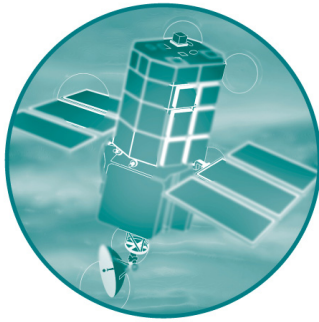


# Defra/Environment Agency Flood and Coastal Defence R&D Programme



## Guide to the Management of Floodplains to Reduce Flood Risks

Stage 1: Development Draft

R&D Technical Report FD2010/TR



**Defra/Environment Agency  
Flood and Coastal Defence R&D Programme**

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**Statement of use**

This technical report contains the results of Stage 1 of a study to raise awareness of floodplain management issues and provide guidance on floodplain management to reduce flood risks. The study is aimed at all those who have an interest in floodplains including flood-prone communities, land use planners, river and coast managers, emergency planners and the emergency services.

- Keywords – Flooding, Floodplains, Management, Emergency, Land use, Planning.

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# EXECUTIVE SUMMARY

## Background

Floodplains are areas of special concern because they are often highly developed but they are at risk of suffering from a severe natural hazard (i.e. flooding).

However the management of floodplains and the associated flood risks is fragmented and not carried out as a single co-ordinated activity:

- Development of floodplains is carried out within the framework of the statutory planning system which is the responsibility of local planning authorities;
- Flood defence and other flood management activities are carried out by “operating authorities”, principally the Environment Agency but also Internal Drainage Boards (in drainage districts) and local authorities (Ordinary Watercourses and coasts). Powers for flood defence are permissive and not statutory;
- The response to flood emergencies is led by the police but also involves the Environment Agency, local authorities and the emergency services;
- Flood-prone communities have no formal ownership of any of the above activities although they are able to consult on land use planning. They are also provided with information on flood warning by the Environment Agency and on flood emergency arrangements by some local authorities.

## Purpose

The purpose of this guide is to raise awareness of floodplain management issues, and provide guidance on floodplain management to reduce flood risks within the present legislative context for land use planning and flood management. The proposed approach includes:

- Raising the awareness and involvement of the public and other stakeholders in flood risks and floodplain management;
- Guidance on how to take account of flood risks on floodplains within the statutory land use planning system. Some local authorities already take flooding into account in preparation of land use plans;
- Guidance on the outputs required from Shoreline Management Plans, Catchment Management Plans and associated Strategy Plans for floodplain planning purposes;
- Guidance on how to prepare Flood Emergency Plans within the overall emergency planning framework. Examples of these already exist in the UK.

## Status of the document

This document is the output of an initial Stage 1 study. It will be applied in pilot areas under Stage 2 of the project to refine the guidance and produce recommended procedures for floodplain management.

## Background to the document

The document has been commissioned by Defra and the Environment Agency under their national research and development programme for flood defence and management. The programme is run under six themes, as follows:

- Policy Development
- Processes
- Broad scale modelling
- Flood forecasting and warning

- Engineering
- Risk and uncertainty.

This document was commissioned under the Policy Development Theme.

### Target audience

The target audience includes all those who have an interest in floodplains including flood-prone communities, planners, river and coast managers and the emergency services. In order to facilitate the use of the guide by stakeholders, specific “stakeholder information sheets” are included in the guide for the following groups:

- Those who live and/or work on floodplains
- Farmers and other landowners who own land in flood risk areas
- Land use planners
- River and coast managers (Environment Agency, Local Authority engineers, IDBs)
- Emergency services
- Those involved with conservation and environmental enhancement
- Those who have assets on floodplains (transport, utilities)
- Business interests (developers, insurance)
- General information for the general public who use floodplains, the media, politicians, etc.

The guidance will initially be targeted at local authorities with the greatest flood risk problems. These will be selected based on the number of properties at risk and the current status of floodplain management and flood emergency planning.

### Acknowledgements

This guide has been based on Floodplain Management in Australia, Best Practice Principles and Guidelines, SCARM Report 73, 2000. Permission by the Agriculture and Resource Management Council of Australia and New Zealand to use the report as a basis for this document, and to use some specific items of information is gratefully acknowledged.

The Australian report recommends the development of Floodplain Management Plans and the formation of Floodplain Advisory Committees. These are not considered to be appropriate in the UK, where there is already a sophisticated planning framework and groups already in place that could oversee floodplain management.

This document has been prepared in consultation with a number of organisations including Defra, the Environment Agency and some local authorities. In particular, contributions by the following are gratefully acknowledged:

Jonathan Chapman	Environment Agency
Dave Crowson	Environment Agency
Lindsay Frost	Lewes District Council
Jim Pithouse	Worcester City Council
Andy Walford	Worcester City Council

# **SUMMARY OF BEST PRACTICE PRINCIPLES FOR THE MANAGEMENT OF FLOODPLAINS TO REDUCE FLOOD RISKS**

The management of floodplains to reduce flood risks includes:

- Definition of the flood problem
- Raising the awareness and involvement of the public and other stakeholders of flooding and flood risk management
- Land use planning including the integration of outputs from flood management plans (SMPs, CFMPs and Strategy Plans)
- Flood emergency planning.

## **1 Proactive approach**

There is a need to prepare and plan ahead in floodplain management, and not be reactive.

## **2 Community expectations**

Communities want to:

- Live and work on floodplains
- Know that adequate arrangements exist for managing floods
- Be involved in floodplain management where appropriate.

## **3 Integration of policies and plans**

Floodplain management is concerned both with land use planning and flood management planning.

There is a need to ensure that floodplain management complies with the relevant policies on flood management set out in the Defra High Level Targets, and policies on development and flood risk set out in ODPM's Planning Policy Guidance Note 25 (PPG25).

There is also a need to ensure that floodplain management can be implemented within the existing planning framework. This includes:

- Structure, Local and Unitary Development Plans, which are statutory land use plans
- Flood management plans for coasts and river catchments including Shoreline Management Plans (SMPs), Catchment Flood Management Plans (CFMPs) and their associated Strategy Plans.

