warnings could best be taken forward, some of the main points raised were:

- It might be advantageous to run probabilistic and deterministic services in parallel, in order to be able to look at results in relation to each other.
- Although probabilistic warnings would make decision-making more effective, providing these warnings might be more resource intensive – this will depend on how much work is done by the system vis-à-vis the forecaster.
- In parallel with the community warning service, a good decision-support system will be needed, otherwise the warning or information will go out too late.

Participants asked whether the introduction of probabilistic warnings would actually change responses on the ground. They felt that if it was unlikely to produce this change, there was little justification for it, even if members of the public and responders 'like it'. There was a concern that resources for probabilistic forecasting and warning would mean fewer resources available for other work such as understanding of hydrological processes.

H1.4 Feedback

1. Participants were invited to complete a feedback form on the value and effectiveness of the workshop. Thirteen feedback forms were returned. All those who responded evaluated the workshop positively in relation to the following aspects:

2. Ability to contribute to discussions
3. Venue

4. All but one participant evaluated the workshop positively in relation to the following indicators:

5. Clarity about the purpose of the probabilistic flood warning project
6. Clarity about how the workshop would contribute to the project
7. Expectations met

8. Most of the participants suggested advice they would give for the successful development of work on probabilistic flood warnings in the future. The two main themes coming through the advice were:
9. the need to trial or pilot the approach before wider roll out
10. the need for continued, effective engagement of staff.

H1.5 Next steps

The results of this workshop and the other elements of the project will be fed back to the Environment Agency as part of the conclusions of the project.

The input received from Environment Agency staff to this project will complement information on the needs and priorities of flood warning staff, for example that obtained from research carried out as part of Science Project SC07007/SR on National Duty Officer Support Assessment.

This research will help the Environment Agency to determine what new methods of warning and disseminating flooding information will most improve responses to flood warnings. It can then start to develop those new services.

Table H.2 List of participants.

NAME	POST	LOCATION (REGION)
Guy Boswell	ABC/FWDO	Wales
Colin Carron	Forecasting & Warning	Thames Barrier
Richard Cross	MFDO	Midlands
Andrew Davies	FWDO	
Julia Farrell	MDO	Southern
Emma Formoy	FWDO	Thames
Mark Fuller	ODO/FIDO	North East
Joanne Grimshaw	FDO	Thames
Matt Hodkin	FWDO	North East
Kate Hudson	FDO	Midlands
Andy Lane	FDO	North East
Wray Morgan	ABC	Midlands
Gavin Robbins	MFDO	Thames
John Sandelands	FWDO	Anglian
Dean Smith	FWDO	Southern
David Snaith	FWDO	North West
Mandy Sullivan	FWDO	
Steve Taylor	FDO	Anglian
Sam Taylor-Heard	FDO	Wales
Adam Tunningley	FWDO	North East
Michael Vaughn	FDO	
George Wright	Technical Specialist	Thames Barrier
Adrian Wynn	MFDO	South West
Facilitators		
Jacqui Cotton	Environment Agency	
Darren Lumbroso	HR Wallingford	
Clare Twigger-Ross	Collingwood Environmental Planning	
Paula Orr	Collingwood Environmental Planning	

Workshop Programme

COMMUNICATING AND DISSEMINATING PROBABILISTIC FLOOD WARNINGS

ENVIRONMENT AGENCY STAFF FEEDBACK WORKSHOP
LONDON, 12 NOVEMBER 2008

PROGRAMME

10.00	Registration, tea & coffee
10.30	Introduction to the day
10.40	Results of survey of Environment Agency staff
11.05	Break out groups: discussion of findings
11.40	Results of workshops with professional partners and of focus groups with members of the public
12.10	Plenary: discussion of findings
12.45	LUNCH
13.45	Break out groups: discussion of different options for using probabilistic information in flood warnings and how to maximise benefits and deal with concerns
14.45	Plenary: Feedback from break-out groups and discussion
15.15	Next steps
15.30	CLOSE

