Understanding of and response to severe flash flooding

Literature review

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Environment Agency

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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 and contaminated land, and improving wildlife habitats.

This report is the result of research commissioned by the Environment Agency's Science Department and funded by the joint Environment Agency/Defra Flood and Coastal Erosion Risk Management Research and Development Programme.

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- **Funding science**, by supporting programmes, projects and people in response to long-term strategic needs, medium-term policy priorities and shorter-term operational requirements;

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- **Delivering information, advice, tools and techniques**, by making appropriate products available to our policy and operations staff.

Steve Killeen

Head of Science

Executive summary

About the report

This report presents the findings of the literature review phase of a research project looking at the public's understanding of and response to severe flash flooding, which the Environment Agency commissioned the Halcrow Group, the Flood Hazard Research Centre at Middlesex University and Ben Cave Associates to undertake in March 2008.

The overall objective of this research project was to understand people's perceptions of severe flash flooding and what their needs are in order to make an appropriate and effective response. Investigation into the meteorological and hydrological conditions that cause flash flooding and flood forecasting and modelling systems are outside the scope of this research project.

The next phase of the project is qualitative research using focus groups and one-to-one interviews with professionals involved in a response operation to a recent flash flood.

Background

The UK has recently experienced a number of flash floods, such as those that occurred in Boscastle in 2004 and Helmsley in 2005. Flash floods are characterised by very short times between rainfall and consequent flooding. They also present an extreme danger to life, property and infrastructure because of the suddenness in the rise in water level, the flow velocity and debris. Consequently, predicting, preparing for and responding to flash floods poses great challenges.

There is some evidence that the hazard of flash floods is growing due to climate change (Intergovernmental Panel on Climate Change (IPCC), 2007). Some researchers have also noted that human vulnerability to this hazard is growing because of increased development (Adams and Hooke, 2001).

Key findings

Key findings of the literature review relating to each of the five themes of the research project are as follows.

Understanding of the term 'flash flooding':

- Key characteristics of flash floods based on professional agencies' definitions are the short lead in time involved (usually defined as less than six hours), the link to heavy rainfall, dam failure as a possible cause, the volume and velocity of water involved, the danger presented by debris, the potential to cause material damage and the urgent threat to life.
- There is little research into how the public understands the term 'flash flood' and on awareness of the danger presented by such flooding.
- Analysis of print media reporting of four flash flood case studies shows a good understanding of the key characteristics of flash floods. However, a broader analysis of print media articles indicates that the media also use the term more generally to describe sudden flooding associated with heavy or excessive rainfall.
- The media have a key role to play in disseminating hazard messages and raising public awareness. However, print media articles rarely give specific public education messages with instructions about what to do in the event of a flash flood.

Appropriate and effective responses before and during flooding:

- Risk management agencies and the public have different ways of judging whether an action is appropriate and effective or not.
- Mortality and injury depend on individual flash flood characteristics, characteristics of the area and people's individual characteristics. However, avoiding risky behaviour, including walking and driving through floods, and climbing to higher ground are the cornerstones of effective response.
- Drivers are especially vulnerable and difficult to warn and often underestimate the power of floodwaters.
- The evidence suggests that evacuation does not always constitute an appropriate and effective response to flash flooding.

Getting those at risk to realise and respond to this type of flood risk

- Public information and awareness-raising activities are key to effective flood response. They should focus on the causes and signs of flash flooding, how to stay safe during a flash flood and when and how to evacuate.
- Local knowledge and involvement in preparing for flash floods is crucial but there is some evidence to indicate that local knowledge is being undermined.
- Whatever the source of a warning, the more times it is received the more likely it is to be believed. Therefore, several different delivery methods should be used, although the message must be consistent.
- Vulnerable groups may not receive a warning unless it is a targeted at them.

False alarms

- Empirical evidence on the public's tolerance of false warnings is difficult to find, with some saying that they would prefer to receive a warning even if there is no subsequent flood, while others state that they would begin to take warnings less seriously if they are received too often without flooding. There is some evidence that response to future warnings will not be diminished by false alarms where the basis of the false alarm is clear to the public.
- Evidence from operational settings indicates that professional partners would prefer to be put on standby at an earlier stage, even if they were subsequently stood down. However, this evidence is limited.

Lead time for warnings

- The evidence suggests that longer lead times for flood warnings may result in increased benefits for health and reduced damage, but the evidence on damage reduction is not sufficient or robust. However, floods for which long warning times are not possible, such as flash floods, may be associated with reduced benefits from warnings whatever the lead time.
- Evacuation may not always be the safest form of action. The characteristics of individual floods, of building type and structure, as well as the warning are crucial in determining if evacuation is desirable.
- There was insufficient evidence in the research literature to determine the needs of professional partners responsible for affected evacuation.
- There is insufficient evidence in the research literature to develop a relationship between deaths due to flood and flood warning lead time. It is therefore not currently possible to indicate any particular warning lead time threshold beyond which the risk of death increases or decreases significantly.

The following areas have been highlighted as requiring further research:

Identified gaps in the research literature include:

- Professional partners' requirements in terms of the time required to disseminate warnings and put evacuation plans in place (this will be further explored in the focus group with professional partners).
- Public understanding of the term "flash flooding" (this will be further explored in the focus groups with the public).
- How the owners and managers of private companies behave in response to warnings.
- The experience of people from ethnic minorities in responding to natural hazards
- How holiday makers and visitors to areas at risk of flash flooding can be reached by warning systems.
- Following on from this, how hotel, restaurant, campsite and other tourist facility managers understand their responsibilities regarding visitors and natural hazards.
- How the media in the UK disseminates warning messages.
- How to quantify and mitigate the environmental impacts of flash flooding.
- When to stay put and when to evacuate during flash flooding.
- Clearer assessment criteria into the effectiveness and appropriateness of action which encompass the timeframe of a flood's development.

Contents

1 Introduction

In March 2008 the Environment Agency commissioned the Halcrow Group, the Flood Hazard Research Centre at Middlesex University and Ben Cave Associates to undertake research into public understanding of and response to severe flash flooding. This literature review forms part of that research project.

In addition to this literature review the research project involves:

- Three focus groups, of which two will be with residents of areas that have experienced flash floods in recent years and one with professionals involved in a response operation to a recent flash flood.

- A series of one-to-one interviews with professionals involved in a response operation to a recent flash flood.

The final report of the research project will be completed by mid October 2008.

This work forms part of the Making Space for Water project RF7 (Rapid Response Catchments) and the combined flood action plans. It also links closely with the related Environment Agency research project "Improving Institutional and social responses to flooding" (SCO60019).

1.1 Background

The Government set out the strategic direction of flood management in the document *Making Space for Water* published on 29 July 2004 (Department for Environment, Food and Rural Affairs (Defra), 2005). The Government will, over the 20-year lifetime of this strategy, implement a more holistic approach to managing flood and coastal erosion risks in England. This includes a commitment to expanding flood warning and flood awareness activities. In addition, it requires the Environment Agency, in partnership with the Met Office, to examine the practicality of providing warnings to the public for extreme flood events resulting from exceptional weather or other environmental conditions, including flash floods.

The UK has recently experienced a number of these severe or high impact flash floods in small steep catchments, such as those that occurred in Boscastle in 2004 and Helmsley in 2005. Flash floods are characterised by very short periods of time between rainfall and consequent flooding, making effective preparation and response very difficult to achieve. They also present an extreme danger to life, property and infrastructure because of the suddenness in the rise in water level, the large volumes of water involved, the flow velocity and debris content.

Consequently, predicting, preparing for and responding to flash floods poses great challenges for the Met Office, the Environment Agency, the emergency services, local authorities, other agencies and affected and at-risk communities themselves. The flooding in North Cornwall in August 2004 highlighted the need to address the risks from severe flash flooding. The recommendations report states: "It is also recommended that the Rapid Response Catchment register be used to review the flood warnings issued in these catchments, to focus the Public Awareness Campaigns and to influence Local Authorities with regard to planning and emergency response plans. The warnings should be focussed on ensuring people evacuate to identified safe locations."

Furthermore, the recently published Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) indicated that Europe is likely to see more flash floods in future (IPCC, 2007). Other researchers have noted that flash floods will become more "frequent, catastrophic and deadly," more due to changes in human activity than climatology (Adams and Hooke, 2001). In short, there is some evidence that the hazard of flash floods is growing and there is much evidence that human vulnerability to this hazard is increasing.

The Environment Agency's long term aim is that "flood risk will be understood, known and acted on by those who live, work, play, travel and invest in areas at risk from flooding" (Environment Agency Flood Risk Management Strategy 2003/04- 2007/08).

However, a recent report commissioned by the Environment Agency to look at how institutional and social responses to flooding can be improved concluded that "the types of flood that are forecast to increase with climate change are those which have rapid onset and are unexpected, the types of flood that are not at the heart of this current service" (Twigger-Ross *et al.*, 2008).

The interim report of the Pitt Review (Pitt, 2007) makes a number of suggestions for improving public responses to flood warnings. These include increasing the degree of personalisation in flood warning information provided by the Environment Agency; obtaining a higher level of engagement of those at risk of flooding in terms of awareness and knowledge of flooding and feasible responses to it; and possibly making greater use of probabilistic flood warnings. Overall, an assumption made by the Pitt Review and in other recent post-flood review reports is that public education about flood risk can be an effective substitute for personal flood experience. However, this assumption has rarely been examined scientifically in UK conditions to discover its veracity and limits.

1.2   Project objectives

The overall objective of this research project is to understand people's perceptions of severe flash flooding and what their needs are in order to make an appropriate and effective response.

Its primary purposes are to provide a knowledge base to:

- Allow the Environment Agency to tailor its awareness message to suit people's needs.

- Form part of the Environment Agency's investigation into the feasibility of a warning service for severe flash flooding.

- Understand the measures the Environment Agency and other agencies can take to prepare in advance for severe flash flooding.

The specifics objectives of the research project are:

- To review the understanding and language used in the context of flash flooding.

- To review the cause and effect of different responses to flash flood warnings and communications.

- To review methods of encouraging those at risk to take appropriate action.

- To review the impact of issuing warnings when flooding does not occur, on trust and response;

- To review the impact of lead time[1] and different methods of delivery on the outcomes of flood warnings for severe flash flooding.

This literature review report has four specific purposes:

- To discover what is currently known in this field.

- To highlight gaps in the literature where further research is needed.

- To provide a foundation for the second stage of the research project by identifying topics for inclusion in focus groups, interviews with professional partners and telephone interviews.

- To update the Environment Agency on progress with the research project and emerging issues.

1.3   The scope and structure of this report

The scope of this report is limited to the five objectives above. These objectives are focused on understanding people's perceptions of severe flash flooding and what their needs are in order to make an appropriate and effective response. There is a considerable technical research literature that explores the meteorological and hydrological conditions that cause flash flooding, and extensive literature on the flood forecasting systems, including meteorological and hydrological monitoring systems. These subjects are clearly important in managing the impacts of flash flooding. However, these are outside the scope of this research project.

There is also a very extensive body of research exploring the theory of risk communication and applying social science paradigms to the examination of how warning systems work (Drobot and Parker, 2007). This research is clearly of direct relevance to this work and has, therefore, been included in the literature review. However, so far as possible in view of the literature available, we have sought to ensure the main focus of the literature review is on the practical and operational aspects of flash flood warning, in line with the brief provided by the Environment Agency. In view of the restricted time available for the work, this focus has necessarily limited the discussion of theoretical debates in this report.

The information generated by the literature review has been analysed using the five key themes laid out for the research project by the Environment Agency, with a chapter of the report dedicated to each theme. Each theme directly corresponds to one of the specific objectives given above. The themes are as follows:

- Understanding of the term flash flooding.

- Appropriate and effective responses before and during flooding.

- Getting those at risk to realise and respond to this type of flood risk.

- False alarms.

- Lead time for warnings.

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[1] In this report lead time is defined as the amount of time between the first warning of a flood, including observation of environmental cues, and its arrival (Downing, 1977).

The Environment Agency also defined a number of research questions for each theme. We have structured each chapter using these research questions to ensure discussion remains focused, with each question having a section within the relevant chapter.

In adhering to this structure, some repetition became unavoidable. For example, issues related to individual warning perception are discussed in sections 3.3, 3.4 and 4.3. However, we have not merged the research questions defined in the terms of reference in order to ensure that the comprehensiveness and integrity of responses is preserved. Instead, we have minimised duplication by cross referencing wherever possible.

Equally, in the course of the literature review, it became apparent that some areas of considerable importance in conclusive thinking on the subject of the public understanding of flash flooding had not been explicitly included in the five key themes. Examples include the social aspects of the warning process and approaches to managing uncertainty. In these instances, we have introduced such topics into the sections in which they have most relevance.

While adhering to the structure of themes broken down into research questions, we have further broken down discussion into sub-sections to facilitate readability, emphasis coherence and highlight important issues.

1.4 Methodology of the literature review

1.4.1 Identifying the literature

Information included as part of the literature review has been identified in the following ways:

- Members of the Environment Agency Project Board overseeing the project were requested to provide relevant references.

- The Flood Hazard Research Centre at Middlesex University provided references and made available its current and recent research on flooding.

- The Environment Agency's Corporate Communication team provided media reports and analyses of reporting of recent flash floods.

- Operational documents and media reporting relating to four flash floods case studies were analysed. These were River Rye, 19 June 2005; Boscastle, 16 August 2004; Polperro, 30 December 1993; Walshaw Dean/Hebden Bridge, 19 May 1989.

- A custom search of the Natural Hazards Centre Library at the University of Colorado at Boulder was undertaken using the following topics as search criteria:

  o Public perceptions of flash floods.

  o What constitutes effective action in response to hazard communication of flash floods.

- o What constitutes effective messages, message construction and effective communication methods for flash floods.

- o What are the barriers to effective action in response to hazard communication of flash floods.

- o What is the optimum lead time required for effective action.

- o What are the effects of false alarms on public behaviour and trust.

- Published annotated bibliographies were used to identify relevant articles.

- Internet searches using the "Google" search engine were undertaken to fill in gaps where inadequate information had been generated using the above methods using the key words "flash floods."

1.4.2   Types of research evidence included

The focus of the 'Public understanding of flash flooding' project is on 'rapid response catchments':

- Where the speed of flood onset is very rapid.

- Where there may be extreme risk to life.

- Where there may only be a very short warning lead time of minutes to one hour or so.

In researching information strictly relevant to this category of flash flood, the evidence is complicated by different understandings of the concept of a flash flood, each of which may be defensible in particular circumstances. In a global context, where river systems range from being very large (for example, the Mississippi, the Danube) to very small (for example, the Rivers Valency and Jordan and Boscastle in Cornwall), most of Britain's rivers are 'flashy' in nature, generating relatively short flood warning lead times. However, much of the research included in this literature review mainly concerns floods on flashy rivers where flood warning lead times are measured in hours ranging from approximately one to 10, and where risk to life is more limited.

While much of the research evidence available is not focused solely on 'our' type of rapid onset flood, what we find is that data relating to these types of events are often included within data on floods for which one to10-hour onset times are typical, but are not discretely identifiable within the data.

The 'evidence relevance' picture is further complicated by the fact that *some* of the findings from research on floods with a one to 10-hour onset time are likely to be applicable to floods with a minute to one hour onset time, whereas *some may not be applicable*. Researchers are presented here with an appreciable dilemma concerning which findings and generalisations are and are not applicable to very rapid onset events. It would be wrong to exclude all research findings from floods of longer onset (one to 10 hours). Consequently in so far as is possible, the material focuses upon flash flood warning situations, with material relating to slow rise floods largely edited out except where the evidence contains data from both flash floods and slightly slower onset floods.

In addition to the research on flooding, there is a wealth of literature relating to public awareness and response to other types of natural hazards. While much of this is not relevant to a discussion of flash flooding, some of it may offer applicable lessons where it deals with incidents with a short lead in time and potentially high impacts.

Where relevant evidence has been included that does not relate to flooding, this has been made clear in the discussion.

Empirical evidence on flash flood warning response is available in various forms:

- Data on how people responded to a flash flood warning according to the responses they gave in questioning after the event (sometimes several years afterwards, which may lead to some memory loss and/or post-rationalisation).

- Data on what people say they will do in response to a flash flood warning in the future, again elicited when questioned. Whether what people say they will do is a sound guide to what they will actually do is to some extent questionable.

- 'Expert opinions' about how people respond to flood warnings, based upon the experience and level of knowledge of the experts interviewed as part of this research project.

- Syntheses of data by researchers which draw together what is known empirically about flash flood warning response.

- Data based upon direct observation of how people responded to a flood warning.

Data in (1) might be considered to be the highest quality data, and possibly more reliable than data in (2) if the indications are that memory loss is not significant. Data in (3) and (4) have undergone a large amount of processing and contain elements of interpretation and generalisation by experts or researchers; it is more or less useful depending on the skill of the expert or researcher, and depending on one's purpose. Data in (5) are very difficult to find, but may well be high quality where they exist, since there may be no possible element of post-rationalisation or influence by memory loss involved. Such data may be more readily available in future in the growing 'surveillance society' in which CCTV coverage is widespread. The relative attributes of these different forms of empirical data clearly need to be taken into account in interpreting research findings.

In addition, this literature review looks at existing research interpretations of data, as opposed to actually undertaking the primary or secondary analysis of data. Therefore, it should be stressed that different research data discussed here are not generally of a comparable or universal quality in that they employ different methodologies, selection criteria and sample sizes. This contributes to the diverse and sometimes contradictory nature of findings reported. While the literature review has involved a critical reading of research, we have focussed on the interpretative findings of authors, rather than examining methodologies and the validity of findings. These caveats should be borne in mind when reading this literature review.

1.5 Gaps in the research evidence

The following areas have been highlighted as requiring further research:

- Professional partners' requirements in terms of the time required to disseminate warnings and put in place evacuation plans (this will be further explored in the focus group with professional partners).

- Public understanding of the term "flash flooding" and the extent to which the public associate flash flooding with particular types of weather or atmospheric conditions and what these are (this will be further explored in the focus groups with the public).

- How the owners and managers of private companies behave in response to warnings.

- The experience of people from ethnic minorities in responding to natural hazards.

- How holiday makers and visitors to areas at risk of flash flooding can be reached by warning systems.

- Following on from this, how hotel, restaurant, campsite and other tourist facility managers understand their responsibilities regarding visitors and natural hazards.

- How the media in the UK disseminates warning messages.

- How to quantify and mitigate the environmental impacts of flash flooding.

- When to stay put and when to evacuate during flash flooding.

- Clearer assessment criteria into the effectiveness and appropriateness of action which encompass the timeframe of a flood's development.

- The extent to which providing those at risk with more information about flooding and flood warning response is an effective substitute for flood experience, and in what circumstances this may or may not be true.

2 Understanding of the term flash flooding

The objective of this chapter is to review the understanding and language used in the context of flash flooding.

2.1 What is the public understanding of the term "flash flooding"?

2.1.1 Definitions offered by professional agencies

While as Gruntfest and Handmer (2001b) have noted there is no clear definition as to what constitutes flash flooding, several working definitions with key common features have been put forward by professional agencies. Before looking at the public perceptions and understandings of the term "flash flood" and how accurate these are, we will briefly review these working definitions proposed with a view to synthesising the key features of a flash flood.

Although the Environment Agency does not have an agreed definition of a flash flood, it has used the following definition of rapid response catchment area (an area known to be at risk of flash flooding):

> A selection of rivers or streams that react rapidly to heavy rainfall, producing flooding that poses an extreme threat to life. What does it mean in terms of flooding?
>
> - Buildings, roads and bridges are destroyed.
> - Trees are uprooted and boulders moved.
> - Vehicles are lifted and carried away.
> - People are disabled by the force of the water and debris[2].

The Associated Programme on Flood Management (APFM) proposes the following definition:

> A flash flood is, in short, a sudden local flood of great volume and short duration which follows within a few (usually less than six) hours of heavy or excessive rainfall, or due to dam or levee failure, or the sudden release of water impounded by an ice log jam.
>
> A flash flood can take place in a time duration that is span counted in minutes, or only a few hours from the event that causes it to happen (excessive rainfall, failure of hydraulic infrastructure and so on). During a flash flood there is a sudden rise in the water level in rivers and streams, and flow velocity can be very high. The force of the water can be so great as to tear

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[2] Based on internal Environment Agency definitions used for the rapid response catchment project.

away boulders, uproot trees, and destroy bridges and buildings that stand in its path.

The damage caused by flash floods is often severe, and distinguishably they present a serious threat to human lives. Statistics published by US NOAA agency state that flash floods are the cause of the majority of flood-related fatalities. (APFM, 2007b)

The National Weather Service (NWS) in the USA defines a flash flood as:

A flood which is caused by heavy or excessive rainfall in a short period of time, generally less than six hours. Also, at times a dam failure can cause a flash flood, depending on the type of dam and the time period during which the break occurs (NWS, 2005).

Key common features of these definitions are the short lead in time involved (usually defined as less than six hours), the short duration of the flooding, the link to heavy rainfall, dam failure as a possible cause, the volume and velocity of water involved, the danger presented by debris, the potential to cause material damage and the urgent threat to life.

However, as Gruntfest and Handmer (2001b) point out, the flash flood problem may need to be re-conceptualised to make it "unambiguously clear that it is qualitatively different from other types of flooding."

2.1.2   Public understanding of flash flooding

There is little research into how the public understands the term flash flood nor into public awareness of the danger presented by such flooding. This area of work will be supplemented by focus groups carried out as part of the research project.

Wagner (2007) used qualitative face-to-face and telephone interviews to analyse mental models of flash floods and landslides in four communities in the Bavarian Alps. Mental models were defined as "the mechanisms whereby humans are able to generate descriptions of system purpose and form, explanations of system functioning and observed system states, and prediction of future system states." He asserts that mental models of natural hazards are generally based on personal experience and information assimilated from mass media, peer groups and responsible agencies. Respondents mentioned weather conditions, problems with drift wood and debris and constructions of the watershed authority as key factors in flash floods. The first key factor influencing the coherence of mental models was whether the interviewee had personal experience of flooding. The second was visibility. The more visible an influencing factor, the better it was understood. Consequently, the impact of woody debris was better understood than that of stones, gravel and sand. Interestingly, while the majority of the respondents proposed torrent control constructions as mitigation measures against flash floods, only a small percentage mentioned personal mitigation measures.

Interviewees speaking about flash floods were more likely to use vigilant strategies (defined as the search for and processing of threat related information) than cognitive avoidance (defined as coping strategies that aim to avert attention from threat relevant cues). The biggest difference in the completeness of mental models was the difference between newcomers and those born in the research communities. While those who had moved to the areas in the last 20 years mentioned an average of 8.2 influencing factors, those who were born there mentioned on average 12.7.

Knocke and Kolivras (2007) undertook an on-line survey in an area prone to flash flooding in Southwest Virginia, USA, to examine flash flood awareness amongst members of the public. Their results showed that a knowledge base of flash floods existed but it was not advanced enough for proper awareness and needed improvement. In particular, knowledge of the required meteorological and hydrological processes that cause flash floods was not strong and there was little understanding that flood waters can rise in urban areas, due to snowmelt and as a result of dam failure.

In addition, they concluded that the public need more information on what flood forecasting tools and warning sources are available. Young adults in the 18 to 25 age range were found not to be as concerned with flash flood impacts and did not perceive imminent danger as seriously as older adults.

Clearly, the mental models that people have of flash floods can be expected to be related most strongly to the environmental conditions in which they live and/or have most experience. Ice-jam conditions are characteristic of parts of northern USA but not England. Flash floods carrying heavy loads of woody debris and boulders are characteristic of much of the Alps and are characteristic also of river valleys such as the Lyn in North Devon. However, those with experience of flash floods through their villages and towns in other parts of England will probably associate flash floods less with these conditions and more with floating cars and other more urban debris and contaminants such as oil.

2.2 How do the media use the term "flash flooding"?

2.2.1 How the print media in the UK use the term "flash flooding" in reporting flash flooding events

To examine how print media have used the term flash flooding in reporting flash flooding events we looked at the following case studies:

- River Rye, North Yorkshire, high profile flooding that caused extreme damage on 19 June 2005.

- Boscastle, high profile flooding that caused extreme damage on 16 August 2004.

- Polperro, low profile flooding that caused major damage on 30 December 1993.

- Walshaw Dean/Hebden Bridge, low profile flooding with record rainfall statistics known as the 'Halifax Storm' 19th May 1989.

In doing so we analysed over 200 articles from national and local print media as well as web-based reporting.   These articles were provided by the Environment Agency and supplemented by our own internet searches.

It was not possible in the time available to undertake a statistical analysis of the frequency with which key words were used and, indeed, this would not have deepened our understanding of the how the media use the term "flash flood" in the context of this question. Instead, our analysis focused on synthesising the most

commonly used descriptions and messages and highlighting those which stood out because of divergent or alternative interpretations.

As we would expect, the reporting of the flash flooding case studies describes the *key characteristics* of flash floods in some detail. Recurring characteristics described are:

- The *speed* with which the flooding rose:

   "Flash flood strikes with little warning, leaving homes and businesses inundated in a matter of minutes." (Yorkshire Post, 21 June 2005. After the deluge.)

- The *velocity* of the water:

   "Then the storm…turned usually tranquil waterways into raging torrents which swept into homes, tore up roads, felled sturdy trees and tossed cars and boulders around like pebbles." (Yorkshire Evening Post, 21 June 2005. Now it's time for the big clean up.)

- The *depth* of the water:

   "…the front of the property had more than 8ft of flood water and at the rear…the water was more than 10ft." (Yorkshire Post, 21 June 2005. A lesson in survival from an ex teacher, 89.)

- The extreme nature of the conditions required to cause flash floods were described:

   "…2 inches of rain - the normal amount for a month – fell in an hour. Flash flooding was the almost inevitable consequence." (21 June, 2005, the Independent. Storms, floods and sunshine: welcome to global warming.)

- Flash floods are contrasted with other forms of flooding:

   "Unlike the slow ponderous floods which have engulfed York, Selby and Carlisle …this one was focused, furious and very fast." (The Guardian, 21 June 2005. Villagers clean up after flash floods.)

Reporting on flash floods also focuses on the *impacts* of the flooding with human interest stories dominating. The threat the flooding presented to life and limb is stressed, often with stories of lucky escapes.

   "It was amazing, at 4.30pm we were sitting outside enjoying the sunshine, an hour later we were having to flee for our lives." (The Daily Telegraph, 21 June 2005. It feels like everything's been destroyed.)

It is interesting to note that a great many reports of incidents of flash flooding mention the loss, rescue and narrow escapes of pets. While this can be seen as reflecting the popularity of animal stories amongst the public, it also underlines the importance of pet safety for their owners.   This is a serious issue which will be discussed in more detail in chapter 2 of the report.