## **4 Identification of flood problem**

The steps needed to define the flood problem are as follows:

- Definition of the defined flood events to be used for flood management, including flood mapping and flood mitigation. These are generally the floods with a 1 in 100 annual probability of occurrence in non-tidal areas and a 1 in 200 annual probability of occurrence in tidal areas;
- Define flood management functions of parts of the floodplain, including flood flow paths and storage areas.

### Existing flood problem

- Define flood risk areas and assets at risk for existing conditions using flood maps.

### Future flood problem

- Identify likely future development in flood risk areas
- Consider future floodplains and assets at risk as a result of changes in flood risk caused by climate change, land use change and other possible changes in the coast or catchment.

### Residual flood problem

- Consider the impact of floods which exceed the defined flood events. The 1 in 1000 annual probability flood is being mapped to assist with this step.

## **5 Risk awareness**

The Public should be aware of the flood risk, and education and awareness raising is needed to achieve this objective. There also needs to be agreed terminology, appropriate documentation, and methods of communication. This should include the distribution of stakeholder sheets which are aimed at giving specific advice to each stakeholder group. Proposed stakeholder sheets are contained in this Guide.

The public should be made aware of floodplain management and flood emergency plans, particularly those who live and work in flood risk areas.

## **6 Flood risk management and land use planning**

Land use planning for floodplains should provide an integrated approach which aims to achieve the best compromise between the many and often conflicting demands on floodplains. Account should be taken of existing development, future development and other land uses, and flood management measures.

Information should be included in statutory plans in order to take account of flood risks on floodplains. In particular, the following should be clearly identifiable in land use plans:

- Extent of floodplains
- Floodplain management policies which take account of flood management policies, from CFMPs and SMPs
- Proposed flood management measures, from coastal and river Strategy Plans.

Flood management measures include structural measures (for example, embankments, walls, diversion channels, etc.) and non-structural measures (for example, flood plain zoning, flood forecasting and warning, etc.). Flood risk management will include a combination of different measures to meet the needs of all parts of the floodplains.

The management of floodplains should be co-ordinated by the planning function of local authorities but in close liaison with the Environment Agency. Advisory committees are recommended to review plans and check that flood risk management is fully taken into account. These should be based as far as possible on existing groups, for example Coastal Defence Groups who are involved with the production and implementation of SMPs.



## **7 Outputs from flood management plans**

In order to ensure that appropriate information is delivered by flood management plans for use in local planning, outputs needed from SMPs, CFMPs and associated Strategy Plans should include:

- Present and future flood risk areas on a GIS layer
- A statement of flood management policies for each section of the floodplain
- A summary of proposed flood management measures together with a GIS based map showing the location and extent of the measures.

In many areas, some of these plans will not be available for some time. In such cases, information must be obtained from alternative sources.

## **8 Flood Emergency Plan**

Flood Emergency Plans should be developed for all significant settlements at risk from flooding. A Flood Emergency Plan is an inter-Agency plan for flood warning, preparing for floods, responding to flood emergencies, and flood recovery. It should provide clear guidance for local authorities and emergency services, and members of the public who are directly affected by floods.

The Flood Emergency Plan should be developed and co-ordinated by Unitary Authorities in areas where they exist, or County Councils and/or local authorities in other areas depending on local circumstances. They should link with other relevant plans including County Emergency Plans and the Environment Agency's Local Flood Warning Plans.

## **9 Land use**

Land use planning and development control should link land use to the degree of flood risk and the floodplain function, for example flood flow paths and storage areas. PPG25 provides guidance on land use and degree of flood risk. In addition, any development or land use in flood flow paths must not impede flood flow, and any development in flood storage areas must not reduce overall flood storage.

It is important to distinguish between defended and undefended parts of the floodplains. Defended areas generally have a higher standard of protection but are liable to sudden and very hazardous flooding if defences overtop or fail.

## **10 Implications for buildings and infrastructure**

Land use planning and development control should take account of the impacts of flooding on infrastructure. In particular, infrastructure on floodplains including transport links and utilities should be designed to:

- Minimise effects of flooding on the operation and safety of infrastructure
- Minimise the effects of infrastructure on flood risks elsewhere
- Minimise the effects of floods on essential services
- Facilitate emergency response, evacuation and recovery.

Consideration should be given to flood proofing and local protection (for example, temporary flood barriers) for new and existing buildings. Building codes should be modified to take account of flood proofing of both new and existing buildings, although this cannot be done until the suitability of materials and techniques has been adequately demonstrated.

## **11 Performance indicators and data collection**

Data are needed to improve the understanding of flood behaviour and flood risk, which in turn will lead to more effective floodplain management and flood emergency plans.

Performance indicators are needed to assess the success of floodplain management, and may include such indicators as number of properties provided with a certain standard of protection, and number of properties or communities with a flood forecasting and warning system.

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# 1. INTRODUCTION

## 1.1 Flooding and floodplains

### What are floodplains?

Floodplains are the areas adjacent to rivers and coasts which flood during periods of heavy rain and high river flows, or severe sea conditions. Flooding is a natural process but the development of land in floodplains has resulted in a risk of flooding to properties and other assets.

### Floodplains on rivers

The natural function of floodplains on rivers is to store flood water and also permit the passage of floodwater downstream. Developments in the floodplain are clearly at risk of flooding. In addition they can reduce flood storage, thereby causing more flood water to pass downstream, and impede the flow of floodwater, thereby raising flood levels upstream.

The channelisation of some rivers and construction of flood defences has changed the natural regime and the level of flood risk in adjacent floodplains. Whilst the risk of flooding may have been reduced in these areas it has not been eliminated.

### Floodplains on the coast

The natural function of floodplains on the coast is to provide a buffer between the sea and the land during periods of extreme bad weather where sea levels may be high and waves conditions severe.

The construction of flood defences on the coasts has resulted in very large areas of land protected from the sea, but the defences form a hard barrier which constantly requires maintenance and repair as a result of attack by the sea.

### Floodplain definition

The exact definition of the floodplain is based on the magnitude of particular flood events (the “defined flood events”). In the UK a flood with a 1 in 100 chance of occurring in any year is used for rivers in non-tidal areas, and a flood with a 1 in 200 chance of occurring in any year in tidal areas including the coast. However, larger floods than these can occur, and plans are in hand to identify the floodplain for the estimated flood with a 1 in 1000 chance of occurring in any year.

