Joint Defra / Environment Agency Flood and Coastal Erosion Risk Management R&D Programme

Understanding of and response to severe flash flooding

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Environment Agency

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Department for Environment Food and Rural Affairs

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Steve Killeen

Head of Science

Executive summary

About this report

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

The research project was made up of four key stages:

- A literature review (report available separately).
- Two focus groups with members of the public.
- One focus group with professional partners.
- Telephone interviews with professional partners.

The report is divided into four main chapters dealing with: understanding the term 'flash flooding'; appropriate and effective responses to flash flooding; warnings for flash flooding; and raising awareness of flash flooding. Key findings and recommendations are presented at the end of each chapter. The final chapter of the report draws conclusions and brings the key findings and recommendations together in a table and presents them in the context of other initiatives, principally relevant recommendations in the Pitt Review (2008).

Context

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 subsequent flooding. They can 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. Predicting, preparing for and responding to flash floods poses great challenges.

The national policy context that frames this research is complex and rapidly evolving. It includes *Making Space for Water* (Defra (Department for Environment, Food and Rural Affairs), 2005), the Pitt Review into the lessons learnt from the 2007 floods (Pitt, 2008), the proposed National Flood Emergency Framework and the proposed Floods and Water Bill expected in the legislative programme for 2009/10.

Overall findings

Understanding the term flash flooding

Key features of flash floods as defined by flood risk management and response agencies 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.
- The urgent threat to life.

There is a lack of clarity amongst the public, professional partners and the media about how flash flooding relates to surface water and ground water flooding and whether it is inherently dangerous. Individuals with experience of flash flooding demonstrate a good understanding of its key characteristics. However, those who do not have experience of high velocity floodwater and debris do not necessarily demonstrate a spontaneous understanding of the danger flash flooding presents.

Appropriate and effective responses to flash flooding

Whether flash flooding results in death and injury depends on the interaction of many factors. It is therefore difficult to prescribe a "one size fits all" response to flash flooding, beyond the key messages of "go to higher ground" and "do not drive". It is also not possible to definitively state which types of building can always be considered safe during flash flooding. However some types of location should be considered unsafe, including caravans, tents, mobile homes, timber frame buildings and single storey, ground floor or basement properties.

It is not possible to be specific about the amount of time the public need to evacuate an area. Nor is it possible to be specific about the amount of time professional partners need to carry out evacuations. This depends on the interaction of many factors unique to the particular incident.

It is not possible to quantify a possible reduction in mortality with a minimum warning time. However, it is probable that a warning with a very short lead in time that enables people to get inside and upstairs can save lives, even if organised evacuation would not be possible within this timeframe.

Warnings for flash flooding

The Environment Agency's existing warnings were considered by focus group participants to provide insufficient practical information on what to do in response to flooding. The timing, speed, velocity and depth of flooding affect how individuals are able to respond to flash flooding and can determine the emergency services' ability to attend.

Tourists and other visitors are more at risk of death and injury from flash flooding. Campers and caravaners are particularly vulnerable. Communicating this risk is potentially sensitive because of the desire of local communities to protect tourism.

The warning process needs to be seen as a complex social process, rather than the issue and receipt of a warning message. Understanding how people interpret warnings helps explain why they often do not respond to warnings as those issuing warning expect and want.

A warning system for flash floods could have potential negative impacts including causing undue alarm to the public, promoting "flood tourism" and creating an expectation amongst the public that warnings will always be issued in cases of flash flooding.

Unofficial warnings, including self-warning as a result of personal observations of danger signs, is an important source of warning for flash floods.

The Environment Agency and Met Office are seen as the best sources of a warning for flash flooding. Many and varied dissemination methods are preferable but it is important the warning message is consistent.

Evidence about the public's tolerance of false alarm is sparse and inconclusive. Participants in the public focus groups indicated that false alarms would affect future response but only if they happened on a regular basis.

Raising awareness of flash flooding

Raising awareness is crucial for effective response and is especially important for flash floods as in general there will be very little lead in time. The link between awareness-raising and response is not straightforward and the extent to which awareness-raising activities can replace flood experience in improving preparedness is unclear.

Awareness-raising messages need to include advice for independent action as the very short period of time between the warning and the onset of a flash flood means that people may have to take action themselves without the support of the emergency services.

Awareness-raising messages need to be standardised but the methods used to disseminate those messages should be diverse. No one method can be expected to reach all audiences and no one method can be considered most effective. A combination of local, regional and national approaches may be most effective.

Local knowledge and involvement must be used in such a way that recognises the characteristics of flash flooding. Parish Councils operate at an appropriate level for the encouragement of local action and provide a useful dissemination route.

Conclusions

The report draws out a number of important key findings and makes 28 recommendations on how these can be taken forward. These key messages and recommendations have been formulated to assist the Environment Agency with its investigation into the feasibility and advisability of a warning service for severe flash flooding and its development of effective awareness-raising strategies and messages.

The research has relied heavily on an extensive literature review. Primary research has been limited by the timescale and budget for the project. Additional primary research, in the form of focus groups and telephone interviews, will be essential to building a more detailed and more representative picture of public and professional perceptions of flash flooding and the nature of particular vulnerabilities. It will also be crucial to developing interventions that support effective and appropriate response.

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Contents

1 Introduction

1.1 Background

In March 2008 the Environment Agency commissioned Halcrow Group Limited, Ben Cave Associates and the Flood Hazard Research Centre at Middlesex University to undertake research into public understanding of and response to severe flash flooding. This final report presents the findings and recommendations of that research project.

England and Wales have recently experienced a number of 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 not a new phenomenon. Similar flash floods have occurred in the past causing serious damage and loss of life, for example at Lynmouth in 1952.

Flash floods are characterised by very short periods of time between rainfall and subsequent flooding, making effective preparation and response very difficult to achieve. While not all flash floods pose a serious threat to life, property and infrastructure, in many cases they present an extreme danger because of the suddenness of the rise in water level, the large volumes of water involved, the flow velocity, the debris content and the presence of floodplain users and damageable assets.

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. At the present time no national warning system for flash flooding is in place. The Environment Agency is currently defining rapid response catchment areas that are at particular risk of flash flooding.

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 are some indications that flash flood hazards may become more common, and that human exposure and vulnerability to this hazard may increase in the future.

The national policy context that frames this research is complex and rapidly evolving. The Government set out the strategic direction of flood management in the document *Making Space for Water* published on 29 July 2004 (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 final report of the Pitt Review into the lessons learnt from the 2007 floods (Pitt, 2008) found that the greatest advances in flood forecasting, modelling and warning were needed in areas of the greatest risk – vulnerable to flooding with significant depth and high velocities, such as flash floods. The Review made a large number of

recommendations to improve flood warnings and public responses to flood warnings, public awareness of and preparation for flooding, and emergency response to flooding.

In response to the Pitt Review, the Government has announced its intention to produce a National Flood Emergency Framework which will bring together national polices, guidance and information as a resource for all those involved in flood risk management and response (Defra, 2008a). In addition, the Government's draft legislative programme for 2009/10 includes consultation on a draft Floods and Water Bill which is expected to clarify responsibilities for flood risk management.

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).

1.2 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 purpose is 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 specific objectives of the research project are:

- To review the language used in the context of flash flooding and how well it is understood.
- 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 on trust and response when flooding does not occur.
- To review the impact of lead time[1] and different methods of delivery on the outcomes of flood warnings for severe flash flooding.

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

1.3 The structure and scope of this report

This report is structured in four key chapters as follows:

- Understanding the term flash flooding.
- Appropriate and effective responses to flash flooding.
- Warnings for flash flooding.
- Raising awareness of flash flooding.

Each of these chapters is divided into sections based on a number of research questions defined by the Environment Agency in the brief for the research project. Key findings and recommendations are provided at the end of each chapter.

The final chapter brings together the key findings and recommendations of the research and places them in the context of other initiatives.

The scope of this report is limited to the five specific objectives given 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. In addressing these objectives, this report considers all flash floods that pose some threat to people and property including those flash floods generally termed generally 'severe flash floods' because they are associated with potentially high impacts.

There is considerable technical research literature exploring 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 and considering the feasibility of warning systems for 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 and is discussed in section 4 of this report, which looks at warnings for flash floods. However, we have sought, as far as possible to ensure the main focus of this report is on the practical and operational aspects of flash flood warning, response, awareness and preparedness, in line with the brief provided by the Environment Agency.

1.4 Methodology

The research project was made up of four key stages as described below.

1.4.1 Literature review

A search and review of research, grey literature and media reporting of flash flooding was undertaken. Research and information included as part of the literature review was identified in a number of ways. A custom search of the Natural Hazards Center Library at the University of Colorado at Boulder was undertaken; 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; and operational documents and media reporting relating to four flash floods case studies were analysed.

The literature review is available as a separate report.

1.4.2 Focus groups with members of the public

Two focus groups were held with residents of areas that have experienced flooding (including flash flooding) in recent years, one in Polperro on 7 July 2008 and one in Hebden Bridge on 10 July 2008.

The purpose of the focus groups was to explore how communities at risk of flash flooding understand this risk. As only two focus groups were held and the recruitment to these groups was not randomly undertaken, they in no way provide a representative sample of these communities. Instead they provide a "snapshot" of the experience and views of some individuals.

The discussion comprised a series of structured open questions designed to explore participants' understanding of flash floods, warnings and appropriate response. The term "flash flood" was not defined at the beginning of the focus group so participants could describe their existing understanding. However, after the first set of questions, the key characteristics of flash floods were given to ensure the discussion stayed focussed on this type of flooding.

The discussion guide used for the public focus groups is attached as appendix 1 of this report.

1.4.3 Focus group with professional partners

A focus group with professionals involved in responding to flash floods was held on 8 July 2008. The Environment Agency proposed that the focus group with professional partners should take place as part of a broader meeting of the South West Local Resilience Forum flooding sub group because of this group's experience of responding to flash flooding.

The discussion again comprised a series of structured open questions designed to explore participants' experience and understanding of flash floods. In particular, the group explored professional partners' capacity to respond to flash floods, factors affecting that capacity and the requirements of professional partners responding to flash floods. A constraining factor for the focus group was the limitation of discussion to only one hour. The professional partners' focus group was drawn from one region only. The results may well not reflect perceptions of flash floods among professionals across the country as a whole.

The discussion guide used for the professional partners' focus groups is attached as appendix 2 of this report.

1.4.4 Telephone interviews

Telephone interviews with professionals with experience of responding to flash floods were carried out to further explore the operational aspects of this type of response. Notes of each telephone interview were made and sent to each interviewee to check for accuracy. Representatives of the following organisations were interviewed:

- Devon and Cornwall Constabulary.
- West Devon Borough Council.
- Devon and Somerset Fire and Rescue Service.
- Environment Agency South West Region.

2 Understanding the term flash flooding

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

The research team explored this question through focus groups with two local communities who had experienced flooding and were at risk of flash flooding. Polperro experienced flash floods in both in 1976 and 1993. Hebden Bridge has experienced many incidents of flooding, for example in 2001, 2004, 2006 and 2008. This flooding is usually caused by rising river levels (fluvial flooding). Flooding has also been caused by rising groundwater levels following heavy rainfall runoff from surrounding high ground, although such flooding was less serious than that produced by fluvial sources.

All the participants of both focus groups were long term residents of the areas which had experienced the flooding, so their views must be seen as illustrative of people with experience of flooding, rather than of the general public. It is also important to note that two focus groups does not provide a large enough sample for the results to be considered significant, and that participants were invited to join these focus groups by local organisers rather than being randomly selected, introducing a further element through which the sample should be considered unrepresentative of the general public.

Participants of both public focus groups had an accurate understanding of some of the key features of flash flooding which they identified as speed, suddenness, high volume of water and heavy rain running off hills. They suggested the Boscastle flood of 2004 as an example of flash flooding.

Participants also demonstrated a good understanding of the causes of flash flooding as heavy rain, dam failure or snowmelt. They also discussed the importance of surface conditions for flash flooding with the ground either being baked hard or sodden from previous rain. Both public focus groups believed there were other factors that contributed to flooding including:

- Inadequate drain maintenance by councils.
- Changing farming practices.
- The loss of local knowledge.
- The deterioration of river and watercourse management.

The Polperro group also thought that development and the walling in of the river were key factors contributing to flash flooding.

The participants of the Polperro focus group also discussed velocity and debris as important and dangerous features of flash flooding. They referred to their experiences of flooding when cars and other large objects were lifted and carried through the village, causing structural damage and acting as dams, which increased the flood level in places. They discussed the way in which tide can exacerbate flash

flooding in seaside communities, referring to the way in which fluvial floodwaters back up when the tide is high.

The participants of the Hebden Bridge focus group distinguished flash flooding quite separately from fluvial flooding. Fluvial flooding was perceived to be the cause of the most serious flooding experienced in the village in recent years, and the main threat for the future. On the other hand, the group described flash flooding as any flooding originating from the hills behind the village, regardless of its severity. While flash flooding was seen as potentially dangerous, in comparison to the separately categorised fluvial flooding, it was not perceived to be always or inherently dangerous.

As regards the impacts of flash flooding, the Polperro focus group stressed the human impacts of flash flooding, including the death of an elderly resident during the first flood, the increased mortality of older people after both floods and the on-going stress and anxiety caused by the flooding. Participants also talked about the mud, the damage to sewage pipes, the smell and the impact this had on the tourist industry that is vital for the village's economy. The speed and severity of the flooding was considered to make action to protect property impossible. The only actions possible were to warn neighbours and go upstairs.

By contrast, the Hebden Bridge group focused more on the impacts of flooding on individual properties. With the exception of basements, which were seen as a dangerous place to get caught, the emphasis was on how the water could be prevented from entering property. Participants were interested in how they could obtain and place sandbags as effectively as possible within the time available.

This different emphasis can be attributed to the very different experiences of flooding the two communities had experienced, with the Polperro focus group participants having direct experience of two flash floods that resulted in loss of life and significant structural damage.

The literature review found little research into how the public understands the term flash flood. 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. 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 interviewees had the 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. The biggest difference in the completeness of mental models was the difference between newcomers and those born in the research communities.

Knocke and Kolivras (2007) undertook an online 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 exists 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.

2.2 How do professional partners understand the term “flash flooding”?

This research question was not included in the original brief for the project but was considered by the research team to provide information necessary to meet the specific objectives of the project.

The focus group with professional partners was made up of the membership of the South West Local Resilience Forum flooding subgroup, whose members consist of category 1 and category 2 responders, as defined by the Civil Contingencies Act 2004. Some participants in this group had many years experience of responding to flooding, including flash flooding, while others were relatively new to their posts and did not have such experience.

The professional partners’ focus group stressed the severe, unexpected and short nature of flash flooding. It was also defined as highly localised and unpredictable. The group agreed it resulted from heavy rain, as distinct from that arising from tides or rivers.

One definitional question that arose in the focus group with professional partners was whether severe surface water flooding could be described as flash flooding and whether rainwater run off from hills (such as that which caused the Boscastle flood) could be defined as surface water. As one participant put it:

> “Is Boscastle counted as surface water flooding?”

The professional partner focus group participants stressed that because of these features flash flooding requires a different type of response from other types of flooding and presents a much more difficult challenge.

The literature highlighted that while there is no single agreed definition of what constitutes flash flooding, several working definitions with key common features have been put forward by professional agencies (Gruntfest and Handmer, 2001b).

Although the Environment Agency does not have agreed formal definition of a flash flood, it has used the following definition of a 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.

In terms of flooding this means that:

- 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 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 etc.). 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 away boulders, uproot trees, and destroy bridges and buildings that stand in its path.*

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.

2.3 How do the media use the term “flash flooding”?

2.3.1 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,’ 19 May 1989.

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

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. The full analysis is available in the literature review.

As we would expect, the reporting of the flash flooding case studies describes the key characteristics of flash floods in some detail. For illustration we focus on ways in which the 2005 flood was reported. Recurring characteristics described are:

The *speed* with which the floodwater 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." (The Independent, 21 June, 2005. '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'.)

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 described in section 1.2. 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, and which might make them more able to predict, assess and identify an increasing risk of flash flooding - is not wholly accurate. 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.

2.3.2 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 of 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 coastal towns'.)

> "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'.)

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

Participants in the focus groups with the public and professional partners used the following terms to describe flash flooding:

- Speed
- Severe
- Unexpected
- Sudden
- High volume of water
- Heavy rain running off the hills

The words 'velocity' and 'debris' were not used by participants in the Hebden Bridge focus group.

Key words and phrases frequently used in the printed media to describe flash floods include:

- Sudden
- Unexpected
- Raging torrents
- Extreme event
- Surging
- Rapid
- Dangerous
- Fast
- Great flood
- Serious flooding

Although the severity and seriousness of flash flooding and the danger it presents were discussed by the focus group participants and printed media when describing flash flooding, it is by no means clear that flash flooding is by definition considered to encompass these characteristics. For example, the focus group participants at Hebden Bridge used the term "flash flooding" to describe flooding that came from rainfall on the hills behind the village regardless of the severity and danger this presented.

This begs the question whether it is useful to use the term “severe flash flooding”, as does the title of this research project, or “dangerous flash flooding” in warning and awareness-raising activities as this would imply that not all flash flooding is severe or dangerous. The confused way that general printed media articles use the term “flash flooding” and the importance of clear, unambiguous messages for awareness-raising suggest that it would be more useful to develop a definition of flash flooding that makes it clear that danger and severity are intrinsic qualities of this type of flooding.

The use of the term ‘severe’ in Met Office Severe Weather Warnings may also be pertinent. The National Severe Weather Warning Service warns the community by providing warnings of ‘severe or hazardous weather which could cause problems, ranging from widespread disruption of communications to conditions resulting in transport difficulties or threatening lives’. Severe weather warnings are issued on a frequent basis. The degree of severity implied by use of this term without definition may be confusing. In addition, the Environment Agency use the term “severe flood warning” to describe the highest level of alert in the existing flood warning system. In this instance the word “severe” refers to the certainty with which flooding is predicted and the extent of that predicted flooding, rather than the danger to life it is predicted to present. Therefore, it may be beneficial to use a term which either needs no qualification, or use a qualifying descriptor other than ‘severe’, for instance ‘extreme’.

Furthermore, there is confusion and lack of clarity about whether the source of the floodwaters is important in defining flash flooding. In general flooding is categorised by its source, for example coastal, fluvial, groundwater, surface water and pluvial flooding. However, these terms are often used without definition and this creates confusion amongst the public and professional partners who do not understand how flash flooding fits into this. This confusion was discussed at the focus group with professional partners who asked whether severe surface water flooding could be described as flash flooding and whether rain water run off from hills such as caused the Boscastle flood could be defined as surface water.

Flash flooding is usually associated with rapid over-ground runoff of rain from steep slopes or on saturated ground. However, flooding with the same potentially dangerous impacts of flash flooding may arise from other sources, for example the coast has many ‘rapid inundation zones’ where overtopping of sea defences can occur relatively suddenly and where defences or structures may collapse or be breached causing very sudden and dangerous flooding It is these potentially dangerous impacts of flash flooding, including its velocity, suddenness, depth of water and associated debris, that mean this type of flooding requires prompt recognition and action by members of the public and professionals. This means it needs to be clearly distinguished from other forms of flooding, such as surface water flooding which is often characterised as slow moving and slow rising, to emphasise the threat to life posed and to encourage prompt and effective action.

For these reasons, Gruntfest and Handmer (2001b) have suggested that 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”. Such a reconceptualisation may require a new descriptive term and definition that makes the potentially dangerous impacts of flash flooding explicit. No suggestions for new descriptive terms or definitions for flash flooding were found during the literature review. However, “sudden, dangerous flooding” is an example of such a term proposed by the authors of this report. This could be defined as “a localised flood with very high volumes of fast flowing water, often carrying large debris, that rises very quickly, with an immediate threat to life.”

The Pitt Review’s recommendation (Pitt, 2008) that the Environment Agency should be an agency with “a national overview for all flood risk, including surface water and

groundwater flood risk" and the development of a National Flood Emergency Framework (Defra, 2008b) present an opportunity for reconceptualisation of flash flooding, with a clear definition that stresses the implicit danger and severity of this type of flooding.

2.5 Key findings and recommendations

- Individuals with experience of flash flooding demonstrate a good understanding of its key characteristics. However, those who do not have experience of high velocity floodwater and debris do not demonstrate a spontaneous understanding of the danger flash flooding presents.
- Key features of flash floods as defined by flood risk management and response agencies 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.
- In general media the reporting of flash flooding presents an accurate picture of the characteristics of flash flooding. However, reporting of the causative factors leading to flash flooding is less complete and less accurate.
- Media reports of flooding tend to use the term 'flash flooding' to describe any type of floodwater that rises quickly. This use of the term does not tally with the Environment Agency's working definition of flash flooding.
- Use of terms to quantify the severity of flash flooding may also be misleading.
- There is a lack of clarity amongst the public, professional partners and media about how flash flooding relates to surface water and ground water flooding and whether it is inherently dangerous.

Recommendation 1: The Environment Agency should seek to develop a description and definition of flash flooding that stresses the potentially dangerous impacts of this type of flooding. One example is "sudden, dangerous flooding," which could be defined as " a localised flood with very high volumes of fast flowing water, often carrying large debris, that rises very quickly, with an immediate threat to life."

3 Appropriate and effective responses to flash flooding

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?

3.1.1 Defining an "appropriate and effective response"

Currently the Environment Agency employs a small number of flood warning performance indicators. These include reported appropriate actions and effective actions taken by at-risk properties in response to flooding. Data reporting is through post-flood social surveys. The Environment Agency has therefore adopted simple working definitions of what constitutes appropriate and effective responses in order to report the performance of its flood warning service.