Appendix I: Interview Schedule

Communication and Dissemination of Probabilistic Flood Warnings

INTERVIEWS WITH SMALL BUSINESSES

Interview Questions

Collingwood Environmental Planning is involved in carrying out a project on Communicating and Disseminating Probabilistic Flood Warnings for the Environment Agency. As part of this work, we are holding interviews with owners and managers of small and medium enterprises (SMEs) in South East England to get a sense of how they understand and use flood warnings and the pros and cons of receiving earlier information about the probability of a flood occurring.

The following questions relate to your experience of flood warnings and, if relevant, of flooding. In particular, we would like to explore whether and how you take account of information on the probability of flood events occurring and what impact it might have on you and your business if flood warnings were to include this kind of information.

Please remember that there are no right or wrong answers, we want to hear your opinions. All the interviews will be used without names, so anything you say will be confidential. We will send you a copy of the interview to check before we use it anonymously in any reports or publications.

Understandings of probability

1. Are there any situations in your business activities where you may come across or use information on the likelihood or chances of things happening? *Prompt:* chances of snowfall, chances of winning contracts, likelihood of accidents, etc. Give 2 examples (of both the situation and the probabilistic information):

i.

ii.

iii.

(3 mins)

2. *[The Met Office warnings used in Q2 and Q3 will be sent to interviewees before the interview – the format sent to the interviewee is attached in a separate document.]* What do you understand by the following information issued by the Met Office on its website during the snowy period at the beginning of February, particularly the highlighted sections (you can find this information in the briefing information we sent to you).

> There is a high risk of a severe weather event affecting parts of southern and eastern England on Friday. Periods of snow will be heavy at times and will give accumulations of 5 to 10 cm over large areas and locally 15 to 20 cm over high ground. This is likely to cause disruption to travel.

If you received this information for the area where you work, would you take any action in response? If so, what would you do? Why? If not, why not?

(4 mins)

3. What do you understand by this:

   There is a moderate risk of a severe weather event affecting parts of southern and eastern England and southeastern Wales. Periods of snow may give accumulations of 2 to 5 cm over large areas and up to 10 cm over high ground.

   If you received this information for the area where you work, would you take any action in response? If so, what would you do? Why? If not, why not?

4. Both examples above are predictions by the Met Office of the same snow event. Does this surprise you? If so, why?

(Q 3 & 4 - 4 mins)

Flood warnings

5. Have you had any direct or indirect experience of flooding? If so, could you briefly describe this experience? *If not covered:* What about flooding affecting your business? Could you briefly describe this?

(3 mins)

6. Is your business signed up to the Floodline Warnings Direct (FWD) service?
   If so, could you describe what warnings you get through this service?
   What are the main advantages for your business of receiving flood warnings? Are there any disadvantages?

7. *If you are not signed up to FWD*, do you get any other flood warning information on a regular basis and could you describe this information? Why have you chosen not to sign up to FWD? What are the main advantages and disadvantages for your business of the way your currently receive (or do not receive) flood warnings?

(Q 6 & 7 – 5 mins)

8. Are you familiar with the current flood warnings? If so, what do you understand by and how would you respond to :

   - Flood Watch
   - Flood Warning
   - Severe Flood Warning

(2 mins)

Information on risk/uncertainty in flood warnings *[examples are attached in separate document]*

9. The Environment Agency is looking at how useful businesses would find it if they were to receive earlier flood warnings. In order to provide earlier warnings, the Environment Agency would have to include uncertainty as it's technically it's impossible to know with

certainty if it will flood until about 2-4 hours before this happens. I want to now find out what you think of some possible ways of showing information about probability or uncertainty in flood warnings.

Looking at the first example,

- What does this mean to you?
- How do you interpret tit?
- Does it make sense to you?
- How would the source of the information (the organization providing it) affect how much you trusted it? Would it affect the action you took in response to the warning?
- Would it make you more or less likely to take the warning seriously or act?