### Standard of protection against flooding

In general it is not economically or practically feasible to provide complete flood protection. Defined flood events (for example, the flood with a 1 in 100 chance of occurring in any year) are adopted for planning and development purposes. This represents a compromise between the level of protection we can afford and the risk we are prepared to take with the consequences of larger floods.

### Defended and undefended floodplains

Floodplains can be divided into two types: those which have flood defences and those which do not. Flooding on floodplains which are not protected occurs relatively slowly as the river or sea level rises. However flooding in protected areas tends to occur very rapidly as defences are overtopped and/or fail.

## Floodplains in the UK

The approximate distribution of floodplains in the UK is shown on Figure 1. Whilst Figure 1 indicates the major floodplains, there are many smaller flood risk areas as outlined in Section 1.2 where the floodplain extent is not recorded.

This guide is concerned with all floodplains whatever the cause of flooding.

### **1.2 Causes of flooding**

Flooding can occur from a range of sources, either independently or in combination. Each type of flooding has different characteristics, and different responses may be needed for different cases. Causes of flooding include the following:

- **Tidal flooding**, where high tidal water levels cause inundation of land on coasts and estuaries, and overtopping/failure of flood defences;
- **Waves**, which cause overtopping and damage to coastal structures, and can exacerbate the impacts of tidal flooding;
- **“Fluvial” or river flooding**, where high river water levels cause inundation of land adjacent to rivers and overtopping/failure of flood defences;
- **Wind set-up**, where high winds cause local increases in water level and exacerbate tidal and fluvial flooding;
- **Blockages of structures and screens**, where debris accumulates on bridges, culverts and other structures, reducing their effectiveness and increasing flood levels;
- **Local drainage** flooding, where the capacity of drainage systems is exceeded by storm runoff. This includes urban drainage systems, where floodwater in areas drained by combined sewers is often polluted by foul sewage;
- Other sources including rising groundwater in wet periods (especially in chalk catchments), overland flow, etc.

Flooding on the coasts tends to occur in very severe weather conditions, and can be very sudden if defences overtop or fail.

The time taken for a flood to rise varies, from days on a large river such as the Severn to less than two hours on a minor watercourse. Thus the amount of warning time for flooding on rivers varies depending on the size of river. “Flash” flooding in small urban catchments can occur very suddenly. Flooding can also occur very suddenly if defences overtop or fail.

Flooding from local drainage and other sources tends to be localised in extent but can be very traumatic for those affected because it is often completely unexpected.

### **1.3 Characteristics of flooding and impacts on land use planning**

#### **River flooding**

The depth of water on the floodplains of rivers and the extent of the floodplain is directly related to the quantity of water in the flood and the ability of the river and floodplains downstream to convey floodwater. If the characteristics of the system are altered by development and/or defences, the volume of water does not alter for any particular event. Instead, the flow patterns and flooded extents will change to ensure that the volume of floodwater is able to pass downstream.

This can cause flooding in areas hitherto not expected to flood, both upstream and downstream of the development. For example, if development and/or flood defences reduce the area of the floodplain at a particular location, the water that would have been stored on the floodplain will pass downstream resulting in an increased downstream flow and associated flood risk. The development and/or flood defences may also constrict the flow area available for floodwater, and this can increase the flood level upstream.

In addition, it is expected that flood flows will increase in magnitude and frequency in the future as a result of climate change. Thus the effects of developments and/or flood defences on flood risk elsewhere is likely to increase in the future.

When undertaking developments and other works on river floodplains, mitigation works should also be undertaken to prevent increases in flood risk elsewhere. These works should be as sustainable as possible. For example, the removal of floodplain obstructions to prevent an increase in flood risk is preferable to the construction of new defences for the areas where the flood risk is increased.

The more that floodplains on a particular river are developed and defended, the greater the risk of flooding elsewhere will be. In addition, constriction of the floodplain by development will raise flood levels in the river, necessitating more or bigger flood defences. In the long term, there is a limit to the extent that floodplains can be developed because the cost of providing defences becomes greater than the benefits achieved as a result of these cumulative impacts.

Planners should therefore be aware that floodplain developments on rivers can increase flood risk upstream and downstream of the development. Planners should also be aware of the cumulative impacts of floodplain development on rivers.

#### **Coastal flooding**

For flooding from the sea, the mechanisms are different to those of river flooding as the source of the floodwater is from the sea, which is effectively an infinite volume of water. The floodplain is where the water flows when the sea ‘overflows’ onto the land. The amount of flooding depends on the water level that the sea reaches during a particular high tide. Sea defences prevent overflow (or reduce the amount of the overflow during a high tide that exceeds the level of the defences), thus reducing the size of the area at risk from flooding. However, if flood defences are breached the amount of overflow increases.

The actual inundation depth is dependent on the distance from the sea, the hydraulic characteristics of the flow paths and the height of the event causing the flood. Planners should therefore be aware that developments near flood defences are at risk from rapid and

deep flooding if defences are overtopped or fail. The further that developments are away from the flood defences, the less the flood hazard will be. In addition, overtopping of defences by waves increases the hazard to developments near flood defences.

Furthermore, sea levels are rising as a result of climate change and the risk of flooding of areas behind coastal defences will increase unless the defences are improved.

Planners should therefore be aware of the hazards associated with coastal flooding, particularly where developments are proposed near to flood defences. The long-term sustainability of defended areas must also be considered bearing in mind the need to maintain the defences and the impacts of climate change.

#### **1.4 Floodplains – a national asset**

Floodplains have always been used for human activity as the social, economic and environmental benefits have outweighed the risk of periodic flooding. Reasons for using floodplains include:

- Relatively flat land, suitable for development;
- Access to water for water supply, waste disposal, water power and river transport;
- Transport corridors for roads, canals and railways;
- River crossing points;
- Good quality agricultural land.

As a result, floodplains are used for existing settlements, new developments, agriculture, and transport links. In addition, floodplains provide amenity and recreation areas, many of which are important for the local tourist industry.

Floodplains also have important natural functions where the combination of land and water including wetlands provides important habitats for a wide range of species. Floods have an important function in the dynamics of ecosystems, much of which has been lost by floodplain development.