What is appropriate and effective will clearly depend on the time available to make a response and the particular circumstances (Sime, 1997). The professional partners' focus group said these circumstances would include the depth and velocity of the flooding and the time when the flooding occurred, for example day or night.

Furthermore, agencies with responsibility for flood risk management and flood response and individuals may have different interpretations of "effective". Whereas the Environment Agency links effectiveness with 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. Fielding *et al*. (2007) cite the work of Thrush *et al*. (2005), who in a study of victims of floods in the autumn of 2000, showed 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.

In addition, 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).

3.1.2 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 therefore examined the causes of death and injury during flash floods and consider what action may prevent them.

As Gruntfest and Handmer (2001b) have noted, fewer people are injured in flash floods but more are killed relative to slow rise flooding. 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). Research by H.R. Wallingford has indicated risk to life or serious injury is 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 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 a defence breach) to human settlements (Jonkman, 2007).
- Flood waters are deep.
- Extensive low lying, densely populated areas are affected so that escape to high ground is not possible.
- No effective warning is received (that is, where there is less than approximately 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 in 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).

Mortality associated with a flood will depend on the flood characteristics (such as depth, velocity and speed of onset) and where people are when the flood occurs. However, the way people respond to floods is also a critical factor, including whether they evacuate. In European floods particularly, deaths are strongly related to risk-taking behaviour (Jonkman, 2003) and the World Health Organization (WHO) (2002a) estimate that up to 40 per cent of health impacts due to flooding result from such behaviour. We examine each of these factors in turn.

Flood characteristics

Flood characteristics are determined by the local topographical, geological and hydrological conditions as well as catchment characteristics, such 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). 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

area is essential when estimating flood depths and velocities (Wallingford, 2003). The layout and nature of the area 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). Difficulties in accessing the village was raised as a concern in both public focus group discussions.

The timing of a flood will also affect death and injury as this will determine the location of people. If a flood event begins in the middle of the night, a flood might be reaching hazardous levels before many people are aware of the danger, 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 others to safety.

The season in which flooding occurs is also important. Regions which experience large numbers of visitors, in either the summer or the winter months, face particular challenges including:

- Language.
- Greater number of people at risk.
- Lower proportion of population aware of the risk.
- Lower proportion of population aware of how to respond to a flash flooding event.

Some people may also be participating in activities that would inherently make them more vulnerable to flooding should a rapid-onset event occur (for example, fishing, canoeing, and camping).

Jonkman and Kelman (2005) and Poole and Hogan (2007) state that in some circumstances the season will affect the ability of people to escape floodwaters or even 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 the instances of mortality.

Where people are when flooding occurs

Where people are when flooding occurs may be a significant factor affecting risk to life during flood events.

Floods can have a damaging effect on buildings, which can cause fatalities if the building collapses (Jonkman, 2003). Damage to buildings caused by a flood depends on the flood characteristics, such as the depth, velocity, presence of debris, and the characteristics of the buildings affected, such as the structure of the building, quality and type of construction materials and methods (Roos, 2003). The interaction of these factors is very difficult to predict.

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 in UK flooding, where the only major flood incident where building collapse has been a significant cause of mortality was in Lynmouth in 1952. This is due to the faster and deeper waters experienced in some parts of Europe and differences in building type, materials and construction methods.

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. 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)

Significant loss of life can also occur in floods where people cannot find refuge inside. 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).

Caravan parks and campsites are at particular risk and are often located in areas prone to flooding, including rapid response catchment areas prone to flash flooding, because the natural beauty of these areas attracts tourists. Residents of caravan parks and campsites have specific requirements in terms of flood warnings because it is essential they evacuate to stay safe. These residents may also have limited knowledge of the area and may not be aware of flood risk.

Because many factors influence the stability of buildings and structures during flash floods it is not possible to definitively state which types of building can always be considered safe. However, people in caravan parks, campsites, 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 implications of the increased vulnerability are discussed in more detail in section 4.3 of this report.

Evacuation as an appropriate and effective action

It is sometimes assumed that evacuation is the safest form of action in the event of flash flooding as buildings may collapse or flooding may reach levels higher than the upper storey. The majority of the deaths in the 1952 Lynmouth flood were caused in this manner (Delderfield, 1976).

Gruntfest (1977) analysed actions taken by the survivors and those who died in the Big Thompson Flood in Colorado. This flood killed 139 people in 1976. Gruntfest 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.

However, there is also evidence that evacuation is not always the safest form of action. One 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). Therefore undertaking evacuation at inappropriate times, such as when the floodwaters have risen in depth and velocity, can increase the chance of death.

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.

The professional partners' focus group said the type of action taken by the public must depend on the depth and velocity of flooding. Getting clear of the flooding and moving to higher ground were basic steps. In addition, professional partners involved in flood evacuations interviewed as part of this research stated that evacuation on foot was not generally safe if floodwaters had already reached people's houses. A simple rule of thumb was that if the emergency services are able to knock on doors to advice people to leave, it was safe to evacuate. However, if the flooding was already too severe for the emergency services to reach people, it would be safer to go upstairs.

Participants in the Polperro focus groups stated that in both the 1976 and 1993 floods evacuation was impossible because they did not have time. All they could do was go upstairs. They also said that there was nowhere for them to evacuate to. The road leading out of the village was already flooded and climbing the valley, a rough and steep climb, was not considered an option.

However, evacuation is necessary for those living or staying in basement and single storey properties, mobile homes, caravans, tents and other vulnerable dwellings. Special arrangements for evacuation, awareness-raising and preparedness in advance are required. The Environment Agency South West Region launched one such initiative in August 2008. The information pack "Flooding – minimising the risk" aims to encourage caravan and campsite owners to put in place evacuation plans and other flood preparedness measures.

In addition to undertaking awareness activities, it is important to identify and enforce statutory requirements for the owners of caravan parks, campsites, holiday homes and other vulnerable locations to make provision to evacuate their visitors in the event of danger, including flooding. These statutory requirements provide important levers in situations where owners and managers may be resistant to putting in place such provisions for fear of frightening off custom. Section 4.2 discusses the specific vulnerabilities of tourists and other visitors to the impacts of flash flooding in more detail.

The identification of safe havens and safe exit routes would assist safe evacuation and help those in vulnerable structures get to a place of safety quickly. The Environment Agency is identifying such safe havens in or close to rapid inundation zones in coastal areas. This should be extended to areas identified as at risk of flash flooding, for example rapid response catchment areas.

In discussing the effectiveness of evacuation, it is also important to consider that people may not evacuate, even if instructed to do so. Professional partners involved in flood evacuations interviewed as part of this research stated the police cannot order people to evacuate, only advise them to do so. People often refuse, preferring to wait and see what happens.

Many people do not believe the flooding will be bad enough to necessitate evacuation, even if the emergency services are advising them to evacuate. By the time it is clear that the flooding is sufficiently serious to warrant evacuation, it may be too late to safely do so. Participants in the Hebden Bridge focus group believed that local people were unlikely to evacuate because they would not wish to leave their homes, even though the community had experience of flooding. When asked if participants ever feared for their safety, they agreed they did not. One member said they all lived on the side of a hill so it was not an issue. This shows the extent to which assumptions are made about future flooding risk based on previous experience of flooding.

Another factor professional partners reported that restricted evacuation was the refusal of people to leave if they cannot find their pets. 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 as much as possible mass shelters 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".

Other appropriate and effective actions

Participants in the professional partners' focus group said that another important action that needed to be done before the flood was the preparation of an emergency "grab" pack. It was also important that families should have an individual flood plan ready to put into action. Taking medications in event of evacuation was essential and people needed to be told this and it had been an issue in previous evacuations. However, participants in the Hebden Bridge focus group said they did not think people would follow advice to have a flood plan or an emergency pack as the type of flooding previously experienced by the community was not serious enough to justify this.

Participants in both the Polperro and Hebden Bridge focus group believed closing the roads was an important action. In Polperro participants explained that it was crucial to get the cars out of the village and stop others coming in because they would be carried down as debris causing more damage and could make the flooding worse by damming the river. However, this was difficult as there are only three roads in and out of the village. The group agreed this is a major problem.

In the longer term, participants in the focus groups placed a great deal of emphasis on action that might prevent flash flooding. These were seen to include river maintenance and keeping the drains and watercourses clear. There was strong agreement that maintenance of drains and watercourses has deteriorated in recent years. Whereas in the past councils were seen to regularly clear drains, this was no longer seen to be the case. As properties had changed hands over the years, participants believed knowledge of the location and maintenance requirements of waterways had been lost, which was seen by participants in the focus groups as a major cause of flash flooding. Although such preventative measures may not stop flash flooding, it is important to note that communities who have experienced flash flooding often believe they will.

The focus groups differed in their views of the use of sandbags in a flash flood. In Polperro the group said sand bags were no use in "a real flood" as the water level was too high and the flooding happened so quickly that there was no time to put them down. There was agreement that the top priority was warning vulnerable neighbours and getting older people upstairs. One explained:

"People are more important than property."

In Hebden Bridge, participants said the priority was to stop the water entering property and that sand bags were useful for this. There was a great deal of dissatisfaction in the focus group about the availability of sandbags, with participants expressing concern that the local authority did not supply these quickly enough after a flood warning nor in a systematic way. When questioned whether sandbags were effective, the group agreed they were not enough alone, but as one participant put it:

"People feel like they can achieve something."

The priorities displayed by the focus groups, with the Polperro participants prioritising action to protect life and the Hebden Bridge participants primarily concerned with saving property reflect different experiences of flooding. In Polperro participants had seen a flash flood and understood that sand bags would be ineffective. In Hebden Bridge sand bags were seen as effective because the community had experienced groundwater flooding and slower rising, shallower fluvial flooding.

Behavioural factors

In addition to evacuation, there are other actions that people take in response to a flash flood that can affect the likelihood of death and injury. Certain forms of behaviour are particularly risky.

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). 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 show that a large number of disaster deaths occurred on the road among motorists (Glass *et al*., 1980; French *et al*., 1983; Mooney, 1983; Schmidlin and King, 1996; Hammer and Schmidlin, 2001; Jonkman and Kelman, 2005; Kundzewicz and Kundzewicz, 2005),

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, vehicle deaths are still a leading cause of mortality. For example, motorists represent 40 per cent of the people who lost their lives due to flooding in the last 50 years in France (Antoine *et al*., 2001; Lescure, 2004).

Informal research carried out by Devon and Somerset Fire and Rescue Service found drivers stranded in vehicles to be the single biggest cause of fire and rescue service flood-related rescue work. The research, based on questionnaires completed by fire crews, cannot be considered representative as not all crews responded, but it does illustrate the significance of this problem.

In addition, drivers are a particularly difficult group to warn as:

- They will not be in a position to receive warnings disseminated door to door, on television or by telephone.
- It is illegal to drive while using a mobile telephone, so text and phone call warning dissemination is not effective for drivers travelling alone.
- They may be in an area they do not know, and therefore unable to pick up on environmental cues of danger.
- They are likely to be separate from friends and family who would confirm a warning.

Participants in the focus groups said that radio is the most effective way of warning motorists and that the automatic cut-in facility used for traffic information would help.

Walking through floodwater can also be a very dangerous activity. 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, 2008).

Professional partners interviewed for this research highlighted other dangers of walking though flood waters. Flood water can displace manhole and drain covers so people can fall down these holes and drown, as happened with a young girl in September 2008, where only the quick actions of her father saved her life (BBC1 TV news). People can also become trapped by the water against barriers such as walls. People may also underestimate the depth of waters or become disoriented and drift into deeper waters, thus being swept away.

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. 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. A review of flood fatalities in Australia between 1788 and 1996 showed that male outnumber female fatalities by 4:1 (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).

In conclusion, flash flooding has been a significant cause of injury and mortality internationally, and to a lesser extent in the UK. Because of this, it warrants specific attention in the Environment Agency’s “risk to life” modelling and planning, as well as that of other agencies involved in flood management and water rescue. Death and injury associated with a flash flood will depend on the interaction of complex and variable factors including flood characteristics, time of flood, where people are when the flood occurs and their subsequent behaviour. Because of this interaction of factors, every event is different. Therefore, it is very difficult to define a response to flash flood that always constitutes appropriate and effective action.

In view of the importance of local factors in determining what constitutes effective action in the event of flash flooding, hazard mapping should be undertaken in those areas identified as at risk of flash flooding; that is, those in rapid response catchment areas. This hazard mapping of rapid response catchment areas should be used to develop local action plans for flash flooding. Appropriate local action could include the identification of safe havens for those in vulnerable structures, the identification of evacuation routes, traffic diversion routes and the identification of places where debris may create logjams and whether debris interceptors could be used. Local community involvement and the engagement of parish councils will be key to developing local plans.

In addition, it is possible to propose general responses that are most likely to protect the life of individuals caught in flash flooding. These would include avoiding risky behaviour, such as walking and driving through floods. It is not possible to say that any structure is completely safe in the event of flash flooding but some structures are much more likely to collapse or be washed away. Therefore, people in certain types of structures, such as single storey or basement properties, caravans and tents, are more at risk of death or injury from flash flood and should evacuate to the nearest two storey brick structure. Evacuation from the area at risk of flash flooding may be an appropriate and effective response. However, if flooding has already reached door levels before evacuation can take place, evacuation may be more dangerous than going upstairs.

3.2 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?

In section 3.1 we show that evacuation is not always the safest course of action. Evacuation is no longer safe if floodwater has already reached the affected area.

Focus group participants were asked about whether they would spontaneously evacuate in the event of a flash flood. In Polperro there was strong agreement in the group that evacuation was not an option. During the first flash flood in 1976, there was no warning and by the time local people were aware that flooding was imminent, much of the village was already covered by floodwater. During the second flash flood, a siren warning system was in place but by the time this went off, part of the village was already flooded. As one participant put it:

> *"You never had a chance to evacuate."*

Instead, residents said the only way to escape the water was to go upstairs. Furthermore, the participants felt strongly that because of the nature of the flooding, it would not have been possible to have a warning.

Going upstairs may not always be an option, for example for people in vulnerable structures, such as basement and single storey properties, mobile homes, caravans and tents. However, because different conditions apply to each of these, it is not possible to suggest an optimum lead in time. For example, somebody living in a basement flat could go upstairs to a neighbour's property if flooding occurred during the early evening. Alternatively, if flooding threatens a campsite or caravan park during the night, a much longer period would be needed to wake and move all those staying there to safety. The exact amount of time required would depend on many factors including the number of visitors, the staff available and whether the site had an evacuation plan in place.

The research evidence provides some information on desirable warning lead times. A large-scale survey carried out in 30 locations in England and Wales (Risk and Policy Analysts *et al*., 2004) analysed the impact of warning receipt as one factor which may influence the health effects of flooding. 23 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. The receipt of a flood warning of some kind made no 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 the 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).

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.

3.3 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?

Professional partners from the South West region with experience of many different types of flood-related evacuations, including evacuations during flash flooding, interviewed as part of this research said it was not possible to specify warning lead times required for evacuations. This was considered to depend on many factors specific to each incident including the population size and density, the location of the village, capacity of local crews at that time, including where they are and what other incidents may be happening at the time, and the weather and flooding conditions.

The police service is responsible for taking the decision to evacuate. If evacuation is being considered in advance of flooding, the police would take advice from the Environment Agency on the severity of flooding predicted and discuss with the local authority before reaching a decision on whether to pre-evacuate. If the threat arrives before pre-evacuation can take place, the first police units to arrive will undertake a dynamic risk assessment on the ground to decide if evacuation is necessary.

The police service representative interviewed said evacuation would generally commence within one hour although it could begin as soon as the first police units arrive on scene which would usually be within 15 minutes. Day would normally be quicker than night.

All available methods would be used to warn local people to evacuate including door knocking, loud hailers on vehicles and local radio. Vulnerable people would need to be identified and given special assistance to evacuate. The police service said that

Primary Care Trust and local authority lists could be used to identify these but would be supplemented by face to face contact and discussion with neighbours.

The capacity of local emergency services is a key factor influencing evacuation. The professional partners' focus group stressed that capacity to attend incidences was dependent on the resources available at that time, which would in turn depend on the time of the incident and other events. Some of the areas with many rapid response catchments are geographically large and depend on retained fire crews. In the event of flash flooding, it may not be possible to attend in time. As one participant put it:

> *"A lot of us on the professional side will not be there and won't have the time to get there."*

In many areas, there may also be insufficient resources available to support evacuation. While the police are responsible for taking the decision to evacuate, there is no one agency that has the responsibility to carry out an evacuation. Different scenarios for evacuation are anticipated in local emergency plans but there are no defined evacuation protocols. The fire service currently has no statutory responsibility for water rescue and does not receive funding for this. Nevertheless, many services have developed capacity for water rescue but this varies from region to region. The Pitt Review (2008) concluded that "a lack of clarity about who was responsible for carrying out and co-ordinating flood rescue placed the public and responders at unnecessary risk". The review therefore proposes fire and rescue services are given a statutory responsibility for water rescue and necessary funding.

In Devon, local authorities have been working with parish councils to encourage them to develop parish level emergency plans that include evacuation plans. The police would seek to use these and work with the local community.

Other factors that may affect evacuation include whether emergency services can access the site, which may be blocked by falling debris or rising water. The Polperro focus group reported that in both flash floods in their village the emergency services were unable to reach the village because of the water levels.

Sorensen and Mileti (1989) note that emergency response systems typically comprise law enforcement officers, fire fighters, civic employees and sometimes volunteers. Sorensen and Mileti conclude that these official response systems can issue an effective warning given three to four hours of lead time and that when the threat is urgent it is possible to disseminate a warning 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. The extent to which the lead time reduces the effectiveness of the warning depends on the severity of the threat and the options for quick protection. This is also not straightforward, as the lead time can only be ascertained after the event (Gruntfest, 1977).

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

As discussed above, professional partners who participated in the focus group discussions were unable to specify a minimum time required to respond to a flood warning. There was consensus that this depended on factors such as:

- Availability of staff.
- Other events happening at the same time.
- The location of the flooding.
- The severity of the flooding.

Professional partners stressed that high velocity flooding requires specialist teams and there are few of these available to cover wide geographical areas. It was suggested by one participant that response with a two hour lead in time would be "rough and ready" and anything less than that would be difficult. This participant suggested that any response to incidents with very short lead in times "has got to be a community led plan". The police representative interviewed indicated that generally the first crews would be able to arrive on scene within 15 minutes of an incident and would be able to undertake a dynamic risk assessment and begin evacuation immediately if necessary. However, as this report has discussed, if flooding has already reached the area, the emergency services may not be able to access flooded properties.

Participants in the Polperro focus group had experienced two flash floods. They did not receive a formal warning of the first flood and the siren alert went off during the second flood when part of the village had already flooded. Despite the very short lead time, focus group participants reported that people in Polperro took action and warned each other of the increasing risk of imminent flooding. Unofficial or informal warnings began to circulate very shortly before the floodwater and debris flowed through the village and as parts of the village were already flooding. These unofficial warnings, or self warnings, were prompted by people noticing environmental cues and communicating about these with their neighbours. People talked to neighbours, especially elderly neighbours and advised getting themselves and their families upstairs.

Participants reported there was one fatality in the first flood that was caused when an elderly man was dragged out of a window by floodwaters. There were no fatalities in the second flood. It is not possible to say for certain that going upstairs always saves lives. However, if the action of going upstairs can save lives, then it follows that even a warning with a very short lead in time may be able to reduce mortality, albeit that organised evacuation would not be possible within this timeframe. Therefore, going upstairs may be the best advice available when lead times are very short.

There is very little evidence in the research literature about warnings of less than 15 minutes. Research by Wallingford has found that risk to life or serious injury is likely to be greatest where no warning is received or where there is a warning of less than 60 minutes (Wallingford, 2003). 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. The research was based on 40 historical dam breaks. It suggests that in an area with 10,000 people, the loss of life would be 5,000 if less than 15 minutes' warning was received, 250 if between 15 and 90 minutes' warning was received and two if more than 90 minutes' warning respectively for the three categories listed above.

3.5 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?

There is little evidence of how responses made at the time of the flash flood can mitigate its effect. Where possible, we have applied the evidence for flooding in general to flash flooding, drawing attention to any likely differences. The impacts of flash flooding may be direct (such as death or the loss of property due to flood waters), or indirect (such as the value of lost business or days off work due to ill health resulting from flooding) (Petersen, 2001). Here we consider both direct and indirect impacts and look at the effects on economic, social and environmental factors.

3.5.1 Economic factors

There is some evidence about how 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, which 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. 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.

Factors associated with higher damage savings are:

- Having prior experience of flooding.
- Receiving more informative warning messages.
- Receiving help from outside of the home.
- Being connected to an Automatic Voice Messaging (AVM) system.

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. 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 were therefore not prepared for it.

Nearly three-quarters of the respondents surveyed were not pleased with the flood warning component of emergency response measures considered in Bimal's 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 floods perceived they would have been able to do more to mitigate its impacts if they had been warned.

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, Tapsell *et al*., 1999; Tapsell, 2000, Walker *et al*., 2005). 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).

However, because of the difficulties in predicting flash flooding, it is likely that any warning would have a very short lead in time. Therefore, time to take action to prevent damage to property is likely to be very limited.

3.5.2 Social factors

The participants in the Polperro focus group stressed that the worst after-effects of the flooding were its impacts on ill health and stress. As one participant put it:

> *"It was very, very stressful. We lost a lot of old people after the flood because of what had happened."*

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) quote 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, based on analysis of actions of the survivors and those who died in the 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.

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 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*. (2005). (Note: The actual death toll in the three events analysed was 38)

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.