The destructive power of flash flooding is stressed by most articles:

   "The cost in terms of property and sheer misery was almost incalculable, with homes virtually destroyed, pets lost, livestock killed and belongings swept away by walls of filthy brown water." (The Yorkshire Post, 21 June 2005. It came from nowhere.)

The traumatic impact of lost homes on individuals involved is emphasised in many of the articles:

> "'I couldn't sleep a wink' said Mrs Lamond…'I can't describe it. It was just unbelievable. I felt totally numb.'" (Daily Mail, 21 June 2005. The heartbreak after the torrent.)

The effects of the flooding on infrastructure are described:

> "The force was such that the road's tarmac was ripped up and carried away in huge sheets." (20 June 2005, Yorkshire Evening Post. After the deluge.)

Many articles emphasise the monetary value of the damage caused. These articles frequently quote representatives of insurance companies:

> "Insurers last night warned the cost of the storm damage could run into tens of millions of pounds and take months to repair." (The Northern Echo, 21 June 2005. Counting the cost of flash flood damage.)

The impacts described in reports of these case studies corresponds with the types of impact we would expect to see from flash flooding in that they are high impact, representing risk to life and damage to infrastructure and property.

Reports of the case studies also discuss the causes of flash floods in some detail. There is wide agreement on some of the causes. For example, most articles refer to the weather conditions necessary for flash floods. These are described in many of the articles, and were generally described as needing to be dry then very wet:

> "A combination of hard ground and lots of rain is the basic recipe for a flash flood." (The Guardian, 21 June 2005. Villagers clean up after flash floods.)

Most articles also make reference to climate change in discussing the causes of flash floods. However, there is no consensus between different reports. Most articles assert a link between climate change and flash floods and stress that there is an increased likelihood of flash flooding due to climate change.

> "The Environment Agency said these types of floods were quite rare, but are likely to occur with more frequency as climate change tightens its grip." (BBC News, 20 June 2005. More flash flooding on the way.)

However, several articles disputed this:

> "There is not thought to be a link between the extreme weather that causes flash floods and global warming." (Times Online, 21 June 2005. How flash floods happen.)

Some articles refer to a lack a structural defence, but interestingly only do so in reporting the views of residents or local representatives:

> "Some locals muttered about the absence of a flood defence system in Helmsley." (The Independent, 21 June 2005. Villagers fled from flash floods on a night of chaos and confusion.)

However, most articles stated that flash floods could not be prevented by structural defence measures:

> "It was so ferocious and unexpected that even the most sophisticated defences may have failed to withstand the volume of rain which fell in

such a short period." (Yorkshire Post, 21 June 2005. Climate lessons flooding in.)

The fact that flash floods can affect areas not normally prone to flooding is mentioned in several articles:

"The North York Moors is not an area where flooding is common." (Times Online, 21 June 2005. Sudden rain brings flash floods to North Yorkshire.)

However, there is no consensus on this:

"Serious floods are relatively common over the North York Moors and the Yorkshire Dales." (The Daily Telegraph, 21 June 2005. George II was right: three fine days and a thunderstorm.)

These differences reflect how quoting from one local person who has not experienced flooding or does not have an extensive knowledge of the history of flooding in the area may be misleading.

Several articles attribute flash flooding to rivers bursting their banks:

"…a devastating rainstorm burst the banks of the river Rye and engulfed the village." (Daily Mail, 21 June 2005. The heartbreak after the torrent.)

Some articles assert that flash flooding is more likely to occur in low lying areas:

"Flash floods tend to happen in low lying areas following intense spells of rainfall." (Yorkshire Post, 21 June 2005. Flash floods bring climate of fear.)

In general, while there is a clear understanding that flash floods are caused by excessive rainfall, there is less clarity about what causes this excessive rainfall. Many articles attribute extreme weather events to climate change. In addition, reporting of the hydrological conditions likely to cause flash floods is not consistent. This probably reflects the fact that while weather is relatively tangible, comprehensible and regularly discussed in the media in the context of climate change, hydrology is much less so.

The characteristics reported in printed media are in line with the features of flash floods outlined in definitions provided by professional partners as descried in section 1.1. Therefore, it is possible to conclude that certain aspects of media reporting of flash flooding present an accurate picture of the characteristics of flash flooding. However, media reporting of the causative factors leading to flash flooding - from which people might learn about the precursors of flash flooding which might make them more able to detect the flash flood risk – is superficial and much less complete and accurate than it could be. Current media reporting of flash flooding therefore does well in descriptive terms but fails to help people understand much about the processes leading to flash flooding.

Furthermore, no media articles were found which reported positive stories about how developments in flash flood warning systems can help to reduce the impacts of such floods.

2.2.2 How the print media in the UK use the term "flash flooding" in general reporting

We also looked at how print media in the UK use the term "flash flooding" more generally, with a view to ascertaining if the term was used accurately while not reporting specific incidents of flash flooding. To do this we undertook an analysis of articles generated by internet searches using the key words "flash flood" from 2000 to the present date in the following national newspapers:

- The Guardian

- The Independent

- The Observer

- The Daily Express

- The Telegraph

- The Daily Mail

- The Mirror

- The Sun

In looking at these reports it becomes clear that the term "flash flood" is used much more loosely and inaccurately than looking at reports of flash floods alone would suggest.

Usually the term "flash flooding" is applied to sudden flooding associated with heavy or excessive rainfall. However, frequently the flooding described as "flash" does not describe flooding displaying the key characteristics of speed, velocity, debris and depth, as becomes clear later in the articles:

> "Heavy rain and flash flooding have caused havoc across the country as more storms swept through the UK." (Daily Express, 6 May 2008. Storms batter Britain again.)

In many cases the term "flash flooding" is used to describe surface water flooding but is used to underline its severity:

> "Many areas of Berkshire and on the Surrey/Hampshire border were hit by flash flooding. At least two schools were closed in Maidenhead and Windsor." (The Mirror, 20 July 2007. Severe storms bring more flooding.)

This general application of the term is not confined to the tabloid press:

> "Flash flooding hit Whitstable in Kent yesterday, leaving several streets knee deep in water." (The Guardian, 22 August 2007. Man dies trying to save home.)

Often reports of flash flooding attribute the use of the term to a spokesperson or report, and in several cases this information is inaccurate:

> "Hundreds of people today battled flash floods after drainage systems in two coastal towns were "overwhelmed" by torrential rain, a water company said." (Daily Mail, 25 September 2006. Flash floods hit costal towns.)

> "Grampian Police said the problem had been caused by flash flooding…A spokeswoman said that the force had received a flood warning from the

Met Office." (Daily Mail, 8 September 2002. Scottish towns hit by flash flooding.)

"The city council, the Environment Agency and Yorkshire Water had all failed to work together. This resulted in confusion and an unwillingness to take responsibility, said the report (commissioned by Hull City Council), which found that the city had no contingency plans, no list of strategic locations, and no flash flood warning system." (The Guardian, 22 November 2007. Water Company failed to take action on flood warning, report alleges.)

"Oliver Blackburn, a spokesman for the Environment Agency, said it was difficult to prepare for flash floods which could sometimes occur in less than 30 minutes. He said the main reason for the flood was poor drainage." (The Guardian, 3 August 1999. Flash flood warning as heat wave ends.)

There is accurate reporting in several articles about the respective roles of the Met Office in issuing weather warnings and the Environment Agency in issuing flood warnings. For example:

"The Environment Agency issued 18 severe flood warnings mostly in the North and West, the Met Office issued the severe weather warnings." (The Independent, 26 June 2007. The great flood.)

However, several articles also attribute flood warnings to the Met Office. For example:

"The Met Office had issued three severe flood warnings indicating "extreme danger to life" for Yorks and Lincs." (The Daily Mirror, 16 June 2007. Rain of terror)

Several articles also reported "flash flood warnings" that were attributed to either the Met Office or the Environment Agency, although no such flash flood warning system exists.

"Flash flood warnings were issued on the rivers Aire, Wharfe and Colne." (The Guardian, 1 August 2002. Torrential rain brings floods and chaos.)

Headline "Motorists stranded as flash-flood warnings issued on seven rivers." (The Independent, 10 September 2002. Motorists stranded as flash-flood warnings issued on seven rivers.)

2.2.3   Evidence for the impact of the media on public understanding and perceptions

Having looked at how print media in the UK use the term flash flood, we now consider how the public use media and what evidence there is that media messages impact on public understanding and perceptions.

Petts *et al*. (2002) reported a perception amongst senior Environment Agency staff that "the media are sensationalist and, as such, are bad communicators of risk information." Petts also identifies other case studies and risk literature which reveal that professionals commonly believe that the media distort risk information, sensationalise and are main drivers of what is considered inappropriate public concern. However, the research evidence does not support this view.

On the contrary, numerous studies over a long time period, of both newspapers and television, have failed to identify any link between media consumption and public perceptions of risk. Recent work on the media has stressed the active and social nature of people's interpretation of the media. People know that some sections of the media can be sensationalist. They interpret media information accordingly (Petts *et al*., 2002).

The Social Amplification of Risk Framework (SARF) was developed to describe the various processes that might lead to some hazards and events experts regard as presenting a relatively low statistical risk to become a focus of social and political concern and activity while other, potentially more serious events, receive comparatively little public attention (Petts *et al*., 2001). The framework used data analysis in relation to the life cycles of four hazards: AIDS, BSE, the 'contraceptive pill scare' of 1995 and the citing and development of a Shell NGL plant.   This research reached the following conclusions regarding the role of the media in the social amplification of risk:

- The media are not transmitters of official information on risk but dynamic interpreters and mediators, who seek to respond to and reflect social preferences and concerns.

- The media are highly effective interpreters of public concerns, arguably far more so than Government departments and agencies.

- The media can only amplify or attenuate risk if they capture or resonate with an existing public mood, and even then the media are not alone in this function.

- The lay public are not passive recipients of media messages but sophisticated and 'media-savvy' users.

- The media do set agendas for public concerns, but this selective attention is most important in relation to risks where people do not have first-hand experience.

It is also important to understand how the public consumes media. Again Petts *et al*. (2002) reached some interesting conclusions. Firstly, for many people media consumption was fragmented, snatched and continually squeezed into a busy day. Images, pictures and headlines became important. Secondly, for many in the lower socio-economic groups, the 'suits' (that is, the risk managers (politicians, government ministers, corporate managers) were not perceived to be working in their interests nor to be in tune with their worlds. Thirdly, they had an inherent belief that television is a regulated media (unlike the newspapers) and therefore is more likely to present factual and correct information (particularly on the news). Fourth, individual presenters and reporters attracted considerable allegiance as trusted communicators in tune with lay concerns. Finally, the public were not passive absorbers of media information, but collectors of information to inform their desire to "make up their own minds."

Petts' research also emphasised the importance of local news as circulating local knowledge and responding to people's grounded experience. Eighty-nine per cent of participants in the research reported reading a local newspaper (including 'free' papers), whereas 25 per cent did not read a daily paper and the largest percentage reading a single daily was 24 per cent reading the *Daily Mail*.

Therefore, the media should be seen as active mediators of information which is generated by a large number of communicators, including political institutions, scientific experts, corporations and campaigning groups. As such the media are key

players in the link between public officials and the public. They have a key role to play in disseminating hazard messages and raising public awareness (UN/International Strategy for Disaster Reduction (ISDR), 2001).

However, to fulfil this role effectively the media require information. Professionals with responsibility for hazard communication must recognise this and work proactively with the media. Journalists are information hungry and are often dependent upon those who provide it. They are ripe for proactive information delivery and open for government departments to be more proactive in providing information. If information is not provided openly, this may be seen as incompetence and as part of a tendency to cover up. The major implication of this is that if the media are not provided with accurate information they will go elsewhere and get whatever information is available - accurate or not (Petts *et al*., 2002).

Research into hazard communication has also drawn attention to the lack of news presented or written by specialist reporters in either science or the environment in large sections of the media. This may result in a "dumbing down" of more complex scientific information. A practical consequence is that hazard communication messages should be clearly presented to the media, rather than expect media journalists to analyse complex information and develop messages themselves.

A further consequence is that when delivering information on levels of uncertainty to the media, the use of any figures that might be misinterpreted should be avoided. The media may translate any figures into a format they feel will be more easily understood by the public and this could lead to misunderstanding (Petts *et al*., 2002).

2.3 What terminology has been used, and should be used, to explain, warn of or describe this type of flooding, for example "severe flash flooding" or "dangerous flash flooding"?

2.3.1 Terminology used by the media to describe characteristics, impact and causes

Section 1.2 discusses the way media reporting in four case studies describes the key characteristics, impacts and causes of flash floods.

Key words and phrases frequently used to describe characteristics include: sudden, unexpected, raging torrents, extreme event, surging, rapid, dangerous, fast, great flood, serious flooding.

Key words and phrases frequently used to describe impacts include: havoc, chaos, devastation, misery, damage, terrible, tragedy, massive disaster, bill, the cost is millions of pounds, heartbreak, the force and climate of fear.

Key words and phrases frequently used to describe causes include: burst banks, excessive rain, baked earth, climate change, freak summer storm, thunderstorms, hot weather, freak weather, unprecedented downpour, global warming.

2.3.2   The media's contribution to warning

In printed media articles reporting the flash flooding case study events reviewed as part of this work, a warning purpose was not immediately evident. These articles reported on flash floods after they had occurred and it was therefore too late for them to serve a warning purpose. Instead the reporting focuses on the characteristics and impacts of the flash flooding, with human interest stories dominating. Although this does not constitute "warning," it does play a role in awareness-raising and public education, which are themselves crucial in encouraging appropriate responses to warnings. This is discussed below.

Articles reviewed which included the key words "flash flood" but were not reporting the flash flooding case study events did report on warnings issued. As discussed above, many of these articles were reporting extreme weather conditions and flood warnings in place as a result. However, there was some confusion evident in several of the articles reviewed about who issues a warning and what type of warning is issued. The Met Office and the Environment Agency were both quoted as issuing "flash flood warnings" although no national system of flash flood warning is in place. Therefore, there is some evidence that the media contributes to confusion around warning systems.

The capacity of the print media to play a role in warning dissemination for flash floods is clearly limited by the very short lead in times which characterise such floods. However, other forms of media, in particular television and radio, do have a role to play in warning dissemination for flash floods. Warning dissemination and the role of different media are dealt with in chapter 3 as part of the discussion of appropriate and effective responses during flooding.

2.3.3   The research literature's findings on effective terminology for warnings

The content, style and format of a warning is discussed in more detail in section 3.3 of this report. This section briefly introduces the concept of signal words.

A considerable amount of research has gone into exploring the relative strengths of signal words that may be used in warnings (Edworthy and Adams, 1996). Wolgater and Silver (1990) tested the arousal strength of 20 words (including 'note', prevent', 'harmful', 'warning', 'urgent', 'danger', 'fatal' and 'deadly'). The word 'note' had the lowest arousal strength whereas the word 'deadly' had the highest arousal strength, and in general this body of research has found that differences in signal strength of words are common and fairly robust.

Handmer and Ord (1986) report that adaptive behaviour appears to be directly related to the number of warnings a person receives, with more warnings for the same event resulting in improved response.

2.4   What messages have been used to promote public understanding of the flooding impacts we are warning of?

2.4.1   Messages used by the printed media to promote public education and raise awareness

The reporting of the four case study flash floods analysed for this review outlined in section 2.2.1 is mainly concerned with describing what happened, where and to whom. However, it includes several broader messages that could be described as contributing to public education and raising awareness of flash floods.

The most widely reported of the messages is "what is a flash flood," focusing on the key characteristics of speed, velocity, depth and power of the water as described above.

The unpredictability of flash floods and the fact that warning is often not possible, as stressed in many reports of the case studies, can also been seen as a public education message:

> "It is a reminder that flooding can happen at any time and in unexpected places." (BBC News, 20 June 2005. Power restored after flash storms.)

The focus on reporting of the case studies on human interest stories which illustrate the threat to life and property, itself presents the important message that flash floods are very dangerous.

However, specific public education messages giving instructions about what to do in the event of a flash flood are much rarer.   Several articles outlined the danger of driving in flash flood conditions:

> "Experts estimate that just six inches of fast moving water can carry away the average 4 x 4 vehicle." (Times Online, 21 June 2005. How flash floods happen.)

Nevertheless, no article was found which gave explicit advice as to what to do in the event of being in a vehicle during very heavy rain with a threat of flash flooding.

Similarly one article warned:

> "Fifteen centimetres of water is enough to sweep a sturdy human off his or her feet." (The Guardian, 18 August 2004. A phenomenon that is difficult to forecast and impossible to prevent.)

However, it did not go on offer advice as to what people should do if they see rising flood waters.

Furthermore, to persuade people to register on flood warning systems and to take floods and flood warning information seriously, it would be useful for the media to cover not just flash floods and their awful impacts, but also the good news stories of how a well functioning flood warning system with a flood aware population can lead to success. There is no evidence of such reporting now so the Environment Agency may need to consider how to encourage these success stories to the media in future.

2.4.2   Messages proposed by the research evidence to promote public education and raise awareness

Promoting public understanding of the impacts of flash flooding is crucial in order to:

- Ensure the public can recognise the danger signs of flash flooding.

- Increase the public's recognition and confirmation of warning messages.

- Improve the effectiveness of responses to a warning message.

- Increase the effectiveness of response to situations of danger where no warning has been issued.

Gruntfest and Ripps (2000) suggest that videos are helpful to educate people about flash flooding. The National Weather Service and Arizona Association of Floodplain Managers made brief but powerful public education videos to explain the basics about flash flooding. The topics they covered included:

- How fast-flowing water does not need to be very deep to be dangerous.

- How paying attention to environmental cues may save your life.

- How dangerous it is to drive during flash floods.

- How climbing to high ground and safety is the best action in threatening situations.

However, according to Gruntfest and Ripps, no matter how many times people see the power of water in flash floods and hear how driving through deep water is dangerous, it is difficult to convince people they are better off wet than dead. They therefore suggest that public education on flood hazards needs to be encouraged from the classroom to the boardroom. Signs directing people to high ground are not enough – education is the key mitigation measure.

Instytut Meteorologii i Gospodarki Wodnej's (IMGW Poland) research shows that educational activities aimed at residents and flood land users should concentrate on three main topics:

- Floods are inevitable.

- Everyone can change the amount of damage that a flood can cause their home or property.

- There exists a structure of services and institutions to support residents and land-users in flood-risk areas.

Figure 1 below provides an example of web-based public information messages used in the United States.

During A Flash Flood Or Flood

Your local authorities have issued a <u>Flood Warning</u>.

What do you do? Stay near your television to get updates on The Weather Channel or listen to your radio.

The decisions you make now are **critical!**

Surviving A Flash Flood

- There many be no time for a warning to be issued.
- You may have only seconds to escape.
- It could be a life-and-death decision for you and your family.
- If you suspect a flash flood is about to happen **immediately climb to higher ground.**
- Remember, it does not have to be raining for a flash flood to occur. Some of the most dangerous floods originate many miles away.
- See what happens when people are caught unawares by <u>flash floods</u>.

Surviving A Flood

- If on foot, **do not** attempt to walk through flood waters. Instead, turn around and go directly to higher ground.
- Make sure to keep children and pets away from flood waters, storm drains, and sewers.
- If you are in a car, drive away from flooded areas, never try to take a shortcut through them.
- If your car stalls, immediately abandon it and climb to higher ground.

If No Evacuation Has Been Ordered

- Collect your <u>Family Emergency Supplies Kit</u> plus extra blankets and sleeping bags and keep them with you.
- Call your emergency contact person to report your plans.
- Keep children and pets indoors.
- Make sure you have cash and your car has a full tank of gas in case you must evacuate.
- Make sure a battery-powered radio is nearby.

If Evacuation Is Advised

- Turn off all utilities (water and electricity).
- Pack your <u>Family Emergency Supplies Kit</u> plus extra blankets and sleeping bags.
- Lock the windows and doors of your home before leaving.
- Tune your car radio to a news station to hear updates on evacuation routes.
- Be sure to follow the recommended evacuation routes. Your favourite shortcuts may already be blocked by flood waters.

Check Out Other Information Resources

- American Red Cross
- Your city or municipal Emergency Management Agency (EMA)

Figure 1:   An example of public information messages in the United States.
Source: the Weather Channel, 2008a.

Public education and awareness are dealt with in more detail in chapter 4 of the report as part of the discussion on getting those at risk to realise and respond to this type of flood risk.

2.5   Summary of key points

- Key characteristics of flash floods based on professional agencies' definitions are the short lead in time involved (usually defined as less than six hours), the link to heavy rainfall, dam failure as a possible cause, the volume and velocity of water involved, the danger presented by debris, the potential to cause material damage and the urgent threat to life.

- Flash flooding may need to be re-conceptualised and packaged to make it clear that it is qualitatively different from other types of flooding.

- There is little research into how the public understands the term 'flash flood' and awareness of the danger presented by such flooding. What research evidence exists indicates that there is a knowledge base of flash floods in communities in flash flood-prone areas but it is not advanced enough for proper awareness and needs improvement. Personal experience and visibility are key in shaping public understanding of flash floods.

- Analysis of print media reporting of four flash flood case studies shows a good understanding of the key characteristics of flash floods including speed with which the flooding rose, the velocity of the water, the depth of the water and the extreme nature of the weather conditions required to cause flash floods. The destructive impact and danger presented by flash floods were reflected in reporting. There is a clear understanding that flash floods are caused by excessive rainfall but reporting of the hydrological conditions likely to cause flash floods is not consistent.

- Analysis of print media articles that include the key word "flash flood" but that do not relate to the four case studies show the term "flash flooding" is applied to sudden flooding associated with heavy or excessive rainfall. However, frequently the flooding described as "flash" does not describe flooding displaying the key characteristics of speed, velocity, debris and depth.

- Recent work on the media has stressed the active and social nature of people's interpretation of the media. The media should be seen as active mediators of information. They have a key role to play in disseminating hazard messages and raising public awareness. However, to fulfil this role effectively the media require information. Hazard communication messages should be clearly presented to the media, rather than expecting journalists to analyse complex information and develop messages themselves.

- The capacity of the print media to play a role in warning dissemination for flash floods is limited by the very short lead in-times which characterise such floods. However, other forms of media, in particular television and radio, do have a role to play in warning dissemination for flash floods.

- Promoting public understanding of the cause and impacts of flash flooding is crucial to improving response.

- The media reporting in four case studies describes the key characteristics, impacts and causes of flash floods. Key words and phrases frequently used include: sudden, unexpected, raging torrents, extreme event, surging, rapid, dangerous, fast, great flood, serious flooding.

- Print media reporting of flash floods contains several broader messages that contribute to public education and raising awareness of flash floods.

- The most widely reported of the messages is "what is a flash flood," focusing on the key characteristics of speed, velocity, depth and power of the water as described above.

- Specific public education messages giving instructions about what to do in the event of a flash flood are rare.   Several articles outlined the danger of driving in flash flood conditions and walking through flood waters.

3 Appropriate and effective responses before and during flooding

The objective of this chapter is to review the cause and effect of different responses to flash flood warnings and communications.

3.1 Is it possible to be specific in general terms about what an appropriate and effective response to flash flooding should be or does this need to vary for different locations, people and buildings?

In answering this question, we need to examine how to determine whether a response is appropriate and effective, what a response is and what generalisations we can make about appropriate and effective responses to flash flooding.

3.1.1 What is an "appropriate and effective response"?

What constitutes an "appropriate and effective" response to flash flooding has not been clearly defined in the research literature. What is appropriate and effective will clearly depend on the time available to make a response and the particular circumstances involved (Sime, 1997). In addition, the effectiveness of response will depend on an individual's perception of risk and the warning process (discussed in more detail in section 3.3). For this reason it is not possible to put forward objective criteria for assessing suitability and effectiveness of responses. However, the literature does provide some useful perspectives on what may contribute to a response being considered appropriate and effective by different players.

Whereas the Environment Agency links effectiveness with an avoidance or limiting of material damage and loss of life, the public's interpretation is often more complex, being also concerned with actions designed to alleviate psychological as well as physical or material discomfort. This means that there may be some divergence between what risk management organisations (the Environment Agency being just one example) and the general public consider to be 'effective'. Fielding *et al*. (2007) cite the work of Thrush *et al*. (2005) who showed in a study of flood victims in the autumn of 2000 that the first action for domestic pet owners was to move their animal to safety. This response took precedence over saving property or material possessions and was considered to be effective even in hindsight.

An important measure of "effectiveness" is how flood victims rate their experience. In their secondary analysis of post-event survey data compiled by British Market Research Bureau (BMRB) for the Environment Agency, Fielding *et al*. (2007) found the receipt of appropriate and timely warnings in the face of imminent flood significantly raised the percentage of flooded respondents that reported their actions as effective. Actions taken in response to flood warning were numerous, and fell into four principal categories: seeking further information; protecting property and

belongings; helping to protect people and animals; and evacuation. The most significant factor in predicting the likelihood of reporting effective action was found to be a perception of being prepared for flood. However, the reporting of effective action was significantly reduced in households experiencing flooding above floor level, which may demonstrate that the capacity for action the public consider effective would be limited in flash floods situations.

3.1.2   What constitutes a "response"?

What constitutes a "response" needs to be considered in the light of the recent shift from an approach which seeks to respond and recover from these natural disasters including flooding, to an integrated approach to flood management that seeks to reduce the losses and break the cycle of event-disaster. This requires a paradigm shift in perceptions, attitudes and practices in order to move from the current model of post-disaster response and recovery to one of investing in the holistic disaster management process (UN/ISDR, 2001).

Integrated flood management has also been described as a flood forecasting, warning and response system and total flood warning system.

This approach comprises preparedness for floods; providing flood information; communicating the risks of flooding to raise public awareness; detecting and forecasting floods; communicating flood warnings to the public and to professional partners; promoting effective warning responses to flooding; effective emergency exercises and planning; co-operation between emergency services; media management and effective aftercare; and reviewing the lessons learned.

Ketteridge and Fordham (1998) identified six stages to response. These are pre-flood preparedness, the flood emergency stage, evacuation, emergency accommodation, the return and longer term recovery.

In England and Wales the principal professional actors involved in flood incident management are the Meteorological Office, the Environment Agency, local authorities, the police, the emergency services (such as. fire, ambulance and voluntary services), and the media (McCarthy *et al*., 2007).

In addition, the policy framework for flood management in England and Wales has moved away from flood defence towards flood risk management (Defra, 2005), bringing the human dimension more to the fore. This is illustrated by two examples. First, the Foresight 'Future Flooding' project concluded that changing societal characteristics had a greater influence than climate change on the rate of risk enhancement (Evans *et al*., 2004). It also concluded that a portfolio approach to flood risk management — combining traditional flood defence with non-structural alternatives such as flood warning systems — was the best means of countering increasing flood risk. Second, the new UK government policy for flood risk management articulated by the Department for Environment, Food and Rural Affairs — termed 'Making Space for Water' (Defra, 2005) — sees human behavioural change as equally important as flood defence measures in developing sustainable policies.