Floodplains form an essential component of both riverine and coastal systems, not only for flood management but also biodiversity. In order to manage floodplains most effectively an integrated approach is needed, which takes account of flood management and the needs of communities and the natural environment.

#### **1.5 Floodplains – a national cost**

The capital value of assets potentially at risk in the floodplains of England is well in excess of £200 billion. If there were no flood defences, the Annual Average Damages (AAD) are estimated to be about £2.8 billion.

The actual Annual Average Damages in England are estimated to be about £0.6 billion, the difference between this figure and the total AAD being the effect of the many flood defences on rivers and coasts. About £200 million per year is currently spent on flood defences although this figure is not sufficient to maintain the present standards of defence.



Assets at risk of flooding or coastal erosion in England include:

- over 1.7 million residential properties
- approximately 130,000 commercial properties
- approximately 1.3 million hectares of agricultural land including 61% (218,000 ha) of Grade 1 land.

It is estimated that between 4 and 5 million people (about 10% of the population) could potentially be directly affected by flooding, and many more who use transport links which cross floodplains or work in businesses which are affected when flooding occurs. (All figures from MAFF 2001b).

Thus there is a huge national cost associated with the use of floodplains and this is likely to increase as floodplain development continues and the impacts of climate change become more apparent. An important challenge of floodplain management is to manage floodplains in such a way so that the costs are manageable and a more sustainable environment is created.

## **1.6 Objectives of floodplain management**

The purpose of floodplain management is to manage the wide range of uses and demands on floodplains in the most effective way. There are many stakeholders who have an interest in the way that floodplains are managed. These include:

- Resident
- Businesses
- Those who use floodplains for amenity and leisure
- Land use planners
- Managers of rivers and coasts
- Conservation organisations
- Those involved in planning for flood emergencies and emergency response.

An integrated approach is needed where the interests of these and other stakeholders are taken into account. This includes the resolution of conflicts between, for example, development and conservation.

The objectives of floodplain management are to:

- Limit to acceptable levels the effect of flooding on the well being, health and safety of flood-prone individuals and communities
- Limit to acceptable levels the damage caused by flooding to property and other assets
- Ensure that the natural function of the floodplain (to convey and store floodwater) is preserved together with flood dependent ecosystems
- Encourage the planning and use of floodplains as a valuable and sustainable resource capable of multiple but compatible land uses to the benefit of the community.

All the above objectives must take account of both existing and future conditions, including the impacts of climate change.

In addition:

- Stakeholders must be aware of how floodplains are managed and be able to contribute to it
- Floodplain management must be integrated with catchment and shoreline management, and urban drainage
- There must be integration between all agencies involved in floodplain management.

### **1.7 Floodplain management – a planning process**

The planning of land use and the control of development is the responsibility of local planning authorities, including the planning of land use in floodplains. Considerations which must be taken into account in floodplain land use and development planning include:

- The needs for local development including residential, commercial and amenity land uses
- The availability of suitable sites
- Local infrastructure including the ability of existing infrastructure to service future growth and the need for new infrastructure
- The natural resources of the floodplain
- The desired uses of the floodplain by the local community
- The risk of flooding, and the management of flood risks including flood alleviation infrastructure
- How to deal with flood emergencies.

If floodplain management is to be successful, it needs to be integrated with the land use planning process. An appropriate planning horizon is also needed to ensure that floodplain management forms part of a consistent long-term development strategy.

The requirements for floodplain management must therefore be included in statutory land use plans and related guidance on development control. These plans must include flood management policies and measures from flood management plans. This should embody the community's considered opinion on how best to manage floodplains for the benefit of present and future generations.

### **1.8 Responsibilities for floodplain management**

There are a number of agencies who are involved in floodplain management including the following:

- Local Authorities, who have general responsibilities within local communities including planning. They are also responsible for some coastal defences and Ordinary Watercourses in their district, and have an important role in flood emergency planning and response;
- The Environment Agency, who has a general supervisory duty for flood defences matters and specific responsibilities for some coastal and river defences, Main Rivers and flood warning;
- Internal Drainage Boards, who are responsible for watercourses in their drainage districts;
- Water Companies, who are responsible for stormwater drainage systems.

The definitions of Main River and Ordinary Watercourse are given in the glossary.

The Environment Agency, Internal Drainage Boards and Local Authorities all have responsibilities for different watercourses. They are generally referred to as “operating authorities”.

There are thus four different types of organisation with flood management responsibilities. A single local agency should be responsible for floodplain management. In general it is recommended that this should be local planning authorities as they are:

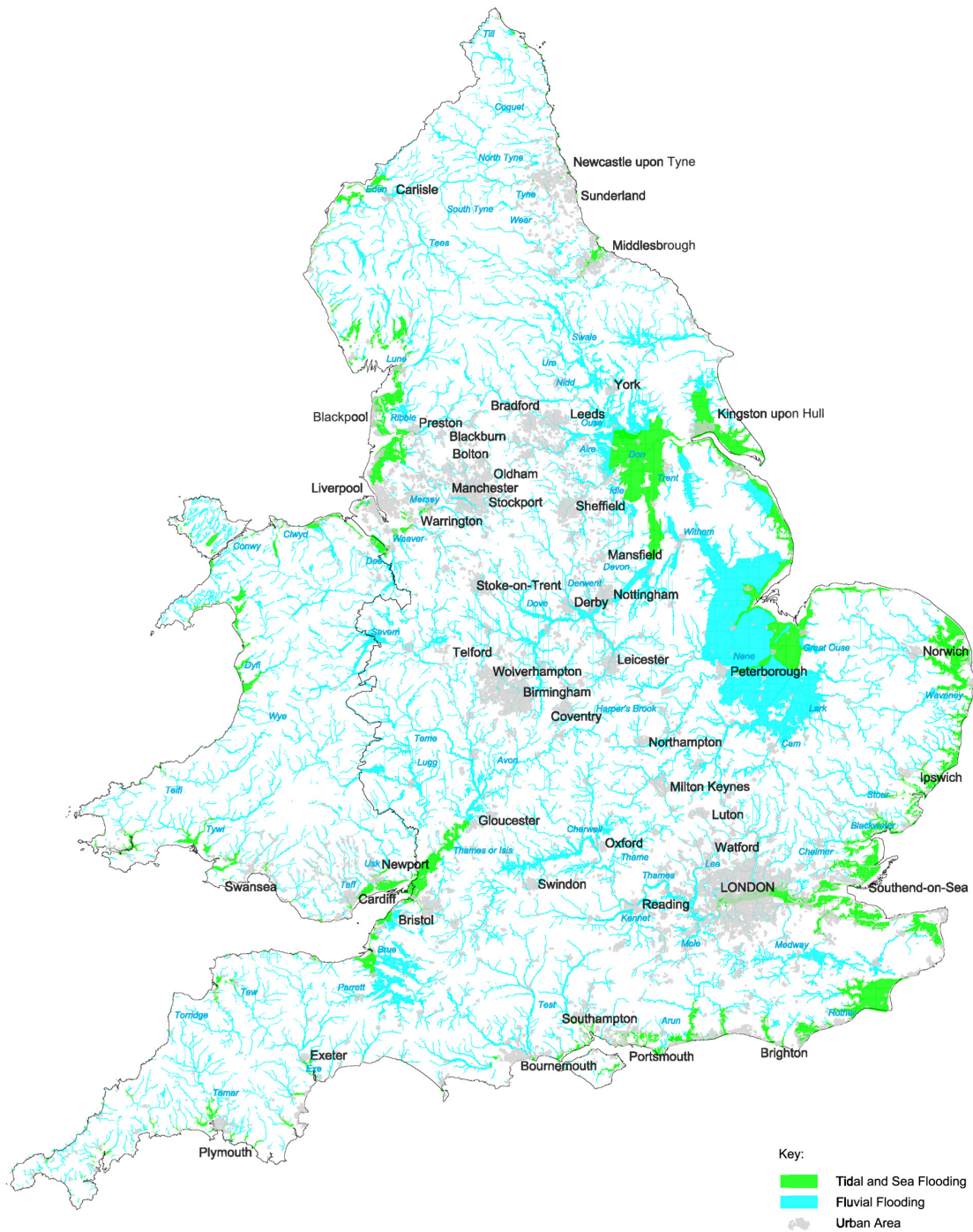
- In the best position to determine local community requirements
- Responsible for local land use planning
- Able to mobilise resources of labour, materials and equipment to respond to flood emergencies.

### **1.9 A brief history of floodplain management**

Development has always taken place on floodplains although early towns and settlements tended to be on elevated land adjacent to floodplains. The massive urban expansion of the industrial revolution resulted in extensive floodplain development together with engineering works on rivers designed to contain floodwater and minimise flood risk. This trend has continued into the 20<sup>th</sup> century.

In rural areas there have been considerable drainage works on the floodplains of major rivers including the Severn, the Trent and rivers in East Anglia to provide additional high quality agricultural land. In these areas the rivers are contained between embankments and have in some cases been engineered to increase conveyance capacity.

In the last twenty years there have been considerable changes in environmental awareness and a realisation that the provision of engineering works alone is not a sustainable solution to flood management. The importance of an integrated approach to floodplain management has become apparent which involves a greater appreciation of the natural function of rivers, captured in the publication *Learning to live with rivers* (ICE, 2001).



**Figure 1.1 Flood risk areas in England and Wales**  
 (Courtesy: Environment Agency and Jeremy Benn Associates)

## 2. AN INTEGRATED APPROACH TO FLOODPLAIN MANAGEMENT

### 2.1 Introduction

An integrated approach to land use planning and development on floodplains is required to bring together the diverse issues and many stakeholders affected by floodplain management. This requires integration of policies and plans, floodplain management measures, and the roles and responsibilities of the organisations involved. The end products of this process will be statutory land use plans that take account of floodplain management and a flood emergency plan, which together provide an approach to achieving the objectives set out in Section 1.5 above.

### 2.2 Need to integrate policy and plans

The key policies which need to be considered in floodplain management are:

- Defra's aims and objectives and associated *High Level Targets for Flood and Coastal Defence* (MAFF, now Defra, 1999a);
- ODPM's Planning Policy Guidance (PPG), particularly PPG25 on *Development and Flood Risk* (DTLR, now ODPM, 2001a);
- ODPM's Regional Planning Guidance, for each Region of the country.

Both Defra's and ODPM's policies support the need for controlling development on floodplains and provide a supportive basis for floodplain management.

Local land use planning is implemented through Structure Plans, Unitary Development Plans and Local Plans, although this system is under review.

The current high level flood management plans being developed for rivers and coasts are the Shoreline Management Plans (SMPs) and Catchment Flood Management Plans (CFMPs). Both of these plans aim to identify preferred policies and associated measures to reduce flood risks. Examples of policies are to "hold the line" or "advance the line" on coasts, or provide strategic flood storage on rivers.

Having identified the preferred policy, Strategy Plans are developed for sub-divisions of the river catchment or coastal cell which identify appropriate schemes to implement the policies. Individual schemes are then developed and implemented. This includes the provision of flood warning, particularly for areas that cannot be defended effectively.

There is a need to ensure that SMPs, CFMPs and the associated Strategy Plans are linked with statutory land use plans to ensure that floodplain management measures are taken into account in local planning. This documents aims to provide guidance to achieve this objective.

In addition, it is recommended that flood emergency plans should be prepared for all significant settlements at risk from flooding. Such plans have already been successfully implemented by some County and local authorities. These should be integrated with generic emergency plans where appropriate.

There is also a need to consider other sources of flooding in planning which are not covered by the plans referred to above. These include flooding from small watercourses and drainage ditches, and urban drainage systems.

### **2.3 Integration of floodplain management measures**

There are a wide range of possible measures for managing floods. These are summarised in Section 3.4.4 and covered in Appendix A. They cover such items as structural measures (for example, flood protection embankments and walls), non-structural measures (for example, flood warning and flood emergency measures), land use planning, development control and building control (for example, flood proofing of buildings).

The important point is to made here is that an integrated approach is needed involving an appropriate combination of measures to achieve the objectives of floodplain management. Part of this integrated approach should be to include policies from high-level flood management plans (CFMPs and SMPs), where they exist, and flood management measures from associated coast and river Strategy Plans in land use plans.