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 example of the Boscastle flood on 16 August 2004 would suggest that an effective response can greatly mitigate the negative impacts. This was arguably the most serious flash flood that has occurred in the UK in many years. There was serious damage to property and infrastructure, around 100 people required rescuing by helicopter from rooftops and 115 cars were swept away. However, no-one was killed or seriously injured. 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 surfers who were strong and able to rescue other people.

As this report has already discussed in section 3.2 above, the research evidence suggests the receipt of 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 (Parker *et al*., 2007b).

3.5.3 Environmental factors

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. The participants in the Polperro focus group stressed that the damage caused to the sewage system by the flash floods had long term negative impacts on the village's economy because the harbour was polluted by raw sewage that was not cleaned up for some time and the village depends on tourism.

Recent flash floods such as Boscastle on 16 August 2004 and North Yorkshire on 19 June 2005, resulted in significant environmental damage, although 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 recovery and land use policies.

3.6 Key findings and recommendations

- Flash flooding has been a significant cause of injury and mortality internationally, and to a lesser extent in the UK. Because of this, it warrants specific attention in the Environment Agency's "risk to life" modelling and planning, as well as that of other agencies involved in flood management and water rescue.
- Whether flash flooding results in death and injury depends on the interaction of many factors including the characteristics of the flood, where people are at the time the flooding occurs and their response to it. Because of the interaction of these factors, every event is different so it is not possible to define a "one size fits all" response to flash floods that always constitutes appropriate and effective action. Local hazard mapping and planning in those areas identified as at risk of flash flooding is essential.
- The identification of safe havens and safe exit routes would assist evacuation. This is particularly important for those people in vulnerable structures. Debris interceptors may also prove effective but their use requires further research.
- It is not possible to definitively state which types of building can always be considered safe during flash flooding. However, some types of structure should be considered particularly vulnerable including caravans, tents, mobile homes, timber frame buildings and single storey, ground floor or basement properties. Awareness raising and enforcement of statutory requirements for evacuation plans are essential in protecting inhabitants and visitors to these vulnerable structures.
- Evacuation by foot should not be considered safe if floodwater has already reached the area. In this case, the best course of action is to get inside a two or more storey building and go upstairs.
- Driving or walking though floodwaters or other forms of risk taking behaviour are a major cause of mortality during flash flooding.

- It is not possible to be specific about the amount of time the public need to evacuate an area. Nor is it possible to be specific about the amount of time professional partners need to carry out evacuations. This depends on the interaction of many incident-specific factors.
- At the present time no single agency has statutory responsibility and resources for water rescue. Many fire and rescue services have developed capacity for water rescue but this varies from region to region.
- It is not possible to quantify a potential reduction in mortality with a minimum warning time. However, it is probable that a warning with a very short lead in time that enables people to get inside and upstairs can save lives, even if organised evacuation would not be possible within this timeframe.
- The economic and environmental impacts of flash flooding may be severe. Research has indicated that warnings have limited potential to mitigate these impacts in cases of fluvial and surface water flooding and this is likely to be even more limited in cases of flash flooding.
- The potential for formal warnings to mitigate the social impacts of flash flooding, including mortality, may be less significant than supposed. However, recent examples of flash flooding show that informal warnings can mitigate these impacts.

Recommendation 2: Messages to promote appropriate and effective response to flash flooding should include:

- *Do not walk through floodwaters.*
- *Do not drive through floodwaters.*
- *If it is safe to evacuate to high ground without walking or driving through floodwaters, do so.*
- *If it is not safe to evacuate, go upstairs.*

If you are in a basement or single storey dwelling, a mobile home, caravan or tent or are caught outside, immediately seek shelter in the nearest two or more storey building or travel to higher ground.

The wording of these messages will require testing on sample groups to ensure they are appropriate and easily comprehensible.

Recommendation 3: The Environment Agency should work with partners, including local communities, to undertake hazard mapping and local planning in those areas identified as at risk of flash flooding.

Recommendation 4: The Environment Agency should work with partners to identify and enforce statutory requirements for the owners of caravan parks, campsites, holiday homes and other vulnerable locations to make provision to evacuate their visitors in the event of danger, including flooding.

Recommendation 5: The Environment Agency should give consideration to the need for the definition and identification of safe havens and safe exit routes in or close to flash flood zones, and should consider publicising these.

Recommendation 6: The Environment Agency should undertake further research into the use and effectiveness of debris interceptors.

Recommendation 7: Fire and rescue services should be given a statutory responsibility for water rescue and necessary funding.

4 Warnings for flash flooding

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

4.1.1 Different audiences

Different audiences require different information and dissemination methods to warn them of flash floods and inform them what to do. Recipients of flash flood warnings can be divided into two principal categories. Firstly, there are the responses of individuals who live, work or who are in transit through the area when a flood occurs. This includes members of the public and other organisations with a permanent address in a flood risk area such as:

- Permanent residents.
- Shops and other businesses.
- Public services and organisations, 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 area.
- People temporarily resident in the area: tourists, travellers, caravan or boat owners.
- People who own assets in the area.
- Farmers who have livestock in the area.
- Organisations with assets in the area, such as utility companies, rail authorities, train operating companies, highway and port authorities and so on.

Secondly, there are the organisations that are responsible for managing a flood emergency such as local authorities, police authorities, fire and rescue services, health organisations, the military and other organisations. These include 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.

4.1.2 The content and style of warning information

There was consensus at the professional partners' focus group that key information required by partners in a warning was:

- Where the flood is expected.
- When the flood is expected.
- The flood velocity flow.
- The depth.
- Duration.
- Ground conditions.

Mapping of velocity and depths of predicted flooding was considered particularly important because it informs the type of plan that can be used in rescue and recovery. Professional partners stressed that factual information was needed and this should be specific to the locality.

Participants in the Polperro focus group were strongly in agreement that based on their previous experience of two flash floods in the village, there is no time to distribute or receive information in the event of a flash flood. As one member of the group put it:

> *"The flood will have been and gone."*

Members of the Hebden Bridge focus group said the key information they required was:

- Where to go for immediate help.
- Who can help.
- How to protect yourself.
- Who can help vulnerable neighbours.
- Where emergency supplies are.
- Where designated emergency centres are.

Their information requirements were more focused on advice on what to do. The Environment Agency's existing warnings were considered not to provide enough practical information. It is not enough to know that flooding was likely to occur. They need to be told what to do. One participant said that receiving a warning was not a problem. The difficulty was knowing how to respond.

> *"We're getting reasonable warning. We need more information telling people this is the way to use the system."*

In their secondary analysis of post-event survey data compiled by the British Market Research Bureau (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. However, one major criticism concerned the 'general' nature of many flood warnings.

Much of the social science research on flood warnings indicates that a warning is not a proper one unless it contains two key components:

- Factual information (what, where, when and so on).
- Behavioural advice (on the actions which warning recipients should take).

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

1. Convey a moderate sense of urgency
2. Estimate the time before impact.
3. Provide specific instructions for action.
4. Confirm the threat if possible.
5. Describe the actions of others.
6. Tell the number of warnings previously issued.
7. Mention the present environmental conditions.
8. Advise people to stay clear of the hazard zone.
9. 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 its validity and say what people should do (Shaw *et al*., 2005).

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 return after evacuation. Some evacuated householders felt they did not receive adequate information on when it was safe to return.

The focus groups and the literature review indicate that the information people require to respond effectively can be divided into general information and incident- and/or context-specific information. General information covers what to do in the event of flash flooding. It is important that this general information is consistent with the advice on what to do in response to other types of flooding. Practically, this requires the Environment Agency to ensure consistency of message across departments that specialise in different types of flooding and to liaise with other agencies engaged in flood management and response.

Incident/context-specific information is dependent on prior hazard mapping, as this report has discussed in section 3.1, the active engagement of local communities and utilisation of local knowledge. Community engagement in flood risk management and response requires resources and specialist skills. It is essential that such resources are made available at the outset of the hazard mapping and planning process, rather than community engagement being seen as the final “consultation” stage. Community engagement is discussed in more detail in section 5.3.

4.1.3 The feasibility of official warnings for flash flooding

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.

Because of the complex interaction of weather systems, ground conditions and catchment size that cause flash flooding, it is very difficult to predict. In addition, the time from flood forecasting to flood onset can be very short, making it very difficult to issue an effective warning. The Pitt Review (2008) includes several recommendations for the Met Office and the Environment Agency to improve forecasting, modelling and prediction of surface and ground water flooding.

Forecasting, modelling and prediction systems are not within the scope of this research, but it is worth noting that all three of the focus groups expressed reservations about the feasibility of providing an official warning system for flash flooding.

Participants of the Polperro focus group who had experienced two flash floods strongly emphasised that based on their experience, it was impossible to know if there was going to be a flash flood and consequently impossible to provide warnings for such floods. As one participant put it:

> *"How can they know in our circumstances that we're going to have a flash flood."*

After the first flood in 1976 a siren alarm system had been fitted but this was not considered to be effective because it went off too late:

> *"The alarm just told you that you were flooded."*

Rather than consider this to reflect the inadequacy of the system, participants instead felt it reflected the impossibility of official warning against this type of flooding. This is interesting as it contradicts some of the findings in the research literature that victims of flash flooding blame the authorities if they do not receive adequate warning (Bimal, 1999).

The professional partners' focus groups also questioned how feasible providing warning for flash floods was. As one participant put it:

> *"Surely Boscastle was unique because of a combination of factors that no-one could have foreseen. How can you warn against that sort of thing?"*

4.1.4 Potential negative impacts of a warning system for flash floods

The professional partners' focus group raised some concerns about the potential negative impacts of a warnings system for flash floods.

One participant raised concerns that such a system could cause undue alarm to the public, in breach of the Civil Contingencies Act 2004. Another pointed out that forecasting extreme weather or flooding events can actually cause death or injury, as some people want to go and look at the event, thereby putting themselves in danger.

Another participant questioned the very idea of trying to provide a warning service for flash floods because this may create an expectation that warnings would always be issued, and possible legal actions if they were not. Because of the very localised nature of flash flooding, people had to be prepared that a warning would not be issued. There was a danger that if people expected a warning, they would blame agencies if they were flooded without receiving one. As one participant put it:

> *"You could end up creating a rod for your own back. The benefits of all this (a warning system) need to be weighed - the proportion of circumstances when it would be really valuable against those in which it would be a source of criticism because you haven't issued a warning."*

4.1.5 An overview of the research findings on response

The purpose of flood warning information and flood warnings is to reinforce appropriate warning response behaviour when the flooding event is occurring or is 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.

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 floods. In relation to the public's understanding of flash flooding, 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. This 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. The research findings presented in table 3 below have already been through a selection process undertaken by the Flood Hazard Research Centre at Middlesex University. 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 neutralise 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 s/he is 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.
- Persons 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.

Table3 : 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.

4.2 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 people from making, or encourage people to make, an appropriate response to flash flooding. These factors

are complex and interact with each other. 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.
- Individual characteristics that restrict response.
- Message characteristics that restrict response.

While some of these factors may be exacerbated by the absence of an official warning system for flash floods, they are not necessarily caused by this absence. Therefore, these factors are important in the consideration of whether a warning system for flash floods could be effective and how to design such a system to maximise its effectiveness.

4.2.1 Situational factors that restrict response

Situational factors, including the characteristics of the flooding, can either inhibit or encourage levels and effectiveness of response to flash floods and warnings of flash floods.

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. The ability 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 addressed 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 professional partners interviewed for this research also stressed that the timing of the flood would impact on their capacity to respond.

The speed of the flooding will also impact on response. The Polperro focus group participants explained that in both flash flooding events in the village, emergency services had been unable to enter the village because the flooding was already too severe by the time they arrived at the village entrance. Participants said if the emergency services could not attend, this could prevent many people taking action.

Variables such as the severity of the flood threat, including the perception of flood risk severity, the rate of rise (or flood-to-peak interval) of floodwaters, 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 to be appropriate and effective. The deeper the flood and the higher the velocity, the more challenging rescue becomes.

There is also research evidence that flood severity affects the effectiveness of action. 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 the response as the flooding incident develops. The multi-agency debriefing of the Boscastle incident shows there was a delay in the incident being declared and accepted by all agencies as a 'Major Incident'. Whilst this was a relatively short delay, the declaration of a major incident has practical implications that affect the response for many agencies. A further problem hampering effective response was the lack of multi-agency training and exercising at the strategic level. Media management was another area where there were some concerns. It was recognised 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 (Government Office for the South West (GOSW), 2006).

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.

The professional partners' focus group agreed that lack of co-ordination in the early stage of an incident could hamper response. Different organisations sometimes said different things during an incident. During a major incident "gold" level command would be set up. Although this can happen very quickly, it may not do so if the seriousness of the incident is not initially clear. The focus group proposed that organisations need to agree on the messages they will issue in the event of flash flooding and systems need to be standardised across the country.

The Pitt Review (2008) concluded that during the 2007 floods, there were clear benefits where Gold Commands were activated at an early stage on a precautionary basis and proposes this approach should be more widely adopted in the future.

Communication presents a significant problem during major incidents. Participants in both the Polperro and Hebden Bridge focus groups said they used digital telephones which do not work if the electricity supply fails. While several members of the groups said this shouldn't be such a problem next time because of mobile phones, it was also pointed out that only one mobile phone network has coverage in the village of Polperro. Although the local population are aware of this and use the network that works, it does mean that many visitors to the village may not be able to use their mobile phones in the event of an emergency.

Communication between response agencies has been found to be a major challenge in several recent flooding incidents. The 'blue light' agencies' initial responders were unable to communicate with their control rooms, as Boscastle was found to be a communications blank spot. Mobile telephones also did not operate at the incident location (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).

4.2.2 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, they suggest 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.
- People do not understand the concept of residual risk from flood defences.
- People 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.

In illustration of this point, professional partners interviewed for this research said the public often has an expectation that local authorities will provide sandbags in the event of flood warning, even though they have no statutory responsibility to do so and frequently cannot because of logistical constraints. The importance placed by several of the participants in the Hebden Bridge focus group on the distribution of sandbags by the local authority and their level of dissatisfaction with this service is also an indication of the expectations members of the public have that protection will be provided by the state. One participant said it was not acceptable that if you were not in when sandbags are distributed you don't get them. As they put it:

> *"You have to chase the lorry down the road."*

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:

- Under-estimate the risk to themselves.
- 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 (De Marchi *et al.*, 2007).

By way of illustration, several of the participants in Hebden Bridge said that the only real solution to the problem of flooding in the village was a structural flood defence system. Taking this point further, one member of the group expressed the belief that there was no point in focusing on warning individuals because they won't believe the warning anyway. Instead they felt it is better to focus on the emergency services who should know what to do in the event of a flood. As they put it:

> *"I don't think there is a lot of advantage in getting individual people to think about what to do in an emergency."*

In Polperro, participants in the focus group said they felt the village was now protected by the flood defence system. They said they were "lucky" to have been flooded early because this has resulted in the construction of a flood defence scheme that cost £5 million. There was consensus that if the flooding had happened recently this scheme would be considered too expensive by the state and the village would not have been protected.

In addition to illustrating the expectation that the state is responsible for flood prevention, this also suggests that communities with experience of flooding believe that structural flood defence systems are the best solution to the risk of flash flooding.

Clearly, there is a dilemma for policy makers between allocating funding for flood defence and recovery and encouraging individuals to take more responsibility for flood risk. The dilemma is particularly difficult in the case of flash flooding where there may be little individuals can do to protect property because of the difficulty of predicting flooding and identifying areas at risk of flash flooding, the severity of flooding and the speed of onset. Nevertheless, the research evidence suggests that public messages which suggest that responsibility for flood loss can be transferred from the flood victim to the general taxpayer carry a risk of undermining flood preparations and flood warning response other than life-saving responses, although they may not always do so (Bimal, 1999; De Marchi, *et al.*, 2007; Fernández-Bilbao and Twigger-Ross *et al.*, 2008).

4.2.3 Individual characteristics that restrict response

The social circumstances of those who receive flood warnings 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 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
- Household type

Individual risk perception factors may also be important, such as experience, outlook and preparedness. We also look at the extent to which panic can act as a barrier to effective response.

Demographic factors:

Twigger-Ross (2008) concluded that certain groups are more vulnerable to the impacts of flooding because they are disconnected from systems, resources and officials, and the current system is likely to reproduce those vulnerabilities rather than mitigate them. This means that people with vulnerability characteristics are those least likely to receive a warning from current services unless there has been specific effort to target those people, for example through some locally based tailored service. In the case of flash flooding where no official warning system exists, these findings are still relevant as some vulnerable groups are less likely to receive or be able to act on an unofficial warning, including one based on personal observation of signs of danger.

The research evidence on the impact of age on warning receipt and response is contradictory. Some studies have found that those aged under 45 or over 55 were less likely to be flood aware than those aged 45 to 54 (Thrush *et al*., 2005). Others have found that younger people were more aware of flooding (Thrush *et al*., 2005). This makes it difficult to generalise about the impact age has on flood warning response. The British Market Research Bureau (BMRB) post-event surveys have shown single pensioners were the category most likely not to respond to Flood Watch.

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 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 per cent of the sample of 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.

Outside help may compensate for individual infirmity. Participants in the focus groups stressed that an important action in the event of flooding was assisting elderly or disabled neighbours. Research by Parker *et al*., (2007a) showed about 40 per cent of all householders reported that they had received outside help and 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 (Flood Hazard Research Centre (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). The University of Surrey research found that women are more likely than men to do nothing or to seek advice 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.

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).

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 these languages. There may also be 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 the UK 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 connect with 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; p253).

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.

Other factors which may contribute to special difficulties and vulnerabilities in making an appropriate and effective response include:

- Household structure, for example single parent families.
- Low incomes/resources.
- Lack of education or employment.
- Lower social status/power (for example, particularly women in some cultural groups).
- Homelessness.
- Living alone (often the elderly).
- Living in solitary geographical locations.

However, while some demographic groups are less likely to receive a warning or to respond to it, it is important to stress that not all individuals from these groups will

always be vulnerable. The situation will depend upon the individual's particular circumstances (FHRC, 2008).

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 to a flood warning. 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 if panic can be considered a barrier to effective response.

A great deal of evidence points to prior experience of flooding as one of the most powerful predictors of both the extent and the prevalence of preparatory measures and flood warning 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 was significantly correlated with the number of flood preparedness measures taken (Parker *et al*., 2007c). Similarly, in the German research the proportion of people adopting protective measures after the 2002 flood was greater than prior to the flood (Steinfuhrer and Kuhlicke, 2007). Other researchers have also noted the link between previous flood experience and flood awareness (Fielding *et al*., 2007; Benight *et al*., 2007).

The participants in the Polperro focus group emphasised that their response in the second flood was informed by the first flood. One participant spoke of the difficulty of getting newcomers who had not experienced the first flood to perceive the imminent danger and need for action as the second flood began.

Both public focus groups stressed the increased vulnerability to the impacts of flooding of people who have recently moved into the local area because they do not understand the risk and potential impacts. Participants said as many as 70 per cent of local properties in Polperro have changed hands in recent years and are now owned by people originally from outside the region. The conversion of basements into kitchens by many of these newcomers was suggested as evidence of their lack of awareness of the potential impacts of flooding.

At both public focus groups, participants said concerns about property values acted as a disincentive for people to discuss flood risk when selling a property. Because vendors do not want to “scare off” buyers they do not communicate information about flood risk. The Pitt Review (2008) picks up this point and recommends that flood risk be made part of the mandatory search requirements for Home Information Packs.

Another potential barrier to action suggested by the focus groups was that people who have newly arrived in the area are too optimistic. They do not believe the flood will reach their level because they have never seen this. This was considered to be a particular problem in Polperro where more and more properties are owned by people from outside the area.

The professional partners’ focus group suggested the transience of the population presented a problem for flood response. Tourists and other visitors do not know what a warning means or what to do and so are more at risk than the local population. One participant suggested a national alert system that is the same throughout the country, such as that issued for the pollen count, as this would help develop universal understanding of the warning.

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.

Furthermore, 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 they had seen similar conditions before which had not deteriorated. In Germany during the 2002 floods people did not expect the flood to be worse than previous flooding incidents. 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.

Participants in the Hebden Bridge focus group illustrated this as they believed the type of flooding they were prone to in the future was the same as they had suffered in the past: fluvial or low depth groundwater. When asked if participants ever fear for their safety, they agreed they did not. As one participant put it:

> *"Flooding here is not a big deal compared to that (indicating picture of Boscastle)."*

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). However, research indicates that this is not generally the case (Quarantelli, 1984; Torterotot, 1993).

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 proportion of respondents agreeing with the statement 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).

4.2.4 Message characteristics that restrict response

The importance of warning content, style and dissemination has already been discussed. Here we examine the evidence that warnings can actually restrict or create barriers for effective response.

Research has indicated that the public believe little information accompanies flood warnings advising how they should act (Tapsell *et al*., 1999, 2002; Thrush *et al*., 2005; Fielding *et al*., 2007). Participants in the Hebden Bridge focus group also made this point.

In addition, research has shown icons and text used on current codes are not popular with the public. Many people feel that a sense of urgency is lacking and that greater clarity is needed in the existing flood warning system, 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). Participants in the Polperro focus group also made this point. Most did not understand the system of flood watch, flood warning and severe flood warning and did not feel this was logical.

The warning may not convey the necessary sense of urgency, in which case no action will be taken. Handmer and Ord (1986) identify that the following factors affect response to flood warnings:

- Warning source and mode of communication.
- Credibility of the warning source.
- Urgency of the announcement.
- Whether or not the message is delivered personally.
- Number of warning sources.