The logic of such an integrated approach is that each of the components is essential for the functioning of the whole (Sime, 1997) and must, therefore, be considered in assessing the effectiveness of response.

However, when considering what constitutes a "response" it is important to recognise that taking no action in response to a threat constitutes an action in itself (Gruntfest

1987). Taking no action or forming one's own assessment of risk, may well be an appropriate response in certain cases. It is possible that some of those who report inaction are the very people who have a high level of awareness and who are very well prepared with regard to a flood event (Fielding *et al*., 2007).

3.1.3   Factors affecting cause of death or injury

Clearly a key criterion for judging the appropriateness and effectiveness of action in the response to a flash flood must be whether the action prevents death and injury. We must, therefore, examine the causes of death and injury during flash floods and consider what action may prevent them.

General factors affecting mortality and morbidity

As Gruntfest and Handmer (2001b) have noted, fewer people are injured in flash floods relative to slow rise flooding, but more are killed.

In flash floods and other situations where the impact is more immediate, most deaths are due to drowning while injury is usually a result of moving debris and high winds (Legome *et al.*, 1995). Mortality associated with a flood will depend on the flood characteristics (such as depth, velocity and speed of onset), but the way people respond to floods is also a critical factor. In European floods particularly, deaths are strongly related to risk-taking behaviour (Jonkman, 2003) and the World Health Organization (WHO) (2002a) estimates that up to 40 per cent of health impacts due to flooding result from such behaviour.

Flood hazard factors used to calculate how floods impact upon people include depth of water, rate of rise, velocity, wave characteristics and debris and pollutant load (Jonkman and Kelman, 2005). Rescues from fast flowing waters in particular present high hazards. Risk to life or serious injury is thus likely to be greatest when one or more of the following flood conditions exist (Wallingford, 2003):

- Flow velocities are high.

- Flood onset is sudden as in flash floods, for example the Lynton/Lynmouth floods, UK, in 1952, Big Thompson flood, USA, in 1976 and flash floods in Southeast China in 1996. This includes the fast arrival time of floodwaters from the source of flooding (such as defence breach) to human settlements (Jonkman, 2007).

- Flood waters are deep.

- Extensive low lying, densely populated areas are affected, as in Bangladesh and Myanmar (Burma), so that escape to high ground is not possible.

- No effective warning is received (for example where there is less than, say, 60 minutes of warning).

- Flood victims have pre-existing health/mobility problems.

- Flood alleviation and other artificial structures themselves involve a risk to life because of the possibility of failure, for example by a dam or dyke.

- Poor flood defence assets lead to breaches or flood wall failure, leading to high velocities and flood water loadings on people in the path.

- Debris in the floodwater that can cause death or injury.

- Flood duration is long and/or climatic conditions are severe, leading to death from exposure.

- Poor quality of buildings, which determines the possibility of building collapse (Jonkman, 2007).

Velocity

Some experimental studies have been conducted to calculate the flow characteristics of a flood (that is, the product of velocity and depth) that causes humans to lose stability when trying to walk through floodwaters. In a study by Karvonen *et al*. (2000), the product of depth times velocity causing loss of stability varied from 0.64 to 1.26, with taller and heavier individuals managing better in flowing water. Abt *et al*. (1989) reported that a product of 1.0 is the safe limit. Similar results have been obtained in Australia (Emergency Management Australia, 1999a; New South Wales Government, 1986). However, more recent research by Penning-Rowsell *et al*. (2003) reproducing circumstances closely resembling urban flash flooding showed that low depth/high velocity floods are much more dangerous than suggested by Abt *et al*. and other studies. For the purposes of public education a simple message that just six inches of rapidly moving flood water can knock a person down has been used in the United States (The Weather Channel, 2008a).

Behavioural factors

Based on an analysis of victims and survivors of the flash flood in Big Thompson Flood in Colorado that killed 139 people in 1976, Gruntfest (1977) concluded that the best action to take in the event of a flash flood warning is to climb to higher ground. Those who climbed the canyon wall had the best chance of survival; those who took no action were more likely to die in the flood.

Interestingly, Gruntfest (1977) also notes that the size and nature of the group individuals were in was significant to survival rates. Peer groups were more likely to have taken action to escape by climbing the canyon wall than families who were more likely to take no adaptive action. Also groups of three to five people survived with more frequency than bigger or smaller groups. However, those who were alone were at the highest risk.

People may often underestimate the depth of waters or become disoriented and drift into deeper waters, thus being swept away. Also, in flooded urban areas, people attempting to move about, particularly where flood waters are turbid or discoloured, may fall down blown manholes, into excavations or into ditches (Wallingford, 2003).

Data from the 1997 floods in Poland, cited by Kundzewicz and Kundzewicz (2005), shows that some of the victims died by taking a risk, either consciously or unconsciously. For instance, several cases (all male) were recorded as 'fell into a river and drowned,' possibly after attempting to swim and being hit by debris. Other victims died trying to save a dog or collect their belongings, and some just wanted to watch or possibly photograph the flood waters. 'Flood tourism' has been reported in several recent European floods, including large groups of people gathering on river banks and pursuing recreational boating on flooded streams (Jonkman and Kelman, 2005; Wilson, 2006). Many of these people underestimate the dangers that they may be exposing themselves to. A review of flood fatalities in Australia between 1788 and

1996 showed that males outnumber female fatalities by 4:1. Most of the deaths (38.5 per cent) occurred when people attempted to cross river channels, bridges or roads during a flood. Moreover, 31.5 per cent of the victims died inside buildings while awaiting rescue or while unaware of the flood (Coates, 1999).

Risky behaviour is often caused by lack of knowledge of what is best to do in a flood situation. One of the main difficulties of flood management lies in educating the public to react in an appropriate way before or during a flood (WHO-Europe, 2002b).

During the Big Thompson Flood in Colorado which killed 139 people in 1976, 95% of those killed were trying to outrun the waters along their path rather than climbing rocks or going uphill to higher grounds (The Weather Channel, 2008b). Many people in London, when asked what they would do in the event of a flood, said that they would descend into the underground railway system to escape (WHO- Europe, 2002b).

Driving

Many flood-related deaths occur when people attempt to drive in floodwaters. Wallingford (2003) argues that 0.3m of water is sufficient to cause instability to small, light or low motor vehicles while emergency vehicles may resist waters of up to 1m in depth (Wallingford, 2005). Safe evacuation by higher and larger vehicles is only possible up to the depth of 0.4m. The US Federal Emergency Management Agency (FEMA) website (2006) warns that "two feet of rushing water can carry away most vehicles including sport utility vehicles (SUV's) and pick-ups". Once vehicles are floating, the pressure of the water will prevent the doors from being opened (Jonkman, 2003).

Driving and the purpose for travelling may be a powerful constraint on risk perception and people's behaviour when facing natural hazards. Studies (Glass *et al.,* 1980, French *et al*., 1983; Mooney, 1983; Schmidlin and King, 1996; Hammer and Schmidlin, 2001; Jonkman, 2005; Jonkman and Kelman, 2005; Kundzewicz and Kundzewicz, 2005) show that a large number of disaster deaths occurred on the road among motorists, especially in the face of flash floods (Ruin *et al*., 2007). In the US, where the National Weather Service has documented flood fatalities since 1903, more than half of all flood fatalities are vehicle related. Although not such a significant cause of death in Europe as the in United States, vehicle deaths are still a leading cause of mortality. For example, motorists represent 40 per cent of the people who lost their lives in the last 50 years in France (Antoine *et al.*, 2001; Lescure, 2004).

Ruin *et al*. (2007) used an innovative methodology merging traditional questionnaire-based surveys with cognitive mapping to look at motorists' perception of risk associated with flash floods in the French Mediterranean region, where 27 people were killed in 1999 and another 24 in 2002. The research concluded that drivers have a higher tendency to underestimate the risk than to overestimate it and that some areas are more prone to underestimation of risk. Three factors always appeared relevant in the case of underestimating risk: area of residence, previous flash flood experience and profession.

Gruntfest (1977) found that those driving alone were the highest risk population in the Big Thompson Flood in Colorado. She concluded that if time allows, closing a road (or canyon) is an immediate action that should be taken by officials as soon as a warning message is heard.

In addition, drivers are a particularly difficult group to warn as, clearly, they will not be in a position to pick up on warnings disseminated door to door, on television or by

telephone. They may also be in an area they do not know so be unable to pick up on environmental cues of danger. They are likely to be separate from friends and family who would confirm a warning. Radio is likely to be the most effective way of warning motorists. However, further work is needed to understand how radio stations broadcast warning messages.

An appropriate and effective response to flash floods must therefore include messages to avoid risky behaviour, including walking and driving through floods, and to climb to higher ground.

3.1.4 Locational characteristics

Area characteristics can determine the local topographical, geological and hydrological conditions and catchment characteristics, as well as local climate, land use and spatial development. For example, they can affect the speed of onset of flooding. Floods in areas with steep hillsides and 'flashy' catchments are difficult to warn against and prepare for and can be particularly dangerous due to mudslides and the amount of debris in the floodwaters (Environment Agency, 2005a). Therefore, the hydraulic and topographic characteristics of an area will affect the nature of a flood event, particularly the depth and velocity of the floodwaters. Factors such as the presence of trees, caravans and other sources of large debris also depend upon the type of area where the flood event occurs. Hence, knowledge of the floodplain is essential when estimating flood depths and velocities (Wallingford, 2003). The nature of the floodplain may also affect evacuation, for example in some urban areas access to residents may be lost early in the flood due to the floodwaters blocking roads (Defra/Environment Agency, 2003; cited in Wallingford, 2003).

New building developments in a flood-prone area can affect the consequences of a flood by changing the topography and thus the effects on people and property in the inundated area.

3.1.5 Building characteristics

The characteristics of people's individual dwellings may be significant factors affecting risk to life during flood events. Floods can have a damaging affect on buildings which, if the building collapses, may cause fatalities (Jonkman, 2003). Damage to buildings caused by a flood depends on a series of circumstances. The main factors are the flood characteristics (depth, velocity, presence of debris) and those characteristics of the buildings being affected (number and structure of buildings) (Roos, 2003).

The failure of walls and the scour of foundations were the most relevant failure mechanisms identified for Dutch properties affected by flooding by Roos (2003). Velocity and depth damage curves derived by Roos' model showed that 'failure of walls' would cause the most damage. The flood factor that has the greatest effect on the failure of walls is the debris load. Wave action did not cause damage at all and velocity and depth have less impact on structures than debris, although Kelman and Spence (2004) suggest that both breaking and non-breaking waves can have significant impacts. In an overview of flood action on buildings, Kelman and Spence (2004) state that the characteristics related to direct building damage include forces, pressures, chemical reactions and other impacts. Buildings need to be designed to resist both hydrostatic and buoyancy forces (an uplift force which could result in the building or parts of it floating away, for example in timber buildings). Three forms of

debris action also exist which can cause damage to buildings: static actions for example the forces exerted on a wall by sediment deposited by the flood), dynamic actions (being hit by a moving object in the debris) and erosion.

Significant loss of life can also occur in floods where people cannot find refuge inside or where buildings collapse or are swept away (Wallingford, 2003). A survey of 45 housing clusters comprising 1,123 people showed that nearly 22 per cent of people that failed to reach a concrete or brick structure died whilst everyone who sought refuge in such structures survived (Bern *et al.*, 1993). Problems are also exacerbated by the fact that in many countries floodplains are the only available space for settlements, particularly for poor and migrant people who, in addition to settling in these more vulnerable areas, usually lack the resources to build robust structures (Wallingford, 2003).

Timber framed buildings and mobile homes may cause particularly significant loss of life or hazardous rescues in floods (Wallingford, 2003). Single storey buildings, ground floor or basement apartments, car parks and metro systems are especially at risk, not only from flash floods but also from burst mains and sewer flooding. Additionally, people trapped in buildings or on roofs may die from exposure, although this is less likely in European flood events due to speedier search and rescue operations.

Caravan parks are considered a highly exposed floodplain use and their residents have specific requirements in terms of flood warnings, particularly as residents may have limited knowledge of the area and may not be aware of flood risk. There are several examples of loss of life in campsites; for example, in 1996 an intense storm occurred over the Arás catchment near Biescas in the central Pyrenees. Eighty-seven people were killed as a result of the subsequent flood of a campsite. Five of the 24 victims of the 2002 floods in the South of France were tourists or campers (Twigger-Ross *et al*., 2008).

As part of the RESCDAM project Karvonen *et al.* (2000) conducted a review of literature regarding the permanence of buildings in flowing waters. Table 1 shows the flood conditions that would cause total or partial structural damage to buildings.

House type	Partial damage	Total damage
	vd = velocity x depth	
Wood framed- unanchored	$vd \geq 2$ m^2/s	$vd \geq 3$ m^2/s
Wood framed-anchored	$vd \geq 3$ m^2/s	$vd \geq 7$ m^2/s
Masonry, concrete and brick	$v \geq 2$ m/s and $vd \geq 3$ m^2/s	$v \geq 2$ m/s and $vd \geq 7$ m^2/s

Table 1:   Flood conditions leading to the partial or total damage of buildings
                 Source: Karvonen *et al*. (2000).

One of the significant causes of death from flooding in Continental Europe appears to be from the structural collapse of buildings, either directly leading to death or preventing escape from the floodwaters. However, this appears to be more relevant in Continental European flooding than it is in UK flooding, where the only major flood incident where building collapse has been significant was in Lynmouth, 1952. This is due to the faster and deeper waters experienced in some parts of Europe. Differences in building type, materials and construction methods are important in determining whether a building will be severely damaged or destroyed by flood

waters. Figure 2 is a photograph taken following the flooding in Troubky, Czech Republic. All nine fatalities in this event were caused by structural collapse. In this case building materials consisted of non-fired bricks.

Figure 2:   Photograph of the destruction to properties following the 1997 flooding Troubky
              © Nové Přerovsko

Buildings are not the only problem when considering structural collapse. A number of people within the European floods lost their lives when either roads or bridges that they were travelling on were destroyed. Again, the numbers of people who are killed in these types of circumstances are difficult to predict due to the fact that the numbers of people within a collapsed building or travelling over a bridge when it fails are extremely variable.

Many factors influence the stability of buildings and structures during flash floods. However, mobile homes, timber frame buildings and single storey, ground floor or basement properties are more at risk and this could be used as the basis of a general message.

3.1.6   The significance of flood timing

The location of people during a flood is also influenced by a number of factors, such as the time of the day or time of year of the flood. Particularly in the absence of an official flood warning system, the timing of the onset of the flooding is likely to be significant as it will influence whether people are aware of waters rising, or indeed of any heavy precipitation, and therefore whether they become aware of the danger. If a flood event begins in the middle of the night a flood might reach hazardous levels before some people are aware, which may affect their options and their ability to react. This is obviously more important when considering fast flowing, rapid onset flood events. The time of day will also affect whether people are at home or at work, which can lead to an increase or decrease in the numbers exposed, depending upon where the flooding occurs. For instance, if a flood occurs during the evening or at a weekend, more people are likely to be in their homes, whereas a daytime flood during the week will mean that many people are at their workplace. However,

generally the working population will be younger and able-bodied and therefore would be present to assist in moving others to safety.

The seasonality of the flooding is also important. In those regions which experience large numbers of visitors, in either summer or winter months, not only will this mean that flooding at this time of year potentially impacts upon more people, but might also affect those with a lower awareness of the risk, those who have a more limited understanding of how to respond, and potentially present language difficulties, causing problems for both warning and response. Some people also might be participating in activities which would inherently make them more vulnerable to flooding should a rapid-onset event occur (such as fishing, canoeing, and camping).

It has also been argued (Jonkman and Kelman, 2005; Poole and Hogan, 2007) that in some circumstances seasonality will affect the ability of people to escape floodwaters or indeed directly cause their death. The temperature of the water and/or the surrounding air temperature for those displaced, and having to spend significant time outside, may increase instances of mortality.

3.1.7   Is evacuation an appropriate and effective response?

Deaths can happen inside buildings when the water levels rise very quickly and people are trapped in lower levels or are unable to reach higher floors. Eventually the floodwaters can exceed the highest floor of a property. Most of the fatalities in Romania during the August 2005 floods drowned as floodwaters rushed into their homes (CBS News, August 25, 2005). This raises the question of whether to evacuate or to stay in the property.

An examination of those who died who did not have any particular vulnerability, such as being elderly or hampered by illness or disability, highlighted that in most floods people are *more* likely to be killed or injured if they are outside of their home or in their cars during the flood (Jonkman and Kelman, 2005). Thereby undertaking evacuation at inappropriate times (for example when the floodwaters have risen in depth and velocity) and of those who are not in immediate danger by staying in their own homes (for example from building collapse or deep water) often increases their chances of death. It can be concluded that the effectiveness of evacuation procedures in preventing fatalities is very closely linked to both the type and characteristics of the flooding as well as the timeliness of the evacuation and associated flood warning.

Sorensen (2000) states that the most common recommendation for a protective action in a warning is to evacuate. However, he cites research where evacuation is not the best action. As we have already discussed, a major cause of fatalities in flash floods is attempted evacuation in a vehicle. As a result Sorensen suggests that planning should consider an extended range of alternatives such as vertical evacuation for floods and hurricanes and in-place sheltering for tornadoes. He quotes Liu *et al*. (1996) and states that very little research has been conducted on the response to warnings to seek shelter.

In discussing the effectiveness of evacuation it is also important to consider that instructions to evacuate may not be followed. Quarantelli's research (1984) has shown non-evacuation is preferred to evacuation as individuals under stress typically attempt the least disruptive behaviour option. When people feel endangered they attempt to maintain their traditional and routine ways of behaving. There are also very practical reasons why people do not wish to evacuate, such as fear of looting. In addition, evacuation is not likely to occur if family members are separated. They

avoid mass shelters as much as possible and chose to go to the homes of friends and family. However, while local residents are usually reluctant to evacuate, tourists, travellers and strangers are likely to leave at the first indication of danger.

In addition, evacuation itself has negative impacts on health and well-being. Ketteridge and Fordham (1998) examined flood evacuation in two communities in Scotland. They concluded that "the physical, social and psychological effects of both flooding and evacuation are so deeply embedded in each other that many householders who have been through the experience of a major flood refer to the problems and anguish at having to leave their homes rather than referring directly to the flood itself."

However, they also noted that while evacuation may not always be the appropriate response, for those living in single storey or ground floor accommodation or mobile homes, it is often a necessity. As older people tend to live in this type of accommodation, they may be disproportionately affected by the trauma of evacuation.

In conclusion, the evidence examined shows that evacuation is not always an appropriate and effective response to flash flooding. However, where evacuation is necessary, it is crucial that vulnerable people within the community are identified so assistance can be properly targeted to meet their needs. We now go on to discuss vulnerable groups and their special needs.

3.1.8   Vulnerable groups

Qualitative research undertaken by the University of Surrey for the Environment Agency addressed the concept of 'vulnerability' in three ways:

- In terms of certain groups being more likely than others to be flooded.

- In terms of certain groups being less likely to be aware of flood warnings.

- In terms of certain groups being less able to respond to flood warnings.

Social and demographic factors that may prevent people making an effective response are discussed in more detail in section 3.4. Key target audiences for public education and awareness-raising and their respective needs are discussed in chapter 4. Here we summarise what the evidence tells us about groups with risk factors that may require particular types of response in order to be effectively protected against the dangers of flash floods.

Certain types of holiday makers are more at risk of death or injury from flash flooding. Just 35 per cent of those who died during the Big Thompson Canyon Flood of 1976 were permanent residents. The rest were tourists, visitors from elsewhere in Colorado and seasonal residents (Gruntfest, 1977). It was the height of tourist season in Big Thompson Canyon, a popular camping area an hour west of the city of Denver, Colorado. In 1997, 12 tourists were killed in Antelop Canyon on the Colorado plateau by a flash flood (Climb Utah, 2008). Many of those rescued in the Boscastle flood were also holiday makers (Environment Agency, 2004). Gruntfest (1977) concludes that operators of hotels, campsites and restaurants should be aware of safe places to which their customers can go in the event of a flash flood.

Based on case studies and research we can conclude that holiday makers are more at risk for four main reasons. Firstly, they are more likely to be camping or staying in

mobile homes or caravans which are likely to be washed away during flash flooding. Secondly, they are more likely to be involved in activities that leave people exposed, such as hiking or cycling. Thirdly, they may not know the local characteristics and vulnerabilities that alert people to hazards and help them keep safe and understand local environmental cues. Finally, they are less likely to receive official warnings.

Gruntfest *et al*. (1987) suggests that older people are less likely than younger people to receive warnings and evacuate and are more likely to die in a disaster.

Many elderly and infirm people live in single storey and ground floor properties and so are more at risk from flooding. Therefore, elderly people also tend to lose more irreplaceable items in floods because more has been accumulated over the years that can be destroyed if flood waters enter their home. Elderly people may also be less likely to benefit from the help available to them, for example emergency accommodation (Ketteridge and Fordham, 1998).

Disabled people are less likely to be able to take effective action because their disability hampers them. Also, people with hearing and visual impairments will require special communication methods to receive effective warnings.

People from ethnic minorities who do not speak English (and Welsh in Wales) may not be able to understand warnings issued in English. Tapsell *et al*. (1999) report that Asian women in Banbury had not been able to communicate with the authorities or understand what was going on during flooding. A major concern for the Asian women was that any information made available about flooding should be in their own language. For example, the Environment Agency has flooding leaflets produced in a number of languages, including Urdu, but none of these had been issued to the Asian community in Banbury, except after the focus groups by the researchers.

The gender implications of flooding have been more widely examined in recent years. Ketteridge and Fordham (1998) have suggested that women may feel greater attachment to their homes because, due to traditional gender roles of caring for the home, they have a greater investment in it and may suffer its loss more. They also report that women take a stronger role in emergency and recovery actions than their partners and so could benefit from targeted warning messages.

Some studies have also found that women are less likely than men to perceive flash floods as life threatening (Knocke and Kolivras, 2007) and less likely to take action in response to a flood warning (Fielding *et al*., 2007).

However, there is some evidence that men are more likely than women to be killed during flooding because they are more likely to participate in risky behaviour. A review of flood fatalities in Australia between 1788 and 1996 showed that males outnumber female fatalities by 4:1 (Coates, 1999).

In conclusion, the inclusion of awareness raising messages aimed at holiday makers should be considered because of their particular needs. Elderly people, people with disabilities and people from ethnic minorities may also require targeted warning and support to make an effective response.

In addition to gender, other factors which may contribute to special difficulties and vulnerabilities in making an appropriate and effective response include:

- Age, including being a child or young adult.

- Household structure.

- Single parent families.

- Low incomes/resources.

- Lack of education or employment.

- Lower social status/power (particularly women in some cultural groups).

- Homelessness.

- Living alone (often the elderly).

- Living in solitary geographical locations.

However, it is important to note that these groups/individuals may not always be vulnerable. The situation will depend upon the individual's particular circumstances (Flood Hazard Research Centre (FHRC), 2008).

3.2 What evidence is there that if people are able to make an appropriate and effective response to flash flooding, its impacts can be significantly mitigated?

Having looked at some of the concepts and definitions of appropriate and effective responses, we now explore what evidence there is that these responses can mitigate the impacts of flash flooding. The impacts of flash flooding may be direct (such as death or the loss of property due to flood waters), indirect (such as the value of lost business or days off work due to ill health resulting from flooding) (Petersen, 2001). Here we have discussed both direct and indirect impacts as economic, social and environmental.

In considering how impacts can be mitigated by effective action, it is also important to bear in mind that the negative impacts of flash floods result from two independent components. The first of these is hazard, that is, the flash flood. The second is the vulnerability, that is, the human activity that could be destroyed or disturbed by the hazard. Researchers have concluded that expanding populations, development and changing recreational activities are actually increasing vulnerability to flash floods (Handmer *et al*., 2001).

3.2.1 Economic impacts

There is some evidence on how effectively flood warnings reduce the impact of material damage due to flooding. Parker *et al*. (2007a) undertook a survey on flood warning responses and savings in household flood damage. The findings are based upon two interview samples as follows: (a) the full sample of 408 residential interviews described above, and (b) a core sample of 341 interviews. The survey found the value of flood warnings in terms of damages saved is modest, and lower than indicated by previous applications. The research demonstrates that the extent of flood warning damage savings by moving and raising household assets is limited by the value of what can be moved. Only 21 per cent of the total flood damage potential for UK residences is avoidable by householder's damage-saving responses to flood warnings, and only about a quarter (24 per cent) of this damage is currently avoided by their warning responses. This research is not specific to flash floods. Other research has shown that people who experience flooding above floor level are

significantly less likely to report effective action (Fielding *et al*., 2007). Therefore, it may be that in cases of flash flooding, the impact of effective action on property is even more reduced.

Having prior experience of flooding, receiving more informative warning messages, receiving help from outside of the home, and being connected to an Automatic Voice Messaging (AVM) system are all factors associated with higher damage savings. Although the majority of householders whose homes are flooded take action to save assets, these actions are often ineffective (Parker *et al*., 2007a).

Bimal (1999) examined the experience of several counties in south-central and south-east Kansas that experienced flash floods in the first week of November 1998. The communities of Arkansas City and Augusta were among those most severely affected by these floods. Based on field work and a questionnaire survey administered among the residents of these two cities, this study analysed the performance of emergency actions taken by local government in response to a major flash flood event.

According to the estimates provided by 77 respondents, damages incurred amounted to about $2.24 million; this figure represents an average loss of $29,000 per flood victim. This amount can be considered substantial and it provides an indication of the severity of the 1998 flooding. One reason for this substantial loss was that most flood victims did not expect the flood and therefore were not prepared for it (Bimal, 1999).

Nearly three-quarters of the respondents surveyed were not pleased with the flood warning component of emergency response measures considered in this study. Several respondents believed the authorities of both cities knew several hours in advance that certain parts of the city were going to be flooded, but deliberately informed people that they had nothing to worry about in order to avoid creating a panic situation (Bimal, 1999). One could deduce from this that there was a perception that the victims of these flash flood felt they would have been able to do more to mitigate its impacts if they had been warned.

However, it is important to recognise that protecting items of little monetary benefit may ultimately produce its own economic impact and is therefore far from negligible. It is now widely recognised that the psychological effects of flooding have an adverse impact upon physical health (for example see Tapsell *et al*., 1999; Ohl and Tapsell, 2000; Walker *et al*., 2006). By taking action that helps to maintain well-being at a psychological level, people affected by flood are thus less likely to succumb to physical ill-health and its concomitant economic impacts, for example lost working days and use of health services (Fielding *et al*., 2007).