Go through each of the five examples in turn, asking the same questions.
(12 mins)

10. Which of the examples we have discussed, including the current version of warnings, would you prefer to receive? What would be the benefits to your business of getting this kind of warning information?

11. Having seen the examples, would you prefer to have information on probability or likelihood added to hazard warnings or to leave them as they are?

(Q 10 & 11 – 4 mins)

12. When you hear or read that a piece of information is 'uncertain' what do you make of this?

    - does it make you trust the information less or more?
    - does it make it harder to use the information?
    - does it depend who is saying this?

(2 mins)

13. Do you have any comments on the information you currently receive about the possibility of flooding and how you deal with it in your business that we haven't already covered?

(2 mins)

Many thanks for your time.

Glossary

Accuracy – Closeness to reality.

Cabinet Office Briefing Rooms (COBR) is a coordination facility of the government of the UK that is activated in cases of national or regional emergency or crisis, or during events abroad with major implications for the UK. It is also referred to as COBRA, given that its meetings are held in conference room A of the Cabinet Office. The term COBRA is used both for the actual facility, and for the Civil Contingencies Committee which meets there.

Category 1 Responder – Organisations that act as the core of the response in most emergencies; as such, governed by a full range of civil protection duties.

Category 2 Responder – A local responder organisation (although it may not be locally based) listed in Schedule 1 Part 3 of the Civil Contingencies Act which is likely to be involved in some emergencies or in preparedness for them.

Civil Contingencies Act 2004 – An Act of Parliament concerning the provision of Civil Contingencies among Category 1 and 2 responders.

Consequence – An impact such as economic, social or environmental damage/improvement that may result from a flood. It may be expressed quantitatively (e.g. monetary value), by category (e.g. High, Medium, Low) or descriptively.

Decision uncertainty – The rational inability to choose between alternative options.

Deterministic process – A process that does not contain a probabilistic element.

Error – Mistaken calculations or measurements with quantifiable and predictable differences.

Flood forecasting system – A system designed to forecast flood levels or flows before they occur.

Flood Warnings Direct – The Environment Agency flood warning service.

Flood warning system – A system designed to warn stakeholders (e.g. members of the public, emergency responders) of the potential of imminent flooding.

Gold Control – The location from which the strategic management of the incident is coordinated and where policy frameworks are established within which the tactical response will be delivered.

Hazard – A physical event, phenomenon or human activity with the potential to result in harm.

Lead time – The time between a flood warning being received and the time when the flood occurs.

Local Resilience Forum (LRF) – A process for bringing together all Category 1 and 2 responders within a local police area for the purpose of facilitating cooperation in fulfilment of their duties under the Civil Contingencies Act.

Precision – The degree of exactness regardless of accuracy.

Probabilistic process – A process in which the variability of input values and the sensitivity of the results are taken into account to give results in the form of a range of probabilities for different outcomes

Probability – A measure of our strength of belief that an event will occur. For events that occur repeatedly the probability of an event is estimated from the relative frequency of occurrence of that event, out of all possible events.

Professional partners – An organisation listed as a responder (or supporting responder) in the Civil Contingencies Act 2004.

Rapid response catchment – This is defined as a catchment for which the lag between the peak rainfall and the peak flow is less than five hours.

Risk – Risk is considered as having two components the probability that an event will occur and the impact (or consequence) associated with that event.

Silver Control – The tactical level management of the incident is coordinated through a multi-agency Silver Control, usually located away from, but close to, the scene of the incident. The point from which resources and additional assets are acquired, prioritised and deployed to support the emergency response.

Uncertainty – A general concept that reflects our lack of sureness about someone or something, ranging from just short of complete sureness to an almost complete lack of conviction about an outcome.

Utilities – Companies providing essential services, e.g. gas, water, electricity, telephones and public transport.

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