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 1 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 (United Nations, 2001). The participants in the professional partners' focus group observed this to be a problem. There was general consensus that the existing Environment Agency warning system worked well but that what happened once the warning had been received was less certain. This depended on the skill, experience and judgment of the person receiving the warning. As one participant put it:

> *"The weak link is what that supervisor does with the information".*

4.3 Which groups are particularly vulnerable during a flash flood?

This research question was not included in the original brief for the project but was considered by the research team to provide information necessary to meet the specific objectives of the project.

Some groups may be more vulnerable to the impacts of flooding, including flash flooding, than others. Increased vulnerability can have many different causes which can be grouped in three ways:

- Certain groups are more likely than others to be flooded.
- Certain groups are less likely to be aware of flood warnings.
- Certain groups are less able to respond to flood warnings (Thrush *et al.*, 2005).

The demographic and risk awareness factors that contribute to whether people are likely to be aware of flood warnings and to take action are discussed in section 4.2 above. In this section we look at how these factors interact with the location of people at the time of flooding to render some groups more vulnerable to death or injury as a result of flash flooding.

The Environment Agency is currently in the process of developing criteria to identify areas that are at particular risk of flash flooding. Some researchers have suggested that certain groups, such as those with lower incomes, may be more likely to live in flood prone areas and less likely to take measures in advance to protect their properties against the impacts of flooding. However, the evidence is far from clear. Furthermore, as flash flooding can affect areas that are not traditionally seen as flood prone (in that they may not be situated on floodplains), this is not likely to be the case. In addition, traditional flood protection methods are not generally effective against flooding with the depths and velocities associated with flash flooding.

However, certain groups may be more likely to find themselves in particularly exposed areas that present danger to life during flash flooding. Campers, caravaners, and hikers are more at risk of death or injury in the event of flash flooding than those with access to a second storey in a brick or stone structure.

There are several examples from the United States and Continental Europe of flash flooding in campsites and caravan parks resulting in significant loss of life. 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. Gruntfest found just 35 per cent of those who died during the Big Thompson Canyon Flood of 1976 were permanent residents, the rest being tourists, visitors from elsewhere in Colorado and seasonal residents (Gruntfest, 1977). 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).

A survey of 71 flood prone caravan parks in coastal New South Wales, Australia was recently undertaken (Yeo, 2003). This found an increasing number of caravan park residents are long term residents residing in caravans that cannot be moved. Many parks are ill-equipped to deal with flooding due to the following factors:

- A high turnover of park managers who do not have direct experience of floods.
- Prevailing attitudes of denial.
- Most parks have no means of raising community flood awareness.
- The process of flood response planning is patchy and of poor quality.

The authors recommend a more rigorous implementation of tighter regulations that better guard the health and safety of park residents, and equipping park managers to self-manage risk (Yeo, 2003).

In addition to being in more exposed locations, visitors to an area are less likely to receive a warning and less likely to know how to respond to it. This does not just apply to campers and walkers. Even those visitors staying in two storey brick structures are more at risk as they are likely to be unfamiliar with the local conditions and not notice important signs of danger, such as a small stream reaching a dangerous size. They may therefore not know how to avoid risky behaviour and when it is important to evacuate the area or go inside and get upstairs.

For this reason, it seems that special measures need to be put in place for tourists and other visitors to the area. Campsites and caravan parks need to have evacuation plans in place so visitors can quickly move to a place of safety in the event of the threat of flash flooding. However, provision also needs to be made to inform tourists in areas at risk of flash flood of the danger signs and how to keep safe.

This is a sensitive topic. Residents of areas that rely on tourism and those who work in tourism may be reluctant to take measures which they perceive as likely to scare visitors off. In both Hebden Bridge and Polperro tourism is crucial to the local economy. There was consensus amongst the participants of the focus groups in these areas that it was not necessary to have special provisions for warning visitors to the area about the flood risk. There was particularly strong opposition to the idea of external signs warning people what to do in the event of flash flooding, such as those used in flash flood prone areas in the United States. This type of warning was considered to be “bad for business”.

In Polperro participants agreed that holiday homes may benefit from special notices, informing holiday makers what to do in the event of a warning, such as fire notices. However, in Hebden Bridge even this measure was considered unnecessary by the majority of participants.

In Polperro, participants said they felt the village was now protected by the flood defence system. In Hebden Bridge, participants felt that the type of flooding experienced was not sufficient to warrant measures to alert visitors to the risk of flash flooding. In addition, warnings for tourists were considered to scare people unnecessarily. By way of illustration of the hostility that local people feel towards external signs about flooding, the Polperro focus group described how a sign to illustrate the maximum flood level was removed less than 24 hours after it was erected.

In view of this hostility, it will be important to work closely with local communities to ensure they better understand the level of risk and potential impacts of flash flooding and the importance of special measures to target tourists. The Environment Agency South West Region has recently launched an initiative to work with campsite and caravan park owners to minimise the risk of flooding. An evaluation of that initiative is likely to provide useful lessons for this area of work.

Elderly people are more likely to live in mobile or single storey structures. As discussed in section 4.2 above, there is some evidence that elderly people may also be less likely to receive a warning or to take action if they do receive a warning (Gruntfest 1987).

Although some studies have found that women are less likely than men to perceive flash floods as life threatening (Knocke and Kolivras, 2007), 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). The increased likelihood of men to participate in risk taking behaviour is an important issue when formulating messages to reduce risk-taking behaviour, and in disseminating these messages effectively.

4.4 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?

4.4.1 How people interpret warnings

In considering whether people will take the initiative to warn themselves or rely on a warning service, it is important to understand how people interpret warnings. The assumed model is that the warning message is a stimulus and the response the reaction to it. However, there is a wealth of research that indicates 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). Therefore, the warning process must be seen as a social system.

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.

Warning confirmation is as important as message perception. 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. Members of the household become involved in decisions about how to respond, which may either reinforce or reduce belief in the warning (Drabek, 1986).

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.

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

- The availability heuristic, whereby conclusions are drawn about the probability of an event in the light of how easily it can be retrieved from memory.
- The representativeness heuristic, which describes how people commonly ignore base rates and misunderstand chance phenomena when estimating probabilities. For example, 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 heuristics help explain 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 whereby 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, and also leads to 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).

Language used by flood risk managers seems to exacerbate this. The participants in the Polperro focus group believed that after the 1976 flood there would not be another flood for 100 years because they were told it was a 'one in a 100 year' flood. When the 1993 flood occurred, they concluded those responsible for flood management had made a mistake.

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). Participants in the Hebden Bridge focus group believed that they were not at risk of the type of flash flooding seen in Boscastle because that was not the sort of flooding they had experienced before. As one participant put it:

> *"We won't get a situation like that here because this is a V shaped valley. It drains away very quickly and just leaves the mud."*

Understanding how people receive and interpret warnings helps explain why they often do not respond to warnings as those issuing the warning expect and want. It is also essential to developing warning messages that promote effective response and must be taken into account when considering the development of a warning system for flash flooding.

4.4.2 Unofficial warnings for flash flooding

In the case of rapid response catchments, unofficial or informal warnings, including ones derived from personal observation of environmental cues, are of considerable significance.

Participants in both public focus groups stressed that they did pay close attention to the weather and potential signs of flooding. All the participants listened out for severe weather warnings and flood warnings. In Hebden Bridge the focus group participants said they regularly check the river height during periods of heavy rain and look out for "markers" that could indicate flooding, such as the water covering a particular point in the wall and how quickly it is rising.

Participants in the Polperro focus group reported being very "weather aware." They reported regularly checking the river height and speed at which it was rising during heavy rain, even now the flood defence system is in place. They also said they always know the wind direction and tides, and how these could interact and exacerbate flooding. They attributed their awareness to having always lived by the sea. Because of this and their previous experience of flooding they were very alert to signs of potential flooding.

The professional partners' focus group also stressed the need for local communities to take the lead on warning themselves and outside agencies. One participant explained that a key lesson from Boscastle was that a member of the public had taken responsibility for getting help. Consequently he asked:

> *"Do we actually need to identify key members of the community who will be in at risk locations to inform the emergency services when something happens? Not a forecast, but a nowcast, a spotter. "*

Several participants said voluntary sector agencies had a key role to play in responding to flash flooding and gave the example of the Neighbourhood Watch as a scheme that could be replicated for such flooding. One participant put forward the flood warden scheme in Shaldon as an example. In Shaldon, the local community has been involved in developing a flood risk management scheme. The scheme relies on volunteers to disseminate warnings and undertake strategic sandbagging.

Concerns raised by professional partners about relying on unofficial warnings included the need to provide volunteers with training to ensure they do not put themselves at risk, for example by trying to walk through flood waters, and the need to overcome public apathy.

4.4.3 The advantages of unofficial warnings

Clearly, the ability of unofficial warnings to generate a response needs to be considered in deciding if they are effective. However, empirical evidence is patchy. With few exceptions, most available research does not clearly distinguish responses that take place at different warning stages or levels. Evidence on the response 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 - 124cases
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.

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, and leads to no loss of credibility for official agencies in the event of a false warning.

4.4.4 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 alone (for example see Lauriola *et al*., 2005; Wang, 2006; Benight *et al*., 2007). This report has already discussed in section 4.2 the factors which influence individual risk perception and can, therefore, compromise people's ability to recognise and act on environment cues.

Emergency Management Australia (1999b) 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 create needless anxiety.

4.5 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?

The focus group participants in Hebden Bridge expressed frustration with their interactions with government bodies on flood risk and management. These included dissatisfaction with the way sandbags are made available and distributed; concerns that the local authority no longer maintains drains; and, above all, a belief that issues they raise are not listened to or taken seriously. There was consensus that people who telephone into the Environment Agency or any other agencies concerned with flood response need to be taken seriously and see action taken as a result of their call. If not, the agency concerned will not be trusted.

Additionally, one participant said they did not have confidence in the services that accompanied flooding. However, the warning system itself was considered to work well. As they put it:

> *"I don't have a problem with the warning system. What I was criticising was the ability of the emergency services to respond to it in the right, appropriate way."*

Another participant said they could not trust the Environment Agency because it was difficult to trust a national agency to act effectively in a local situation. None of the participants were aware that the Environment Agency has regional and local offices.

The Polperro focus group participants agreed that "there was no alternative to the Environment Agency," and that part of the problem in trust was caused by what the

group perceived to be central government failing to adequately support the Environment Agency:

> *"It all comes down to money. The Government must back the Environment Agency. You've got to have someone take responsibility from the top."*

In Polperro, the group agreed with one of the participants who said the Government had got it wrong when they said the flood in 1976 was a one-in-100-year flood because they believed this meant there would not be another flood for 100 years. Although the participants did not say this had affected their trust, it was raised several times as an example of how government agencies make mistakes.

Both the Hebden Bridge and Polperro focus groups believed that the Met Office now issue severe weather warnings at a lower threshold of risk than in previous years. In Polperro this was attributed to the hurricane in the South East in 1987. Because of this participants said many people do not take weather warnings seriously.

One participant in the professional partners' focus group believed that the existing Environment Agency severe flood warning predicted damage from flooding that was often far more severe than the damage actually sustained, causing many people to not take these warnings seriously. They believed that this would impact on the credibility of warnings for flash flooding where potential impacts were indeed very severe.

The research literature indicates that 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.

There is evidence that this has affected public trust of agencies involved in flood risk management. For example, University of Surrey surveys revealed wide variations in the trust that respondents had in the flood warning agency (the Environment Agency). They also showed 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 (Fielding *et al*., 2006).

The Polperro focus group participants agreed that the most trusted sources of information were their neighbours and their own instincts.

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 so on.
- Trust can be issue-specific.

4.6 What should the source of a 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?

4.6.1 The source of the warning

In terms of previous experience of warnings, most of the participants in the Hebden Bridge focus group said they were aware of the Environment Agency's Flood Line Warning Direct telephone service. However, only two said they had been registered and they were unsure if they were still registered, as they did not know how often it is necessary to re-register. One of these said the service had worked well in the past. However, it was considered insufficient by most participants because it is only available to those who live in flood risk areas. Most participants were aware of the Environment Agency's Flood Line telephone information service. One said this works very well and provides specific local information. If they expected heavy rain, they always phoned. Other participants had not used this service. .

In Polperro, one of the eight participants was registered with the Environment Agency's Flood Line Warning Direct service. The other participants were not aware of this service. All of the participants were aware of the Flood Line information service and several reported having used the service.

Regarding which agency is best placed to issue a warning, in Polperro the focus group felt that "there was no alternative to the Environment Agency" when it came to issuing flood warnings. However, the group also said that when it came to flash floods, no agency was best placed to issue a warning because they judged that it is "impossible to know if there is going to be a flash flood".

Participants in the professional partners' focus group agreed that the Met Office or the Environment Agency should issue warnings.

Research evidence is inconclusive regarding the best source of information. Several 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).

4.6.2 Warning systems and warning dissemination methods

As this report has already discussed, warning is a social process. Confirmation plays a key role in the warning process. For this reason several researchers have noted that the more times a warning is heard and the more sources from which it is received, the more likely it is to be believed (Quarantelli, 1982). This was confirmed by Gruntfest's (1977) analysis of the survivors and those who died in the flash flood in Big Thompson Flood. This is an important point to bear in mind when considering warning systems and warning dissemination.

There was consensus amongst participants in the professional partners' focus group that warnings should be disseminated to the public by the coast guard if appropriate, or the police or fire service, as these emergency services were seen by participants as the "most listened to." However, participants also said that all category one responders should be involved in warning dissemination.

Suggested warning systems and dissemination methods included sirens, electronic notification systems, local radio and local television. Several professional partner participants agreed that with just two hours to issue a warning they would use any means available to spread the word. One said the type of system used would depend on the location.

"It's very different if you're warning 10 properties or 1,000 properties."

Professional partners interviewed as part of this research said all available methods would be used to disseminate a warning with a short lead in time where evacuation was being advised. This would include door knocking, use of loudspeakers on vehicles and the identification of vulnerable people. However, participants agreed that door knocking to disseminate a warning in the event of an imminent flash flood was not feasible as staff would be put at risk.

The professional partners and public focus groups raised the limitation of telephones in disseminating warning messages, as most people now have digital telephones which do not work if the power fails. One Hebden Bridge participant said they were unable to telephone the Environment Agency during previous flooding for this reason.

Several participants in the Hebden Bridge focus group said that they wanted a single local telephone number that they could use to get information about flood risk and what to do. They said the current system was too uncoordinated, with the Environment Agency having responsibility for some issues, the local authority for others and agencies such the Highways Agency for still more. However, there was not agreement in the group on this.

Based on their previous experience, participants in the Polperro focus group believed that there would be no time to disseminate a warning. However, if it was a different type of flooding and there was time, a combination of different types of warning was felt to be most appropriate. These should include loud speakers, telephone, television and radio messages and sirens. A person driving round with a loud hailer was considered especially effective. This would be the same for all times of the day or night.

There was no agreement as to the effectiveness of radio and television in warning dissemination in the Hebden Bridge focus group. Some participants felt it could be useful, but one said they never watched or listened to local television or radio. Participants in the professional partners' focus group agreed BBC local radio was an effective way of getting information out. Another participant suggested using roadside matrices to display information on flooding risk, like they do in other countries for avalanche risk. Another participant disagreed because people tend to ignore messages on matrices as they are often left up too long so are no longer valid.

During the flooding in Carlisle in January 2005, BBC Radio Cumbria and CFM (another local radio station) 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 during

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).

Research shows 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).

Both public focus groups discussed siren warning systems. In Polperro a system had been in operation before the construction of a flood defence system. In Hebden Bridge a siren system was still in place. Both focus groups agreed that a siren system would be the most useful single mechanism for warning as it was considered to be universally understood, with the proviso that regular practices and maintenance takes place. It is particularly interesting that participants in Polperro focus group believed a siren to be effective as the siren system in operation after the first flash flood was considered to have been activated too late to give an effective warning for the second flood.

In Hebden Bridge there was disagreement as to exactly where the siren could be heard. Participants agreed that such systems would need to be overhauled to ensure they were audible in all parts of the village. However, in general the existing siren system was considered by the majority of participants to work well and to be as effective during night as well as day. Comments included: "the siren's fantastic" and "the siren definitely works." However, those with poor hearing would need to be warned by different means.

Results of a recent consultation on the North Norfolk flood siren system carried out by the district council provide additional evidence of the popularity of such systems. Presented with a proposal to close the siren system as it was not considered fit for purpose, the five parish and town councils concerned said they wanted to retain the system. Consultation meetings and questionnaires with the public showed that the overwhelming majority of people who responded were in favour of some sort siren system (North Norfolk District Council, 2008).

However, the same consultation exercise revealed that "general understanding of flood sirens amongst the public is poor." This is in contrast to the belief that sirens are universally understood. Many people did not understand that the current use of the system was solely for evacuation, instead believing it was part of a flood warning system.

As this report has already discussed, drivers are particularly at risk of death in flash floods. They are a uniquely difficult group to warn as they will not be in a position to pick up on warnings disseminated door to door, on television or by telephone. Furthermore, it is illegal to drive while answering a call or responding to a text message on a mobile telephone, so this dissemination method should not be considered effective for drivers. They may also be in an unfamiliar area and unable to pick up on environmental cues of danger. They are likely to be separated 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.

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 (now replaced by Floodline Warnings Direct) 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 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).

With the use of newer technologies, including the internet and mobile phones, Tapsell *et al*. (2004) highlight that a concern in placing reliance upon these technologies is their penetration and acceptability to people at risk. Hayden *et al*. (2007) found that in the US, 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. They conclude it is consequently 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 mobile phones will replace televisions nor be in widespread in use 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.

4.6.3 Dissemination warnings to agencies

Participants in the professional partners focus group were also asked about how their agencies preferred to receive a warning that flash flooding may be about to occur. In general the group said that during working hours, e-mails and faxes were best and out of hours e-mails and SMS. However, this also depended on organisational systems, which varied. Most category one organisations have 24-hour control rooms and levels of escalation which could receive warnings at all times.

There was general consensus that the existing Environment Agency warning system worked well. However, the weak link was how the warning was acted on by professionals. This depended on the skill, experience and judgement of individual supervisors who received the warnings. There was agreement that organisational relationships were key in understanding how organisations act on warnings.

4.7 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?

4.7.1 Public tolerance of false alarms

The participants in the focus group in Polperro agreed that any warning should be as far in advance of the event as possible. It should include an estimation of certainty to avoid the "cry wolf" effect, for example say there is a "strong indication," and be re-issued regularly as information on certainty changes. One participant said they would prefer to be warned even if nothing happened:

> *"Personally I would prefer any kind of warning."*

There was agreement amongst the Hebden Bridge focus group participants that accurate warnings with long lead in times are very difficult to provide. When asked further if it would be helpful to have a percentage chance of flooding given with an earlier warning, the group agreed that not everybody would understand this. There was also agreement that people would not take action until the chance reached at least 50 per cent.

One participant said they did not think that advance warnings on the possibility of flooding are that helpful. Instead they felt it was best to wait until the river reaches a certain level, such as that required to trigger the siren. This was because that when told there is a possibility of flooding, they have to take action to protect their business and this will be a nuisance if they are warned unnecessarily. As they put it:

> *"I don't want to waste time waiting for the river to rise because I've been told there's a possibility of flooding."*

One participant in the professional partners' focus group suggested the public should be educated on flood risk issues so they can decide what level of warning they want to receive. Another participant suggested it was important to provide a percentage chance of the event occurring to help the public understand how likely it was to happen so they could make their own decision as to what to do.

However, as the prediction of flash floods is so challenging, the expressed aspiration of the members of the public that a degree of certainty be attached to a warning is unlikely to be viable.

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

4.7.2 Professional partners' tolerance of false alarms

Participants in the professional partners' focus group agreed that as much warning time as possible was needed. However, there was also consensus that the information must be specific to the locality. The overall view of the group was that the level of certainty at which action would be taken depended on the magnitude of the threatened event. If this was significant, organisations would stand up with less certainty. One participant said their organisation would take action when there was a 50 to 60 per cent certainty.

One participant said a problem for their organisation at the moment was that the warnings from the Met Office and Environment Agency did not include information on certainty. If warnings could include probability, this would assist response.

There was general consensus that there was no one answer to the question. Worst case scenarios and probability were important factors. Participants said they would consider the information and make a decision. As one participant put it:

"You tell us what you can provide and we'll then have to weigh it up."

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).

Associated Programme on Flood Management (APFM) guidance (2007b) states 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.

4.7.3 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. A key factor in the effectiveness of any flash flood warning system will be improving understanding of uncertainty.

Clearly those involved in communicating meteorological information, making decisions about whether to issue flood warnings and initiating response plans have different organisation cultures, different responsibilities, different associated capabilities, and different timelines for action. These are not necessarily coincident. 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.

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).

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.

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.

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 whom in the discussion has the competency to judge the uncertainty. Concern was expressed that responsibility for interpretation, that is, handling the uncertainties, all the tools should remain where the expertise lies, and should not overburden others' decision-making responsibilities

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

The general consensus amongst participants in the Polperro focus group was that false alarms would affect future response but only if they happened on a regular basis, rather than just once or twice.

In Hebden Bridge several members of the group said they had had experience of false alarms but that this did not happen very often. One member of the group said that "people in this area would take a warning seriously because there have been so many previous floods and lots of people have already been affected." There was broad support for this view.

One participant in the professional partners' focus group suggested that the local population would be more tolerant of false alarms than the visiting population who are only there in the summer so are less likely to have experienced flooding before.

Evidence of the impact of false alarms on public response to future warnings in the research literature is sparse.

Dow and Cutter (1998) examined evidence from hurricane warnings and evacuation in the 1996 hurricane season in South Carolina, USA. The influence of premature evacuations for the earlier 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.

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 site 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.