In addition to a quantitative approach to assessing the impact on property of effective responses to flash flooding, the importance of the home in terms of place identity and family and individual well being must be stressed. As Sime (1997) explains, "home is a geographical and emotional reference point in people's lives which becomes increasingly threatened if a flood progresses." Displacement caused by the need to evacuate can cause stress and emotional disturbance as significant as the flood itself (Ketteridge and Fordham, 1998).

Some groups may be even more vulnerable to the loss of home, such as elderly people who may have spent much of their lives in one place (Sime, 1997) and women who may spend more time at home (Ketteridge and Fordham, 1998).

3.2.2 Social impacts

The Emergencies Disaster Database (EM-DAT: The OFDA/CRED International Disaster Database (www.em-dat.net, Université Catholique de Louvain, Brussels, Belgium) records a total of 2,516 flood disasters in the period 1980- 2006, accounting for 176,824 deaths and some 2,600 million people affected world-wide. Knocke and Kolivras (2007) quoted US government figures which estimate flooding caused nearly 9,000 deaths in the twentieth century in the USA alone.

Although, in general, mortality in floods has not been curbed, there has been a tendency towards a decrease in the number of flood-related fatalities per flood event. Kundzewicz and Kundzewicz (2005) argue that this is a sign that flood preparedness and warning systems are saving lives.

Interestingly, in an analysis of victims and survivors in the flash flood in Big Thompson Flood in Colorado, Gruntfest (1977) concluded that those who climbed to higher ground and, therefore, had the best chance of survival, were less likely to have received a warning than those who did nothing or drove out. However, loss of life in floods remains a hazard, and few recent major European floods have occurred without fatalities (European Environment Agency, 2003).

A British-based model of the factors likely to influence loss of life in floods has been developed by Penning-Rowsell *et al*. (2005), taking the form:

$$N(I) = N \cdot X \cdot Y$$

where N(I) is the number of deaths/injuries, N is the floodplain population, X is the proportion of the population exposed to a chance of suffering death/injury (for a given flood) and Y is the proportion of those at risk who will suffer injury. The model defines the characteristics of the area (effectiveness of warning; speed of onset; land use) and of the population (age profile; presence of very infirm people) as affecting fatality rates. The model appears to achieve good calibration results, albeit for just three floods (Lynmouth in 1952; Norwich in 1912; Gowdall in 2000); the actual death toll in the three events analysed was 38 compared with the model's prediction of 35 fatalities. Separating out the effects of warning and response systems, table 2 below gives the reduction in fatalities with an increasingly effective flood warning system, again as predicted by the model.

Warning status	Calculated fatalities	Calculated fatalities rounded down	Reduction in fatalities (%)
No flood warning system	37.5	37	–
Flood warning system present but limited	35.5	35	5.2
Effective tried and tested flood warning and emergency plans	33.1	33	11.7

Table 2: The reduction in fatalities with an increasingly effective flood warning, as predicted by the model developed by Penning-Rowsell *et al*. (2005b). (Note: The actual death toll in the three events analysed was 38).

In analysing this work Parker *et al*. (2007b) conclude that warnings appear to be less effective in saving lives than one might suppose, with a reduction in loss of life of only some 12 per cent for the difference between a situation with no warnings compared with an "effective tried and tested flood warning and emergency plans.'. This small predicted difference is because the determinants of the fatality rate in the model are many and varied (as they are in reality) and the floods used to calibrate the model are characterised by a rapid rate of rise, high depths and velocities, which mean that the events are predicted by the model to be hazardous even if warnings are given.

The model has limitations, not least of which is that it is based on data from just three flood events, all of which are extreme events (with estimated return periods of 100, 750 and 800 years). Further research is required to refine this model so that it satisfactorily addresses types of flooding which are more the norm in Britain.

Furthermore, the example of the Boscastle flood on 16 August 2004, arguably the most high profile and serious flash floods that have affected the UK in many years, would suggest that an effective response can greatly mitigate the negative impacts. There, despite serious damage to property and infrastructure, around 100 people requiring rescue by helicopter from rooftops and 115 cars being swept away, no-one was killed or seriously injured. However, the prompt action and the swift arrival of the helicopter was the result of luck; a local off-duty coastguard recognised the signs of danger, warned visitors not to wade through the flood waters and alerted the Falmouth coastguards of the developing incident (Environment Agency, 2004). Another factor at Boscastle was the fortunate presence of many young, fit surfers who rescued other people.

Parker *et al*. (2007b) interpreted a recent large-scale survey carried out in 30 locations in England and Wales, which included questions on the impact of warning on the health effects of flooding. In this, 23 per cent of respondents were warned in some way prior to flooding. As to the effects, some 59 per cent of those with houses flooded attributed some physical health effects to flooding. Simply receiving a flood warning of some kind made hardly any significant difference to the incidence of the respondents' self reported physical or psychological symptoms.

However, the research did find some evidence that a longer warning lead time has a mitigating effect on the mental health of flood victims at the time of flood and later. When those who had no warning were excluded, a longer warning time was associated with significantly less reported shock. Similarly, although those who received a warning were as likely as others to report experiencing 'fear, helplessness and horror' as a result of the flood (40 per cent for the warned compared with 46 per cent for the unwarned), the trauma again lessened significantly with a longer warning lead time. Therefore warning lead time, rather than receiving a warning or not, appears to be the crucial factor in reducing the adverse psychological effects of flooding. This means that the characteristics of floods where earlier warnings cannot be given, such as flash floods, may produce more adverse psychological effects (Parker *et al*., 2007b).

Ketteridge and Fordham (1998) found that the way evacuation was carried out and the provision of emergency housing exacerbated the impacts of flooding on health. Some interviewees reported additional stress caused by being treated with disdain as homeless people and suffering three or four moves before being offered suitable temporary accommodation. They also found that interviewees reported a lack of support at the re-entry phase. They cite the findings of other research that supports the conclusion the return phase is often assigned the least attention in terms of

official assistance. Some householders expressed concerns that they returned home before it was safe to do so.

Ketteridge and Fordham (1998) also report several important obstacles to community recovery from a flood that can mitigate the effectiveness of responses to flooding by negatively impacting on community cohesion. These obstacles arise from perceived inequalities in the distribution of hardship funds, the difficulties experienced by people who were underinsured but not eligible for hardship fund payments because they had some insurance, and the perceptions in the different levels of support available to homeowners and tenants and between local authority and housing association tenants.

3.2.3   Environmental impacts

Environmental impacts could include the destruction of flora and fauna, damage to habitats and species diversity, damage to natural recreational resources, damage to scenic resources and damage to archaeological and historical resources (Petersen, 2001). Clearly the loss of such resources may also have indirect economic impacts where tourism is affected.

Recent flash floods such as Boscastle on 16 August 2004 and North Yorkshire 19 June 2005 resulted in significant environmental damage, though no attempt has been made to quantify this.

There is no evidence as to whether these impacts may be reduced by effective response. It may be assumed that once a flash flood is happening, very little action can be taken to limit environmental damage. Measures to prevent environmental damage must focus instead on flood prevention and land use policies.

3.3   What do people at risk consider that they need to know in order to make an appropriate and effective response?

As we have already discussed, the receipt of a warning is a key factor which determines whether people feel they have made an effective and appropriate response (Fielding *et al*., 2007). However, in England and Wales, the public's response to flood warnings is currently low and is a key benefit-limiting factor which could begin to undermine a recent major shift in national flood risk management policy towards a more people-centred, portfolio approach in which changing human behaviour is viewed as important (Parker *et al*., 2007b). We now examine what the research tells us about how to ensure a warning message conveys the necessary information to enable appropriate and effective response. Sections 4.3, 4.4 and 4.5 include discussion of types of warning and sources of warning.

3.3.1   The process of warning response

The assumed model is that the warning message is a stimulus and the response the reaction to it. However, studies have concluded that there is no such thing as a warning message; there is instead what is perceived or believed by people, the meaning they give to the message, which may or may not correspond to the warning

message intended by those who issue it (Quarantelli, 1984). Warning is, therefore, a social system.

Applying a social science paradigm to warning focuses on human perceptions of risk information and the underestimated complexities of communicating risk between actors, and stresses that uncertainty must be managed rather than eradicated. The use of social science in improving flood warnings, and flood risk management in general, is now a significant issue in England, and is becoming so in the rest of Europe (Drobot and Parker, 2007).

Parker *et al*. (2007d) developed the model shown in Figure 3 to describe the process of risk communication.

The process of risk communication aimed at influencing perceptions, attitudes and behaviour

D J Parker 12.3.07
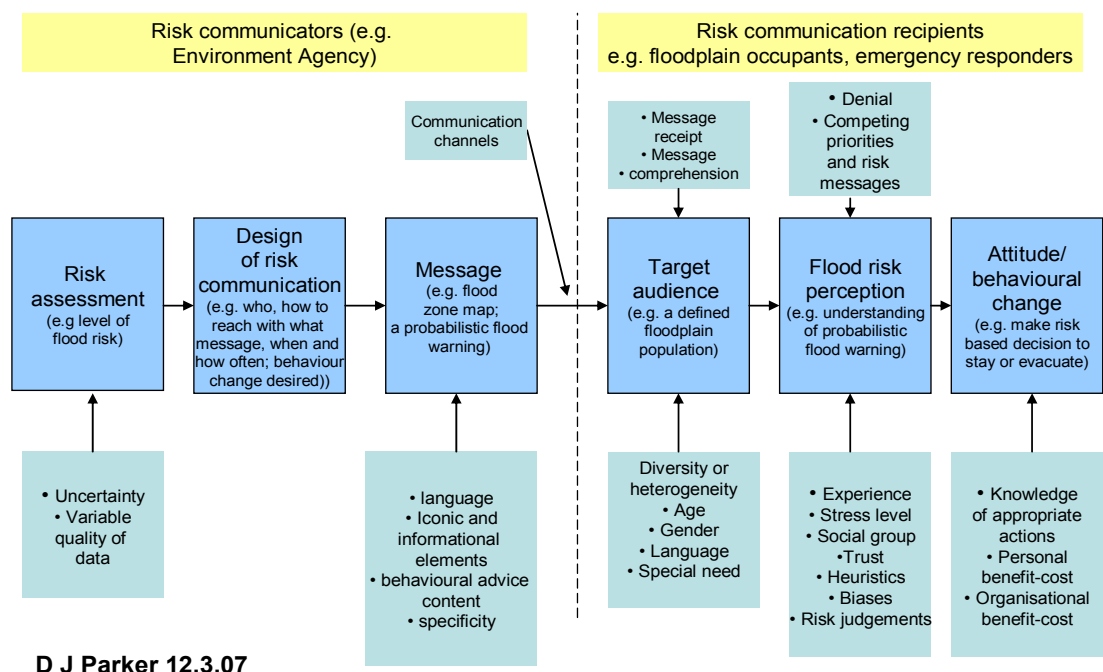
Figure 3:   The process of risk communication aimed at influencing perceptions, attitudes and behaviour. Source: Parker *et al*., 2007d.

Mileti and Sorensen (1990) characterise the warning process as sequential:

- Hearing the warning.

- Understanding the contents of the warning message.

- Believing the warning is credible and accurate.

- Personalising the warning to oneself.

- Confirming that the warning is true and others are taking heed.

- Responding by taking a protective action.

Additional research by Blanchard-Boehm (1998) indicates that the "confirmation" of the warning process can take place at different stages and may be repeated.

Lindell and Perry (1992) characterise warning response as a four-stage process:

- Risk identification: does the threat exist?

- Risk assessment: is protection needed?

- Risk reduction: is protection feasible?

- Protective response: what action to take?

It is important to stress that warnings received by an individual are often, in reality, received by the social group (for example, a household) of which the recipient is a member. The interpretation of the messages is usually a group or collective process (Quarantelli, 1984). Members of the household become involved in decisions about how to respond which may either reinforce or reduce belief in the warning (Drabek, 1986). These factors become important in considering the central issue of how to go about motivating more people to act, which in turn underpins the economic effect of warnings. Warning recipients must also be capable of acting to reduce potential losses, and so risk communication must also focus upon people being made aware of what to do to protect themselves and their property. Last, people must understand the need to respond effectively within the available time window. Warning recipients do not respond in a pseudo-mechanical manner to warnings. Research indicates that people's images of the future are shaped by the experience of the past, and a major limitation of human ability to use hazard information, such as a flood warning, is a basic reliance upon experience, or what Kates (1962) termed the 'prison of experience.'

Equally important as message perception is warning confirmation, the inevitable interaction to obtain additional information or validation. Unless the danger is immediate and directly threatening, how other people are seen as reacting becomes crucial in confirming or refuting the individual perception of the warning message. There is normally a reaction rather than a response to warning messages. This reaction involves interaction with others. Out of this interaction may develop social confirmation of a threat and this can lead to a response (Quarantelli, 1984).

Socio-psychological and behavioural research emphasises that in risk response people do not behave as linear thinkers and responders, but get involved in complex cognitive processes. For example, disbelief in warnings is a pervasive initial reaction, which is most probably followed by a variety of behaviours that may confirm, or neutralise, the warning, if indeed there is any response at all (Perry *et al*., 1981).

During the warning process people sometimes make large errors as a result of using cognitive short cuts known as heuristics.

- The availability heuristic: sometimes conclusions are drawn about the probability of an event in the light of how easily it can be retrieved from memory. The likelihood of vivid imaginable causes of harm can be systematically overestimated.

- The representativeness heuristic: when estimating probabilities people commonly ignore base rates and misunderstand chance phenomena – six tosses of a coin resulting in heads, tails, tails, heads, tails, heads is considered more likely than heads, heads, heads, tails, tails, tails as it is considered more representative of randomness.

- Adjustment and anchoring: these heuristics help understand the way in which people adjust estimates of the likelihood of an event occurring in relation to the information that they anchor the estimate to (Petts *et al*., 2002).

In addition, there are also motivational explanations for biases in risk judgments. Probably the most well known of these is the phenomena of unrealistic optimism (Weinstein, 1980). This refers to the phenomena where people believe that their chances of experiencing negative events are lower than the group mean. This may well be linked to people over-estimating their personal control (Petts *et al*., 2002).

It is known that people often underestimate the risk of a hazard recurring due to a cognitive error known as "gamblers fallacy." This is where people perceive probability as not being unique to each event, but as varying over time in response to what previous outcomes have been. People like certainty and seek to avoid uncertainty. They are also poor at understanding and using probabilistic information. This desire for certainty leads to fallacious working models, such as gamblers fallacy. It also leads people to attribute certainty to probabilistic information, for example 'there will be a flood every 10 years' rather than 'there is a one in 10 chance of a flood every year' (Shaw *et al*., 2005).

All this explains why people do not respond to warnings in a pseudo-mechanical manner, and why it is commonplace for warning responses to fail to meet the expectations of those issuing warnings. Research indicates that people's images of the future are shaped by their experiences of the past, and a major constraint on human ability to use hazard information, such as a flood warning, is basic reliance upon experience (Drobot and Parker, 2007).

Understanding warning as a social process is key to developing effective warning messages that promote effective response. It is not enough to simply provide real-time information. The warning message must also be understood and used; as such, a successful warning, including the response, depends on both psychology and technology as risk perception is a complex process. The link between awareness and response is not necessarily direct. Successful warnings must incorporate risk perception in order for warnings to be meaningful to recipients and motivate risk acceptance and the adoption of risk reduction behaviour (Hayden *et al*., 2007).

3.3.2   Different audiences for responses

There are two principal categories of recipients of flash flood warnings which need to be distinguished. Firstly, there are the responses of individuals who live, work or are in transit through a floodplain when a flood occurs. This includes members of the public and other organisations with a permanent address in a flood risk area such as:

- Residents living permanently in a flood risk area.

- Shops and other businesses in the flood risk area.

- Public concerns in the flood risk area, such as schools, hospitals and old people's homes.

Crucially it also includes others without a permanent address in a flood risk area who may easily be left out of official warning dissemination. These include:

- People travelling through the flood risk area.

- People temporarily resident in the flood risk area: tourists, travellers, caravan or boat owners.

- People who own assets in the flood risk area, such as caravan site owners.

- Farmers who have livestock in the flood risk area.

- Organisations with assets in the flood risk area, such as utility companies, rail authorities, train operating companies, highway and port authorities and so on.

Secondly, there are the responses of organisations which are responsible for managing a flood emergency, such as local authorities, police authorities, fire and rescue services, health organisations, the military and other organisations. It also includes agencies that may be required to disseminate the warning such as local and national media and other local networks. Parker *et al*. (2007b) have highlighted that flood warning systems are not just about warning people as individuals, but also about providing information for agencies and institutions so that they can close flood barriers, begin emergency response and mobilise the necessary resources.

The focus of this report is mainly on what is known about how individuals, particularly householders, respond to warnings, although some evidence about owners and managers of business enterprises is also included where available. Most of the available evidence relates to how householders respond to flood warnings and the protective behaviours which they adopt or fail to adopt.

3.3.3   The content and style of a warning

Evidence shows the style and content of a message can have a dramatic effect on public response (Sorensen and Mileti, 1989; Vogt and Sorensen, 1992). The five specific topics that have been found to enhance a warning's effectiveness are the nature, the location, the guidance, the time and the source of the hazard or risk. The style aspects that are considered most important are message specificity, consistency, accuracy, certainty and clarity (Sorensen, 2000).

In their secondary analysis of post-event survey data compiled by BMRB for the Environment Agency, Fielding *et al*. (2007) found satisfaction with content and dissemination of flood warnings was generally good, particularly amongst people with prior experience of flooding. One major criticism concerned the 'general' nature of many flood warnings.

The implications of warning as a social process is that planning for warning should focus on the anticipated behaviour of the people likely to be involved, not the words used to warn them. There is a need to plan in a way that will provide social confirmation rather than disconfirmation of warning messages. In crisis situations people will be proactive as well as reactive. Therefore, warning messages will be only one element in the total picture. If warning messages are unclear, ambiguous or easily interpreted as not involving immediate danger, no warning will be perceived. The more specific and detailed the message is the more likely it is to be believed. Personal risk must be seen as high and relatively certain (Quarantelli 1984; Twigger-Ross *et al*., 2008).

Gruntfest *et al*., (1987) has suggested nine guidelines for the wording of warning messages with short lead times:

- Convey a moderate sense of urgency.

- Estimate the time before impact.

- Provide specific instructions for action.

- Confirm the threat if possible.

- Describe the actions of others.

- Tell the number of warnings previously issued.

- Mention the present environmental conditions.

- Advise people to stay clear of the hazard zone.

- Estimate the size of the expected flood.

As warnings will be issued using a number of channels, it is important to keep the message:
- Consistent.

- Clear.

- Timely.

- Accurate.

- Simple.

- Convey confidence in the validity.

- Say what people should do (Shaw *et al*., 2005).

Elliot and Stewart (2000), in discussing early warning for flood hazards in relation to their experiences in Australia, suggest that an effective warning message will say to each member of the target audience: what is happening, what it means to that person and what that person can do. The key influences on the design of warning messages are knowledge of the physical characteristics of the flooding and an understanding of the communities at risk.

Knowledge of the impacts is also required for all three components. It is important to recognise that the 'public' is not a uniform group of people who think and act in the same way. Warning messages need to be designed with the characteristics of different recipient groups in mind. Factors which create these differences within a community which might need to be considered in message design include:

- Degree of exposure; severity of impact.

- Degree of flood experience.

- Financial or emotional 'stake' in the flood-prone area (for example residents as opposed to tourists).

- Household structure (for example, age, health status)

- Language.

- Employment status (likelihood of being home during the day).

Each group may have different requirements and may also have particular difficulties in translating the message into appropriate action. Therefore it is important that those

at risk are involved in system design, development and operation, and that messages are reviewed regularly.

Information about the likely flood duration is important in making arrangements to minimise economic and social disruption arising from flooding. If it is known that flood duration is likely to be long (say a few days or up to a week rather than a few hours) then warning responses can be tailored to this knowledge to minimise loss, especially indirect, consequential loss to businesses.

Ketteridge and Fordham (1998) report that many of those evacuated in the flooding incidents examined in Scotland would have welcomed information on what to take as they left the house, particularly medication and clothing. They also found that people who evacuated did not know about the rest centre and the additional information that was available there.

Ketteridge and Fordham (1998) also draw attention to the need to provide support and information for the return after evacuation. Some evacuated householders felt they did not receive adequate information on when it was safe to return.

Sorensen (2000) suggests that a well-constructed message prototype for an emergency is important to the quick dissemination of information. Therefore, organisations with responsibility for issuing warnings need to be prepared with such prototypes and aware of the importance of content and style of warning messages.

3.3.4   How a warning is issued

Warning is a social process that passes onto people a sense of understanding that they are vulnerable to a certain risk, as well as to inform them of the most effective protective actions they can take. Therefore, risk managers need to repeat the message several times using a variety of communication channels. It is important to recognise how people come to believe certain messages, often confirming them by interaction with other significant persons such as family, friends and co-workers.

The primary way that a warning response can be affected by the issuing authority is in the design of the warning system, including the channel of communication, public education, and specific wording of the emergency message. In addition, incentives can be offered to increase response, including information hotlines, transportation assistance, mass care facilities, and security and property protection (Lindell and Perry, 1992).

It is important that the way a warning is issued reinforces a sense of urgency. For example, if a radio station continues with normal broadcasting after the warning has been issued or a television station issues a warning in sub-titles during normal broadcasting, the public will not believe the message is urgent (Gruntfest 1987; Quarantelli, 1984).

National television is generally not considered to be a good source of warnings for flash floods because they are highly localised events situated far from broadcasting cities (Gruntfest 1987).

Research (Quarantelli, 1984; Handmer and Ord, 1986) suggests that warnings delivered by other people are more likely to be believed than those communicated by an impersonal medium. The more personal the manner, the more credence given. However, warnings sent via mass media are more credible if issued by government or emergency agencies rather than private individuals. The more sources from which

the warning message is received the more likely it is to be believed. The significance of which agency issues a warning is discussed in more detail in chapter 4.

3.3.5 Preparedness

Underpinning the process of warning and response, and a key component of integrated flood management, is preparedness. Preparedness is concerned with both long and short term factors, and includes feeling adequately informed about how and when to act as well as taking preparatory defensive action both in advance of and immediately prior to a possible flood. This highlights the importance of flood warnings and flood-related advice from the Environment Agency as well as a fostering of self-help and community action. Being prepared for a flood is an important part of living with flood risk, and the 'feeling' of preparedness may well act as a buffer against psychological distress (Fielding *et al*., 2007).

Preparedness is especially important for flash floods as they can occur in seemingly unexpected places and with very short lead in times. The effective response of those at risk depends on the level of their awareness of flood risk, as well as their knowledge of the principles of the flood warning and response system (APFM, 2007b).

Furthermore, a lack of relevant knowledge has been found to not only constrain appropriate response, but also to exacerbate the long-term adverse effects of flooding with personal, social and economic consequences (Fielding *et al*., 2007).

Preparedness is linked to community education, discussed in more detail in section 4.4 of this report.

3.3.6 An overview of the research findings on response

The purpose of flood warning information and flood warnings is to reinforce appropriate warning response behaviour where it is occurring or under way, and to change otherwise inappropriate warning response behaviour. It is clear from the examination of evidence on flood warning response and related protective behaviours that, although there is an evident degree of similarity about how people currently respond to flood warnings (or how they say they will respond to them), the factors influencing warning response and protective behaviours are complex and inter-related. Apart from anything else, this suggests that it may be difficult, but by no means impossible, to create the conditions in which flood warning systems will work well – when working well includes inducing high levels of appropriate response and damage- and loss-saving. This kind of view prompted Handmer (2000) to ask whether flood warnings are futile. We examine the possible barriers to response in the next chapter of the report.

The current trends of flood warning response, as they arise from the evidence presented above, appear to be as follows:

- A significant proportion of people are likely to do nothing to prepare for floods and flood warnings, and are likely to take no action following a flood warning.

- A significant proportion of people will use personal observations and family and community networks (that is, personal and unofficial warning

systems), and may prefer these as more trustworthy than official flood warnings.

- Many people use a combination of personal, unofficial/community, and official warning systems when they perceive a flood threat.

- Staged warnings (where there are different levels of warning according to expected severity of event) appear to elicit greater response as the warning level is increased.

- People have a strong need to gain confirmation of a flood warning, no matter what the source of this warning may be – in some circumstances the actions people take to confirm a flood warning may lead them into danger.

- People have a higher incentive to save their lives than to prevent flood damage, and many will respond effectively to protect their life (for example by 'running away' or evacuating) once they assess the threat reasonably accurately.

- Many people seek to save possessions, especially valuables and memorabilia when they receive a flood warning.

- Many seek to move vehicles to flood-free ground on receipt of a flood warning.

- Many seek to prevent entry of floodwaters to their properties, but the inexperienced and un-knowledgeable resort to methods which are likely to be ineffective.

- A minority are prepared for a flood and a flood warning with contingent flood proofing methods (for example, flood boards and flood gates).

- A minority adapt their homes to make them more resilient and resistant to flooding.

- Warning responses which reduce psychological trauma and stress are counted by flood victims in their definition of 'effective' response.

- Many will posses flood insurance where flood insurance is widely available.

- The possession of flood insurance may be negatively associated with adoption of other warning responses (unless required by insurance companies).

- Those experienced in flooding will make more preparations and take more actions on receiving a flood warning than those who are inexperienced.

- Drivers may underestimate flood risks, especially flash flood risks, and need to be included into flood risk awareness-raising and flood warning measures.

Drabek (1986) provides a very useful inventory of sociological research findings relating to human responses to disaster. This inventory has the advantage of summarising the conclusions of vast quantities of research and research publications on this subject, much of it highly-regarded. Drabek's inventory of research findings applies to all types of disaster including the common flood disaster. In relation to the

'Public understanding of flash flooding' project, the findings appear to be of three types:

- Findings which are likely to be applicable to the flash flood situation whether the empirical evidence derives from such a situation or not (that is, the findings are likely to have broad relevance).

- Findings which come directly from rapid-onset disaster situations.

- Findings which come directly from slow-onset disaster situations and are likely therefore not to be relevant or applicable.

We have concluded that Drabek's findings still remain largely relevant and pertinent today as long as caution is used in interpreting them (which means that if local conditions indicate that there is reasonable doubt that a research finding does not apply, it should not be used in policy formulation). Unfortunately, the inventory has not been brought fully up to date, although Drabek did later summarise some of the key findings in relation to the social factors that constrain human responses to flood warnings (Drabek, 2000).

There are several questions in drawing upon Drabek's findings:

- Whether the early findings have stood the test of time and remain pertinent to "tomorrow's conditions."

- Whether findings from research on hazard warnings other than flood warnings are fully transferable to flood warnings.

- Whether Drabek's largely American data base and research findings inventory can be transferred to Europe where there may be cultural and other differences which may affect the feasibility of transfer.