### **2.4 Integration of roles and responsibilities**

A summary list of key stakeholders in floodplain management is given in Section 1.5. The roles and responsibilities of these stakeholders are covered in Chapter 4. There is a clear need to ensure that the activities of these and other stakeholders are integrated into the management of flood risks and flood emergencies to provide a co-ordinated approach which makes best use of resources.

The most effective way to ensure integration of stakeholder roles is to involve them in the development of statutory land use plans that take account of the management of flood risk, and Flood Emergency Plans.

### **2.5 Integration of the management of flood risks and flood emergency planning**

It is envisaged that statutory land use plans will take account of flood risk in land use planning, and include appropriate policies for the control of development in flood risk areas. It is also envisaged that Flood Emergency Plans will be developed for significant settlements at risk from flooding. These plans should be complementary.

Statutory land use plans should address issues related to land use and the associated flood risk, including flood management measures (see Appendix D).

The Flood Emergency Plan is intended to provide a structured response to a flood emergency in order to minimise the impacts of the flood. It includes flood warning, preparedness, response, evacuation, clean up and flood recovery (see Appendix E).

There is a need to ensure that plans are compatible, for example statutory land use plans must take account of the requirement for emergency access during flood events. Co-operation and liaison between Local Authorities, the Environment Agency and the emergency services is needed in the preparation of both types of plan.

The floodplain currently defined in land use plans will normally be restricted to the areas covered by the Indicative Flood Map (i.e. floods with a 1 in 100 chance of occurring in any year in non-tidal areas and 1 in 200 in tidal areas). In order to comply with PPG25, a new flood map is being produced for floods with an estimated 1 in 1000 chance of occurring in any year. This will define the limit of the floodplain for development control purposes, and will also define the limit of areas covered by the Flood Emergency Plan.

Both land use plans and Flood Emergency Plans must contain compatible information about flooding including flood risk areas.





### 3. THE FLOODPLAIN MANAGEMENT PROCESS

#### 3.1 Introduction

This Chapter outlines a recommended approach to managing flood risks on floodplains. The approach assumes that floodplain management will take place within the present institutional arrangements in England and Wales, and also takes account of existing initiatives and information.

The overall approach to floodplain management is shown on Figure 3.1. The general process is as follows:

- The flood risk is estimated. This is currently carried out at three levels: high (SMPs and CFMPs), medium (Strategy Plans) and local;
- The high level identifies policies for flood management (for example, maintain existing defences to the current defence standard) together with an outline of the preferred flood management measures;
- The medium or strategy level identifies flood management measures in detail;
- The policies and measures should be integrated into statutory land use plans;
- The strategy level of flood risk estimation should include information on flood hazard;
- The flood emergency plan is developed using flood hazard information, and reconciled with the statutory land use plans.

#### 3.2 Floodplain management policy

The policy statements related to floodplain management are those of Defra, who is responsible for flood defence policy, and ODPM, who is responsible for planning policy.

Defra's policy aim is:

*To reduce the risk to people and the developed and natural environment from flooding and coastal erosion by encouraging the provision of technically, environmentally and economically sound and sustainable defence measures.*

Their key objectives to achieve this policy are:

*To encourage the provision of adequate and cost effective flood warning systems*

*To encourage the provision of adequate, economically, technically and environmentally sound and sustainable flood and coastal defence measures.*

*To discourage inappropriate development in areas at risk from flooding and coastal erosion*

These are supported by a series of High Level Targets which include measures aimed at conserving and enhancing the environment, and ensuring that flood risk is taken into account in local planning (MAFF 1999a).

ODPM's main policy guidance on floodplain management is PPG25 (DTLR 2001a) which states that:

*The susceptibility of land to flooding is a material planning consideration*

*The Environment Agency has the lead role in providing advice on flood issues, at a strategic level and in relation to planning applications*

***Policies in development plans should outline the consideration which will be given to flood issues, recognising the uncertainties that are inherent in the prediction of flooding and that flood risk is expected to increase as a result of climate change***

*Planning authorities should apply the precautionary principle to the issue of flood risk, using a risk based search sequence to avoid such risk where possible and managing it elsewhere*

***Planning authorities should recognise the importance of functional floodplains, where water flows or is held at times of flood, and avoid inappropriate development on undeveloped and undefended flood plains***

*Developers should fund the provision and maintenance of flood defences that are required because of the development*

***Planning policies and decisions should recognise that the consideration of flood risk and its management needs to be applied on a whole catchment basis and not be restricted to flood plains***

These policies provide a supportive environment for floodplain management and demonstrate the recognition by Government of the role and importance of floodplains. The policies also recognise the impacts of flood management measures on other parts of river catchments and the need to mitigate against any adverse impacts.

### **3.3 Planning system**

The current statutory planning system in England consists of:

- Regional Planning Guidance, which provides a strategic planning framework in each of the eight English regions. In London there is a spatial development strategy;
- Development plans are produced by county authorities (structure plans), district councils (local plans) and, in unitary authorities, a unitary development plan which combines elements of both;
- Development control, which determines planning applications.

The current system adopted by Defra and the Environment Agency for flood management planning is as follows:

- High Level Plans including Shoreline Management Plans (SMPs) and Catchment Flood Management Plans (CFMPs), as outlined in Section 2.2. These feed into Strategy Plans;
- Strategy Plans, which identify preferred flood management options for sub-divisions of the river catchment or coastal cell. These feed into studies for individual schemes.

The land use planning system is currently under review by the Government in order to simplify the system and improve integration with other strategies and plans (DTLR 2001b). This provides an opportunity to improve the links between flood risk management and land use planning.

### **3.4 Flood management studies**

#### **3.4.1 Introduction**

In order to manage flood risks on floodplains, it is necessary to determine the following:

- The flood risk
- The flood hazard
- Flood management measures.

These are determined by a series of studies as indicated in Figure 3.1. Where suitable information is not available, it may be necessary to carry out additional studies or seek information from other sources.

#### **3.4.2 Flood risk**

Flood risk is defined as:

$$(\text{Probability of flooding}) \times (\text{Consequence of flooding})$$

The probability of flooding is the chance of a flood occurring, and may be expressed as the chance of a particular flood occurring in any one-year (for example, the flood with a 1 in 200 chance of occurring in any year).