One issue worthy of further consideration is the extent to which the phrase "false alarms" is unhelpful. Moving to a conceptualisation of a warning of an event that did not unfold with the predicted level of severity as a "near miss" instead of a "false alarm" may be helpful. While the public will obviously not welcome such "near misses," the level of public, and to some extent political, expectation that warnings will only be issued when the events they relate to are certain, is clearly not realistic.

4.9 Key findings and recommendations

- The focus groups and the literature review indicate that the information people require to respond effectively can be divided into general information and incident/context-specific information. General information must be consistent across all types of flooding and local information must be built on community engagement and knowledge.
- The Environment Agency's existing warnings were considered by focus group participants to provide insufficient practical information on what to do in response to flooding. Information is needed on how to protect oneself, how to get help and who can help. Those with responsibility for flood response said they need to know expected velocity and depths because it informs the type of plan that can be used in rescue and recovery.
- The timing, speed, velocity and depth of flooding affect how individuals are able to respond to flash flooding and the emergency services' ability to attend.
- In the early stage response can be hampered by problems with communication and co-ordination between agencies responding to flash flooding. Gold Commands should be activated at an early stage on a precautionary basis.
- The views of participants in the public focus groups provide an indication of the extent to which the public hold the Government responsible for flood prevention and believe structural measures are the best solution to flash flooding.
- Some demographic groups are less likely to receive a warning, including an unofficial warning, or to respond to it. However, not all individuals from these groups will always be vulnerable.

- There is evidence that indicates experience of flooding is one of the most powerful predictors of response to flood warning. However, the relationship between previous experience and response is not straightforward.
- Tourists and other visitors are more at risk of death and injury from flash flooding. Campers and caravaners are particularly vulnerable. Communicating this risk is potentially sensitive because of the desire of local communities to protect tourism.
- The warning process needs to be seen as a complex social process, rather than the issuance and receipt of a warning message. Understanding how people interpret warnings helps explain why they often do not respond to warnings as those issuing warning expect and want.
- A warning system for flash floods could have potential negative impacts including causing undue alarm to the public, promoting "flood tourism" and creating an expectation amongst the public that warnings will always be issued in cases of flash flooding.
- Unofficial warnings, including self warning as a result of personal observations of danger signs, is an important source of warning for flash floods.
- The Environment Agency and Met Office are seen as the best sources of a warning for flash flooding. Many and varied dissemination methods are preferable but it is important the warning message is consistent. Telephone warning systems are unreliable if the power fails because many people have to rely on digital telephones.
- Local flood warning sirens are popular with the public where they exist but understanding of what they mean is poor.
- New technologies such as those relying on mobile telephones and the internet will not reach all of the population at risk and, therefore, should not be relied upon exclusively.
- There was general consensus amongst professional partners that the existing Environment Agency warning system worked well, although this is not aimed at flash flooding. However, the weak link was how the warning was acted on.
- Evidence about the public's tolerance of false alarms is sparse and inconclusive.
- Professional partners would prefer information on probability with warnings and would in general prefer to be put on stand by earlier, even if this means they are stood down later.
- Participants in the public focus groups indicated that false alarms would affect future response but only if they happened on a regular basis, rather than just once or twice. Evidence from the United States suggests that people may be less likely to follow official instructions, instead preferring to make independent decisions, after false alarms.

Recommendation 8: When formulating and disseminating awareness-raising messages, the Environment Agency need to highlight the dangers of risk-taking behaviour. These messages need to be particularly targeted at male recipients. However, the wording of these messages will require testing on sample groups to test their effectiveness, to ensure they are appropriate and easily comprehensible.

Recommendation 9: The Environment Agency should ensure that the design of any future warning system for flash floods takes account of the need for warnings to provide practical information on what to do, as well as information on when and where the flooding is predicted to occur. The wording of these messages will require testing on sample groups to ensure they are appropriate and easily comprehensible.

Recommendation 10: The Environment Agency should make available specialist resources to encourage community engagement in hazard mapping, local planning and flood response and awareness-raising.

Recommendation 11: The Environment Agency should ensure that the design of any future warning system for flash floods takes account of the need for warnings to be targeted to vulnerable groups.

Recommendation 12: The Environment Agency should undertake an evaluation of the initiative to work with campsite and caravan park owners to minimise the risk of flooding in the South West region after an initial implementation period.

Recommendation 13: The Environment Agency should work with mobile home park owners to develop initiatives to facilitate response to flash floods.

Recommendation 14: The Environment Agency should ensure that the design of any future warning system for flash floods takes account of how people receive and interpret warnings, recognising warning as a social process. It should also take account of the perception that the Environment Agency and Met Office are seen as the best sources of a warning for flash flooding, but that many and varied dissemination methods are preferable as long as the warning message is consistent. A nationally uniform system will assist public recognition of warnings.

Recommendation 15: The Environment Agency should develop new ways of describing the risk of hazards that are less open to misinterpretation that the term 'a one in 100 year flood.'

Recommendation 16: Warning schemes that rely on public volunteers need to incorporate training to ensure members of the public do not put themselves at risk when disseminating warnings.

Recommendation 17: Agencies with responsibility for disseminating warning messages need to bear in mind that many people will not be able to use landline telephones if the power fails due to severe weather. In this case, they will also be unable to access radio and television.

Recommendation 18: Agencies with responsibility for operating flood siren systems must inform local communities what the siren means on a regular basis. Ensuring the meaning of the system is clear must be considered as part to the design of any new flood siren systems.

Recommendation 19: The Environment Agency should ensure that the development of any future warning system for flash floods includes close work with category one and category two responders to develop protocols for how warnings for flash floods should be dealt with.

Recommendation 20: The Environment Agency should ensure that the development of any future warning system for flash floods includes close work with category one and category two responders to improve shared understanding of uncertainty and probability.

5 Raising awareness of flash flooding

5.1 What are the most effective messages and methods for raising awareness of flash floods? 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?

5.1.1 The link between awareness-raising and effective action

The research into effective flood response stresses the importance of public awareness-raising. As Gruntfest and Handmer (2001b) have stressed, warnings do not save lives and property, it is the responses that people make to those warnings that save lives and property. In order to make effective responses people need to be aware of how to recognise a warning, whether it is an official or an unofficial warning, they need to know how to respond and they need to be prepared to respond. This is especially important for flash floods as they can occur in seemingly unexpected places and with very short lead in times.

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. The high levels of support for the flood siren system in North Norfolk, but the poor understanding of what the siren signal actually meant, is a good illustration of this point (North Norfolk District Council, 2008).

It would be a mistake to assume the connection between awareness and effective action is straightforward (Gruntfest 1987). As the Pitt Review (2008) concluded based on its examination of the 2007 floods, measures to improve risk awareness must be accompanied by information on what constitutes effective action. If people are informed about the risk but do not understand what to do to protect themselves, there is a danger they will experience increasing anxiety and a sense of powerlessness.

This danger of increasing public anxiety through raised awareness could be particularly pertinent in the case of high impact flooding, such as flash flooding, where there is a risk to life and possible actions to protect property from flooding are extremely limited. This needs to be considered when developing awareness-raising messages for flash floods. One way to do this would be to focus on the effectiveness of actions to protect life, such as going upstairs or evacuating and avoiding risky behaviour.

As this report has already discussed, there is evidence indicating that experience of flooding leads to an increase in the proportion of those at risk of flooding who adopt appropriate flood response, although the evidence is not conclusive. Therefore,

many flood awareness-raising initiatives seek to replace flood experience as the driver for effective action. However, there are different, and to some extent conflicting, perspectives on the likely effectiveness of public education on floods, flood warnings and flood warning response awareness. On the one hand there is a conservative view, backed up by some research, that public flood education and awareness-raising is likely to have limited effectiveness in most, though perhaps not all, circumstances. 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. Certainly, the view of the participants in the Polperro focus group was that experience of flash flooding was the factor that determined their response behaviour. The group agreed that outsiders and newcomers were likely to ignore information and not take the required action because they would not understand how the flooding could affect them.

On the other hand, an alternative perspective, also backed up by some research, is that public flood education and awareness-raising can achieve a great deal, and that education can successfully replace flood experience as a driver for appropriate and effective flood warning response. This view perhaps underlies much of what is contained in the Pitt Review about flood warnings and awareness-raising, and is consistent with the argument that the full panoply of public flood education methodologies should be employed to help people understand flooding risks and to help them respond effectively to floods. Unfortunately, this approach also carries with it an implicit and insidious message that the authorities are not only there to help but are 'responsible' for flood protection, which is sometimes a powerful facilitator for people stepping back from bearing their own responsibility for protecting themselves against flooding.

It is conceivable that different perspectives may be appropriate for different social settings which complicates the picture, and which certainly may complicate policy choice in this field. On the whole, the recent series of post-flood reports may have too easily accepted the premise that flood warning response can be radically improved by the public education approach, when in practice what can be achieved is, in many circumstances, likely to be rather more limited.

5.1.2 Public education messages

Given the limitations of public education and the danger that people believe the authorities are responsible for their protection, an important part of a public education strategy should focus upon making those at risk aware that it is primarily their responsibility to monitor weather forecasts and rivers, and their responsibility to protect themselves from flooding. This can be supported by making information on appropriate flood warning responses available to those at risk.

In raising awareness of flash flooding, it is also important to stress that such flooding presents a serious threat to life. As this report has already discussed in section 3.1, much of the risk-taking behaviour that members of the public engage in is based on an incorrect assumption that flooding is not dangerous. Messages using mortality rates could be used as the basis of public awareness raising messages, for example *x* number of drivers were killed or injured over *y* time period attempting to drive through flood waters.

Messages also need to target those groups identified as being particularly vulnerable to the impacts of flash flooding. These groups are discussed in more detail in section 4.3 of this report. Messages targeted at these groups should explain the nature of

these specific vulnerabilities and recommend action to reduce them. For example, residents of mobile homes should be advised of the need to find out what evacuation route they should take in the event of flooding.

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.

Participants in the Hebden Bridge and Polperro focus groups said messages should focus on what actions people should take in the event of a flash flood and agreed that people need to be told what to do in the event of a flash flood or another emergency before it happens and that this needs to be re-iterated regularly to stop people forgetting.

The very short period of time between the warning and the onset of a flash flood means that people may have to take action themselves without the support of the emergency services. Professional partners interviewed as part of this research stressed that emergency services may not be able to arrive at or access areas where flash flooding is expected within the short lead in time. Therefore, action needs to be community led.

This means messages need to describe actions that can be taken independently, rather than waiting for the emergency services to give specific instructions. These messages could include:

- When to evacuate and where to evacuate to.
- When it is unsafe to evacuate and people should move upstairs.
- Risky behaviours that must be avoided.

One participant in the Hebden Bridge focus group said such messages could be framed as a similar type of message to “in case of fire.”

Clearly, messages need to be consistent. One of the findings of the Pitt Review was that during the 2007 floods, there were numerous sources of information and advice given and much of it was inconsistent. The Review recommends the Government develop a single definitive set of flood prevention and mitigation advice. The professional partners’ focus group echoed this, saying that in the early hours of an incident, professional partners can give out conflicting information.

The professional partners’ focus group said that members of the public needed to be advised to have an individual flood plan ready to put into action before flooding occurred and an emergency “grab” pack prepared. They said that people needed to be told to remember medications in event of evacuation, as this had been an issue in previous evacuations. The Pitt Review (2008) also recommends that the public should make up a flood kit as part of their preparedness.

However, when this issue was discussed at the Hebden Bridge focus group, the group agreed that flooding did not happen often enough to justify households developing flood plans. If individuals who have had several experiences of flooding do not feel it necessary to take measures such as preparing a flood plan, this suggests it will be extremely difficult to motivate communities who have not experienced flooding to do so.

5.1.3 Methods of raising awareness

There are different target groups for awareness-raising and they will respond to different types of public education. Target groups include:

- Members of the public.
- Business and organisations.
- Agencies with responsibilities for flood risk management and response, such as local authorities and the emergency services.

Members of the public can be further divided into groups with different needs and are likely to respond to different methods. These include households with children, employees, older people and people with disabilities. Tourists and other visitors are a group requiring particular attention. They are often over-represented in areas at risk of flash flooding as these areas tend to be particularly attractive to tourists due to their scenic beauty. The vulnerability of visitors is discussed in more detail in section 4.3 of this report.

The Polperro, Hebden Bridge and professional partners' focus groups said that children were a key target audience. It was suggested that children be taught about flood risk and how to respond at school in the same way Japanese school children learn about earthquakes. As one participant put it:

> *"Children have saved people's lives by being aware."*

Children are a relatively easy group to reach as they can be educated through the school curriculum. Lessons learnt in childhood may be more likely to stay with people throughout their lives. Children can also play a role in educating the adults in their families. For this reason, children should be seen as an important audience for messages about flash floods. One way of doing this would be to include awareness-raising of flooding in the national curriculum. Clearly, this would involve negotiation at a national level with the Department for Education. In the shorter term, targeted activities could be undertaken in schools in areas identified as at risk of flash flooding.

Adults are a diffuse group who are difficult to access. There is no single point of contact or organised form of education that can be used for flood education purposes. The Polperro focus group suggested that work places should undertake awareness-raising and have flood drills like fire drills.

One relatively easy way of reaching new drivers is through the driving test system. The inclusion of a question in the driving theory test about how relatively shallow, fast flowing water can carry off a vehicle, could do much to raise awareness amongst drivers, a group who have been identified as at increased risk of death and injury during flash floods (see section 3.1). Such a question could read something like "At which of the following depths is fast flowing water likely to carry away an average saloon car?"

Both the Polperro and Hebden Bridge focus groups suggested regular practices to prepare for flooding. However, there was some concern that these would worry elderly people. One participant suggested a "flood awareness day" like no smoking day and this was supported by the group. Involving children and making it fun was considered very important.

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. However, there was strong feeling in both

the Polperro and Hebden Bridge focus groups that visual signs around the village warning of the danger of flash floods were not necessary and were considered unwelcome because they would devalue property and scare people, particularly tourists.

Both focus groups also agreed that too much printed information is already distributed and this was not useful as people do not read it. There were suggestions for information materials that people could keep, such as laminated sheets or fridge magnets but no agreement within the group if these would be useful.

There is evidence that printed materials may not be effective for awareness-raising as they are not memorable. Waterstone (1978) asked respondents about a brochure designed to raise awareness amongst residents of a flood hazard zone. One year later, only 37 per cent or respondents remembered receiving the brochure.

Twigger-Ross *et al*. (2008) looked at what types of awareness-raising measures are perceived as effective by the public through focus groups. 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 get 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 are.
- Lack of co-ordination of national campaign with the local one or wrong timing of national campaign.
- Confusing and contradictory mailings.

Innovative ways of raising awareness of the risk of flash floods and effective action could include using popular television though soap opera stories lines or items on 'daytime' magazine television shows. Involving local celebrities could also be helpful. Local media and local events, such as country shows, could be used. Gruntfest and Ripps (2000) suggest that videos are helpful to educate people about flash flooding.

A fire and rescue service representative interviewed as part of this research had used local press, including newspapers and radio, to undertake awareness-raising for drivers of the dangers of driving through flood waters. There was some interest with the media asking for interviews at the time flooding warnings were in place. However, it was difficult to maintain the interest of the media after the flood warnings had passed.

Just as warnings may exclude vulnerable groups if they are not properly targeted, so may awareness-raising initiatives. Vulnerable people such as older people and disabled people could be targeted for awareness-raising through community organisations or service providers. Focus group participants pointed out that older people were more likely to suffer from anxiety because of flood risk so special attention must be given to this group. People from ethnic minorities may need to receive printed materials in other languages and be targeted in different ways. Those with sensory impairments will also need special materials and measures.

The professional partners' focus groups believed that the Environment Agency has the lead role in awareness-raising, with local authorities and other agencies involved in disseminating messages.

In conclusion, while awareness-raising messages need to be standardised and consistent, the methods used to disseminate those messages should be diverse. No one method can be expected to reach all audiences and no one method can be considered most effective. A combination of local, regional and national approaches may be most effective.

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

5.2.1 Messages used by the printed media

As discussed above we reviewed press coverage of a number of case studies. The most widely reported message was "what is a flash flood." This focussed on the key characteristics of speed, velocity, depth and power of the water.

The unpredictability of flash floods and the fact that warning is often not possible, as stressed in many reports, 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')

A focus on human interest stories which illustrate the threat to life and property, 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')

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.

To encourage people to take flash floods and information on what to do in the event of a flash flood seriously, it would be useful for the media to cover not just flash floods and their impacts, but also the good news stories of how appropriate behaviour avoids death and injury. The Environment Agency may need to consider how to encourage these success stories to the media in future.

5.2.2 Messages put forward by professional partners

A fire and rescue service representative interviewed as part of this research had used local press to promote messages about the dangers to life presented by flooding. They included:

- Motorists should not attempt to drive through flooded roads or fords. The water is often deeper than it looks and may be moving quite fast. Your vehicle may be swept away or become stranded.
- Do not attempt to walk through flooded areas. Even shallow water moving fast can sweep you off your feet and there may be hidden dangers such as open drains, damaged road surfaces, submerged debris or deep channels; these can cause serious injuries or even death.
- Children should not be allowed to play in flood water, which can become contaminated with sewerage and chemicals.
- Do not smoke, eat or drink whilst in contact with floodwater and always wash your hands afterwards.
- Keep an eye on weather reports on local television or radio news channels. Do not travel in heavy rain storms unless absolutely necessary.
- Look after neighbours. People have been known to suffer from hypothermia after their homes have become flooded with cold rainwater even in the summer time.
- Remember that during a storm the emergency services will be very busy, only call for immediate assistance if there is a risk to life or serious property or environmental damage.
- Following a flood in your home, make sure all electrical circuits are fully dried out and checked by an electrical engineer before switching back on.

These messages are based on guidelines for telephone operators who advise members of the public calling for assistance. Developing universally applicable messages was reported to be very difficult because local conditions vary so much and can change so quickly. There is no national guidance on messages about driving through floodwater. National guidance would be considered to be useful in that it would make issuing advice easier for local services and it would ensure that all agencies give the same advice.

5.2.3 Examples of messages from other countries

The National Weather Service and Arizona Association of Floodplain Managers have used 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.

Figure 1 below provides an example of web-based public information messages used in the United States. It was developed by the Weather Channel and made available on its website.

During A Flash Flood Or Flood

Your local authorities have issued a Flood Warning.

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 flash floods.

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 Family Emergency Supplies Kit 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 Family Emergency Supplies Kit 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 (Available from: http://www.weather.com/ready/flood/during.html?from=safety_flooding)

5.3 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?

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

Community-based knowledge and involvement is essential for several reasons. First, communities are the ones who suffer the most as a result of the impacts of flash flooding. Second, community-based organisations act faster in responding to disaster before the arrival of external help. Third, 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.

Participants in both the Polperro and Hebden Bridge focus groups said they were knowledgeable about the history of flooding in their areas, the causes of flooding and the signs of imminent flooding. Both focus groups demonstrated this knowledge in the descriptions of previous flooding events and in their explanations of how they monitored local conditions to check for signs of flooding.

In both flash floods in Polperro the emergency services were unable to attend so community members were responsible for warning each other and taking action.

As this report has already discussed in section 3.5, local knowledge and action played a key role in saving lives in the flash flooding in Boscastle on 16 August 2004 (Environment Agency, 2004).

5.3.2 The challenges in utilising local knowledge and involvement

While acknowledging its importance, it is important to be realistic about the challenges of local involvement. Local concerns are often not the same as those at play in implementing specialised services, such as flood risk management, forecasting and warning. For example, participants in both the Polperro and Hebden Bridge focus groups were adamant that deterioration in river and drainage maintenance was an important cause of flooding, including flash flooding, in their areas and placed a high degree of importance on the relevant agencies improving such maintenance. They also believed that structural measures were the best solutions for flooding, including flash flooding. It will be difficult to engage these communities in flood risk management measures that assume structural flood defence mechanisms are not an appropriate response to flash floods.

In addition, while the benefit of broad stakeholder involvement is recognised, it should not be assumed that the involvement of more stakeholders will automatically translate into a more efficient system or a better result. There is the risk that the

sense of responsibility to deal with the issue of flash floods will become diluted between various individuals and institutions and lacking in co-ordination (APFM, 2007b).

Jennings' 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 (2008). This belief that local knowledge and expertise around water management, linked to farming practices, had been rapidly lost was shared by the participants in both the Polperro and Hebden Bridge focus groups.

Commercial concerns such as wanting to protect property values were seen by the focus group participants as real barriers to maintaining local flood knowledge. As one participant said:

> *"That creates a layer of ignorance."*

The concern to protect tourism expressed by both focus groups contributes to this ignorance. The high flood mark sign which was erected in Polperro, could have contributed to awareness of flooding risk. However, according to the focus group participants, it was taken down very quickly by an anonymous resident who was concerned it would scare tourists and reduce property values.

5.3.3 Ways to utilise and develop local knowledge and involvement

Ways of utilising local knowledge to support effective response for flash floods must take account of the characteristics of this type of flooding. In particular, it is very difficult to predict, lead in times are generally very short, it can occur in areas not considered at risk of other types of flooding, it involves high depths and fast velocities and it presents a danger to life and property. This means some of the techniques used to utilise public knowledge in other types of flooding may not be appropriate.

Because of difficulties in predicting flash flooding, local knowledge is essential in recognising its signs and asking for help, as happened during the Polperro and Boscastle flash floods.