In fact, many of Drabek's findings published in 1986 (and drawn from research dated earlier than this) appear to be replicated in more recent empirical studies suggesting that at least some of the research findings have not dated and remain relevant today. Also, as long as important differences in hazards are clearly taken into account when engaging in transfer of research findings from one hazard to another, there appears to be no reason why such transfers should not be considered. Drabek (2000) addresses the latter point by recognising that cultural differences may alter relationships among variables and when considering inter-societal comparisons. He suggests that they are feasible within a framework of models of societal change that take into account the particular stage reached in the development of a society. Of course, the same issue exists in treating Europe as a culturally homogeneous area, which it is patently not.

The research findings presented in Table 3 have already been through a selection process undertaken by Dennis Parker; this selection process considered relevance to today's conditions and relevance to flash flood hazards.

The greater the disaster frequency, the greater the proportion of the population who will have engaged in preparatory actions.
If encouraged to develop emergency plans for threats that have a high probability of occurring within a fairly short time frame, by authorities who are perceived as credible, a majority of families will do so.
Following a disaster, a majority of families will express general support for and a willingness to participate in emergency procedures designed to unify and protect families and their possessions.
The initial response to a disaster warning is disbelief.
After receiving a disaster warning, individuals tend to search for alternative interpretations that will neutralize the threat conveyed by the message.
Human beings under stress initially tend to interpret new data in terms of the known and familiar. People will generally believe they are not in immediate personal danger until perceptions indicate almost indisputably otherwise.
The interpretation of such apparently 'uncertain' expert information in a positive vein by the public is consistent with research on other natural hazards which suggests that members of threatened populations will seize upon any 'vagueness' in a warning message which allows them to reinterpret the situation in a non-threatening fashion.
Behaviourally, initial warning responses are variable, ranging from immediate adaptive actions, confirmation efforts, to total denial.
Misinterpretation of warning and refusal to consider it, occurs very often.
More specific warning messages produce higher levels of warning belief and perceived risk.
As the warning message increases in its accuracy, and/or information about survival choices, and/or consistency with other warnings, and/or clarity about the nature of the threat, the probability of adaptive response increases.
People who receive a vague or non location-specific message tend to define risk as low or believe they are outside the risk area altogether.
The higher the credibility of the message sender, the more likely the individual is to believe that they are at risk simply on the word of the authority – the warning message itself is an important source of risk relevant information for the individual, particularly regarding where, when, and the probable force of disaster impact – the individual's past experience with the disaster agent also forms a basis for assessing risk.
The probability of undertaking any adaptive behaviour is greatly enhanced by the presence of past experience.
The law of initial credibility posits that a warning system that enjoyed high credibility will lose more credibility following a false alarm than a system whose credibility was lower in the first place.
A curvilinear relationship exists, in some instances, between socio-economic status and warning belief. There appears to be a tendency for persons of low and high education to disregard the formal meaning of a signal, while persons of middle socio-economic status are more likely to accept the formal meaning.
Women are more likely to interpret a signal as valid than men.
Older persons are less likely than the young to receive warnings regardless of warning source, and less likely to take protective actions.
The greater the frequency of contacts with kin, the greater the number of warnings an individual will receive.
The greater the level of community involvement, the greater the number of warnings an individual is likely to receive.
Among people who tried to confirm a message, the perception of the threat as real was higher when confirmation was achieved than when the individual failed to get confirmation.
The proportion of people who try to confirm a pre-impact warning is positively related to the

amount of lead time prior to impact.
The more warning messages received by an individual, the fewer the attempts at warning confirmation.
People who see others behaving as if they believe a warning to be valid are themselves more likely to believe the warning.
A person is more likely to believe a warning of impending danger to the extent that perceived changes in his physical environment support the threat message.
Informal group interaction is a major source of reinforcement of disbelief in disaster warnings.
Unless all members are accounted for, families will be slow to undertake any kind of protective action.
Evacuation is a family phenomenon: for the most part, families evacuate as units.
As warning times increase, the official flood warning system is increasingly likely to find itself working in tandem with an unofficial system. At its simplest, this could be individuals making their own assessments based on environmental indicators such as heavy rain. However, it is more likely that those at risk will receive warning messages from many different sources.

Table 3:   Selected research findings on social behaviour in hazard and disaster situations with specific reference to a) preparations for flooding, b) flood warning response and c) self-protective behaviour according to Drabek 1986, 2000.

3.4   What are the barriers that may prevent people from making an appropriate and effective response?

There are a large number of factors that can prevent or encourage people to make an appropriate response. These factors are complex and interact with each other in intricate ways. Researchers have developed various models to help understand these processes. Figure 4 below shows the variables which determine flood warning response either by inhibiting or enabling response by individuals occupying flood-prone locations (Parker *et al*., 2007d).

This section divides discussion of the factors influencing response and potentially creating barriers into the following:

- Situational factors that restrict response.

- Social and political contexts that restrict response.

- Warning recipient characteristics that restrict response.

- Warning message characteristics that restrict response.

Socio-political, institutional context & conditions

Flash flood warning response

Disaster culture e.g. culture of self -protection

Presence of flood risk management agencies

Media filter

History of flood protection

Flood characteristics e.g. speed-of-onset depth, velocity, debris load, duration

Factors determining warning response effectiveness e.g.
• perceived life threat
• proportion of assets moveable
• warning lead time
• number of storeys
• availability of help

Cognitive processes incl. biases

Public education

Characteristics of population at risk e.g. age, gender, income, education, tenure, disability, family, social networks

Awareness and knowledge of population at risk of -
• Flood risk
• Environmental cues
• Flood warning processes
• Precautionary & preparatory measures
• Emergency measures
• Appropriate responses to flood warnings

Level of flood experience among the population at risk

Forms of warning
• personal observation
• unofficial/community-based
• official warning system

Trust in authority

Current level of community flood protection

Warning recipient availability to receive warning & ability to respond to warning

Trust in civil protection & flood agencies

Degree of public openness about flood risk information

Expectations and norms about responsibility sharing for flood protection

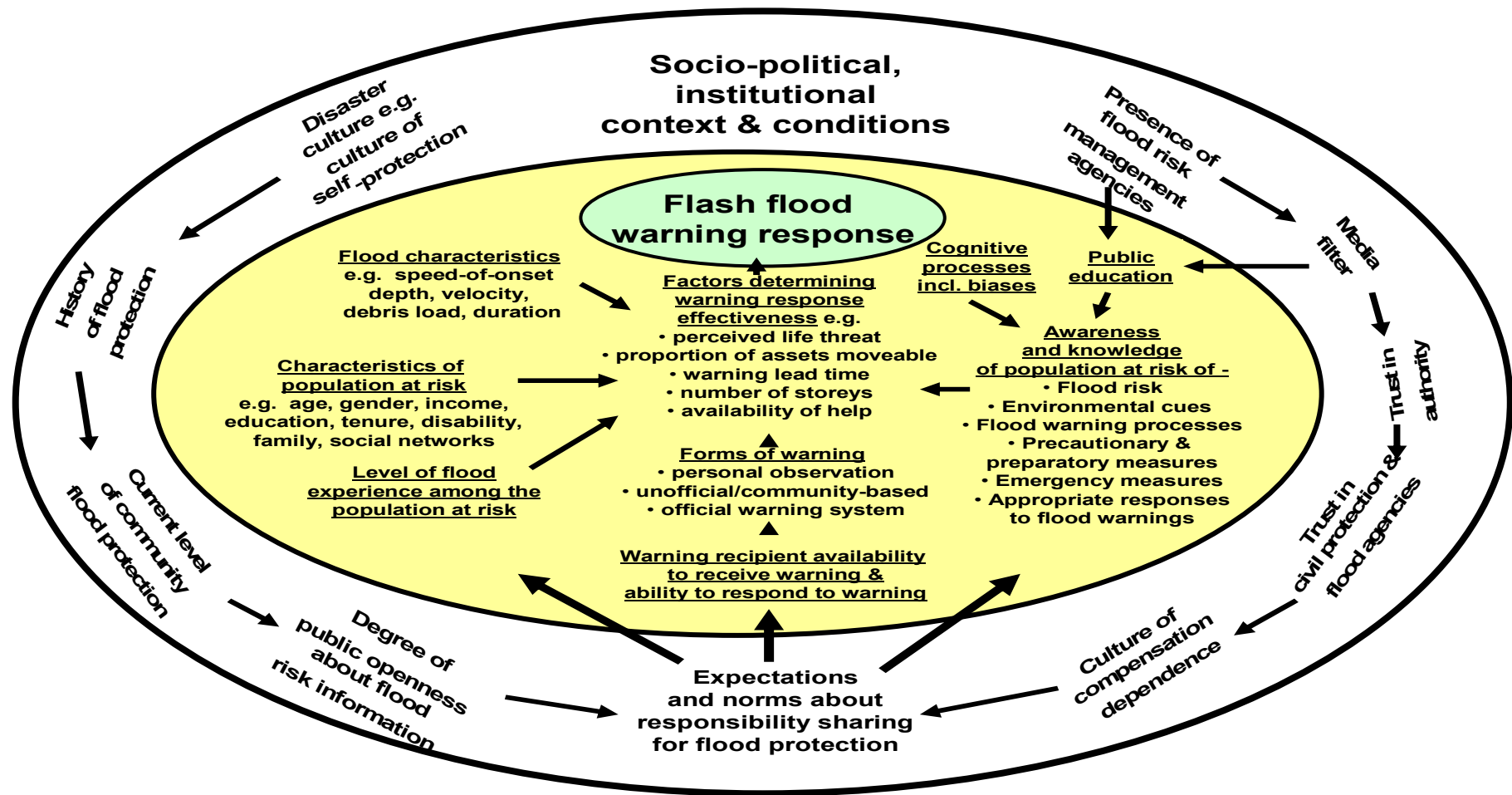Culture of compensation dependence

Figure 4: The variables which determine flood warning response either by inhibiting or enabling response by individuals occupying flood-prone locations (Parker *et al*., 2007d)

3.4.1   Situational factors that restrict response

Situational factors, including the characteristics of the flooding, can either inhibit or encourage levels and effectiveness of flash flood warning response.

The timing of the flooding is a key factor. People may find it difficult to respond to a flood warning if it is received after night-fall. Certainly in England farmers who have to move livestock out of the path of floods report that receiving a flood warning at dusk is problematic because they then have to move stock in the dark and conditions on floodplains can be dangerous. In Mauritius the tropical cyclone warning system has been constructed so that a warning is given out several hours in advance of nightfall rather than at nightfall to enhance response (Parker and Budgen, 1998).

The availability of property owners/tenants to receive a flood warning and to respond to it depends upon their being contactable. A proportion of any flood-prone population can be expected to be away from home or away from their business and this inhibits response. Unavailability at a flood-prone address can be tackled to some extent through mobile telephone and similar technologies that allow people to be contacted wherever they are located.

Floods may also occur in holiday periods when a high proportion of flood-prone people may be away from their homes. The Easter 1998 floods in England occurred on an Easter Bank Holiday weekend when such factors became relevant.

Variables such as the severity of the flood threat, including the perception of flood risk severity, the rate floodwaters rise (or flood-to-peak interval), and the time available between a flood warning being received and the onset of flooding, are usually considered to be critically important variables in understanding if and how people respond to a flood warning. Whether a flood is a slow-onset, medium-onset or rapid-onset event can be expected to greatly affect warning response. In the case of flash floods, the lead in time for warning will be short, reducing the amount of time for response.

Flood depth and velocity are also important variables because they have major implications for what warning responses are considered appropriate and effective. Warnings should give information to the public on expected depths and whether velocities are likely to present a hazard to life. A warning response which may be effective in shallow and/or low velocity flooding can be positively dangerous in a deeper flood (especially if flood depths are likely to exceed one metre) and in medium to high velocity events. The picture is made more complex, however, because local topography is likely to present a range of flood depths and possibly also a range of flood velocities in the same flood location. In these situations, the information presented in a warning should focus upon the more dangerous side of the expected conditions.

Flood severity was found to be significant. The reporting of effective action was significantly reduced in households experiencing severe flooding. In addition, where flooding was above floor level, a significantly greater proportion of action was 'advised' (that is, following advice given in a warning) amongst those reporting effective actions than amongst those whose actions were seen as not effective (Fielding *et al*., 2007).

Situational factors also include local operational factors affecting response as the flooding incident develops. In Boscastle there was a delay in the incident being declared and accepted by all agencies as a 'major incident.' While this was a relatively short delay, the declaration of a major incident has some practical implications for

many agencies. The delay was a result of a number of factors, many of which, like communications, feature later in this report. Others, like a lack of early appreciation of the scale of the incident, aggravated this delay (Government Office for the South West (GOSW), 2006).

In addition, communications problems caused significant negative aspects during the initial stages of the emergency response. The 'blue light' agencies' initial responders were unable to communicate with their control rooms, as Boscastle was found to be a communications blank spot. As more resources were committed to the scene, they successively found themselves out of radio contact. Mobile telephones did not operate at the incident location either. The media response to the incident at Boscastle was swift and it was early pictures on broadcast television that gave responders' control room staff a real appreciation of the scale of the problem, in the absence of direct communication with their staff at the scene (GOSW, 2006).

The lack of multi-agency training and exercising at the strategic level was a further problem hampering effective response that emerged as a theme at the debrief.

Media management was another area where there were some concerns. The point was made that it is essential that all agencies co-ordinate their media releases through the lead agency, rather than "getting picked off individually" as one participant put it. Some of the operational agencies at the scene found the physical intrusion of the media operation was initially problematic (GOSW, 2006).

The experience of flooding in Carlisle provides another example of how operational communication problems can hamper effective response. The flooding of Willowholme sub-station resulted in the loss of power to telecommunications systems that soon threatened the fragile communications that were working, including the police UHF network. In addition, a major telephone cable fault occurred in the vicinity of the Civic Centre, resulting in failure of all landline telephones in the north of the city. This meant that there was no '999' emergency service available in North Carlisle and the County Plan for telephone failure was activated. This was achieved by placing Mountain Rescue Radio Operators in vehicles located at all public call boxes. A base station was established in the County Council Control Centre (Government Office for the North West (GONW), 2005).

The lack of electricity meant that some people were unable to hear radio broadcast output as they did not have access to battery powered radios. Bearing in mind the Government advice for people to "go in, stay in, tune in" during an emergency, more clearly needs to be done to ensure people can "tune in" during a power cut. Other methods of disseminating information to the public were used such as the print media, the internet, telephone messaging systems, loudhailers, and door knocking. However, many of these were also unusable due to the power cuts (for example digital cordless phones (DECT) and switch boards would not work) (GONW, 2005).

Crisis services require regular professional training, but frequently, as in Poland, for example, non-structural methods of flood damage limitation have been either entirely disregarded in this training, or considered to a very minor extent. Integrated flood management guidelines stress that government authorities should undergo training in the range of flood damage limitation techniques most appropriate for their local conditions (APFM, 2007b).

3.4.2   Social and political contexts that restrict response

Social and political contexts determine how people understand risk, attribute responsibility and decide if and how to respond. These contexts can, therefore, lead to barriers to response.

Fernández-Bilbao and Twigger-Ross (2008) concluded that there is a clear gap between the public's perception of their own responsibility and that of authorities in terms of reducing flood risk. Whilst the scientific community and institutions have moved from flood defence to flood risk management, this paradigm shift has not trickled down to the general public, thus emphasising the knowledge gap between the scientific community and local populations. This has a series of implications: people do not take responsibility for protecting themselves against flood risk, do not understand the concept of residual risk from flood defences, and do not understand the distinction between structural and non-structural measures. The public's stance in terms of flooding is mainly that it is the authorities' job to protect them.

The findings from the FLOODsite Task 11 Italian case studies reveal a situation in which those living in the villages with significant flash flood/debris flow risks underestimate the risk to themselves; they feel protected by the presence of dams, embankments and barriers even though residual risks are present and these control structures have been defeated recently. Residents delegate the responsibility for safety to local service departments and agencies. There is a widespread opinion that the costs of flood defence must be borne by public institutions, and individuals therefore absolve themselves of the responsibility for defending themselves. Therefore, most respondents take no steps to protect their dwellings either before or after a flood, and this response is reinforced by a lack of confidence in available measures and a lack of knowledge about what measures individuals can adopt.

The findings from the FLOODsite Task 11 German case study locations reveal a flood-prone population living in high risk flash flood locations with relatively infrequent flooding. This population is reliant and dependent upon flood defence structures which proved to be completely inadequate during the 2002 event. At the time of the 2002 flood the flood warning system was unable to deliver a prior warning of a flood to the people of Erlln and Sermuth (although we understand that steps have since been taken to improve the flood warning system); but the authorities in Eilenburg had prepared a flood evacuation plan which was effective. The flood-prone population displays a high degree of unpreparedness for flooding and appears to have delegated that responsibility for flood defence and safety to the authorities.

The socio-political context is significant in this respect. This part of Germany has been in post-socialist transition since 1990. Political structures under socialism were highly centralised and people learned to rely upon the state for protection and safety. Since 1990 and reunification there has been a transition to a federal structure, but attitudes towards personal responsibility take time to change. A further significant contextual factor is that following the 2002 flood there has been a very high degree of compensation (100% in many cases) for flood damage provided by governmental institutions.

The very existence and presence of State or municipality sponsored and financed flood risk management agencies can create a belief that flood protection is not the responsibility of the individual but is that of the State, unless the arrangements for sharing responsibility are clearly laid out and constantly repeated and reinforced.

Even in England and Wales, where the government and municipalities generally take a no compensation approach to flood victims (in contrast to many other parts of Europe), recently flood damage compensation has flowed to local communities and been used to temporarily re-house flood evacuees while their houses are repaired. This occurred following the serious flooding in Hull, Yorkshire during 2007 in which the media portrayed the area as 'the forgotten community' at a time when a new Prime Minister was seeking to gain public confidence. In deciding how to proceed on the issue of flood damage compensation, understandable and credible arguments for social solidarity and support for the vulnerable during and after flooding need to be compared with arguments for creating a less dependent flood-prone population who are capable

of engaging in actions to reduce their exposure to flood risk. There is clearly no straightforward answer to the dilemma posed by those counter-arguments. However, public messages which suggest that responsibility for flood loss can be transferred from the flood victim to the general taxpayer carry a significant risk of undermining flood preparations and flood warning response other than life-saving responses, although they may not always do so.

Bimal's research (1999) found one of the important reasons for widespread dissatisfaction with the emergency response efforts in response to flash flooding in Kansas was that respondents did not expect flooding to occur and most city residents were not prepared for it. The reason, in part, was that the levees generated a false sense of security for residents and many perceived that the threat of flooding had been eliminated through the construction of the levees. Unfortunately, some of the levees were over 40 years old and many were not properly maintained.

The participation of local communities can bring many difficulties. The passivity of local communities in solving their own problems results from the conviction that only structural solutions can limit flood damage, and also from a lack of faith amongst local people that they can have any power (APFM, 2007b).

3.4.3   Warning recipient characteristics that restrict response

The social circumstances of those to whom flood warnings are issued are *absolutely crucial* to any understanding and interpretation of how people respond to flooding and flood warnings. In this sense 'context is everything' in understanding and interpreting flood warning response, and ultimately in identifying the circumstances which are most conducive to an effective response to flood warnings. These social circumstances can be divided into demographic factors, such as age, gender, social class, ethnicity and household type, and individual risk perception factors, such as experience, outlook and preparedness. We also look at the extent to which panic can contribute as a barrier to effective response.

In research into responses to warnings about earthquakes Blanchard-Boehm (1998) found message recipient characteristics to be more significant than message characteristics in determining whether an individual takes action in response to a warning.

Demographic factors:

Twigger-Ross *et al.* (2008) concluded that vulnerability can be characterised as disconnection from systems, resources and officials, and the current system is likely to reproduce those vulnerabilities rather than mitigate for them. This means that people with vulnerability characteristics are those least likely to receive a warning from this current service unless there has been specific effort to target those people, for example through some locally based tailored service.

Here we look at the evidence that certain demographic characteristics may render people less aware of the dangers of floods, less likely to receive and understand warnings and less likely to take effective action. The following demographic characteristics are discussed in turn:

- Age.

- Disability or illness.

- Gender.

- Ethnicity.

- Social class.

- Employment.

- Housing status and tenure.

- Other factors.

Thrush *et al*. (2005) found that those aged under 45 or over 55 were less likely to be flood aware than those aged 45 to 54. Quoting research findings by Gruntfest (1977) and Downing (1977), Handmer and Ord (1986) provide the following generalisation, based on correlations found in the research: "the elderly respond less adaptively, often because of lack of mobility and difficulties in understanding warning messages." However, Steinfuhrer and Kuhlicke (2007) found that in the German case studies there was a strong correlation between age and uptake of flood insurance, with uptake rising sharply in the 40 to 49 and 50 to 59 age groups (although some of this was a result of people retaining existing policies from before German unification). By using Handmer and Ord's generalisation one might easily be tempted to conclude that the elderly take fewer measures to prepare and respond to flooding, and flood warnings, than other age groups. However, the direction of correlation depends entirely upon which actions are the focus of attention. Waterstone (1978), for example, found that younger people were more aware of flooding.

Single pensioners were the category most likely not to respond to Flood Watch. This is a group already known to the Environment Agency as particularly vulnerable in terms of ability to take action.

Even if they receive a warning, a proportion of households may be unable to take any damage reducing action owing to age, infirmity, disability or being alone (Tapsell *et al*., 2004). In the British Market Research Bureau (BMRB) post-event surveys, the proportion of such households has ranged from 17 per cent (BMRB, 2001) to 23 per cent (BMRB, 1998). Twenty-seven percent of the sample of the 408 householders interviewed as part of the research were disabled or over 75 years of age, and 35 per cent fell into a composite category of 'vulnerable households' with at least one of three characteristics: ill/disabled, over 75 members, or those living alone.

Fielding *et al*. (2007) concluded that the presence of long-term illness within the household was one of two demographic factors which influenced whether action was reported as effective, the other being respondents' work status.

The University of Surrey data indicate that respondents with a long-term illness were significantly less likely to report effective action than those without an illness (here the focus is upon the effectiveness of the actions taken), but they also report that the presence of disability or long-term illness did not significantly affect reported actions taken (here the focus is upon the actions taken rather than their effectiveness).

Outside help may compensate for individual infirmity. Research by Parker *et al*. (2007a) showed about 40 per cent of all householders reported that they had received outside help, sometimes citing more than one source of help (the percentages which follow therefore cannot be aggregated). Neighbours and friends were the most commonly cited source of help (55 per cent), followed by family outside the household (25 per cent), local authorities (24 per cent), and the emergency services (12 per cent). However, the 'vulnerable households' were no more likely to receive help than other households (Parker *et al*., 2007a).

Those with sensory or visual impairments may not be able to see or hear the warning if it is transmitted only through written, televisual or audio media. It is important to use a mixture of different types of media to ensure those with different sensory impairments can receive the message. Human contact warning systems such as door knocking or wardens generally work well (FHRC, 2008).

The effect of gender on flood warning response does not appear to be straightforward. Some research asserts that gender does not affect attitude or response to warnings (Baker, 1979). However, other research suggests that females tend to believe warnings more readily and respond more rapidly (Mack and Baker, 1961; Drabek, 1969). However, the University of Surrey research found that women are more likely to do nothing or seek advice than men when receiving a flood warning. Fielding *et al*. (2007) found that young men and middle-aged women were likely to say they would do nothing in response to flood warnings, even at the most severe level.

There is very little research on how ethnicity affects response to natural hazards, including flash floods. The emphasis so far has mainly been on people from ethnic minorities who do not speak English (and Welsh in Wales) so cannot understand a warning issued in this language. There may also other cultural factors that affect how people from ethnic minorities respond to the warning process. For example, Tapsell *et al*. (1999) report the experience of a woman who had recently arrived from Pakistan and had been shocked at the fact that a country as technically advanced as England could experience a flood. She had thought that only countries like Bangladesh experience floods and that authorities in more developed countries are able to control flooding. In addition, McEwen (2007), found that ethnic minority communities in Gloucester did not engage in the 'Community engagement with its flood history: understanding risk' project except as part of class contributions in the 'schools project.'

Parker *et al*. (2007a) conclude that those in higher social grade groups are more likely to receive warnings than those in lower groups. There is corroborating evidence that those in lower social grade groups are less likely to be reached by a flood warning than others, almost whatever methods of communication are used. This finding comes from the research on the social performance of flood warning technologies (Tapsell *et al.,* 2004) and is found in Handmer and Ord (1986). Parker and Budgen (1998) found the same in Mauritius regarding tropical cyclone warnings. Because of this the warning response of those in lower social grades can be expected to be less than those in higher social grades.

The analysis suggests the reporting of action as effective may be affected by two demographic characteristics: respondents' work status and long term illness within the household. Respondents who fell into the category 'looking after home' were significantly more likely than average to report effective action (Fielding *et al.*, 2007).

Many householders remain unwarned because of the limitations created by warning system reliability and householder availability problems.

There appears to be good reason to believe that tenure usually influences warning responses taken, with those renting taking far fewer actions to save flood damage than owner occupiers of houses. The same applies to the owners and renters of commercial buildings. In a flood-prone population which comprises a high proportion of those who rent their properties, it can be expected that many will pass on responsibility for flood protection to the landlord and will not exhibit a high level of flood warning response. Thrush *et al*. (2005) also found that being in a pre-1970s property increased awareness, as did being a long-term resident of an area.

Other demographic factors that may contribute to people being less likely or able to take effective response include living in solitary geographical locations, being homeless, living alone and low educational attainment. Findings in the hazard literature reveal a number of social factors that increase warning response. These

include the observation of social cues (Cutter, 1987; Bateman and Edwards, 2002) and membership of a strong social network (Gruntfest, 1997; Drabek 1994a). Being responsible for children (Carter *et al*., 1983) or people with medical needs (Bateman and Edwards, 2002) also increases the likelihood of a response to hazard warning, as does being in the same place as other family members (Cutter, 1995). Being part of a large group at the time a warning is received is, however, found to decrease response (Dow and Cutter, 1998), although working for a large organisation has the reverse effect (Drabek, 1994b; Fielding *et al*., 2007).

In general those who are disadvantaged in society in normal times are likely to be more adversely affected by hazards such as floods. They may also be disadvantaged when it comes to receiving and acting on warning messages.

Thrush *et al*. (2005) ran regression analyses of the 2001 'At Risk' and 'Post Events' surveys by BMRB, which showed that the following factors *decrease* the level of flooding awareness in at risk areas (in order of impact):

- Not been flooded before.

- Social class C, D, E.

- Renting accommodation rather than owner occupier.

- New to area – moved in last year.

- Not in Environment Agency serviced area.

- Unemployed.

- Aged under 45 or over 55.