The consequence of flooding is the impact of the flood including economic damages and social impacts.

The probability of flooding for floodplain management purposes is expressed using flood maps. The following maps are currently available:

- Section 105 Surveys, which is a national programme of detailed flood mapping based on hydrological and hydraulic modelling. The programme covers a relatively small proportion of river length;
- Indicative Flood Plain Maps which cover the coastline, estuaries and the larger rivers. These maps show the estimated flood limit with a 1 in 100 chance of occurring in any year on rivers and 1 in 200 chance on coasts. They incorporate Section 105 Surveys where available;
- Other locally produced floodplain maps, for example on Ordinary Watercourses.

Floodplain maps generally do not delineate floodplain functions, for example routes for the passage of floodwater and areas for flood storage. This information would be helpful for planning land use on floodplains.

Flood risk is estimated by undertaking a flood study as outlined in Appendix B, which refers to the different types of flood studies shown on Figure 3.1.

When considering flood risk, the following conditions should be considered:

- Present day conditions with existing land use, existing climatic conditions, and existing
- Future conditions:
  - Changes in land use, particularly new developments
  - Possible changes in the flood risk area, caused by climate change
  - Changes in the flood defence sys.
- Floods which exceed the standard of flood management measures.

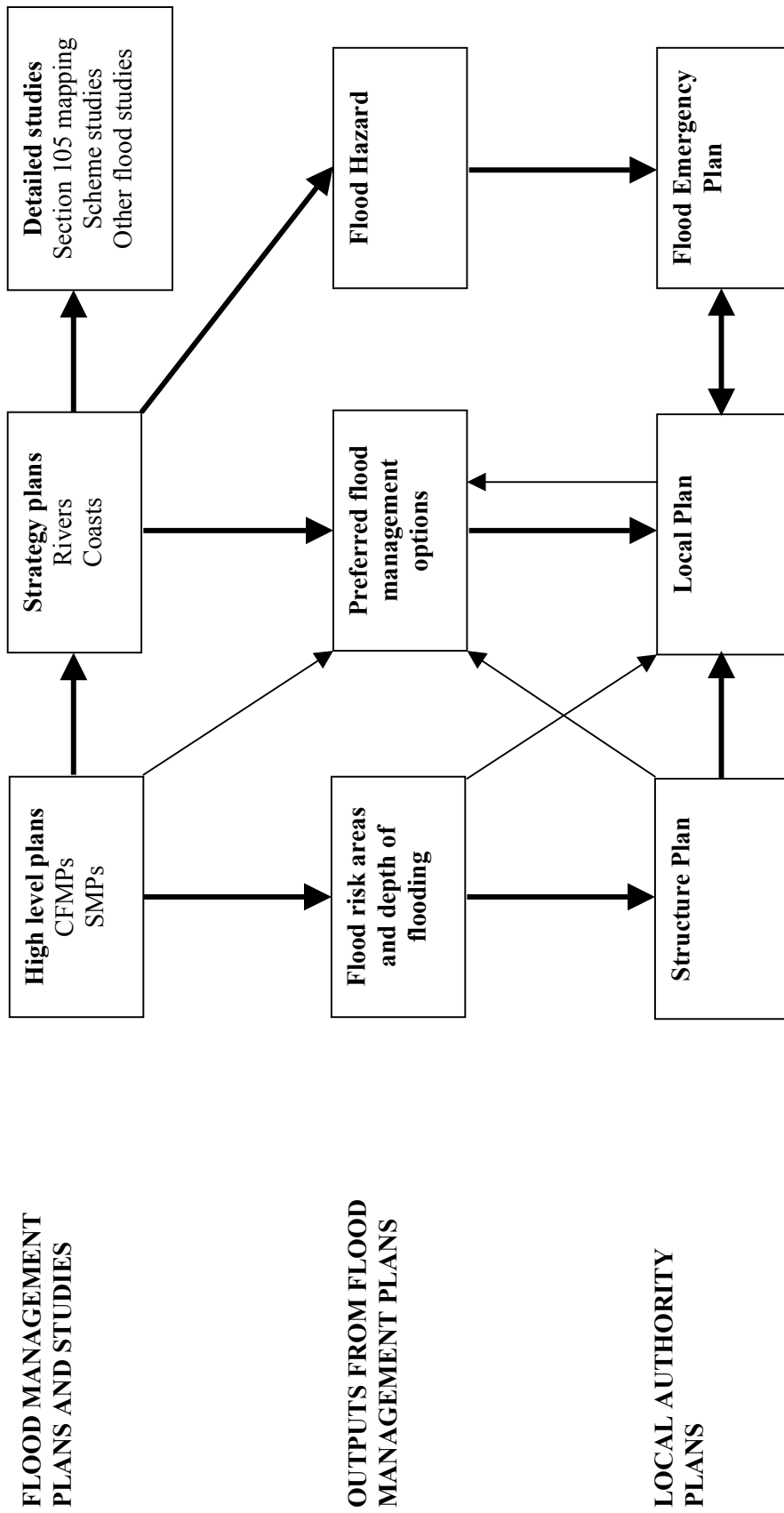
### **3.4.3 Flood hazard**

Flood hazard varies both in time and place across the floodplain. Floodwaters flow swift and deep in some places but are shallow and slow moving in others. The variation of hazard and flood behaviour across the floodplain needs to be understood by stakeholders who live on and/or use the floodplain, floodplain managers and flood emergency staff.

Particular aspects that must be considered in order to define the flood hazard include:

- Flood extent, which is determined for planning purposes using the mapping outlined in Section 3.4.2 above
- Flood depth
- Flood flow velocities
- Rate of rise of flood water and warning time
- Duration. This has social implications and also affects damage to building and other structures. It should also be noted that flood defences can inhibit floodplain drainage and extend the duration of flooding.

An approach to assessing flood hazard for flood emergency planning is given in Appendix C.



**Figure 3.1 Floodplain management process**

### 3.4.4 Flood management measures

Once the flood risk is established, it is then necessary to identify the preferred flood management measures that reduce the risk of flooding and do not have adverse impacts elsewhere within the catchment. These include both structural measures (those which involve engineering and building works) and non-structural measures. A fundamental principle of good floodplain management is that measures should not be considered in isolation, but a combination of measures should be used to achieve the best overall solution.