In view of the difficulties emergency services may experience in getting to the site affected by flash flooding, local knowledge will be crucial to the initial response. It could be used to alert neighbours, especially vulnerable people. Cascading phones systems have been suggested, although the Polperro focus group participants said they would not have had time to use these. A system of flood wardens to warn immediate neighbours and vulnerable people could be used. The identification of vulnerable people in advance would also be useful, although it is important to bear in mind such lists would be subject to the Data Protection Act and would require regular updating. Flood wardens engaged in warning would need to be trained in order to ensure they do not put themselves at risk by attempting to door knock when the floodwater has reached the area.

Local initiatives to prevent flood water reaching areas of the village or property, such as strategic sandbagging, are not likely to be of use in the event of flash flooding and could actually be dangerous for those attempting it. Therefore, schemes which use local people to set up these types of defences are not appropriate.

Devon County Council has a policy of encouraging parish councils to develop local emergency plans which include provision for flooding. To assist parish councils, a support pack has been produced which includes a template that guides parish councils through undertaking a risk assessment and developing an emergency plan. Parish councils are encouraged to talk to the emergency services in developing their plans. Other support available to parish councils is the network of emergency planners in Devon and a regular newsletter - “Helping you to help yourselves” - produced by Devon County Council.

Clearly, there are limitations. Parish councils have no statutory responsibility in this area so it is based on persuasion. Currently, around 10 of the 55 parish councils have such plans, though some of those that do not are not at risk of flooding. Local individuals’ motivation and expertise are key in the development and quality of these plans.

However, the size of local parish councils suggests this is a good level at which to encourage local action. They have a superior local knowledge of the area, of available local assets/expertise, of specific risks and of the location of vulnerable residents. Initiatives to specifically target those parish councils covering areas identified as containing rapid response catchment areas with messages on flash flooding may prove a good way of utilising local knowledge. This will involve close working with district, county and borough councils.

Surveys conducted with project partners in the FLOODsite Task 10 work on developing a model to assess the benefits of flood warnings show 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*., 2007b). A high degree of individual responsibility and self-help, and a low degree of dependence upon the state, requires a strategy of openness and the provision of high quality information for public consumption. Open dialogue and a willingness to share information are essential in utilising and developing public knowledge.

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.

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.

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, 2001a). 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 International Strategy for Disaster Reduction (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.

However, as this report has already discussed, concern to protect tourism and property values can hinder the development of local knowledge about flooding. One interesting question is what factors determine whether the local population consider it important to mark the flood, sometimes to the extent it becomes a local tourist attraction, as in Lynmouth where there is a flood museum, or not to mark it or even to conceal it.

5.4 Key findings and recommendations

- The link between awareness-raising and response is not straightforward. There are conflicting perspectives on the extent to which awareness-raising activities can replace flood experience in improving preparedness.
- Awareness-raising messages need to stress personal responsibility for monitoring local weather forecasts and other conditions.
- Tourists and other visitors are a group requiring particular attention. They are often over-represented in areas at risk of flash flooding as these areas tend to be particularly attractive to tourists because of their scenic beauty.
- Awareness-raising messages need to include advice for independent action as the very short period of time between the warning and the onset of a flash flood means that people may have to take action themselves without the support of the emergency services.
- Children are a key target group for awareness-raising. They are relatively easy to reach, lessons learnt in childhood may be more likely to stay with people throughout their lives and children can also play a role in educating the adults in their families.
- Awareness-raising messages need to be standardised but the methods used to disseminate those messages should be diverse. No one method can be expected to reach all audiences and no one method can be considered most effective. A combination of local, regional and national approaches may be most effective.
- Local knowledge and involvement must be used in such a way that recognises the characteristics of flash flooding.
- The size of local parish councils suggests this is a good level at which to encourage local action.

Recommendation 21: The Environment Agency needs to develop awareness-raising messages which focus on actions as well as signs and impacts of flash flooding, whilst minimising anxiety amongst the public.

Recommendation 22: The Environment Agency should seek to take a measured approach to what may be achieved through public education and awareness-raising in the flood warning response field. It should certainly continue to engage in significant public flood education work, but it should also seek to manage the expectations of external parties and professional partners about the likely limitations of this approach and the impacts this will have during flood emergencies.

Recommendation 23: The Environment Agency should work with other agencies to develop innovative methods of awareness-raising. These include the inclusion of a question in the driving theory test about how little fast flowing water can carry off a vehicle and the inclusion of flood awareness in the national curriculum.

Recommendation 24: Messages to increase public awareness of what to do in the event of a flash flood need to focus on actions that can be taken independently of the emergency services.

Recommendation 25: The Environment Agency should explore developing a schools' information pack to encourage schools to teach children about flood risk and effective response.

Recommendation 26: The Environment Agency needs to work with local agencies to ensure that vulnerable groups are targeted for awareness-raising initiatives.

Recommendation 27: The Environment Agency needs to consider how to encourage success stories in the media describing how people avoid death and injury by taking appropriate action.

Recommendation 28: The Environment Agency needs to develop ways of working with local authorities to encourage parish councils within rapid response catchment areas to develop emergency plans with specific provisions for flash flooding.

6 Conclusions

6.1 Conclusions

This report has presented the findings of a research project looking at people's perceptions of severe flash flooding and examining what they need in order to make an appropriate and effective response. It has drawn out a number of important key findings and made 28 recommendations on how these can be taken forward.

These key messages and recommendations have been formulated to assist the Environment Agency with its investigation into the feasibility and advisability of a warning service for severe flash flooding and its development of effective awareness-raising strategies and messages. The messages are drawn together in the table below, together with a column to which can be added possible ways of implementing such recommendations, which is beyond the scope of this study.

The report is structured using the research questions posed by the Environment Agency in the brief for the project and seeks to answer these questions as fully as possible. However, it has not been possible to provide definitive answers to all of these questions because the interaction of many incident-specific factors means the impacts of each flash flood are different. In these cases, the report has discussed different perspectives that help explain why a definitive answer is not possible.

The research has relied heavily on an extensive literature review. Primary research has been limited by the timescale and budget for the project. The professional partners' focus group was drawn from one region only and the results may therefore not reflect perceptions of flash floods among professionals across the country as a whole. The only discussions with members of the public took place at two focus groups. **These do not provide a sufficiently large sample for the results to be considered significant or representative.** Nevertheless, the focus groups and telephone interviews have provided important insights.

A number of groups who are often particularly vulnerable to the negative impacts of flash flooding have been identified by this research. These include tourists and other visitors to an area; people living or staying in those structures most vulnerable to damage or destruction; drivers; and those who may be more vulnerable because of specific demographic factors.

Additional primary research, in the form of focus groups and telephone interviews, will be essential to building a more detailed and more representative picture of public and professional perceptions of flash flooding and the nature of particular vulnerabilities. It will also be crucial to developing interventions that support effective and appropriate response.

Summary of key findings, recommendations and implementation

Summary of key findings	Recommendations	Implementation
Understanding the term flash flooding *Specific objective 1:* to review the understanding and language used in the context of flash flooding.		
• Individuals with experience of flash flooding demonstrate a good understanding of its key characteristics. However, those who do not have experience of high velocity floodwater and debris do not demonstrate a spontaneous understanding of the danger flash flooding presents. • Key features of flash floods as defined by flood risk management and response agencies 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. • In general media reporting of flash flooding presents an accurate picture of the characteristics of flash flooding. However, reporting of the causative factors leading to flash flooding is shallow and much less complete and accurate. • Media reporting of flooding in general often uses the term 'flash flooding' inaccurately to describe any type of floodwater that rises quickly.	*Recommendation 1:* *The Environment Agency should seek to develop a description and definition of flash flooding that stresses the potentially dangerous impacts of this type of flooding. One example is "Sudden, dangerous flooding" which could be defined as " a localised flood with very high volumes of fast flowing water, often carrying large debris, that rises very quickly, with an immediate threat to life."*	*Recommendations for 'Understanding the term flash flooding' will be directed towards:* • *Flood Awareness Campaign co-ordinators and Flood Incident Management processes.* • *'Risk to Life' modelling and mapping.* • *Media and corporate communications.*

Summary of key findings	Recommendations	Implementation
• There is a lack of clarity amongst the public, professional partners and media about how flash flooding relates to surface water and ground water flooding and whether it is inherently dangerous.		
Appropriate and effective responses to flash flooding *Specific objective 2: to review the cause and effect of different responses to flash flood warnings and communications.* *Specific objective 3: to review methods of encouraging those at risk to take appropriate action.* *Specific objective 5: to review the impact of lead time and different methods of delivery on the outcomes of flood warnings for severe flash flooding.*		
• Flash flooding has been a significant cause of injury and mortality internationally, and to a lesser extent in the UK. Because of this, it warrants specific attention in the Environment Agency's "risk to life" modelling and planning, as well as that of other agencies involved in flood management and water rescue. • Whether flash flooding results in death and injury depends on the interaction of many factors including the characteristics of the flood, where people are at the time the flooding occurs and what they do. • It is not possible to definitively state which types of building can always be considered safe during flash flooding. However, some types of structure should be considered particularly vulnerable including caravans, tents, mobile homes, timber frame buildings and single storey, ground floor or basement properties.	*Recommendation 2: Messages to promote appropriate and effective response to flash flooding should include:* • *Do not walk through floodwaters.* • *Do not drive through floodwaters.* • *If it is safe to evacuate to high ground without walking or driving through floodwaters, do so.* • *If it is not safe to evacuate go upstairs.* *If you are in a basement or single storey dwelling, a mobile home, caravan or tent or are caught outside, immediately seek shelter in the nearest two or more storey building or*	*Recommendations for 'Appropriate and effective responses to flash flooding' will be directed towards:* • *Communications developed for flood awareness campaigns for Rapid Response Catchments.* • *Emergency planning guidance for Rapid Response Catchments.* • *Flood risk planning for those most vulnerable to flood risk.* • *'Risk to life' modelling and mapping.*

Summary of key findings	Recommendations	Implementation
• Evacuation by foot should not be considered safe if floodwater has already reached the area. In this case, the best course of action is to get inside a two or more storey building and go upstairs. • The identification of safe havens and safe exit routes would assist evacuation. This is particularly important for those people in vulnerable structures. • Driving or walking though floodwaters or other forms of risk taking behaviour are a major cause or mortality during flash flooding. • It is not possible to be specific about the amount of time the public need to evacuate an area. Nor is it possible to be specific about the amount of time professional partners need to carry out evacuations. • At the present time no single agency has statutory responsibility and resources for water rescue. • It is not possible to quantify a possible reduction in mortality with a minimum warning time. However, it is probable that a warning with a very short lead in time that enables people to get inside and upstairs can save lives. • The economic and environmental impacts of flash flooding may be severe. Research has indicated that warnings have limited potential to mitigate these impacts in cases of fluvial and surface water flooding and this is likely to be even more limited in cases of	*travel to higher ground.* *The wording of these messages will require testing on sample groups to ensure they are appropriate and easily comprehensible.* *Recommendation 3: The Environment Agency should work with partners, including local communities, to undertake hazard mapping and local planning in those areas identified as at risk of flash flooding.* *Recommendation 4: The Environment Agency should work with partners to identify and enforce statutory requirements for the owners of caravan parks, campsites, holiday homes and other vulnerable locations to make provisions to evacuate their visitors in the event of danger, including flooding.* *Recommendation 5: The Environment Agency should give consideration to the need for the definition and identification of safe havens and safe exit routes in or close to flash flood zones, and should consider publicising these.* *Recommendation 6: The Environment Agency should undertake further research into the use and effectiveness of debris interceptors.* *Recommendation 7: Fire and rescue services*	• *Media and corporate communications.* • *Development of flood incident health and safety messages.* • *Future research into the impact of severe flash floods.* • *Training for flood incident management teams.*

Summary of key findings	Recommendations	Implementation
flash flooding. • The potential for formal warnings to mitigate the social impacts of flash flooding, including mortality, may be less significant than supposed. However, recent examples of flash flooding show that informal warnings can mitigate these impacts.	*should be given a statutory responsibility for water rescue and necessary funding.*	
Warnings for flash flooding *Specific objective 2: to review the cause and effect of different responses to flash flood warnings and communications.* *Specific objective 4: to review the impact of issuing warnings when flooding does not occur, on trust and response.* *Specific objective 5: to review the impact of lead time and different methods of delivery on the outcomes of flood warnings for severe flash flooding.*		
• The focus groups and the literature review indicate that the information people require to respond effectively can be divided into general information and incident-specific information. General information must be consistent across all types of flooding and local information must be built on community engagement and knowledge. • The Environment Agency's existing warnings were considered by focus group participants to provide insufficient practical information on what to do in response to flooding. • The timing, speed, velocity and depth of flooding affect how individuals are able to respond to flash flooding and the emergency services' ability to attend.	*Recommendation 8: When formulating and disseminating awareness-raising messages the Environment Agency needs to highlight the dangers of risk-taking behaviour. These messages need to be particularly targeted at male recipients. However, the wording of these messages will require testing on sample groups to test their effectiveness, to ensure they are appropriate and easily comprehensible.* *Recommendation 9: The Environment Agency should ensure that the design of any future warning system for flash floods takes account of the need for warnings to provide practical information on what to do, as well as*	*Recommendations for 'Warnings for flash flooding' will be directed towards:* • *Flood Awareness Campaign co-ordinators and Flood Incident Management processes.* • *Communications developed for flood awareness campaigns for Rapid Response Catchments.* • *Emergency planning guidance for Rapid Response*

Summary of key findings	Recommendations	Implementation
• Problems with communication and co-ordination between agencies responding to flash flooding in the early stage can hamper response. • The views of participants in the public focus groups provide an indication of the extent to which the public hold the Government responsible for flood prevention and believe structural measures are the best solution to flash flooding. • Some demographic groups are less likely to receive a warning, including an unofficial warning, or to respond to it. • There is evidence that indicates experience of flooding is one of the most powerful predictors of response to flood warning. However, the relationship between previous experience and response is not straightforward. • Tourists and other visitors are more at risk of death and injury from flash flooding. Campers and caravaners are particularly vulnerable. • The warning process needs to be seen as a complex social process, rather than the issuance and receipt of a warning message. • A warning system for flash floods could have potential negative impacts including causing undue alarm to the public, promoting "flood tourism" and creating an expectation amongst the public that warnings will	*information on when and where the flooding is predicted to occur. The wording of these messages will require testing on sample groups to ensure they are appropriate and easily comprehensible.* *Recommendation 10: The Environment Agency should make available specialist resources to encourage community engagement in hazard mapping, local planning and flood response and awareness-raising.* *Recommendation 11: The Environment Agency should ensure that the design of any future warning system for flash floods takes account of the need for warnings to be targeted to vulnerable groups.* *Recommendation 12: The Environment Agency should undertake an evaluation of the initiative to work with campsite and caravan park owners to minimise the risk of flooding in the South West region after an initial implementation period.* *Recommendation 13: The Environment Agency should work with mobile home park owners to develop initiatives to facilitate response to flash floods.* *Recommendation 14: The Environment*	*Catchments.* • *Development of flood incident health and safety messages.* • *Development of flood incident management processes and communications for reservoir flooding.* • *Training for flood incident management teams.*

Summary of key findings	Recommendations	Implementation
always be issued if flash flooding in cases of flash flooding. • Unofficial warnings, including self warning as a result of personal observations of danger signs, is an important source of warning for flash floods. • The Environment Agency and Met Office are seen as the best sources of a warning for flash flooding. Many and varied dissemination methods are preferable but it is important the warning message is consistent. • Local flood warning sirens are popular with the public where they exist but understanding of what they mean is poor. • New technologies, such as those relying on mobile telephones and the internet, will not reach all of the population at risk and, therefore, should not be relied upon exclusively. • There was general consensus amongst professional partners that the existing Environment Agency warning system worked well, although this is not aimed at flash flooding. However, the weak link was how the warning was acted on. • Evidence about the public's tolerance of false alarms is sparse and inconclusive. • Professional partners would prefer information on probability with warnings.	*Agency should ensure that the design of any future warning system for flash floods takes account of how people receive and interpret warnings, recognising warning as a social process. It should also take account of the perception that the Environment Agency and Met Office are seen as the best sources of a warning for flash flooding but many and varied dissemination methods are preferable but it is important the warning message is consistent. A nationally uniform system will assist public recognition of warnings.* *Recommendation 15: The Environment Agency should develop new ways of describing the risk of hazards that are less open to misinterpretation than the term 'a one in 100 year flood.'* *Recommendation 16: Warning schemes that rely on public volunteers need to incorporate training to ensure members of the public do not put themselves at risk when disseminating warnings.* *Recommendation 17: Agencies responsibility for disseminating warning messages need to bear in mind that many people will not be able to use landline telephones if the power fails due to severe weather. In this case, they will also be unable to access radio and*	

Summary of key findings	Recommendations	Implementation
• Participants in the public focus groups indicated that false alarms would affect future response but only if they happened on a regular basis.	*television.* *Recommendation 18: Agencies with responsibility for operating flood siren systems must inform local communities what the siren means on a regular basis. Ensuring the meaning of the system is clear must be considered as part to the design of any new flood siren systems.* *Recommendation 19: The Environment Agency should ensure that the development of any future warning system for flash floods includes close work with category one and category two responders to develop protocols for how warnings for flash floods should be dealt with.* *Recommendation 20: The Environment Agency should ensure that the development of any future warning system for flash floods includes close work with category one and category two responders to improve shared understanding of uncertainty and probability.*	
Raising awareness of flash flooding *Specific objective 3: to review methods of encouraging those at risk to take appropriate action.*		
• The link between awareness-raising and response is not straightforward. There are conflicting perspectives on the extent to which awareness-raising activities can replace flood experience in improving	*Recommendation 21: The Environment Agency needs to develop awareness-raising messages which focus on actions as well as signs and impacts of flash flooding, whilst*	*Recommendations for 'Raising awareness of flash flooding' will be directed towards:*

Summary of key findings	Recommendations	Implementation
preparedness. • Awareness-raising messages need to stress personal responsibility for monitoring local weather forecasts and other conditions. • Awareness-raising messages need to include advice for independent action. • Children are a key target group for awareness-raising. • Awareness-raising messages need to be standardised but the methods used to disseminate those messages should be diverse. • Local knowledge and involvement must be used in such a way that recognises the characteristics of flash flooding. • The size of local parish councils suggests this is a good level at which to encourage local action.	*minimising anxiety amongst the public.* *Recommendation 22: The Environment Agency should seek to take a measured approach to what may be achieved through public education and awareness-raising in the flood warning response field. It should certainly continue to engage in significant public flood education work, but it should also seek to manage the expectations of external parties and professional partners about the likely limitations of this approach and the impacts this will have during flood emergencies.* *Recommendation 23: The Environment Agency should work with other agencies to develop innovative methods of awareness-raising. These include adding a question to the driving theory test about how a small amount fast flowing water can carry off a vehicle, and the inclusion of flood awareness in the national curriculum.* *Recommendation 24: Messages to increase public awareness of what to do in the event of a flash flood need to focus on actions that can be taken independently of the emergency services.* *Recommendation 25: The Environment Agency should explore developing a schools'*	• *Flood Awareness Campaign co-ordinators and Flood Incident Management processes.* • *Communications developed for flood awareness campaigns for Rapid Response Catchments.* • *Emergency planning guidance for Rapid Response Catchments.* • *Development of flood incident management processes and communications for reservoir flooding.* • *Training for flood incident management teams.*

Summary of key findings	Recommendations	Implementation
	information pack to encourage schools to teach children about flood risk and effective response. *Recommendation 26: The Environment Agency needs to work with local agencies to ensure that vulnerable groups are targeted for awareness-raising initiatives.* *Recommendation 27: The Environment Agency needs to consider how to encourage success stories in the media describing how people avoid death and injury by taking appropriate action.* *Recommendation 28: The Environment Agency needs to develop ways of working with local authorities to encourage parish councils within rapid response catchment areas to develop emergency plans with specific provisions for flash flooding.*	

Table 5: Summary of key findings, recommendations and implementation

References

ABT, S.R., WITTLER, R.J., TAYLOR, A., AND LOVE, D.J., 1989. Human Stability in a high flood hazard zone. Water Resources Bulletin, 25 (4), 881-890.

ADAMS, C.,R., AND HOOKE, W. H., 2001. Improved flash flood predictions. In GRUNTFEST, E. AND HANDMER, J.W., (ed.) 2001, Coping with flash floods. Dordrecht. Kluwer Academic Publisher.

ANDRYSZEWSKI, A., EVANS, K., HAGGETT, C., MITCHELL, B. AND WHITFIELD, D., 2005. Flood Warning – The Next Step-Change, 40th Defra Conference of River and Coastal Engineers, Keele, July 2005.

ANTOINE, J.-M., DESAILLY, B., GAZELLE, F., 2001. Les crues meurtrieres, du Roussillon aux Cevennes. Annales de Geographie, 622 597-623.

ASSOCIATED PROGRAMME ON FLOOD MANAGEMENT, 2007a. Community preparedness and public participation for Flash Flood Management in Europe 29-30 October, 2007, Krakow, Poland, Recommendations. Associated Programme on Flood Management.

ASSOCIATED PROGRAMME ON FLOOD MANAGEMENT, 2007b. Guidance on Flash Flood Management Recent Experiences from Central and Eastern Europe. Associated Programme on Flood Management.

BAKER, E.J. 1979. Predicting response to hurricane warnings: A reanalysis of data from four studies. Mass Emergencies, 4, 9-24.

BBC NEWS. Power restored after flash storms. 20 June 2005.

BENIGHT, C., GRUNTFEST, E. C., HAYDEN, M., BARNES, L. R., 2007. Trauma and short-fuse weather warning perceptions. Environmental Hazards, 7 (3), 220-226.

BERN, C., SNIEZEK, J., MATHBOR, G.M., SIDDIQI, M.S., RONSMANS, C., CHOWDHURY, A.M.R., CHOUDHURY, A.E., ISLAM, K., BENNISH, M., NOJI, E. AND GLASS, R.I., 1993. Risk factors for mortality in the Bangladesh cyclone of 1991. Bulletin of the World Health Organisation, 71, 73-78.