However, it is important to note that these individuals may not always be vulnerable. The situation will depend upon the individual's particular circumstances. It is also necessary to exercise a great deal of caution in using generalisations about the correlates of socio-economic characteristics and warning response. This is because apparently minor differences in circumstances or the focus of the correlation can lead to a reversal of the direction of correlation and subsequent generalisation. The correlates indicate in which circumstances actions taken are more likely; that is, the proportion of people taking a particular action is higher for those with particular socio-economic characteristics (but not that those exhibiting a particular characteristic will definitely respond in a particular manner). In this sense it would be wrong to conclude that having a particular demographic characteristic constitutes a barrier to effective action.

Other risk perception factors:

In addition to demographic factors, a number of other individual characteristics contribute to whether a person or group is able to make an effective response. These include experience, awareness and preparedness. Clearly the relationship between experience, awareness and preparedness is complex and influenced by demographic characteristics. We also briefly examine whether panic can be considered a barrier to effective response.

A great deal of evidence points to experience of flooding as one of the most powerful predictors of the extent of preparatory measures and flood warning responses (especially the proportion of a flood risk population taking measures and making responses). This implies that flood experience encourages flood warning response.

For example, in the Task 11 English case studies experience of flooding clearly increased the take-up of measures, and the number of floods experienced is significantly correlated with the number of flood preparedness measures taken (Tunstall *et al*., 2005). Similarly, in the German research the proportion of people adopting protective measures increased compared with prior to the 2002 flood (Steinfuhrer and Kuhlicke, 2007).

In an in-depth qualitative study, Fielding *et al*. (2007) demonstrate that the experience of being flooded renders members of the at-risk public markedly more aware, more knowledgeable and more responsive with regard to flood warnings than their non-flooded counterparts. Waterstone (1978) also identifies prior experience and having suffered damage from flooding as key characteristics associated with hazard awareness amongst respondents living in a flood zone in Denver, Colorado.

Benight *et al*., (2007) surveyed the link between previous experience of traumatic events and risk and vulnerability, hazard knowledge and risk behaviour. A traumatic event was defined as an event that threatened the life of the person or someone close to them where they felt intense fear, being horrified, or helpless, such as being in a natural disaster, terrorist attack, being in a major accident such as a car accident, or being physically attacked, sexually assaulted or mugged. Their results suggest that highly trauma-exposed individuals are more threat sensitive and more likely to take some action within the context of a flash flood.

Since 1997, the Environment Agency has commissioned BMRB Social Research to conduct a programme of annual surveys with different target populations at risk of flooding in order to establish public awareness of being at risk of flooding, the public's understanding of flood warnings operating in their area, and awareness and understanding of precautions and preparations that can be taken in the event of flooding. In addition, post-event surveys are administered on an *ad hoc* basis as and when a flood occurs.

Thrush *et al*. (2005) argue that the lower one's awareness about some kind of danger, the more one is vulnerable to it, and therefore the variables identified above associated with decreasing awareness could be measuring 'social vulnerability.' Individual awareness is related to perceptions of individual and state responsibility and the role of structural defence. This is discussed in more detail in the above sub-section dealing with social and political contexts. For example, research conducted in Poland shows that residents at risk see structural measures such as river embankments as highly effective, and they demand this kind of security. They underestimate the role of early-warning systems and their own activities in limiting flood damage and overestimate the role of local and state authorities. This is why they do not engage in preventative activities (APFM, 2007b).

Waterstone (1978) identified a general concern about the possibility of flooding and knowledge that a creek had flooded in the past as major variables important for motivating flood mitigation behaviour amongst respondents living in a flood zone in Denver, Colorado.

Fielding *et al*. (2007) found preparedness was a vital predictor of reporting effective action, with those feeling prepared being nearly two and a half times more likely to do so. Understanding what to do, however, was not significant. The secondary analysis suggests that one factor underlying the perception of effectiveness is the provision of sufficient time in which to act on warnings received, reinforcing the overall feeling of being well prepared for a flood.

Whatever the cognitive processes at work, and whatever their effects, it seems reasonable to assume that the provision of information to enable people to define flood risk more accurately and to imagine the event which they might experience, will be helpful. However, there are some caveats to this thinking. For example, cognition of

flood risk might be assisted by making flood maps available to people, but this will only be so if people can orientate and interpret a flood map, and research from Sydney, Australia, indicates that at least some cannot.

However, as with demographic characteristics, it is important not to make generalisations. Lack of experience, awareness and preparation do not always act as a barrier to effective action. Similarly experience, awareness and preparation do not always lead to effective response. In the northern Italian villages studied as FLOODsite Task 11 case studies, De Marchi *et al*. (2007) found that having experienced a flood failed to lead to an increase in adaptive behaviours, although a preparatory orientation was apparent. It appears that experience will only lead to an increase in preparatory measures being taken if the flood-prone have knowledge about the measures which could be taken, and in this case they did not.

Previous experience of hazard does not always lead to a belief that the situation is dangerous. Gruntfest *et al*. (1987) found that some of those with experience of extreme weather did not act on environmental clues because they believed that had seen similar conditions before which had not deteriorated. Ketteridge and Fordham (1998) report similar findings from their research in Scotland. Based on qualitative interviews they concluded that rather than local communities having learnt to recognise the risk of flooding because they lived in an area prone to heavy rainfall, the converse was true. Householders were accustomed to heavy rainfall and water pooling in the streets, so did not expect a worsening of the situation. Respondents in the Task 11 German study also did also not expect the 2002 flood to be any worse than earlier floods (Steinfuhrer and Kuhlicke, 2007).

In addition, people's behaviour in the face of natural hazards is often independent from natural hazards but constrained by social, economic and political forces beyond an individuals' reach (Ruin *et al*., 2007). Hence, risk perception should be seen as one among many other aspects of people's vulnerability in the face of natural hazards, which also includes people's well-being and strength, their livelihood resistance, their ability and willingness to protect themselves, the societal protection and the social capital, among others (Cannon, 1994).

Research by Fernández-Bilbao and Twigger-Ross (2008) challenges the assumption that there is a linear relationship between flood experience, adaptation and preparedness. This research shows that only a very small proportion of flood victims are prepared for a future event. The causes for this low preparedness range from an understandable wish to move on and reduce anxiety, to feeling that they cannot do anything about flooding.

Panic

Traditionally, agencies with responsibility for hazard reduction have been concerned that warnings may provoke a panic response amongst those warned (Sime, 1997). A study in eight regions of France in the 1980s (Torterotot, 1993) showed that there were few panic behaviours among people on receipt of a flood warning. Quarantelli (1984) also concludes that panic is a rare phenomenon in response to warnings.

In BMRB post-event surveys for the Environment Agency, people affected by flooding have been asked whether they agreed or disagreed with the following statement in relation to the recent flood event they have experienced:

'I really panicked when I first heard about the flood'

In the relevant BMRB post-event surveys, the percentages agreeing were:

- Autumn 2000 floods: 23 per cent.

- December 1999 floods: 25 per cent.

- Easter 1998 floods: 23 per cent.

- January 1998 floods: 47 per cent (FHRC, 2008).

Green (1992) suggests that rather than being seen as an irrational response, panic can be interpreted as an inability to take effective action stemming from a lack of appropriate information on which to base a decision.

3.4.4   Warning message characteristics that restrict response

The warning response process and the importance of warning content, style and dissemination have already been discussed (see section 3.3). Here we examine the evidence that warnings may restrict or create barriers for effective response.

Evidence from the German FLOODsite Task 11 case studies suggests that the behavioural content of warning messages is very important and influences warning response. The contrast between those who knew what to do once they had received a flood warning in the 2002 Danube floods compared with those in the Elbe, where the flood warning messages contained no information on how to respond, is large.

Information about how to act on receipt of a flood warning is sparse, particularly at the time it is most needed. Indeed, the necessity for memorable advice regarding appropriate action before, during and immediately after a flood event has been highlighted by the findings of several researchers (Thrush *et al*., 2005; Tapsell *et al*., 2002; Tapsell *et al*., 1999).

Many warnings were considered 'too vague' or applicable to too large an area to be useful. Icons and text used on current codes were the subject of criticism; many people felt that a sense of urgency was lacking and that greater clarity was needed, particularly between Flood Watch and Flood Warning. There was still a preference for the old 'traffic-light' system of colour-coded warnings in many quarters (Fielding *et al*., 2007).

The warning may not convey the necessary sense of urgency, in which case the process of warning confirmation may not take place and no action will be taken. Handmer and Ord (1986) identify that warning source and mode of communication, including credibility (number of false warnings), credibility of the warning source, urgency in the announcement, whether or not the message is delivered personally, and availability and number of warning sources are likely to affect response to flood warnings.

People from ethnic minorities may not understand the warning message. Post-event surveys show that English, the principal language in warnings, is not the first language for about one per cent of the population at risk (Parker *et al*., 2007b).

In addition, a warning may fail to reach the population at risk. Frequently, the lack of ability to disseminate warnings to the population at risk is the weakest link in the integrated system (UN/ISDR, 2001).

3.5 Summary of key points

- The purpose of warnings is to confirm appropriate warning response behaviours or to change these behaviours where they are inappropriate; in other words, warning is about influencing human behaviour and changing it.

- Risk management agencies and the public have different ways of judging whether an action is appropriate and effective or not.

- Warning and preparedness are key to whether people consider their actions an appropriate and effective response.

- Integrated flood management sees response as incorporating preparedness, as well as what happens during and after a flood.

- Mortality and injury depend on individual flood characteristics. However, an appropriate and effective response to flash floods must include messages to avoid risky behaviour, including walking and driving through floods, and to climb to higher ground.

- The vulnerability of drivers and how to warn them needs particular attention.

- Many factors influence the stability of buildings and structures during flash floods. However, mobile homes, timber frame buildings and single storey, ground floor or basement properties are more at risk and this could be used as the basis of a general message.

- The timing of a flood will influence what constitutes an appropriate and effective response.

- The evidence suggests that evacuation does not always constitute an appropriate and effective response to flash flooding.

- Human vulnerability to flash floods is increasing.

- The evidence suggests that appropriate and effective action can reduce the impacts of floods on property, but only marginally, and this may not apply to flash floods. Effective action can reduce the impacts on mortality, injury and health.

- Understanding warning as a social process is vital to developing effective warning messages that promote appropriate and effective responses.

- The content and style of the warning and how it is issued will determine whether the warning is acted upon.

- Situational factors, including the characteristics of the flooding, can either inhibit or encourage levels and effectiveness of flash flood warning response.

- Social and political contexts determine how people understand risk, attribute responsibility and decide if and how to respond and can, therefore, lead to barriers to response.

4 Getting those at risk to realise and respond to this type of flood risk

The objective of this chapter is to review methods of encouraging those at risk to take appropriate action.

4.1 What tools and techniques will work best to keep the risk in people's minds, especially when the chances of it happening are low? What type of messages are the most effective?

In the section we explore the role of public education in enabling effective response to flash floods.

4.1.1 The importance of public education

As Gruntfest and Handmer (2001b) have stressed, warnings do not save lives and property - the responses that people make to those warnings do. Public education in terms of the threat presented by flash floods and proper safety measures are crucial to ensuring effective response.

Parker *et al*. (2007b) have highlighted that flood forecasting and warning services are not just about 'event-specific' warnings, but also about year-round awareness-raising and information provision. If successful, this may create a context in which event specific warnings are less crucial because residents of flood risk areas are more flood aware and prepared.

Although people may be aware of an official flood warning system or be in a position to receive a flood warning, a high proportion may have a poor appreciation of the behavioural instructions or advice associated with the warning.

A knowledge gap between the risk understood by the public and what officials are trying to communicate in warnings is described by Knocke and Kolivras (2007). They conclude that improving the knowledge and awareness of flash floods is essential to improving warning response. Parker *et al*. (2007a) indicate that flood warning effectiveness can be enhanced to some extent by employing education as a substitute for flood experience.

In light of this, flood management guidance proposes that an effective public awareness programme can contribute greatly to reducing disaster-related losses. When developing such a programme, it is important that the seriousness of the risk is accurately perceived and that information is communicated with the appropriate level of urgency. Risk communication should furthermore be viewed as a continuous process, with the contents of the message being continuously reviewed and improved where necessary. However, it is vital that these messages should be as simple as possible and that there should be a designated lead agency for developing and issuing them (UN/ISDR, 2001).

The Easter 1998 flooding revealed the importance of public awareness of the flood warning process. The Bye Report, an independent inquiry into the flooding in October 1998, highlighted the lack of public awareness of the flood warning process. There was a distinct lack of awareness of:

- The level of flood risk many communities faced.

- What flood warnings they could expect to receive.

- What actions to take.

As Gruntfest *et al*. (1987) have pointed out, flood warning and preparedness programmes can also assist in overall water management in non flood periods and act as a core for other disaster preparedness programmes.

However, it would be a mistake to assume the connection between awareness and action is straightforward (Gruntfest 1987). Scientific evidence has been available since at least the 1960s that experience of flooding leads to a significant increase in the proportion of those at risk of flooding who adopt appropriate flood response, including flood warning, behaviours (Kates, 1962). Indeed, Kates referred to 'the prison of experience' - meaning that those who had flood experience had generally learned how to respond to a flood but those who did not have this experience were effectively excluded from knowledge of how to respond to a flood. Given this, the underlying role of public flood education is to provide a substitute or replacement for flood experience (to somehow make the unwise wise). It is often assumed that a good dose of public flood education will do the trick and improve people's flood risk behaviours. However, this remains an assumption which is currently under-tested. It is likely that other factors (such as trust in public authority or beliefs about responsibility for flood response) may well intervene unhelpfully in this process and so this model really needs to be reconceptualised and researched to better identify those conditions in which public flood education is most likely to be successful and those in which it is not.

Sorensen (2000), in summarising the US experience, states that there is no conclusive evidence that a public education or information programme actually makes a difference in increasing human response to warnings.

4.1.2   Types of public education for different target groups

Clearly different target groups will respond to different types of public education. Three main target groups have been identified by APFM (2007b). These are:

- Administrative and self-governmental authorities.

- Crisis services.

- Users of floodplain areas; further divided into adults and children, as well as into various occupational groups.

APFM (2007b) further divides these into the following groups and makes the following suggestions about how they can be effectively reached:

- Children and students can be targeted with lectures and presentations (communicating the basic knowledge), competitions between schools (for example, for the best exhibit on the flood history of the region), and workshop classes (for example devoted to plans to limit flood damage in the area). A condition for success is the prior education of teachers, and

providing the required educational and didactic materials. They point out that children and schools can also be of great use in educating adults.

- Workers in companies, factories and institutions at risk are a group for whom one can organise various types of training affiliated with security and protection (the company's possessions), but also concerning proper conduct during a flood (assistance in developing flood instructions for a factory).

- Adult residents at risk are a group that is difficult to access as its members do not undergo any organised form of education that can be used for flood-education purposes. They must therefore be reached by taking advantage of various opportunities and occasions. A typical way of proceeding is disseminating information on flood risk and ways to combat it during local celebrations and festivities that draw the interest of the inhabitants. Another effective method is educating occupational groups who, through their profession, are in constant contact with the local residents (doctors, mailmen, veterinarians and others). Co-operation with local media also brings results, as their influence and credibility are of great help in getting the message across. The commonly-used brochures, fliers and posters should be seen as mainly supporting the above-mentioned activities, rather than as a separate form of communicating information.

An important consideration here is the importance of education targeted at children and young people, reinforced by Knocke and Kolivras (2007) whose research in Virginia, USA, uncovered a lack of awareness and knowledge of flash floods amongst young adults in the 18 to 25 age range.

The UN/ISDR (2001) undertook an instructional programme for disaster awareness and response instruction for people at the local level in Vietnam to introduce disaster awareness and preparedness to the elementary school system in Vietnam. School children in selected communes were taught how to mitigate disaster damage in their households and families. In addition to educating school children, this "grassroots" approach was also aimed at developing synergetic effects, such as fostering a greater awareness of natural disasters within families and their communities. This project emphasises the importance that children can educate their adult family members, a point also stressed in APFM guidance (2007b).

It would also be worth isolating one more group: all those who can help out in carrying out the educational and awareness-raising activities, such as teachers, social organisations, journalists, local leaders and so on (APFM, 2007b). The importance of this group is also stressed by UN/ISDR guidance (2001) which stresses that besides using the mass media, effective communication may include influential people such as local politicians and traditional leaders, whom the community respects.

The evidence suggests the most favourable conditions in which to increase awareness and knowledge appear to be in a reasonably well-educated, small community, the members of which are capable of finding out more using internet and other resources, where there is already a high level of flood experience; where flooding frequency is relatively high; and where the flood risk is a serious one. The most difficult circumstances are confronted where floodplain populations are very large and diverse; urban or metropolitan in nature; where flood experience is low and where flood frequency and flood experience is low; but where the flood risk holds very serious impact potential.

Public signage represents a relatively inexpensive way of raising awareness. In areas prone to flash floods in the USA signs saying "in case of flash flood climb to safety" have been placed by road sides. Individuals may not be able to see these signs during

times of heavy rainfall but they may remember seeing them on previous trips (Gruntfest 1987).

Gruntfest and Ripps (2000), suggest that public education on flood hazards needs to be encouraged from the classroom to the boardroom. Signs directing people to high ground are not enough – education is the key mitigation measure. The roles of common sense, environmental cues and local knowledge are as important as high technology, both now as they were 50 years ago.

Because floodplain populations change their composition over time, as people move out and others move in, such a public education programme needs to be annual - if not continuous - to be effective, and repetition of the message is an important element. Innovative methods will probably be required to engage floodplain occupants and to get awareness and knowledge across to reinforce the message. Many such methods are being used in Europe and elsewhere, and include local community flood fairs (where flood information, flood discussion groups, and flood protection products are introduced), exhibitions and games for school children and so on (UN/ISDR, 2001).

Waterstone (1978) asked recipients of a brochure designed to raise awareness amongst residents of a flood hazard zone about the nature of the flood problem and measures to mitigate the impact of a potential flood. The brochure was found to be effective in raising awareness and motivating behaviour. However, one year later, only 37 per cent of respondents remembered receiving the brochure. Recommendations for improving the memorability and effectiveness of the brochure included making certain it was only distributed to those actually living in the flood hazard zone, providing a history of flooding and making it clear that the occurrence of one flood does not alter the probability of another occurring in the same area, clearer definitions and more comprehensive information about what can be done by individuals to mitigate the hazardous consequences of floods. In addition, Waterstone concluded that information must be distributed on a more regular basis.

Twigger-Ross *et al*. (2008) used focus groups to look at what types of awareness-raising are perceived as effective by the public. Face to face communication was highlighted as working well, including attending asset management public meetings, information stands in local supermarkets/ libraries and flood fairs and other events. Centralised mailings and/or adverts were not considered to work so well for the following main reasons:

- Strong wording of letters which upsets some people and does not generate the desired response.

- Sending excessive amounts of paper.

- Sending letters in English to non-English speakers.

- Sending letters to people who don't know who the Environment Agency is.

- Lack of co-ordination of national campaign with the local one or wrong timing of national campaign.

- Confusing and contradictory mailings.

4.1.3   Public education messages

Knocke and Kolivras (2007) state that public education should focus on what meteorological and hydrological processes cause flash floods, with a view to improving awareness of how quickly they can develop. In addition, they conclude that the public

need more information on what flood forecasting tools and warning sources are available.

The very short period of time between the warning and the onset of a flash flood means that the optimal activity is the independent response of those at risk, both in terms of preparing for evacuation, and in the evacuation itself. Therefore, public education messages for flash flood should include descriptions of when to evacuate and how to evacuate safely. Advance preparation is necessary for evacuation. This is why family members – including children - should be prepared for such danger, and should know how to respond and what to take with them in the event of an evacuation. It is also important to know about the source, nature and level of the flood threat in the area individuals live in, as well as how the local flood warning and response system works; that is, what information and what form of assistance a citizen can expect from the local authorities (APFM, 2007b).

Family evacuation plans are promoted in many countries, containing information on:

- Evacuation paths and sites for farm animals, automobiles, machines and mechanical appliances.

- Sources to gain information on the impending danger.

- Gathering spots for families if the flood surprises them away from the home (at work, school and so on).

- Objects that should be taken along when evacuating, such as: important documents, medicine, family keepsakes, pets.

- Electricity, gas and water shut-off valves (APFM, 2007b).

In addition to public education messages aimed at individuals and families, messages should be targeted at companies and services at risk of flash flooding. They should have a ready-made action plan for damage minimisation which includes preventive action and evacuation, as well as a plan for clearance of flood damage. These will differ for large production companies or service factories, and differ again in the case of farmlands or hospitals. Such plans are of particular importance wherever valuable possessions are gathered together. Where the service receivers are people, for example, in tourist sites such as bed and breakfasts, hotels, or vacation homes, it is vital that the plan's framework include instructions for the guests on how to proceed in the event of a flood or a flood warning (APFM, 2007b).

Gruntfest and Ripps (2000) suggest that videos are helpful to educate people about flash flooding. The National Weather Service and Arizona Association of Floodplain Managers made brief but powerful public education videos to explain the basics about flash flooding. The topics they covered included:

- How fast-flowing water does not need to be very deep to be dangerous.

- How paying attention to environmental cues may save your life.

- How dangerous it is to drive during flash floods.

- How climbing to high ground and safety is the best action in threatening situations.

Instytut Meteorologii i Gospodarki Wodnej's (IMGW) (Poland) research shows that educational activities aimed at residents and flood land users should concentrate on three main messages:

- Floods are inevitable.

- Everyone can change the amount of damage that a flood can cause their home or property.

- There exists a structure of services and institutions to support residents and land-users in flood-risk areas

Universal understanding and acceptance of these messages is the key to inspiring individual initiative in flood damage mitigation (APFM, 2007b).

For professional partners involved in responding to flash floods, suggested messages include:

- The general characteristics of flash floods, including their impacts.

- Methods of protection and reducing impacts.

- Local flash flood hazards and vulnerabilities.

- Principles of warning systems.

- Means of preparing for flash floods.

- Response plans, including social support and technical methods of liquidating flood impacts (Siudak, 2001).

4.2   Can we utilise the knowledge of local people (including local historic information) to trigger actions, for example through the use of community liaison volunteers or wardens?

In this section we explore the importance of local knowledge and involvement and the challenges in securing this involvement. We also look at ways this knowledge and involvement can be supported.

4.2.1   The importance of local knowledge and involvement in responding to flash floods

Community-based knowledge and involvement is essential for several reasons. Firstly, communities are the ones who suffer the most. Secondly, community-based organisations act faster in responding to disaster before the arrival of external help. Thirdly, local management leads to securing local support and ownership.

Local knowledge is especially important in responding to flash floods because of their localised nature and because short lead in times mean official warning may not be possible, increasing the reliance on unofficial community level warnings. Parker and Handmer (1998) concluded that in the case of localised hazards with a short lead in time such as flash floods, local knowledge is crucial to the warning process.

APFM guidance (2007b) states that it needs to be recognised that the traditional flood management approach employed for low-land riverine floods proves ineffective for flash floods, mainly due to difficulties with accurate forecasting for flash floods, the short warning lead-times, and consequently the requirement to involve local knowledge much more closely, and foster the local preparedness and response capabilities.

Fielding *et al*. (2007) report that, in a small rural village where an automated voice messaging service was not available since flooding resulted from a high water table, residents spoke of the value of information posted by local councillors on parish notice boards. Community-led warnings were especially useful in areas such as these. A great many people said that they wanted to have access to local (and therefore more specific) information than they considered was available from Floodline. They highlighted the need for someone who could act as a point of contact, passing on local knowledge, and the majority of participants said they preferred personal contact to a recorded voice. Many participants said they trusted 'a community set-up' rather than a single piece of information from the Environment Agency. This community approach included access to Environment Agency information and to a body of local knowledge, often gained over many years, as well as individual and community watchfulness. Where local Flood Wardens existed, they were seen as invaluable; where they did not, almost all participants said they wished they did.

Ketteridge and Fordham (1998) also report that interviewees preferred personal contact and informal networks.

One recent example of local knowledge in action was seen in the Boscastle flood on 16 August 2004. A local off duty coastguard recognised the signs of danger, warned visitors not to wade through the flood waters and alerted the Falmouth coastguards of the developing incident. His swift action contributed to saving many lives (Environment Agency, 2004).

4.2.2   The challenges in utilising local knowledge and involvement

It is also important to be realistic about the challenges of local involvement. It needs to be recognised that local concerns are often not the concern of those responsible for specialised services, charged with flood hazard identification or flood forecasting and warning. It is likely that most local officials are primarily concerned with economic development and job creation rather than dealing with natural hazards (APFM, 2007b).

In addition, while the benefits of broad involvement of stakeholders and experts are recognised, it should not be assumed that the involvement of more stakeholders will automatically translate into a more efficient system or a better result. Such an approach involves a number of challenges that, if recognised from the outset, can be minimised. These include, for instance, the risk that the sense of responsibility to deal with the issue of flash floods is diluted between various individuals and institutions (APFM, 2007b).

Jennings' (2008) research into the experience of the Boscastle flooding in 2004 identified processes whereby local knowledge is undermined, including a lack of knowledge about Boscastle in non-Cornish incomers, the national press and government officials, which led to misunderstandings about the history of flooding in Boscastle.

In this case, responsibility for environmental management had shifted from generations of tenants and workmen trained as apprentices and knowledgeable about the local environment to centralised decision-makers and increasingly distant bureaucratic agencies. This process was exacerbated by the development and change of occupancies during the post-war years that gradually altered or destroyed many of the historical watercourses of Boscastle, including culverts, slipways, meadows, and hedges.

Jennings suggests that, in terms of the recovery efforts of Boscastle, rhetoric about climate change, in both the media and government publications, redirected scrutiny

away from questions about government land management practices. It also produced a socially homogenous and coherent view of the village where the opinions of Cornish locals, many of whom already felt marginalised in their own village by the business interests of non-Cornish incomers, were largely ignored. Questions about the extent to which tourism might have played a role in the 2004 flood were eclipsed by concerns about how the flood would affect tourism in future. She concluded that "government interest in tourism for economic growth, and rhetoric about combating climate change work at cross-purposes because tourism often displaces the adaptive strategies and experiential knowledge necessary to ameliorate the effects of extreme weather events" (Jennings, 2008).

As many researchers have noted, there is tendency to limit consideration of knowledge, including community knowledge, to that "generated within the scientific and intellectual paradigms of the Western industrialised world" (Parker and Handmer, 1998).

De Marchi *et al*. (2007), too, found the northern Italian communities, which are the source of at least some of their research flash flood evidence, to have 'lost' their culture of self-protection. They observe that their respondents appear to have lost their local knowledge of flooding and the related hydro-geological hazards of the area, and have become dependent upon a distorted welfare culture in which they now perceive the only responsibility for flood protection as lying with the local authorities. The assumption is that the members of these communities once possessed the local knowledge which they have now lost, and once exhibited a much higher degree of personal and collective (but not municipal) responsibility for self-protection. How far this is the case would rely upon an historical analysis, but there is evidence from elsewhere that individuals and communities often accumulate local knowledge of flooding and protective adaptations (both physical and behavioural) which allow them to reduce their exposure and vulnerability to flood risks (for example see Chan, 1995).