BIMEL. K. P. 1999. Flash flooding in Kansas: a study of emergency response and victims' perceptions. Quick Response Report #118 Kansas State University.

BLANCHARD-BOEHM, R. D. 1998. Understanding Public Response to Increased Risk from Natural Hazards: Application of the Hazards Risk Communication Framework. International Journal of Mass Emergencies and Disasters 16(3):247-78.

BREZNITZ, S., 1984. Cry Wolf: The Psychology of False Alarms. New Jersey: Hillsdale.

CBS NEWS, August 25, 2005 European Flood Deaths Rise to 42. Available: http://www.cbsnews.com/stories/2005/08/25/world/main795798.shtml

CHATTERTON, J.B., PIRT, J. AND WOOD, T.R., 1979. The Benefits of Flood Forecasting. Journal of the Institution of Water Engineers and Scientists, 3, 237-252.

CLIMB UTAH, 2008. Available from: http://climb-utah.com/Powell/flash_antelope.htm [accessed 23 May 2008]

COATES, L., 1999. Flood fatalities in Australia, 1788-1996. Australian Geographer, 30 (3), 391-408.

CROSTHWAITE, P. M., 1921. The Louth flood of 1920. Trans. Instn. Water Engrs., 26, 204ff.

DAILY EXPRESS. Storms batter Britain again. 6 May 2008.

DAILY MAIL. Flash floods hit coastal towns. 25 September 2006.

DE MARCHI, B., SCOLOBIG, A., DELLI ZOTTI, G. AND DEL ZOTTO, M. 2007. Risk construction and social vulnerability in an Italian Alpine Region, FLOODsite Report No. T11-2006-08. Available at www.floodsite.net.

DEEMING, H., Forthcoming. Increasing resilience to storm surge flooding: risks, social networks and local champions. PhD thesis, Geography Department, Lancaster University, Lancaster, UK

DELDERFIELD, E. R., 1976. The Lynmouth Flood Disaster. 8th edition. Exmouth: Raleigh Press.

DEMERITT, D., CLOKE, H., PAPPENBERGER, F., THIELEN, J., BARTHOLMES, J. AND RAMOS, M-R., 2007. Ensemble predictions and perceptions of risk, uncertainty and error in flood forecasting. Environmental Hazards, 7 (2), 115-127.

DEPARTMENT FOR ENVIRONMENT, FOOD AND RURAL AFFAIRS, 2005. Making Space for Water: Taking Forward a New Government Strategy for Flood and Coastal Risk Management in England. Defra.

DEPARTMENT FOR ENVIRONMENT, FOOD AND RURAL AFFAIRS, 2008a. Consultation on Defra policy statement on appraisal for flood and coastal erosion risk management. Defra. Available: http://www.defra.gov.uk/environ/fcd/policy/strategy/sd3.htm (Accessed 12 August 2008).

DEPARTMENT FOR ENVIRONMENT, FOOD AND RURAL AFFAIRS, 2008b. Towards a new national flood emergency framework. Defra. Available: http://www.defra.gov.uk/environ/fcd/floodincidents/contin.htm (Accessed 12 August 2008).

DEVON COUNTY COUNCIL, 2006. Helping you to help yourselves: Community emergency planning – all you need to know to produce a plan for your Parish. Devon County Council. Available: http://www.devon.gov.uk/index/democracycommunities/publicsafety/emergencies/emergency_planning-community_planning.htm (Accessed 12 August 2008).

DOW, K. AND CUTTER, S.L., 1998. Crying wolf: repeat responses to hurricane evacuation orders. Coastal Management, 26 (4), 237-252.

DOWNING, T.E., 1977. Warning for Flash Floods in Boulder, Colorado. Working Paper No.31. Boulder, Colo.: University of Colorado, Natural Hazards Research and Applications Information Center

DOWNING, T.E., 1977. Warning for flash floods in Boulder, Colorado, Natural Hazard Working Paper 31. Boulder: Institute of Behavioral Science, University of Colorado.

DRABEK, T.E., 1969. Social processes in disaster: family evacuation. Social Problems, 16, 336-347.

DRABEK, T.E., 1986. Human response systems to disaster: an inventory of sociological findings. New York: Springer Verlag.

DRABEK, T.E., 2000. The social factors that constrain human responses to flood warnings. In Parker, D.J. (ed.) Floods, Vol. 1, Section 23, 361-76, London: Routledge.

DROBOT, S. AND PARKER, D.J., 2007. Advances and challenges in flash flood warning, Environmental Hazards, 7, 173-178.

DROBOT, S., BENIGHT, C., AND GRUNTFEST, E., 2007. Risk factors for driving into flooded roads, Environmental Hazards, 7 (3), 227-234.

EDWORHTY, J. AND ADAMS, A., 1996. Warning Design: Research Perspective. London, Taylor and Francis.

ELLIOT, J.F. AND STEWART, B.J., 2000. Early warning for flood hazards: lessons learned. In Parker, D.J. ed. Floods. Volume 1. London, Routledge, 391-399.

EMERGENCY MANAGEMENT AUSTRALIA, 1999a. Flood Warning, 2nd Edition, Emergency Management Practice Vol. 3, Guide 5, Australian Emergency Manuals Series Part III. Australia: EMA.

EMERGENCY MANAGEMENT AUSTRALIA, 1999b. Managing the Floodplain, Guide 3, Emergency Management Practice. Australian Emergency Manuals Series, Canberra ACT: EMA.

ENVIRONMENT AGENCY, 2003. Guide to the Management of Floodplains to reduce Flood Risks. Report SR 599, HR Wallingford Ltd, February 2003

ENVIRONMENT AGENCY, 2004. Living with the risk. The floods in Boscastle and North Cornwall 16 August 2004. Bristol: Environment Agency.

ENVIRONMENT AGENCY, 2005a. Post Events 2004 Report, Prepared by R Gosling BMRB Social Research for the Environment Agency. Bristol: Environment Agency.

ENVIRONMENT AGENCY, 2005b. Response to Flooding 2005, Response to Flood Events of January 2005 in the Northwest. Bristol: Environment Agency.

ENVIRONMENT AGENCY, 2005c. Managing flood risk, Dealing with flooding: A review of the floods in northern England and North Wales January 2005. Environment Agency, Bristol.

ENVIRONMENT AGENCY, 2006. Response to Flooding Survey 2006. Response to Flood Events of October 2006 in South West Region. Bristol: Environment Agency.

ENVIRONMENT AGENCY, 2007a. Response to Flooding 2007. Response to Flood Events of January 2007 in Midlands Region and North East Region. Bristol: Environment Agency.

ENVIRONMENT AGENCY, 2007b. Public Response to Flood Warnings, Science Report SC020116. Bristol: Environment Agency.

ENVIRONMENT AGENCY, forthcoming. Flooding – minimising the risk. Your caravan/camp site is in a flood risk area – practical advice on keeping you ad your visitors safe in a flood. Exeter: Environment Agency.

FAULKNER, H., PARKER, D.,GREEN,C. AND BEVAN,K., 2007. Developing a Translational Discourse to Communicate Uncertainty in Flood Risk between Science and the Practitioner. Ambio 36 (7).

FERNÁNDEZ-BILBAO, A., AND TWIGGER-ROSS, C., 2008. Improving Institutional and Social Responses to Flooding: Work Package 2 - Improving response, recovery and resilience Unpublished draft final report Environment Agency.

FIELDING, J., BURNINGHAM, K., THRUSH, D. AND CATT, R., 2007. Public response to flood warning. Science Report SC020116, Environment Agency.

FISCHHOFF, B., RILEY, D., KOVACS, D.C. AND SMALL, M., 1998. What Information Belongs in a Warning? Psychology and Marketing. 15 (7), 663-686.

FLOOD HAZARD RESEARCH CENTRE, 2008. Distance learning teaching materials on Constructing flood warning messages. Prepared for the Environment Agency sponsored Foundation Degree in River and Coastal Engineering held at the University of the West of England. Enfield, FHRC, Middlesex University. Unpublished.

FRENCH JG, ING R, VON ALLMEN S, and WOOD R. 1983 Mortality from flash floods: a review of National Weather Service reports, 1969-81. Public Health Report 98:584-8.

GLASS, R.I., R.B. CRAVEN, D.J. BREGMAN, B.J. STOLL, N. HOROWITZ, P. and KERNDT, and J. WINKLE. 1980. Injuries from the Wichita Falls tornado: Implications for prevention. *Science* 207:734-738.

GOVERNMENT OFFICE FOR THE NORTH WEST, 2005. Carlisle storms and associated flooding, Multi-agency Debrief report. GONW.

GOVERNMENT OFFICE FOR THE SOUTH WEST, 2006. Major flooding at Boscastle and surrounding areas of North Cornwall, 16th August 2004, A summary of lessons identified. GOSW.

GRUNTFEST, E. AND HANDMER, J.W., 2001a. Dealing with flash floods. In GRUNTFEST, E. AND HANDMER, J.W., (ed.) 2001, Coping with flash floods. Dordrecht. Kluwer Academic Publisher.

GRUNTFEST, E. AND HANDMER, J.W., 2001b. Where we go from here: Policy and research recommendations. In GRUNTFEST, E. AND HANDMER, J.W., (ed.) 2001, Coping with flash floods. Dordrecht. Kluwer Academic Publisher.

GRUNTFEST, E. AND RIPPS, A., 2000. Flash floods. Warning and Mitigation Efforts and Prospect. In PARKER, D.J. (ed.) Floods, Vol. 1, Section 24, 377-390. London: Routledge.

GRUNTFEST, E., 1977. What people did during the Big Thompson flood, Natural Hazard Research Working Paper 32, Boulder: Institute of Behavioural Science, University of Colorado.

GRUNTFEST, E., 1987. Warning Dissemination and Response With Short Lead Times. Pp. 191-206 in British and International Perspectives, edited by John Handmer. Norwich, UK: GEO Books.

GRUNTFEST, E., CASSELL, K., PLUSH, T., 2002. An evaluation of the Boulder Creek local flood warning system. Report prepared for the Urban Drainage and Flood Control District, Boulder City/County Office of Emergency Management. , Available at http://www.udfcd.org/pdf/Final%20Copy_1.pdf. Accessed 18th May 2008

HAMMER, B. O., and T. W. SCHMIDLIN, 2001: Vehicle-occupant deaths caused by tornadoes in the United States, 1900-1998. Environ. Hazards, 2, 105-118.

HANDMER, J.W. AND ORD, K.D., 1986. Flood warning and response. In Smith, D.I. & Handmer, J.W. (eds.) Flood Warning in Australia, Section 17, 235-257. Canberra, Centre for Resource and Environmental Studies, Australian National University.

HANDMER, J.W., 1991. Can we have too much warning time? A study of Rockhampton. Pp. 155-59 in Inspiration: Come to the Headwaters, compiled by the Association of State Floodplain Managers. Boulder, Colo.: University of Colorado, Institute of Behavioral Science, Natural Hazards Research and Applications Information Center.

HANDMER, J.W., 2000. Are Flood Warnings Futile? Risk communication in emergencies. The Australasian Journal of Disaster and Trauma Studies. 2000 (2), 1-14, Available at http://www.massey.ac.nz/%7Etrauma/issues/2000-2/handmer.htm. Accessed 26th November 2007.

HANDMER, J.W., HENSON, R., SNEERINGER, P., KONIECZNY, R., MADEJ, P., 2001. Warning systems for flash floods: research needs, opportunities and trends. In GRUNTFEST, E. AND HANDMER, J.W., (ed.) 2001, Coping with flash floods. Dordrecht. Kluwer Academic Publisher.

HANWELL, J. D., NEWSOM, M. D., 1970. The great storms and floods of July 1968 on the Mendip. Wessex Cave Club Occasional publication, 1 (2).

HARRISON, S., 1864. A complete history of the great flood at Sheffield on March 11 and 12, Sheffield: Harrison.

HAYDEN, M. H., DROBOT, S., RADIL, S., BENIGHT, C., GRUNTFEST, E. C., BARNES, L.R., 2007. Information source for flash flood warnings in Denver, CO and Austin TX. Environmental Hazards, 7 (3), 211-219.

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, 2007. Climate Change 2007, Synthesis Report, A report of the Intergovernmental Panel on Climate Change, WMO/UNEP.

JENNINGS, T., 2008. Adaptation to Climate Change in the UK: A Case Study of the Boscastle Harbour Flood Disaster. Paper presented to the 2008 Living with climate change: Are there limits to adaptation conference, London.

JONKMAN, S.N. AND KELMAN, I., 2005. An analysis of the causes and circumstances of flood disaster deaths. Disasters 29 (1), 75-97.

JONKMAN, S.N., 2003. Loss of life caused by floods: an overview of mortality statistics for worldwide floods. Available from: http://www.library.tudelft.nl/delftcluster/theme_risk.html [accessed December 2008]

JONKMAN, S.N., 2007. Loss of life estimation in flood risk assessment: theory and applications. PhD dissertation, Delft Cluster, Delft Netherlands.

KARVONEN, R.A., HEPOJOKI, A., HUHTA, H.K.AND LOUHIO, A., 2000. The use of physical models in dam-break analysis. RESCDAM Final Report, Helsinki University of Technology, Helsinki Finland. Available: http://www.ymparisto.fi/download.asp?contentid=13494&lan=fi

KATES, R.W., 1962. Hazard and choice perception in flood plain management. Research Paper No. 78. Chicago: Department of Geography, University of Chicago.

KELMAN, I. AND SPENCE, R., 2004. An overview of flood actions on buildings. Engineering Geology, 73, 297-309.

KETTERIDGE, A. AND FORDHAM, M., 1998. Flood Evacuation in Two Communities in Scotland: Lessons From European Research. International Journal of Mass Emergencies and Disasters 16(2):119-43.

KNOCKE, E. T., AND KOLIVRAS N. K., 2007. Flash Flood Awareness in Southwest Virginia. Risk Analysis 27(1):155-69.

KREIBICH, H., THIEKEN, A.H., PETROW, T.H., MULLER, M. AND MERZ, B., 2005. Flood loss reduction of private households due to building precautionary measures – lessons learned from the Elbe flood in August 2002. Natural Hazards and Earth Systems Sciences, 5, 117-126.

KUNDZEWICZ, Z.W. AND KUNDZEWICZ, W.J., 2005. Mortality in flood disasters. In Kirch, W., Menne, B. and Bartollini (eds.) Extreme weather events and public health responses. EU, WHO, Springer.

LAURIOLA, M., RUSSO, P.M., LUCIDI, F., VIOLANI, C., IRWIN, P., 2005. The role of personality in positively and negatively framed risky health decisions. Personality and Individual Differences 38, 45–59.

LEGOME, E., ROBBINS, A. AND RUND, D.A., 1995. Injuries associated with floods: The need for an international reporting scheme. Disasters, 19 (1), 50-54.

LESCURE M., 2004. Politique de gestion des inondations en France: L'exemple du Gard, application au bassin des Gardons. Actes des Journées Techniques/Risques Naturels: Inondation, Prévision, Protection /Batna, 15–16 Décembre 2004.

LINDELL, M. AND PERRY, R., 1992. Behavioural foundations of community emergency planning. Washington, Hemisphere Publishing Co.

LIU, S., QUENEMOEN, L., MALILAY, J., NOJI, E., SINKS, T. AND MENDLEIN, J., 1996. Assessment of a severe-weather warning system and disaster preparedness, Calhoun County, Alabama, 1994. Am. J. Public Health, 86 (1), 87-89.

LOPEZ-VAZQUEZ, E. AND MARVAN, M.L. , 2003. Risk perception, stress and coping strategies in two catastrophe risk situations, Social Behaviour and Personality, 31 (1), 61-70.

MACK, R.W. AND BAKER, G.W. , 1961. The occasion instant: the structure of social response to unanticipated air raid warnings, Disaster study No. 15. Washington DC, National Academy of Science-National Research Council, NRC Study Group.

MCCARTHY S., TURNSTALL, S., FAULKNER, H., PARKER, D., HOWE, J., 2007. Risk communication in emergency response to a simulated extreme flood. Environmental Hazards 7 (2007) 179–192.

MCEWAN, L., 2007. Community engagement with its flood risk, Final report to the Royal Society. Environment Agency internal website.

MILETI, D ET AL, 2006. Annotated bibliography for public risk communication on warnings for public protective actions response and public education, Revision 4, Natural Hazards Center, University of Colorado at Boulder.

MILETI, D., SORENSEN, J. AND O'BRIEN, J., 1992. Towards an explanation of mass care shelter use in evacuations. Int. J. Mass Emergencies and Disasters, 10 (1), 25-42.

MILETI, D., SORENSEN, J., 1990. Communication of emergency public warnings. ORNL-6609. Oak Ridge, Tennessee, Oak Ridge National Laboratory.

MOONEY, L.E. 1983. Applications and Implications of Fatality Statistics to the Flash Flood Problems. 127-129 in Proceedings of the 5th Conference on Hydrometeorology, Tulsa, Oklahoma, USA, 17-19 October, American Meteorology Society.

MORGAN, M.G., FISCHOFF, B., BOSTROM, A. AND ATMAN, C.J., 2002. Risk communication: a mental models approach. Cambridge: Cambridge University Press.

NATIONAL WEATHER SERVICE, 2005. National Weather Service Glossary. Available from http://www.nws.noaa.gov/qlossary/. (Accessed 1 M ay 2008).

NEAL, J., PARKER, D.J., AND TUNSTALL, S.M., 1989. Flood Warnings in the Severn-Trent Water Authority Area: An Investigation of Service, Effectiveness and Customer Satisfaction. Geography and Planning paper No.23. Enfield, Middlesex University.

NEW SOUTH WALES GOVERNMENT, 1986. Floodplain Development Manual, PWD 86010. Australia, Government of New South Wales.

NORTH NORFLOK DISTRICT COUNCIL, 2008. North Norfolk flood siren consultation report. North Norfolk District Council.

OWEN, H. J. AND WENDELL, M., 1981. Community handbook on flood warnings and preparedness programmes. US Army Corps of Engineers, Institute of Water Resources, Fort Belvoir, Virginia.

PARKER D. J., TUNSTALL, S. AND MCCARTHY S., 2007a. New insights into the benefits of flood warnings: Results from a household survey in England and Wales. Environmental Hazards 7, 193–210.

PARKER D., TAPSELL, S. AND MCCARTHY, S., 2007b. Enhancing the human benefits of flood warnings. Natural Hazards 43:397–414.

PARKER, D.J. AND BUDGEN, P., 1998. The tropical cyclone warning dissemination system in Mauritius, In UK National Coordination Committee for the International Decade for Natural Disaster Reduction, Forecasts and Warnings, Section 1. London, Thomas Telford.

PARKER, D.J. AND HAGGETT, C., 2001. The development of flood warning technologies in England and Wales, Paper presented at the International Emergency and Disaster Management Conference (TIEMS), Oslo, Norway, June.

PARKER, D.J. AND HANDMER, J., 1998. The Role of Unofficial Flood Warning Systems. Journal of Contingencies and Crisis Management. 6 (1), 45-60.

PARKER, D.J. AND NEAL, J., 1990. Evaluating the Performance of Flood Warning Systems. In HANDMER, J.W. AND PENNING-ROWSELL, E.C. (Eds.) Hazard and the Communication of Risk, Section 8, 137-156. Aldershot: Gower Technical Press.

PARKER, D.J., 2004. Designing flood forecasting, warning and response systems from a societal perspective. Meteorologische Zeitschrift, 13 (1), 5-11

PARKER, D.J., FORDHAM, M., PORTOU, J. AND TAPSELL, S.M., 1994. The Flood Risk in London, Research Report prepared for the Metropolitan Police Service. Middlesex University, Enfield, Flood Hazard Research Centre.

PARKER, D.J., PRIEST, S., SCHILDT, A., AND HANDMER, J., 2007a. Modelling the damage reducing effects of flood warnings. FLOODsite Report No. T11-07-08. Available from: www.floodsite.net

PARKER, D.J., TAPSELL, S.M. AND MCCARTHY, S., 2007b. Why warn? The human impacts of flood forecasting, warning and response systems, Natural Hazards. 43 (3), 397-414.

PARKER, D. J., TUNSTALL, S. M. and MCCARTHY S. 2007c. New insights into the benefits of flood warnings: Results from a household survey in England and Wales. Environmental Hazards 7: 193–210

PAUL, B.K., 1999. Flash Flooding in Kansas: A Study of Emergency Response and Victim's Perceptions. Boulder, Colo.: University of Colorado, Institute of Behavioral Science, Natural Hazards Research and Applications Information Center. Available from http://www.colorado.edu/hazards/research/qr/qr118.html (Accessed 1 M ay 2008).

PENNING-ROWSELL, E., GIBBS, J. AND TAPSELL, S., 2003. Human stability in flash floods. Internal FHRC report. Enfield, Flood Hazard Research Centre.

PENNING-ROWSELL, E.C., 1981. Non-structural approaches to flood control: floodplain land use regulation and flood warning schemes in England and Wales. Paper given at the Eleventh Congress of the International Commission on Irrigation and Drainage.

PENNING-ROWSELL, E.C., TAPSELL, S.M. AND WILSON, T., 2004. Some policy implications of the health effects of floods. Bratislava, Hungary, World Health Organisation Conference.