4.2.3   Developing and supporting local knowledge and involvement

It is clear from surveys conducted with project partners in the FLOODsite Task 10 work on developing a model to assess the benefits of flood warnings that there are widespread public expectations that government and state agencies will provide flood and related information to enable people to help themselves in times of flood, even if individuals do not do so (Parker *et al*., 2007d). A pre-requisite for a high degree of individual responsibility and self-help, and a low degree of dependence upon the state, is a strategy of openness and provision of high quality information for public consumption. Countries vary in the extent to which flood information is open, but there is now a clear trend towards openness and higher quality public information. For example, in the Netherlands and along the Rhine, people have access to water level information from a range of monitoring stations. Similar arrangements exist in some French catchments, and generally regularly updated flood warning information is available on the internet in a number of countries including France. About 10 years ago, the Environment Agency changed its approach to making flood information available in England and Wales, providing indicative flood risk maps for the whole country available on the internet. A wide range of accompanying flood information is now made routinely available to the public in England and Wales in an effort to engage people in understanding and managing their own flood risks and responding appropriately to flood warnings.

APFM (2007b) found that local warning systems allow us to adapt solutions to the locally existing risk, on one hand, and on the other hand, to the capabilities of the local communities. Examples of these solutions might be local monitoring networks, systems

to warn and inform residents through land-lines or cellular phones, Internet facilities, automatic systems signalling danger and closing off the roads backed by stream gauges, or use of volunteers. For the warnings to be effective, organisation (in particular in the form of response plans) needs to be good, and there needs to be a high degree of community awareness in the areas in danger. This requires ongoing education and information, and the training of crisis services.

There are a number of elements which have an impact on the guaranteed effectiveness of the working of such a system, but the most important among them are:

- Co-operation of local authorities with hydrological services, leading to regular, well-informed regional forecasts.

- Assurance of receiving warnings on the approach of undesirable hydro-meteorological situations.

- Planning and implementation of methods of warning people to guarantee that warnings reach people whether it is day or night, and regardless of whether they are at home or out.

De Marchi *et al*. (2007) conclude that strategies which are designed to ensure that local knowledge of floods and indigenous adaptations to floods are maintained will help protect a culture of self-protection rather than its loss. Strategies can also be conceived to increase local knowledge of floods and appropriate adaptations.

The respondents in the De Marchi *et al*. study were found to be positively oriented towards prospective investments in safety and precautionary measures, and in all research locations more than half of residents revealed a precautionary orientation.

In the UK a project entitled 'Community engagement with its flood history: understanding risk' was undertaken by the University of Gloucester with funding from the Environment Agency. This project aimed to increase community engagement and participation in establishing, analysing, debating, disseminating and 'owning' their local flood history and risk information within a longer-term environmental change context. One of the outcomes was the Lower Severn Community Flood Information Network, a community educational resource designed to act as an exciting, informative and accessible point of reference for the public and as a conduit for local knowledge, an effective teaching and learning tool for knowledge transfer at a variety of educational stages (including school and adult learning) and a recognised model of good practice in communicating local information about flood risk and uncertainty effectively.

Imaginative strategies to build, protect and develop local knowledge have been used in a number of settings. In one part of the Netherlands a local flood museum has been created to help communities retain their collective knowledge of past flooding and its effects (Gruntfest and Handmer, 2001).

In looking at the results of this project, McEwen (2007) found through feedback from teachers that pupils were enthusiastic about engaging with local community flood histories. When the teacher was able to adjust sessions to integrate the project, it worked very well. Children needed, however, access to a large amount of local material for their research, mainly from the classroom. Art teachers found engagement easier than geography teachers as teaching art to a middle school allows a large degree of freedom from the National Curriculum. Recommendations for future work included having elderly residents go into schools to talk about major floods and answer pupils' questions and preparation of a local flood pack for schools.

Another important and low cost method of developing community flood memory is placing high water signs commemorating the history of floods in accessible and visible places (Siudak. 2001).

UN/ISDR guidance (2001) also stresses that local communities should be encouraged to document disasters and events at their level in any way possible for future research on flood mitigation and to increase local empirical knowledge of flooding.

4.3 Are people willing to take the initiative to warn themselves, such as looking out for signs of flooding, rather than rely on an official warning service? Is there a trade-off between people recognising a dangerous situation and relying on "gut instinct" versus waiting for an official warning? Is the source of the warning an influencing factor?

In this section we explore types of warnings, the role of unofficial warnings and evidence of the advantages and disadvantages of unofficial warnings.

4.3.1 Types of warning

Most research into flood warning systems focuses upon 'official' or 'formal' flood warning systems designed by governmental organisations, or an agency of government, to warn other agencies and the public of flooding. However, social science research reveals that, in practice, people frequently find out about the possibility of imminent flooding in a variety of ways, only one of which is through an official flood warning system.

The focus on flash floods, and people's awareness and appreciation of the risk and their ability to respond to a rapidly evolving flood event, places the spotlight upon the different types of warnings that people report in research evidence. In the case of rapid response catchments, informal or unofficial warnings (this includes ones derived from personal observation of environmental cues) are of considerable significance. Research on how people recognise the possibility of flooding from environmental and community 'cues' is at a premium in this context but, again, is hard to find.

Schware (1982) and Parker and Handmer (1998) distinguish between official and unofficial flood warning systems and sub-divide the unofficial category further to three basic types of flood warnings (further described in Figure 4 below):

- Warning (that is, self-warning) through personal observation of environmental signs or clues (such as rising river levels, heavy rainfall or through observing the reactions of others).

- Warning through observation by community members (sometimes this may extend to 'informal' measurements of rainfall and 'informal' monitoring of river levels) and their communication of warnings to others using 'social networks.'

- Formal or official flood warnings, which may or may not seek to amplify the warning using social networks. In flash flood events warnings of type 1 and 2 are often likely to be just as important, if not more important, than warnings of type 3.
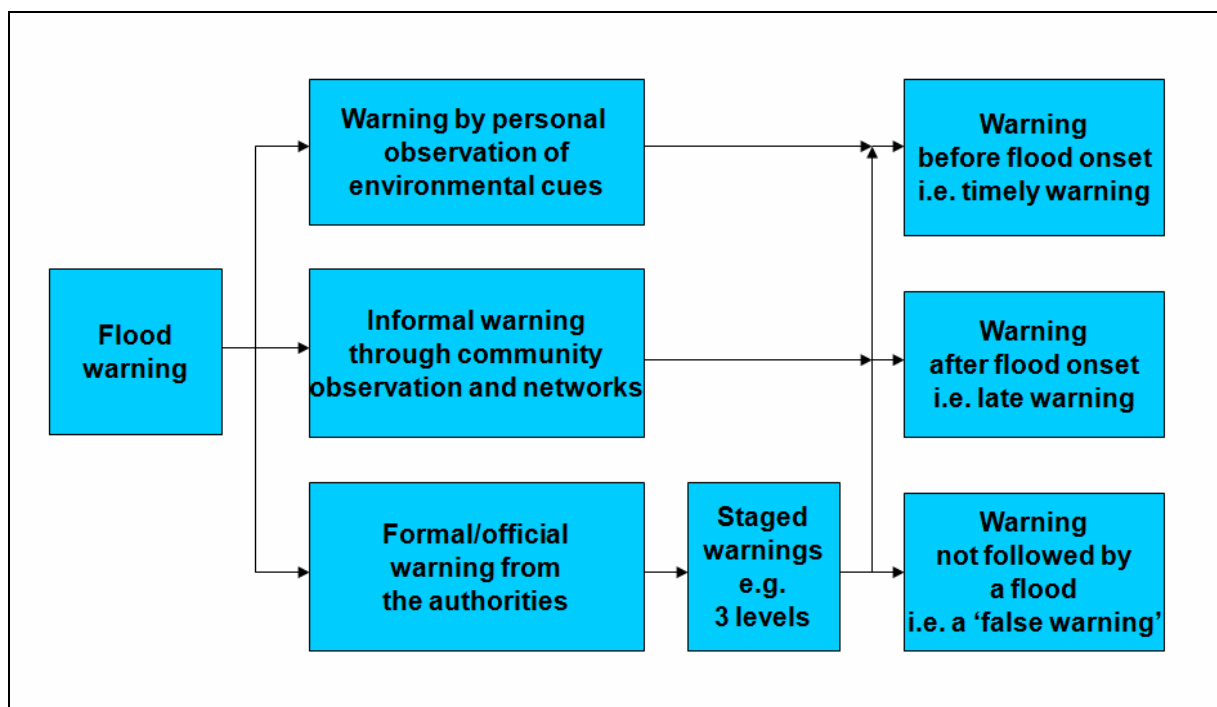
Figure 4:   The different types of flood warnings for which response needs to be considered.
              Source: Parker *et al*., 2007d.

In order to properly understand and interpret the data, it is necessary to distinguish between responses to each of these types of flood warnings. It is also common for a number of flood warnings to be issued to the same population during a flood event, but this is much more common if the event is slow-onset or where several flood waves are involved rather than one.

Official flood warning systems are often 'staged', or have several levels and, where possible, it is necessary to distinguish between the responses to warnings at each of these. Again, in the flash flood warning situation, there may only be time for a single warning message to be disseminated, so the warning system becomes simpler.

Finally, whether they originate from personal, unofficial community or official flood warning sources, flood warnings can be of three further types:

- A timely warning - in advance of the onset of flooding.
- An untimely warning - one which arrives after flooding has occurred.
- A false warning - a warning which is not followed by flooding.

There is also the distinct possibility of no warning being given because of lack of time. Untimely warnings are not uncommon. For example, Parker and Neal (1990) found that in the riverine floods of the late 1980s in the River Severn catchment of England and Wales, 27.8 per cent of 133 flood warning recipients either received their flood warning at the same time as flooding happened, or after the onset of flooding (7.5 per cent received their flood warning between six to 10 hours after the flood). Similarly, in flooding in Hull, Yorkshire, England in the summer of 2007, a severe flood warning was issued two days after flooding commenced. 'False warnings' are also fairly common.

Earlier research indicated that public reliance on "official" warnings from traditional sources may be shifting to more private and informal sources (Penning-Rowsell *et al*., 1978; Baker, 1995; Dow and Cutter, 1998; Drabek, 2001).

4.3.2   The advantages of informal warnings

Clearly, the ability of informal warnings to generate a response needs to be considered when deciding if they are effective. However, empirical evidence is patchy. With few exceptions, most available research does not clearly distinguish responses which take place at different warning stages or levels. Evidence on the response to both self-warnings and to official flood warnings is reasonably plentiful, whereas evidence on response to unofficial flood warnings is more difficult to acquire even though unofficial systems are more prevalent than may at first be expected (Parker and Handmer, 1998).

Table 4 below shows the source of warnings as a percentage of all those warned based on the BMRB post-event surveys for the Environment Agency. Unofficial warning sources are shown in italics. These warnings account for between 17 and 38 per cent of all warnings received.

Source of warning	BMRB 2001 First warning - 692 cases	BMRB 2005 First warning - 52 cases	MORI 2005 All warnings - 124 cases
Automated Voice Messaging (AVM)	30	60	38
Neighbour, friend, relative	*12*	*15*	*23*
Personal observation	*5*	*13*	*15*
Personal call to Environment Agency	5	4	11
From Local Authority	5	2	3
Floodline	3	2	3
Flood warden	5	1	17
Television/radio	10	-	9
Police/firemen	10	-	4
Other/don't know	15	1	15

Table 4:   Source of warnings as a percentage of all those warned based on the BMRB post-event surveys for the Environment Agency.

Emergency Management Australia (1999a) states that the most favourable situation appears to be when personal, unofficial and official flood warning systems are highly integrated and where the flood-prone community feels a high degree of ownership of the official flood warning system which is designed with suitable feedback loops to make good use of local knowledge. This is one of the hallmarks of a total flood warning system.

Parker and Handmer (1998) summarise the advantages of unofficial warning systems as:

- Gets the warning to those at risk.
- Increases the quantity of warning messages received, reducing the need for confirmation and increasing warning belief.
- Increases the quality of information received.
- Gives greater local credibility.
- Addresses emotional needs.
- Greater specificity through local knowledge and detail about local events that officials at a distance may lack.
- Translates warning message into everyday language.
- Provides opportunities for two way interaction.
- Provides personal and specific advice on appropriate local adaptive behaviour.
- Provides an alternative to the official system if this is perceived as unreliable or inaccurate.
- Can provide reinforcement and amplification to the official system.
- Provides some warning if no official warning service exists.

4.3.3 The disadvantages of informal warnings

The concept of individual risk perception is central to understanding how proactive people will be in recognising dangerous situations and taking action to minimise risk. Indeed, there is substantial research that suggests that certain internal aspects of the person (such as self-esteem, emotional states, and so on) can and do influence decision processes rather than relying only on environmental cues (for example see Lauriola *et al*., 2005; Wang, 2006; Benight *et al*., 2007). We have already discussed in section 3.4 the factors which influence individual risk perception and can, therefore, compromise people's ability to recognise and act on environment cues. We have discussed in section 4.1 the role of public education in improving public understanding and awareness of the dangers of flash flooding.

Emergency Management Australia (1999a) states that what is likely to inhibit flood warning response is unhelpful competition between unofficial and official flood warning systems, especially where the latter proved to be less accurate or more unreliable than the former.

Parker and Handmer (1998) summarise the disadvantages of unofficial warning systems as:

- May not have the credibility of the official source.
- Those not part of a network may be missed.
- Those where local networks do not exist may be missed.
- May not provide reliable information.
- Crucial safety-related decisions may be delayed by networks and crucial safety messages may be distorted.
- May compete with, and undermine, the official system.
- May promote rumours that may create needless anxiety.

4.4 Are there any negative attitudes towards or lack of trust in governmental warnings? If so, does this affect people's willingness to take warnings seriously and respond?

4.4.1 Assessing trust

Decline in trust in institutions has been a feature of the North American and European experience. Petts *et al*. (2002) cite several surveys to show that industry and government officials rank lowest on the trust scale, with more perceived independent sources such as doctors, academics, and non-profit making organisations ranking highest. The media and environmental groups occupy a middle ranking. High profile fraud cases such the Enron affair have contributed to this decline.

Petts *et al*. (2002) highlight that, once lost, trust is very difficult to regain. Trust will not be regained by better communication – there is a need to move to participation. They conclude:

- Experts do not command automatic trust, no matter how genuine their expertise.
- Messages are usually judged first by whether their source is trusted.
- Trust is fostered by openness, both in avoiding secrecy and being ready to listen.
- Some scientists are trusted: it depends on affiliation, issue, track record and other factors.
- Trust can be issue-specific.

There is clearly, therefore, a potentially important set of influences around the subject of trust in authorities and openness with flood information. It is clear from the survey evidence that people often have limited trust and confidence in State or municipality sponsored flood risk management agencies. For example, University of Surrey surveys revealed wide variations in the trust that respondents had in the flood warning agency (the Environment Agency). It is also clear that people usually prefer to rely, initially at least, and sometimes well beyond initially, on their own personal observations and upon local community flood information and warnings, rather than rely upon official flood warnings.

In almost all of the empirical studies referred to, this can be implied or is explicit in the data. In the work of Lopez-Vazquez and Marvan (2003) and Slovic (1993), trust or lack of trust in authorities in general is believed to influence people's trust of flood risk management agencies. Clearly trust in the latter is related to public perceptions of these agencies and their perceived record of performance.

It is, of course, very difficult for people to have trust in a flood warning agency if they do not recognise which agency this is. In England and Wales, the Environment Agency (created in 1996 from the National Rivers Authority) struggled in its early years to be recognised by all but a small proportion of the flood-prone population, and indeed the entire population of the country, as the authoritative source of information on flood risks and as the official flood defence and flood warning agency.

A workshop was held for senior Environment Agency staff in April 2001 as a means of raising awareness about current understanding of how the public perceive risk and the implications for risk communication. The workshop revealed some views of public perception of risk typical of many technical experts and scientists; that is, that the public have little understanding of risk as defined and assessed by the Agency; that the media are sensationalist and influence public perceptions adversely, and that there is a decline in trust in experts, including the Environment Agency (Petts *et al*., 2002).

Fielding *et al*. (2007) found that members of the public are also sceptical about pressure groups, while seeing them as important in terms of raising awareness. Rather than assuming that expert information, in this case flood warning, is passively received by the public, this approach recognises that individuals evaluate information in the light of their experience of the institutions providing it and alongside other sources of knowledge.

Parker *et al*. (2007b) undertook a quantitative survey to assess current levels of awareness of flood risk. The results show that even with limited experience of flooding of their homes, 53 per cent of residents had received some form of flood warning in the past. On average, respondents mention 1.6 sources of warning communication. Less than one-third (30 per cent) of residents rely 'mainly' or 'completely' on the authorities. More respondents rely mainly or completely on their own judgement, and many combine both sources of information. The results overall suggest a level of scepticism concerning the official sources, even where the accuracy of flood forecasts and warnings is likely to be relatively high.

Parker (2004) suggests that relatively poor public response to warnings may reflect the public's uncertainty over the reliability and credibility of the information that the warnings bring. Certainly the performance of warning systems in the past has often been poor.

4.4.2   Building trust

The behavioural literature suggests that at the local community level, people often take a broad perspective (Lopez-Vazquez and Marvan 2003), and emphasises trust and credibility issues ahead of specific types of information, such as flood warnings.

Trettin and Musham (2000) report that the erosion of public trust in corporate management and government agencies, in the USA in particular, is a major obstacle to success in risk communication programmes. They found that not withholding or distorting information, in other words, giving people sufficient facts to generate their own opinions, may be important in building trust. They suggest that the best way to build public trust in environmental risk information is not to attempt to build trust in the institutions themselves, but as a by-product of procedures that genuinely involve the public in decision-making.

International research on warning communications (for example Drabek, 1999, 2000; Emergency Management Australia, 1999a) has highlighted the issue of the use of technical, non-transparent language in communications between flood forecasters and those responsible for issuing flood warnings both to the general public (for example, Smith *et al*., 1990; Parker, 2004) and to its professional partners, such as the emergency response organisations (Rosenthal and Bezuyen, 2000). Faulkner *et al*. (2007) identify significant translational discourse issues surrounding risk communications between scientists and professional users of flood risk information, including in the flood warning arena. The Environment Agency has recently established an agenda for research into incident management (Environment Agency and Defra, 2006). The agenda clearly identifies communication across 'external interfaces' as a

key component, although it does not make explicit the need for 'fuller' translations of science into dialogue and communications which might be available and appropriate to the professional recipients.

Knocke and Kolivras (2007) also conclude a knowledge gap exists between experts who are responsible for issuing warnings and the public. They highlight a need for the development of risk communication strategies that build on common knowledge, beliefs, needs and expectations, rather than providing information that reflects the expectations and levels of knowledge amongst the science community.

4.5 What should the source of the warning be? Should it come from the Environment Agency or should it originate locally (for example from a warden or coastguard)? What is the most effective delivery method considering speed and reliability?

4.5.1 The most effective sources and delivery methods for warnings

As regards the source of the warning, we have already discussed in section 4.3 the evidence of the existence and prevalence of both personal and informal or unofficial flood warning systems being used across Europe, in addition to official flood warning systems. A common response to the perceived threat of flooding, perhaps triggered by heavy rain, a weather forecast or news of flooding elsewhere, is for people to observe river levels, the behaviour of neighbours and to seek more information, but not necessarily from official sources. Equally common is the passing of information and opinions between friends, relatives and neighbours in the same or neighbouring communities about the risk of flooding, and it is clear that many use these unofficial flood warning systems sometimes instead of, or commonly as well as, official flood warning services which may or may not be entirely trusted.

Many studies have found that, where they have a high credibility, warning from government agencies stimulates a better response, but the United Nations Disaster Relief Organization (UNDRO) (1984) found that this was the case only for higher socio-economic groups; those of lower socio-economic status may not be reached by hierarchical, powerful agencies (Schware and Lippoldt, 1982). Scanlon and Frizzell (1979) and Schware and Lippoldt (1982) found that 'word of mouth' communication between people was the most effective way of warning people and eliciting an adaptive response. Downing (1977) found that the more sources of confirmation there were for a warning, the better the response, and he and UNDRO (1984) also found that a moderate to high degree of urgency stimulated adaptive responses.

Quarantelli's research (1984) into people's reactions to emergency warnings concluded that government officials and emergency organisation personnel were more likely to be believed than members of other groups.

As regards the delivery method of the warning, in the United States today, the most common technologies used for public warnings are outdoor sirens, the electronic media and officials going through the streets with loudspeakers, known as route alert (Sorensen, 2000).

In the UK, Fielding *et al*. (2007) asked what method of warning dissemination people preferred from the Environment Agency, and discovered that most preferred telephoned warnings. For example, Automated Voice Messaging (AVM)[3] suited them best, even though this may not be the only means of warning that they relied on. The service for mobile telephones was also useful, particularly when people were away from home. A majority, including those who for whom an AVM service was currently not available, said they would also utilise Floodline, warnings from the media (especially local radio), family and neighbours and/or their own observations. Only a few people said that they would not want to join the AVM scheme, or had already withdrawn from it. However, the national registration rate for the AVM service is only around 40 per cent - so it seems that more people do not sign up than do (Pitt, 2007).

During the flooding in Carlisle in January 2005, BBC Radio Cumbria and CFM were used as one of the key methods to disseminate information to the public. They turned over most of their airtime to providing vital public information. The willingness of responders, particularly the police, to put forward staff for media interviews was highlighted as a success. There was also a notable increase in the purchase of newspapers and the use of websites. During the seven day period of the floods, the BBC Cumbria website had over 3.2 million 'page impressions.' The Carlisle Evening News and Star website had 1.7 million hits on the week of the floods (normally around 200,000). Circulation of the News and Star's flood special edition was 65,000 as people purchased multiple copies of the paper (normal daily circulation is 27,000) (GONW, 2005).

Hayden *et al*. (2007) surveyed residents of areas prone to flash floods in both Denver, Colorado and Austin Texas to examine their sources of information about flash floods. They found local television stations are considered the most important source for obtaining weather information, with cell phones and the WeatherBug rarely used as a primary source in either city. In addition to asking about their most important source for obtaining weather information, respondents were also asked about all sources of weather information they use. The results parallel the previous question, with local television used by most people, local radio second and the internet being used by about four in 10 people.

Hayden *et al*. (2007) also asked respondents to comment on the best ways for officials to communicate a flash flood warning at 2:30 am, 11:00 am, and 5:00 pm. In this case, the respondents could select as many warning sources as they wanted. Denver respondents preferred sirens at all three times of the day, with roughly three in four noting that sirens were a good way to warn them. In Austin, the preferred method varied by time of day; at 2:30 am sirens were preferred more than any other method, with local radio the most favoured at 11:00 am, and local television the top choice at 5:00pm. Residents in both cities still prefer traditional sources for weather warnings (such as sirens and television) more than newer technologies (such as e-mail or cell phone).

Their findings also pointed to the fact that age, education, and ethnicity affect warning information sources and that these preferences are particularly relevant when considering the spatial distribution of populations with these characteristics in each city. For example, warning messages tailored to a particular demographic characteristic, such as ethnicity, may be effective in some parts of a city but fail to penetrate others in the presence of strong demographic spatial organisation. This led the research team to conclude that television is by far the primary source for obtaining general weather information (Hayden *et al*., 2007).

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[3] Automated Voice Messaging not longer exists and has been replaced by Floodline Warnings Direct.

As discussed in chapter 3, drivers are particularly at risk of death in flash floods. They are a particularly difficult group to warn as, clearly, they will not be in a position to pick up on warnings disseminated door to door, on television or by telephone. Also they may be in an area they do not know so be unable to pick up on environmental cues of danger. They are likely to be separate from friends and family who would confirm a warning. Radio is likely to be the most effective way of warning motorists. However, further work is needed to understand how radio stations broadcast warning messages.

As regards the use of newer technologies, including the internet and cell phones, Tapsell *et al*. (2004) highlight a concern in placing reliance upon these technologies is their penetration and acceptability to people at risk. Hayden *et al*. (2007) found that they were used by fewer than one in 10 individuals as a primary weather information source. They cite evidence that the divide among the computer internet access 'haves' and 'have-nots' continues to grow particularly among Blacks, Hispanics and other minorities as well as the elderly, the unemployed, single-parent (especially female-headed) households, those with lower levels of education, and those residing in urban areas or especially rural areas. Consequently, they conclude it is vitally important to ensure that local television, not just satellite television, is accessible in the warned area if this is to be the authoritative source for warnings.

Although these newer technologies may become more important in the coming years, Hayden *et al*. (2007) construe that it is not necessarily the case that internet and cell phones will replace televisions nor be widespread in usage in home settings where it may be critical to receive weather warnings. Instead, they conjecture that future populations may use more varied sources for obtaining weather information.

Other studies indicate that warnings are geared toward the cultural majority and are less likely to reach those who are most vulnerable: the poor, the elderly and cultural minorities (Miletti, 1999; Perry *et al*., 1984; Lindell and Perry, 2004). Furthermore, Handmer (2000) notes that populations that are susceptible to flooding are often diverse, which makes it difficult to tailor and deliver warning messages to ensure 100 per cent coverage. Balluz *et al*. (2000) and Noji (1997) suggest that inadequate warnings are a primary contributor to deaths and injuries from 'short-fuse' disasters such as tornadoes.

Twigger-Ross *et al*. conclude (2008) that the people for whom the current system typically works are likely to be those who already have a reasonable level of connection with systems, resources and officials. Vulnerability can be characterised as disconnection from systems, resources and officials, and the current system is likely to reproduce those vulnerabilities rather than mitigate for them. This means that people with vulnerability characteristics are those least likely to receive a warning from this current service unless there has been specific effort to target those people, for example through some locally based tailored service.

Several researchers have also noted that the more sources from which a warning is received, the more likely it is to be believed (Quarantelli, 1983). This was confirmed by Gruntfest's (1977) analysis of the survivors and those who died in the flash flood in Big Thompson Flood.

4.5.2   Factors affecting the reliability of warning system technologies

Owen and Wendell (1981) have divided the warning process into four key stages as follows:
- Flood recognition systems, including data collection and analysis on rainfall and river level.

- Warning arrangements, including making the decision to issue a warning and disseminating the warning.

- Preparedness planning, including describing the actions to be taken before, during and after a flood to mitigate its impact.

- Procedures for the maintenance of the above three stages.

We have discussed preparedness elsewhere. Here we briefly describe some of the factors that can affect the reliability of warning technologies. As Hayden *et al*. (2007) have noted based on their research in areas prone to flash floods in both Denver and Austin, ensuring that warning information is received becomes even more critical in short fuse disasters such as flash floods. Therefore, speed must be considered a key component of reliability.

Not only is the science of weather and flood prediction advancing, but the science and technology of communications is rapidly developing and expanding (McCarthy *et al*., 2007). However, as yet post-event surveys do not indicate any clear improvements in overall warning dissemination rates, such that surveys since 1997 suggest that the percentage in receipt of a warning is on average currently unlikely to be more than 40 per cent (Tunstall *et al*., 2005).

The reasons for warnings failing to reach intended recipients can arise at all stages in the process. Previous research notes that information delivery systems for weather forecasting and flood recognition systems are inadequate or unreliable in many instances (Parker *et al*., 1995; Parker and Fordham, 1996). Faulkner *et al*. (2007) identified gaps between the knowledge and understanding of meteorologists and hydrologists and those professionals responsible for taking decisions to issue warnings. McCarthy *et al*. (2007) also highlighted communication problems between these groups that can lead to delays in decision making. This issue is further explored in chapter 5 of the report.

Issues and constraints relating to warning systems generally arise at two levels: the institutional and the technical. Handmer *et al*. (2001) have pointed to the following classic weaknesses which should be avoided in these systems:

- Complex arrangements for decision making and/or communication.

- Slow, centrally run systems peripheral to local realities, which mean the formal system is ignored.

- Failure to allow for the time taken for each communication step.

- Dependence on one person at some stage who is over cautious.

- Assuming the broadcast media will disseminate the message.

- Assuming that those at risk are a homogeneous group.

- Forgetting that people make decisions rather than follow orders.

- Mindsets limited by experience.

Mileti and Sorensen (1990) point out that a general finding from research into warning system types is that a single warning system will not meet the needs of all hazards and a general alert may not be adequate when a very specific warning is required.

Tapsell *et al*. (2004), in examining the social performance of flood warning communication technologies, found indications that the method of communication of flood warnings has implications for warning receipt and response. Floodplain populations are heterogeneous and different groups have different needs regarding these technologies. The most favourable circumstances arise therefore when a wide range of flood warning technologies and communication channels are used to communicate a warning (as long as the warning emanates from a single source and is consistent). The range of technologies and channels employed clearly needs to be attuned to the characteristics and needs of the receiving population.

Speed-of-onset appears to be by far the most critical flood risk variable affecting the design of flood warning systems, because it has such a major impact upon flood warning lead time and the window of time available for warning response. Any scientific or technological advance which lengthens flood warning lead time is likely therefore to be valuable. In this context the development of the European Flood Alert System is important because it provides this greater alert lead time.

There have been many advances in the technologies of forecasting, modelling and warning systems. Over the last 10 years a large body of literature on warning systems and their related technologies has been developed. However, as Gruntfest and Handmer (2001b) point out, advances in knowledge and experience must find their way into policy and operational changes.

4.6   Summary of key points

- Flood forecasting and warning services are not just about 'event-specific' warnings, but also about year-round awareness-raising and information provision; the connection between awareness and action is not therefore straightforward.

- Public information should focus on the causes and signs of flash flooding, how to stay safe during a flash flood and when and how to evacuate.

- Public information messages need to be targeted and different methods used to target different groups.

- Local knowledge and involvement in preparing for flash floods is crucial but there is some evidence to indicate that local knowledge is being undermined.

- Openness and the provision of high quality information are essential in fostering local knowledge and involvement. Imaginative strategies include flood museums and history projects.

- Trust in authority is likely to be a key factor in public response to flood warnings and therefore it is crucial that the flood warning dissemination agency is the subject of a high level of trust amongst flood warning recipients.

- Evidence indicates that, in practice, people frequently find out about the possibility of imminent flooding through unofficial systems. These include community networks and personal observations.

- Unofficial warning systems have many advantages, but it is important to avoid unhelpful competition between unofficial and official flood warning systems.

- Research points to a decline in trust in institutions and a level of scepticism concerning the official sources of warnings. However, there is also evidence that warning from government agencies stimulates a better response.

- Whatever the source of a warning, the more times it is heard the more likely it is to be believed. Therefore, several different delivery methods should be used.

- A reliance on newer technologies, such as mobile phones and the internet, may exclude more vulnerable groups.

- Vulnerable groups may not receive a warning unless it is a targeted at them.

- Many factors influence the reliability of warning technologies.

- It is crucial that advances in knowledge and experience find their way into policy and operational changes.

5   False alarms

The objective of this chapter is to review the impact on trust and response of issuing warnings when flooding does not occur.

5.1   Is there a greater tolerance for false alarms by the public and professional partners when being warned for severe flash flooding where the impacts and risk to life are high?

In this section we explore the evidence around tolerance of false alarms by the public and professional partners. We also explore approaches to managing uncertainty that may reduce false alarms and mitigate the negative impacts of false alarms.

5.1.1   Public tolerance of false alarms

Empirical evidence on the public's response to false warnings is difficult to find (Parker and Handmer, 1998). Breznitz (1984) examined the attitudes of the public when inconvenienced by false alarms and concluded that it may be easier for the public to respect an incorrect decision if physical evidence in support of the decision has been identified, as is the case if flooding has been seen nearby. Dow and Cutter (1998) also provide evidence that the likelihood of people responding to a warning is not diminished by what has come to be labelled the "cry wolf" syndrome as long as the basis of the false alarm is understood by the recipients.

Qualitative research following the Easter 1998 floods showed that opinion was mixed on the issue of false alarms, with some flooded respondents saying that they would prefer to receive a warning even if there is no subsequent flood, while others stated that they would begin to take warnings less seriously if they are received too often without flooding (Tapsell *et al*., 1999, 2003).

Participants of focus groups of people who had been flooded carried out by Fielding *et al*. (2007) indicated that false alarms were generally preferred to no warning at all, and many participants expressed gratitude for the AVM service.

Work by Gruntfest *et al*. (2002) in Colorado found that respondents would rather be over-warned than under-warned.

5.1.2   Professional partners' tolerance of false alarms

Professional partners involved in the response to the Carlisle flooding said during multi-agency debriefing that they would have preferred to be put on standby at an earlier stage, even if they were subsequently stood down. Whilst it was recognised that the threshold for declaring a "major incident" may be different for each organisation, the important point was that this decision was cascaded to all agencies so they could assess what response their organisation needed to make (GONW, 2005).

APFM guidance (2007b) states that one of the dilemmas faced by crisis services concerning the moment of the decision to warn and inform other services such as fire fighters, police and military, is that too-frequent warning weakens the vigilance of crisis

services, and inaccurate warnings can lead to a lack of trust and result in undue costs. On the other hand, an even greater threat may come about if the warnings to inhabitants at risk are ignored, or acknowledged too late. The guidance proposes that this is one of the most essential reasons why locations particularly vulnerable to flash flooding should receive local-warning systems.

McCarthy *et al*. (2007) report the findings of a real time simulation of an extreme event in the Thamesmead area of the Thames estuary close to London. The Thames Flood Barrier manager has to weigh the social, economic and environmental consequences of flood inundation, as these "outweigh those of operating the defences," including, it seems, operations that turn out to have been inappropriate. The way this was expressed was that there were "no prizes for not taking action when action was required."

5.1.3   Managing uncertainty

One of the key issues at the heart of whether or not to issue a flood warning is how to manage uncertainty. This is especially true of warnings for flash floods where lead-in times are very short and flooding is often localised. There is evidence that current communication models between scientists and professional groups can mask the complexity of uncertainty, rather than encourage a shared understanding and ownership of decision making.

Clearly those involved in communicating meteorological information, making decisions about whether to issue flood warnings and initiating response plans have different organisational cultures, different responsibilities, different associated capabilities, and different timelines for action. These are not necessarily complementary. In the real time simulation of an extreme event in the Thamesmead area of the Thames estuary close to London reported by McCarthy *et al*. (2007), Environment Agency professionals at the Thames Flood Barrier were on alert and communicating with the Meteorological Office and their own scientists from an early stage. By contrast, the particular local focus of the local authority emergency management and police services professionals means that their roles are mainly acted out later in the event and are focused on potentially affected locations. Thus, the differing temporal and spatial focus of each professional's responsibilities substantially affects their need for communication and the nature of the tools that are likely to be most effective for them.

The local authority and police professionals commented that they were dependent upon the accuracy of the Environment Agency's flood warnings. For all three organisations, timely receipt of information was viewed as crucial, but 'accuracy of information' was also of considerable concern. It is clear that the effectiveness of organisations in making strategic and tactical decisions depends to some extent upon the levels of uncertainty associated with the scientific information (McCarthy *et al*., 2007). Faulkner *et al*. (2007) highlight that professionals seek to reduce or constrain decision uncertainty; their overarching need was for accurate information. However this is an aspiration at odds with the reality of uncertain model-based forecasts. There is a considerable risk of loss of information on uncertainty when the message is passed on in some simplified form.

Furthermore, Faulkner *et al*. (2007) conclude that the simple flood warnings currently issued by the Environment Agency, which are tempered by a confidence estimation whose origin is rather unclear but that can be expressed in some settings by quintiles, so reduce the science as to render it relatively opaque and open to misinterpretation. Being inadequately designed for professional use, the existing warnings convey nothing about uncertainty to partners and practitioners and give them only the information the public receives.

In addition, as research by Faulkner *et al*. (2007) shows, differing groups of professionals and scientists use such terms as "risk" and "uncertainty" in differing ways. They cite evidence that it is helpful when exploring the communication of uncertainty at the science/professional interface to distinguish between the decision uncertainty that preoccupies flood risk managers and the scientific uncertainty of a flood risk assessment or within a warning. Whereas to the scientist, scientific uncertainty is a challenging part of the professional domain, for agency professionals and other flood managers, decisions have to be made, decisions often with considerable implications for cost, well-being, and (not least) liability. Because the articulation of these imponderables may be even less certain than the science, it is not surprising that scientific uncertainty is an unwelcome part of decision uncertainty from the perspective of a manager.

If there is to be an enhanced ownership of uncertainty, this must be based upon an improved understanding of the complexity of the science (McCarthy *et al*., 2007). However, one obstacle to developing a shared understanding of uncertainty between different groups of professionals and scientists is the practical observation that scientists do not necessarily agree about how to carry out an uncertainty analysis. Additionally, because there are multiple ways of quantifying scientific uncertainty, there are as a result multiple possible translations of the meaning of an uncertainty estimate. Further, if decision makers in flood risk have an appreciation that uncertainty might change the nature of the decision, then inevitably they will start to ask for predictions to be associated with an estimate of uncertainty (however that might be formulated), a muddying of the decision-making process that previously appeared to be (unrealistically) clear cut (Faulkner *et al*., 2007).

Faulkner *et al*. (2007) conclude that with some imagination, a deeper understanding of the scope and limitations of a scientific projection, model, or forecast, including its uncertainties, can be communicated even to non-mathematically trained professionals, and even in very constrained timeframes. They argue that this requires a translational discourse that would be characterised by some or all of the following stages:

- A definitional exchange, which could include agreement on a list of contested terms.

- The enhancement of understanding of the different domains associated with different groups by articulating mutual constraints, including domain, logistic, and language constraints.

However, there are clearly limits to the sharing of ownership of uncertainty. McCarthy *et al*. (2007) report that it was apparent during the real time simulation event that current ownership is not disputed due to the clear demarcation of who makes the final decision and informal appreciation of who in the discussion has the competency to judge the uncertainty. Concern was expressed that in terms of responsibility for interpretation (that, is handling) of the uncertainties, all the tools should remain where the expertise lies, and should not overburden others' decision-making responsibilities.

5.2 Will false alarms of severe flash flooding lead people to ignore future warnings or will they still respond?

Weather and flood forecasting agencies in the US are often concerned with issuing too many false alarms for flooding (Drobot and Parker, 2000). Demeritt *et al*. (2007) also refer to this tendency amongst European flood forecasters. However, there is little

research on this area, except for example that by Breznitz (1984) and Dow and Cutter (1989) mentioned in section 5.1.1 above.

Dow and Cutter (1989) examined evidence from hurricane warnings and evacuation in the 1996 hurricane season in South Carolina, USA. The influence of premature evacuations for Hurricane Bertha played only a minor role in evacuation decisions for Hurricane Fran. Evacuation rates for Fran increased despite false alarms for Bertha only two months earlier, but Fran was a stronger hurricane. The actual evacuation warnings for both hurricanes were almost identical. However, the research found that the reported role of official advisories and mandatory orders was limited as people sought confirmatory information from a wider variety of sources on which to base their decisions on evacuation, rather than relying purely on official information. Key private sector sources of information in the US are the media, the Weather Channel and weather radio stations – in this research these sources of information were more pronounced than in previous research.

Personal assessment of the storm characteristics and its risks also played a larger role in evacuation behaviour than reported in previous studies. Emergency managers were not perceived as reliable or personally relevant for individuals but instead as traffic control officers, caretakers for tourists and major obstacles to re-entry after the storm. Electronic media information was often inconsistent with official warnings from the governor. People considered the quality of home construction, location, family safety and needs and data on storm tracks, strength and probabilities in their decision-making on evacuation. This all suggests that coastal communities in South Carolina are becoming more sophisticated in their risk calculations and exhibiting more independence in their assessment.

Dow and Cutter (1998) suggest that 'one voice' is needed that gives a consistent message. They suggest placing official evacuation orders on the Weather Channel to help avoid confusion and to improve the credibility of state-elected and emergency response officials. More detailed explanations of the rationale behind evacuation orders and their implementation may also be useful. They also call for more detailed studies on the issue of false alarms. One of the reasons that people chose to stay and not evacuate was because of delay in re-entry to the area after the storm's passage. There was also evidence of an increasingly evacuation-resistant population among some locations. A more detailed study of evacuees might help determine the existence of a disaster culture. The differences between study sites suggest that geographic location and situation may also be important in the formation of such a local disaster culture. More localised studies of evacuation decision-making and behaviour are needed.

5.3   Summary of key points

- Empirical evidence on the public's tolerance of false warnings is difficult to find, with some literature suggesting that they would prefer to receive a warning even if there is no subsequent flood, while others state that they would begin to take warnings less seriously if they received them too often without flooding.

- Evidence from operational settings indicates that professional partners would prefer to be put on standby at an earlier stage, even if they were subsequently stood down. However, this evidence is limited.

- Improving shared understanding between scientists and professionals of the complexity of the science and the nature of uncertainty may help mitigate the negative impacts of false warnings.

- There is some evidence that response to future warnings will not be diminished by false alarms where the basis of the false alarm is clear to the public.

6   Lead time for warnings

The objective of this chapter is to review the impact of lead time and different methods of delivery on the outcomes of flood warnings for severe flash flooding.

As we have already discussed, the issuing of timely warnings for flash floods is very challenging as they are characterised by short lead in times. However, rather than accept that it is not feasible to issue warnings, it seems appropriate to investigate the desirable and minimum time that is required for a useful and effective response to be made to a warning.

6.1   What are the desirable and minimum warning lead times that people need to escape and evacuate from vulnerable locations? How does this differ between locations, people and buildings?

As this report discusses in chapter 3, there is no one definition of what constitutes an appropriate and effective response before and during flash floods. This depends on the characteristics of the flood, the amount of time the warning recipient has to respond and where the warning recipient is when they receive the warning; it is therefore very context-specific.

However, the research evidence provides some information on desirable warning times. A large-scale survey carried out in 30 locations in England and Wales (Risk and Policy Analysts (RPA) *et al.*, 2004) analysed the impact of warning receipt as one factor which may influence the health effects of flooding. Twenty-three per cent of respondents were warned in some way prior to flooding. Some 59 per cent of those with houses flooded attributed some physical health effects to flooding. Simply receiving a flood warning of some kind made hardly any significant difference to the incidence of respondents' self reported physical or psychological symptoms. The researchers did find some evidence that a longer warning lead time had a mitigating effect on the mental health of flood victims at the time of flood and later. When those who had no warning were excluded, a longer warning time was associated with significantly less reported shock. Similarly, although those who received a warning were as likely as others to report experiencing 'fear, helplessness and horror' as a result of the flood (40 per cent for those warned compared with 46 per cent for the unwarned), the trauma again lessened significantly with a longer warning lead time.

One could, therefore, conclude that warning lead time, rather than receiving a warning or not, appears to be the crucial factor in reducing the adverse psychological effects of flooding, although more detailed studies would be needed to confirm this. Alternatively the characteristics of floods where earlier warnings could not be given, such as flash floods, may produce more adverse psychological effects (Parker *et al.*, 2007b).

As regards economic benefits, there is an assumption that flood warning lead time is a significant factor in avoiding flood damages. Available research supports this assumption but the evidence is not widespread or robust. The number of respondents making some saving is no different between those receiving more or less than eight hours' warning. However, those with less than eight hours saved on average £990 - or one-third - less than those with a longer warning lead time (Parker *et al.*, 2007a). Fielding *et al.* (2007) found the receipt of appropriate and timely warnings in the face of imminent flooding significantly raised the percentage of flooded respondents that reported their actions as effective. However, the reporting of effective action was

significantly reduced in households experiencing flooding above floor level, which may demonstrate that the capacity for action the public consider effective would be limited in flash flood situations.

In addition, warning lead time has been estimated to be particularly significant for non residential premises. There would generally be a big difference in the amount of damage/losses that could be mitigated with a two-hour warning compared with a warning of eight hours of more. For many companies, particularly larger ones, anything less than eight hours' warning lead time would be of little use, except to ensure the safety of staff and customers or clients, to secure the premises, or perhaps to save some of the most expensive items (FHRC, 2008). However, the safety of staff and clients is, of course, a crucial benefit.

However, there is some evidence that shorter lead times can be preferable in certain circumstances. Generally, in the United States forecasters have tried to offer longer lead times for severe weather warnings. However, shorter lead times for flash floods might be desirable when the forecasts are more focused geographically on more pinpointed areas. Based on research in the Thames estuary, Drobot and Parker (2007) found flood forecasters believe that a shorter flood warning lead-time than is technically available is preferable otherwise warning recipients may confuse the tide to which a tidal flood warning applies.

Handmer (1991) also found, based on a case study of slow rise flooding in Rockhampton, that as warning times increase, the official warning system is more likely to find itself working in tandem with the unofficial system. While unofficial warnings with a local origin were found to be helpful, the national broadcast media hype may have reduced the credibility of the official warnings. Therefore, a potential benefit of a shorter warning time is that there is not sufficient time for the development of this type of national media hype.

Following on from this, one could ask if it is not possible to provide a warning in the desirable timeframe, what is the minimum time required after the issue of a warning message for the warning recipient to make a useful response? Sorensen and Mileti (1989) conclude that most emergency response systems, typically made up of law enforcement, fire fighters, civic employees and sometimes volunteers, can issue an effective warning given three to four hours of lead time. However, when the threat is urgent, a warning can be disseminated much more quickly. However, if warning time is less than one hour, typically some, and perhaps a substantial portion, of the population will not receive a warning. How much this reduces the effectiveness of the warning in terms of negative impacts mitigated depends on the severity of the threat and the options for quick protection.   However, this is problematic as the amount of time there is from receiving a warning to the arrival of the flood can only be ascertained after the event (Gruntfest, 1977).

Sime (1997) concludes that a delay in the warning followed by an escalation of the threat is more likely to lead to panic type behaviours than a timely warning.

Clearly the evidence discussed in chapter 3, which highlighted that in most floods people are *more* likely to be killed or injured if they are outside of their home or in their cars during the flood (Jonkman and Kelman, 2005), is relevant here. One research question requiring further exploration is when is it better to seek shelter than evacuate? (Soronsen, 2000).

Sorensen (2000) has summarised general lessons in warning dissemination and lead time as follows:

- Officials are often slow at reaching a decision and this often prevents a timely warning to the public at risk.

- Most populations can be notified in about three hours or less without specialised warning systems.

- Warnings are more slowly disseminated at night than in the daytime or evening hours.

- New warning technologies such as telephone ring down systems can achieve very rapid warning.

- Informal notification plays an important part in warning dissemination in most emergencies.

- The time people spend responding to a warning responds to an S-shaped (logistics) curve.

- The time people spend in responding to a warning depends on the perceived urgency of the threat.

- The time required to evacuate a population is unrelated to the size of the population.

6.2 What are the desirable and minimum warning lead times that professional partners require to evacuate people to safety? How does this differ between locations, people and buildings?

There was insufficient evidence in the research literature to answer this question. It will be further explored in the focus group with professional partners.

6.3 Is there any reduction (and if so how much) in deaths from flooding by providing a minimal amount of warning (such as 15 minutes)?

There was no evidence in the research literature about warnings of less than 15 minutes.

Research by Wallingford (2003) has found that risk to life or serious injury is likely to be greatest when no effective warning is received; that is, where there is less than around 60 minutes of warning. This research also quotes work by Graham and Brown for the US Bureau of Reclamation undertaken in 1989 to develop procedures for estimating loss of life from dam failure (Wallingford, 2003). The research was based on 40 historical dam breaks. The rules developed were:

- For areas receiving less than 15 minutes' warning: loss of life = 0.5 (people at risk).

- For areas receiving between 15 and 90 minutes' warning: loss of life = 0.025 (people at risk).

- For areas receiving more than 90 minutes' warning: loss of life = 0.0002 (people at risk).

Thus is an area with 10,000 people, the loss of life would be 5,000, 250 and 2 respectively for the three categories listed above.

Again the evidence that undertaking evacuation at inappropriate times (for example, when the floodwaters have risen in depth and velocity) increases the chance of death is important.

A related question would be whether there is a time threshold after which a warning becomes useless because the time to respond before flooding is adequate. Following on from this, is there a time threshold after which a warning becomes dangerous because taking action at that stage is more dangerous than taking no action, or the message is likely to provoke panic?

As Sime concludes, flood warning design and evaluation would benefit from clearer assessment criteria which encompass the timeframe of a flood's development (1997).

6.4   Summary of key points

- The evidence suggests that longer lead times for flood warnings may result in increased benefits for health and reduced damage. However, the evidence on damage reduction is not sufficient or robust.

- However, floods for which long warning times are not possible, such as flash floods, may be associated with reduced benefits from warnings whatever the lead time.

- Evacuation may not always be the safest form of action. The characteristics of individual floods as well as the warning are crucial in determining if evacuation is desirable.

- There was insufficient evidence in the research literature to determine the needs of professional partners responsible for affected evacuation.

- There is insufficient evidence in the research literature to develop a relationship between deaths due to flood and flood warning lead time. It is not currently possible therefore to indicate any particular warning lead time threshold beyond which the risk of death increases or decreases significantly.

7 Conclusions

The key findings from the research literature for each of the five themes of the "Understanding of and response to severe flash flooding" research project can be summarised as follows:

7.1 Understanding of the term flash flooding

- Flash flooding may need to be re-conceptualised to make it clear that it is qualitatively different from other types of flooding.

- Promoting public understanding of the impacts of flash flooding is crucial to improving response.

7.2 Appropriate and effective responses before and during flooding

- Warning and preparedness are key to whether people consider their actions as appropriate and effective responses.

- Mortality and injury depend on individual flood characteristics. However, an appropriate and effective response to flash floods must include messages to avoid risky behaviour, including walking and driving through floods, and to climb to higher ground.

- The vulnerability of drivers and how to warn them needs particular attention.

- The evidence suggests that evacuation does not always constitute an appropriate and effective response to flash flooding.

- Understanding warning as a social process is key to developing effective warning messages that promote appropriate and effective responses.

- The content and style of the warning and how the warning is issued will determine whether the warning is acted upon.

- Warning messages must be consistent, clear, timely, accurate, simple, convey confidence in its validity, and say what people should do.

- Situational factors, including the characteristics of the flooding, can either inhibit or encourage levels and effectiveness of flash flood warning response.

- Social and political contexts determine how people understand risk, attribute responsibility and decide if and how to respond and can, therefore, lead to barriers to response.

- The social circumstances of those to whom flood warnings are issued are absolutely crucial to any understanding and interpretation of how people respond to flooding. Demographic factors and previous experience are important. In general, people in work, in higher social classes, aged between 45 and 54, who have lived at their current address for longer and

who have experience of flooding are more likely to be aware of the dangers of flooding and report taking effective action.

7.3　Getting those at risk to realise and respond to this type of flood risk

- Public information should focus on the causes and signs of flash flooding, how to stay safe during a flash flood and when and how to evacuate.

- Public information messages need to be targeted and different methods used to target different groups.

- Whatever the source of a warning, the more times it is heard the more likely it is to be believed. Therefore, several different delivery methods should be used.

- A reliance on newer technologies, such as mobile phones and the internet, may exclude more vulnerable groups.

- Vulnerable groups may not receive a warning unless it is a targeted at them.

- Local knowledge and involvement in preparing for flash floods is crucial. How to foster and incorporate local knowledge needs further examination.

7.4　False alarms

- Evidence from operational settings indicates that professional partners would prefer to be put on standby at an earlier stage, even if they were subsequently stood down. However, this evidence is limited.

7.5　Lead time for warnings

- The evidence suggests that longer lead times for flood warnings may result in increased benefits for health and reduced damage. However, the evidence on damage reduction is not sufficient or robust.

7.6　Gaps in the research literature

The following areas have been highlighted by the literature as requiring further research:

- Professional partners' requirements in terms of the time required to disseminate warnings and put in place evacuation plans (this will be further explored in the focus group with professional partners).

- Public understanding of the term "flash flooding" and the extent to which the public associate flash flooding with particular types of weather or atmospheric conditions and what these are (this will be further explored in the focus groups with the public).

- How the owners and managers of private companies behave in response to warnings.

- The experience of people from ethnic minorities in responding to natural hazards.

- How holiday makers and visitors to areas at risk of flash flooding can be reached by warning systems.

- Following on from this, how hotel, restaurant, campsite and other tourist facility managers understand their responsibilities regarding visitors and natural hazards.

- How the media in the UK disseminates warning messages.

- How to quantify and mitigate the environmental impacts of flash flooding.

- When to stay put and when to evacuate during flash flooding.

- Clearer assessment criteria into the effectiveness and appropriateness of action which encompass the timeframe of a flood's development.

- The extent to which providing those at risk with more information about flooding and flood warning response is an effective substitute for flood experience, and in what circumstances it may be or may not be.

7.7 The next stages of the research project

The next stage of the project is to conduct three focus groups. One of these focus groups will involve professional partners and explore the needs to these partners in responding to flash floods, including required lead-in times to implement emergency plans and attitudes to false alarms. This information will be supplemented by structured one-to-one interviews with individuals from professional partner agencies.

The other two focus groups will involve members of the public from two different areas that have experienced flash flooding. These focus groups will explore public perceptions and understanding of flash flooding, attitudes and expectations of warning systems and preferred methods for awareness-raising.

However, bearing mind the small number of focus groups and interviews allowed for, some of the research questions may not be adequately addressed. In addition, the small sample size will make it difficult, if not unwise, to draw generalised conclusions.

The final report of the research project will be presented in October 2008.

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