PENNING-ROWSELL, EC., FLOYD, P., RAMSBOTTOM, D., SURENDRAN, S. 2005. Estimating injury and loss of life in floods: a deterministic framework. Natural Hazards 36:43–64

PETERSEN, M.S., 2001. Impacts of flash floods. In GRUNTFEST, E. AND HANDMER, J.W., (ed.) 2001, Coping with flash floods. Dordrecht. Kluwer Academic Publisher

PETTS, J., HOMAN J., BREAKWELL, G. AND BARNETT, J., 2002. Understanding public perceptions of risk report of an Environment Agency Workshop. R&D Technical Report P5-040/TR1, Environment Agency.

PETTS, J., HORLICK-JONES, T., MURDOCK, G., HARGREAVES, D., MCLACHLAN, S., LOFSTEDT, R., 2001. The Social Amplification of Risk: The Media and the Public. Contract research report, 329/2001, HSE Books Sudbury.

PITT, M., 2007. Learning lessons from the 2007 floods: An independent review by Sir Michael Pitt. Cabinet Office, Ref: 284668/1207.

PITT, M.,2008. Learning lessons from the 2007 floods: An independent review by Sir Michael Pitt. Cabinet Office. Available: www.cabinetoffice.gov.uk/thepittreview (accessed 13th August 2008).
POOLE, J. AND HOGAN, D.E., 2007. Floods. In Hogan, D.E. and Burstein, J.L. Disaster Management. Section 19, 214-222.

PRIEST, S.J., WILSON, T., TAPSELL, S., PENNING-ROWSELL, E., VIAVATTENE, C. AND FERNANDEZ-BILBAO, A., 2007. Building a model to estimate Risk to Life for European flood events. Milestone report T10-07-10 for the Integrated Project FLOODsite

QUARANTELLI, E.L., 1982. People's Reactions to Emergency Warnings. Preliminary Paper No. 75. Columbus, Ohio: Ohio State University, Disaster Research Center. Available from http://dspace.udel.edu:8080/dspace/bitstream/19716/1118/1/ART170.pdf (Accessed 1 M ay 2008).

QUARANTELLI, E.L. 1984 Perceptions and reactions to emergency warnings of sudden hazards. Ekisticts, 309 (November-December).

QUARANTELLI, E.L., 1990. The Warning Process and Evacuation Behaviour: The Research Evidence. Preliminary Paper No. 148. Newark, Del.: University of Delaware, Disaster Research Center. Available from http://dspace.udel.edu:8080/dspace/bitstream/19716/520/3/PP148.pdf (Accessed 1 M ay 2008).

RISK AND POLICY ANALYSTS/FLOOD HAZARD RESEARCH CENTRE, 2004. The appraisal of human related/Intangible impacts of flooding. Report to DEFRA/EA R and D project 2005, DEFRA, London.

ROBERTSON, C., 2005. Flood Risk Communications: Why does the message fail to reach ethnic communities. Unpublished MSc Thesis. Bristol: Environment Agency.

ROOS, I.W., 2003. Damages to buildings. Delft Cluster. Available from: http://www.library.tudelft.nl/delftcluster/theme_risk.html [accessed December 2008]

ROWE, D., 2005. Boscastle 16 August 2004 – the day of the flood. Truran

RUIN, I. AND LUTOFF, C., 2004. Vulnerabilite face aux crues rapides et mobilites des population en temps de crise, La Houille Blanches. 6, 114-119.

RUIN, I., GAILLARD, J.C., AND LUTOFF,C., 2007. "How to Get There? Assessing Motorists' Flash Flood Risk Perception on Daily Itineraries." Environmental Hazards 7(3):235-44.

SCANLON, J. AND FRIZZELL, A., 1979. Old theories don't apply: implications of communications in crisis. Disasters, 3 (3), 315-19.

SCHMIDLIN, T.W. and P.S. KING. 1996. Cars and tornadoes: Where is the research? Bulletin of the American Meteorological Society 77:963-964.

SCHWARE, R. AND LIPPOLDT, P., 1982. An examination of community flood warning systems: are we providing the right assistance? Disasters, 6 (3), 195-201.

SHAW, J., CUDMORE, S., TURNER, D. AND COLLIER, D., 2005. Improving flood warning awareness in low probability and medium – high consequence flood zones. R&D Technical Report W5-024, Environment Agency.

SIME, J. D. 1997. Informative Flood Warnings: Occupant Response to Risk, Threat, and Loss of Place. Pp. 155-75 in Flood Warning: Issues and Practice in Total System Design, edited by John Handmer. Enfield, Middlesex, United Kingdom: Middlesex University, Flood Hazard Research Centre.

SIUDAK, M., 2001. Role of education in reducing flash flood effects. In GRUNTFEST, E. AND HANDMER, J.W., (ed.) 2001, Coping with flash floods. Dordrecht. Kluwer Academic Publisher

SLOVIC, P., 1993. Perceived risk, trust and democracy. Risk Analysis, 13, 675-682.

SORENSEN, J. AND MILETI, D., 1989. Warning and evacuation: answering some basic questions. Industrial Crisis Quarterly, 2 (3-4), 195-210.

SORENSEN, J.H., 2000. Hazard Warning Systems: Review of 20 Years of Progress. Natural Hazards Review, May 2000, 119-125.

STEINFUHRER, A. AND KUHLICKE, C., 2007. Social vulnerability and the 2002 flood, Country Report Germany (Mulde River), FLOODsite Report No. T11-07-08. Available at: www.floodsite.net

TAPSELL, S.M. 2000 Follow-up Study on the Health Effects of the 1998 Easter Flooding n Banbury and Kidlington. Report to the Environment Agency. FHRC. Middlesex University: Enfield.

TAPSELL, S.M., BURTON, R., PARKER, D.J. AND OAKES, S., 2004. The Social Performance of Flood Warning Communications Technologies, Technical Report W5C-016 to the Environment Agency, Enfield, Flood Hazard Research Centre.

TAPSELL, S.M., TUNSTALL, S.M. AND Wilson, T., 2003. Banbury and Kidlington Four Years After the Flood: An Examination of the Long-Term Health Effects of Flooding. Report to the Environment Agency, Enfield, Flood Hazard Research Centre.

TAPSELL, S.M., TUNSTALL, S.M., PENNING-ROWSELL, E.C. AND HANDMER, J., 1999. The Health Effects of the 1998 Easter Flooding in Banbury and Kidlington. Report to the Environment Agency, Thames Region, Enfield, Flood Hazard Research Centre.

THE GUARDIAN. 18 August 2004. A phenomenon that is difficult to forecast and impossible to prevent.

THE GUARDIAN. Man dies trying to save home. 22 August 2007.

THE GUARDIAN. Villagers clean up after flash floods. 21 June 2005.

THE INDEPENDENT. Storms, floods and sunshine: welcome to global warming. 21 June, 2005.

THE MIRROR. Severe storms bring more flooding. 20 July 2007.

THE WEATHER CHANNEL, 2008a. During a flash flood or flood. Available from: http://www.weather.com/ready/flood/during.html?from=safety_flooding [accessed 1 May 2008]

THE WEATHER CHANNEL, 2008b. Facts about flooding. Available from: http://www.weather.com/ready/flood/facts.html [accessed 1 May 2008]

THIEKEN, A.H., KREIBICH, H., MULLER, M. AND MERZ, B., 2007. Coping with floods: preparedness, response and recovery of flood-affected residents in Germany in 2002. Hydrological Sciences, 52, (5), October, 1016-1037.

THRUSH, D., BURNINGHAM, K., FIELDING, J., 2005. Flood warning for vulnerable groups: A qualitative study. R&D Technical Report W5C-018/3, Environment Agency.

TIMES ONLINE. How flash floods happen. 21 June 2005.

TORTEROTOT, J-P., 1993. Analyses of individual responses to flood warning and influence on damage in various regions of France. Euroflood Project Technical Annex for the flood forecasting and warning module, supplementary case study. Noisy-le-Grand, France, CERGRENE

TRETTIN, L. AND MUSHAM, C., 2000. Is trust a realistic goal of environmental risk communication? Environment and Behaviour, 31(1), 310-26.

TUNSTALL, S.M., PARKER, D.J., TWOMEY, G., DOIZY, A. & SANGSTER, E., 1991. The Severn Floods of January and February 1990, Report to the National Rivers Authority. Enfield: Flood Hazard Research Centre, Middlesex Polytechnic.

TUNSTALL, S.M., TAPSELL, S.M., and FERNANDEZ-BILBAO, A., 2005. The damage reducing effects of flood warnings: results from new data collection. Flood Hazard Research Centre, Middlesex University, London.

TVERSKY, A. AND KHANEMAN, D., 1973. Availability: a heuristic for judging frequency and probability. Cognitive Psychology, 5 (2), 207-232.

TWIGGER-ROSS, C., FERNÁNDEZ-BILBAO, A., TAPSELL, S., WALKER, G., WATSON, N., 2008 Improving Flood Warnings: Improving Institutional and Social Responses to Flooding. Unpublished draft final report Environment Agency Science Report – SC060019.

UN INTER-AGENCY SECRETARIAT OF THE INTERNATIONAL STRATEGY FOR DISASTER REDUCTION, 2001. Guidelines for Reducing Flood Losses, UN/ISDR.

UNDRO (United Nations Disaster Relief Organisation), 1984. Disaster prevention and mitigation. Geneva, UNDRO.

VAN DUIN, M.J. AND BEZUYEN, M.J., 2000. Flood evacuation during the floods of 1995 in the Netherlands. In Parker, D. J. (Ed) 2000 Floods. London, Routledge, 351-360.

VOGT, B. AND SORENSEN, J., 1992. Preparing EBS messages. ORNL/TM-12163. Oak Ridge, Tennessee, Oak Ridge National Laboratory.

WAGNER, K., 2007. "Mental Models of Flash Floods and Landslides." Risk Analysis, 27(3):671-82.

WALKER, G, BURNINGHAM, K., FIELDING, J., SMITH, G., THRUSH, D., and FAY, H. 2005 Addressing Environmental Inequalities: Flood Risk. Report to the Environment Agency. Environment Agency Science report ref: EA 144426.

WALLINGFORD, H.R., 2003. Flood Risks to People Phase 1. Final Report. Defra/Environment Agency Flood and Coastal Defence R&D Programme.

WALLINGFORD, H.R., 2005. The Flood Risk to People Methodology. R&D Outputs: Flood Risks to People, Phase 2. FD2321/TR1. Defra/ Environment Agency Flood and Coastal Defence R&D Programme.

WANG, X.T., 2006. Emotions within reason: resolving conflicts in risk preference. Cognition and Emotion 20, 1132–1152.

WATERSTONE, M., 1978. Hazard Mitigation Behaviour of Urban Flood Plain Residents. Working Paper No. 35. Boulder, Colo.: University of Colorado, Institute of Behavioral Science, Natural Hazards Research and Applications Information Center. Available from http://www.colorado.edu/hazards/publications/wp/wp35.pdf (Accessed 1 May 2008).

WEINSTEIN, N. D. 1980 Unrealistic optimism about future life events. Journal of personality and social psychology, 39;806 - 820.

WEINSTEIN, N.D. and KLEIN, W.M., 1995. Resistance of personal risk perceptions to debiasing interventions. Health Psychology, 14, 132-140.

WERRITY, A., HOUSTON, D., BALL, T., TAVENDALE, A. AND BLACK, A., 2007. Exploring the Social Impacts of Flood Risk and Flooding in Scotland, Scottish Executive Social Research. Edinburgh: Scottish Executive.

WILSON, T., 2006. Les risques des blessures et de décès par imprudence lors des inondations. Responsabilité and Environnement, 43, July 2006.

WOLGATER, M.S. AND SILVER, N.C., 1990. Arousal strength of warning signal words, Forensic Reports, 3, 407-420.

WORLD HEALTH ORGANIZATION EUROPE, 2002a. Flooding: Health effects and preventive measures, Fact sheet 05/02. Available from: http://www.euro.who.int/document/mediacentre/fs0502e.pdf [accessed December 2008]

WORLD HEALTH ORGANIZATION EUROPE, 2002b. Floods: climate change and adaptation strategies for human health. Report on a WHO meeting. London, UK, 30 June-2 July 2002. Available from: http://www.euro.who.int/document/E77096.pdf [accessed December 2008]

YEO, S. W., 2003. Flood risk management for caravan parks in New South Wales. Australian Geographer.

YORKSHIRE EVENING POST, Now it's time for the big clean up. 21 June 2005.

YORKSHIRE EVENING POST. After the deluge. 20 June 2005.

YORKSHIRE POST, A lesson in survival from an ex teacher, 89. 21 June 2005.

Appendix 1: Public focus group discussion guide

Polperro: Monday 7 July 2008
Hebden Bridge: Thursday 10 July 2008

Prioritised questions are shown in italics.

Background to this work

- Thank-you for attending. Introduction of Sue and Liza and our respective organisations. Explanation that we are both working on research for the Environment Agency, funded by the Environment Agency. However, the findings from the research will be reported independently.
- The Environment Agency works to reduce the risk and consequences of flooding. To do this, it works with local authorities, the emergency services and others to develop emergency plans and improve flood awareness.
- This research is investigating what people understand about flash floods, what words they would use to describe them and what actions they would take in the event of such a flood.
- The research will help the Environment Agency to improve awareness and responses to this type of flood event in the future in three main ways:
    1. Development of flood risk awareness messages. The Environment Agency tries to inform people of how to look for signs of severe flash flooding and what to do if it happens.

    2. Warnings and warning messages. The Environment Agency is trying to understand if it is possible to provide warnings for this type of flooding and how effective these would be.

    3. Emergency plans. The Environment Agency is working with local authorities in this project to examine the best rescue, recovery and emergency plans for this kind of event so that they can be better prepared in the future.

- If you are interested in any further information on the work or about flood risk generally we can provide details of how to get this at the end of the focus group.

Explanation of how the focus group will be run

- The focus group meeting will last up to two hours. We can have a five-minute comfort break in the middle if needed.
- The focus group will be recorded to assist with writing the report. However, in the report all comments will be anonymous and names of attendees are confidential.
- There are no 'right' answers to the questions. We are interested in hearing your views and experiences. People may have different views and experiences that are equally valid so if you disagree with what somebody else has said, this is OK.
- As we are taping the discussion we request that only one person speaks at a time.

- We would be very grateful if you would assist us by completing a short questionnaire about yourself the end of the focus group. This is designed to help us with the interpretation of the discussion.

[5 minutes]

Introductions of group

Before we make a start we would just like everyone to briefly introduce themselves with your name and where you live and to say briefly whether you have ever experienced a flash flood.

[5 minutes]

Existing understanding of flash floods and knowledge of potential impacts

- *What do you understand by the term 'flash flooding'?*
- What do you think causes this type of flooding?
- Do you know what the signs of this type of flooding could be?
- What do you think the impacts of this type of flooding could be?

[20 minutes]

Explanation of flash floods. The key characteristics of flash floods are:

- The short lead in time involved (usually defined as less than six hours).
- Caused by extremely heavy rainfall or dam failure.
- The large volume and velocity of water involved.
- The danger presented by debris.
- The potential to cause material damage and the urgent threat to life.

Including passing round some photos which show the impacts of recent flash floods.

Knowledge of actions

- *What actions, if any, would you take if you thought you and your property were at risk of flash flooding? Or what actions did you take if you have experienced a flash flood?*
- *What would be (or what were) your priorities in taking any actions?*
- *What do you think is the safest action to take if you are at risk?*
- Would you decide to evacuate yourself or would you wait until told to do so by the emergency services?
- Where would you get information from in the event of this type of flooding?
- What information would you need to know in order to take action?
- What might stop you taking action?
- What different things/factors might affect your behaviour and the actions you would take?
- How much time do you think you would need to evacuate yourself and your family/pets?

- For those of you who have experienced a flash flood, how might that experience influence how you would respond to another flood? Would it affect the actions you would take, and if so in what way?

[30 minutes]

Warnings

- *Are you aware of any of the existing Environment Agency flood warning systems? If so which?*
- Have you used any of these systems? If so which?
- Do you listen to the severe weather warnings issued by the Met Office, for example on the radio and television?
- If there was a flash flood how would you prefer to be warned?
- Would you prefer the warning to come from a local or a national source?
- How would you prefer to be warned if you were away from home, outdoors, at different times of day, if you have special needs?
- Do you trust the organisations who issue official flood warnings? Do you trust the Environment Agency?
- Who do you think is best placed to issue a warning?
- If you had a warning but you were not actually flooded, in other words a 'false warning', how would this affect your response to future warnings?
- Would you prefer to have a longer warning time (but where the likelihood of flooding was more uncertain)? Or would you prefer to have a shorter warning time where the likelihood was more certain? Do you look yourself for signs of flooding? If so which signs?
- Are you aware of any local knowledge about flooding that you may draw upon when watching for flood signs or in responding to a flash flood?

[30 minutes]

Awareness-raising

- What type of information would you need to better understand flash floods and be better prepared for flash flooding?
- How would you prefer to receive this information?
- Can you think of an example of a public information message (on anything - fire, for example) that has worked/been effective for you and your family?
- What sort of words/language/messages do you think would grab your attention about flash flooding?
- Word sort of words/language/messages would not grab your attention?
- What sort of information should be included in a warning message for flash flooding?
- Can you suggest what would be a good way for keeping awareness about risk of flash flooding in people's minds in this area?

[25 minutes]

- Any other questions/comments?
- Thanks.
- Complete brief questionnaire.

[5 minutes]

Appendix 2: Professional partners' focus group discussion guide

Tuesday 7 July 2008

*Prioritised questions are shown in italics**.***

Background to this work

- Thank-you for allowing us to use some of your valuable meeting time for this focus group. Introduction of Sue and Liza and our respective organisations. Explanation that we are both working on research for the Environment Agency, funded by the Environment Agency.
- As you know, the Environment Agency works to reduce the risk of flooding. To do this, it works with local authorities and people like yourselves to develop emergency plans and improve flood awareness.
- This research is investigating what the public understand about flash floods, what words they would use to describe them and what actions they would take in the event of such a flood. A further key part of the work is to explore the needs of professional partners when dealing with flash floods.
- The research will help the Environment Agency to improve awareness and responses to this type of flood event in the future in three main ways:
    1. Development of awareness messages. The Environment Agency tries to inform people of how to look for signs of severe flash flooding and what to do if it happens.
    2. Warnings and warning messages. The Environment Agency is trying to understand if it is possible to provide warnings for this type of flooding and how effective these would be.
    3. Emergency plans. The Environment Agency is working with local authorities in this project so it can examining the best rescue, recovery and emergency plans for this kind of event so that they are better prepared in the future.

Explanation of how the focus group will be run

- The focus group meeting will last up to two hours. We can have a five-minute comfort break in the middle if needed.
- The focus group will be recorded to assist with writing the report. However, in the report all comments will be anonymous and names of attendees are confidential.
- There are no 'right' answers to the questions. We are interested in hearing your views and experiences. People may have different views and experiences that are equally valid so if you disagree with what somebody else has said, this is OK.
- As we are taping the discussion we request that only one person speaks at a time.
- We would be very grateful if you would assist us by completing a short questionnaire about yourself the end of the focus group. This is designed to help us with the interpretation of the discussion.

[5 minutes]

Introductions of group

Before we make a start we would just like everyone to briefly introduce themselves with your name, organisation and role within the organisation. Could you also say whether you have personal experience of dealing with a flash flood situation.

[5 minutes]

Existing understanding of flash floods and knowledge of potential impacts

- What do you understand by the term 'flash flooding'?
- What do you think are the causes of this type of flooding?
- Do you know what the signs of this type of flooding could be?

Explanation of flash floods. The key characteristics of flash floods are:

- The short lead in time involved (usually defined as less than six hours).
- Caused by extremely heavy rainfall or dam failure.
- The large volume and velocity of water involved.
- The danger presented by debris.
- The potential to cause material damage and the urgent threat to life.

Including passing round some photos which show the impacts of recent flash floods.

[20 minutes]

Warning the public about the threat of flash flood

- What do you think is the most effective way of warning the public that this type of flood may be about to occur?
- What or who do you think is the most credible source of a warning?
- Are you aware of any available local networks that can be used to disseminate warnings?
- How much time do professional partners require to disseminate warnings to the public? How might this change in different situations? What would be the minimum length of time needed?
- What do you think the impact of issuing false warnings is on public behaviour in response to future warnings? In your opinion, does it affect how they respond to future warnings?

[25 minutes]

Warning organisations about the threat of flash flood

- What type of warning information does your organisation need to respond to the threat of an imminent flash flood?
- By which method and channels can it receive this information most effectively?
- How certain does the threat of flash flooding need to be before organisational emergency plans are put into place?

- Would your organisation prefer to receive an earlier warning with a higher degree of uncertainty or be warned later when the threat is more certain?
- Is closing roads when there is a threat of a flash flood a viable option? If so, in what sort of situation/location?
- How certain would the flash flood need to be before this action could be taken?
- What other responses/actions by emergency responders would be appropriate or effective in such a situation?
- What do you think the impact of issuing false warnings is on organisational response to future warnings?

[25 minutes]

Responding to flash floods

- What types of action do you think the public should take to stay safe during a flash flood?
- How effectively do existing emergency plans provide for flash floods?
- Communication between agencies during the emergency response phase to flash floods has proved very challenging. How do organisations communicate with each other and with the public during a response to a flash flood?
- How could this be improved?
- What special arrangements, if any, are made for tourists or other visitors to an area?
- 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?

[25 minutes]

Increasing public awareness of flash flooding

- What type of messages do you think would be most effective at raising the public's awareness of flash floods and how to respond effectively?
- Do professional partners currently undertake awareness-raising activities for flash floods? If so what and how effective are they?
- Can you suggest any local networks that could help undertake awareness-raising activities?

[10 minutes]

- Any other questions/comments?
- Thanks.
- Complete brief questionnaire.

[5 minutes]

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