Structural measures include:

- Flood walls and embankments, including demountable defences
- By-pass or diversion channels
- Increase of the channel conveyance capacity
- Flood storage;
- Changes in operation and maintenance
- Flood proofing of new and existing buildings and other assets.

Non-structural measures include:

- Development control, which includes the avoidance of developments on floodplains or the protection of new developments
- Floodplain zoning, to link land use with the flooding function of different parts of the floodplain
- Flood insurance
- Flood warning
- Flood emergency planning
- Raising the awareness of flood risk and preparedness of individuals and organisations to respond to a flood emergency. This includes the floodplain population, floodplain managers and the emergency services
- Emergency response
- Clean up after a flood
- Recovery from flooding.

Flood management measures are discussed in more detail in Appendix A.

Particular issues that must be considered in floodplain management and planning include:

- Special problems of historic buildings and areas (see Appendix C, Section C.5.1)
- Brownfield sites
- Protection of the natural environment
- Protecting (or preferably keeping out of floodplain) key infrastructure
- Building regulations for both individual buildings and whole developments
- Uncertainty and safety factors.

### **3.5 Floodplain management system**

#### **3.5.1 Co-ordination of floodplain management**

##### Present situation

Local Planning Authorities take a leading role in floodplain management as part of their planning duties. Support is provided by drainage authorities, particularly the Environment Agency in the provision of floodplain maps and as statutory consultee in the planning process.

The current system for floodplain management is as follows:

- The Environment Agency have an ongoing programme of preparing Section 105 Surveys which provide flood risk maps for parts of the river system. These Surveys were originally intended to cover areas where future development pressure was greatest. Section 105 Survey maps are relatively detailed, and in some cases show flood risk areas for a range of flood risk probabilities;
- The Environment Agency has produced Indicative Flood Risk Maps for England and Wales, which include the results of the Section 105 Surveys (annual probability of flooding of 1 in 100 in non-tidal areas, and 1 in 200 in tidal areas). The Agency is also producing maps showing the estimated 1 in 1000 annual probability of flooding;
- The above maps are available to Local Planning Authorities who are responsible for land use planning;
- There is currently no formal procedure for taking account of floodplains in land use planning. PPG25 sets out Policy Guidance on Development and Flood Risk which Planning Authorities are expected to follow;
- Operating authorities are statutory consultees in the planning process, although final decisions on planning matters reside with the Planning Authorities.

The degree to which Planning Authorities take floodplains into account varies. Worcester City Council, regarded as an example of current Best Practice, have undertaken the following measures:

- Inclusion of policy for the management of floodplains in the Local Plan;
- Inclusion of floodplains for Main Rivers and Ordinary Watercourses on the Proposals Map. The City Council have prepared floodplain maps where they are not available from the Environment Agency;
- Division of the Main River floodplains into three zones depending on flood plain function and land use. Policies are given for each zone.

Worcester has extensive floodplains which flood regularly, and therefore flooding is an important local issue. The degree to which other local authorities could adopt this practice depends on the relative importance of flooding and the availability of resources.

With regard to the provision of flood management measures, the procedure is as follows:

- Flood management measures are identified by operating authorities. These may arise from CFMPs/SMPs and their associated Strategy Plans, or from local needs;
- Planning permission is required for structural measures and therefore the planning process is followed;
- Planning permission is generally not required for non-structural measures, but the support and co-operation of local authorities is essential for measures such as development control, floodplain zoning, flood warning, etc.

Thus local planning authorities have a key role in floodplain management.

#### *Recommendations for the future*

The following are considered essential for successful floodplain management:

- Flood risk maps, to be shown on Structure, Local and Unitary Development Plans. These are normally prepared by the Environment Agency but may also be prepared by other operating authorities;
- Establishment of floodplain policies for each planning district, based on PPG25;
- Structure, Local and Unitary Development Plans to include flood management policies and measures identified in SMPs/CFMPs and their associated Strategy Plans;
- Public consultation on floodplain management issues. Floodplain management should be developed in partnership with the local communities affected by flooding.

To fulfil the above, the management of flood risk on floodplains must be included in statutory land use plans. Guidance on the information to be contained in the plans is given in Section 3.5.2 below. In addition, guidance on the information to be provided by flood management plans is given in Section 3.7. The way in which information should flow between the plans is indicated on Figure 3.1.

The advantages of including flood risk management in statutory land use plans are:

- The plans have statutory status
- The plans are subject to full public consultation
- The plans are subject to regular review and update.

#### **3.5.2 Guidance for including flood risk management in land use plans**

Structure plans should include flood risk areas and policies related to flood risk management. High level flood management plans will include an outline of flood management measures for the catchment. It will be necessary to link proposed developments with proposed flood management measures during the consultation process for both plans to ensure that preferred flood management options take account of future development.



In order to integrate flood risk management on floodplains into Local Plans, it is recommended that the Local Plan includes the following:

- Areas at risk from flooding together with floodplain functions (flood conveyance, flood storage, etc.);
- Flood defences and other flood management measures already in place;
- Flood management policies identified in CFMPs/SMPs;
- Flood management measures outlined in CFMPs/SMPs and identified in detail in associated Strategy Plans;
- All other issues relevant to floodplain development including conservation, recreation, etc.;
- Other policies for managing the floodplain including:
  - Development and flood risk, based on PPG25 (see Section 3.8);
  - Infrastructure design (see Section 3.9.2);
  - Building and development controls (see Section 3.9.3).
- The proposed land use plan for the floodplain as part of the overall land use plan. This should aim to provide the best compromise between the conflicting demands which include future development needs, flood management and conservation. The land use plan should take account of:
  - The impacts of development on flooding;
  - Proposed conservation measures including enhancement and restoration of the river and floodplain environment;
  - Social factors including the needs of the local community.

Guidance on information to be included in Local Plans is given in Appendix D.

There may be a need for additional investigations before the plan can be prepared. The main sources of information for the flood risk management are as follows:

- SMPs and associated Strategy Plans on the coasts, which provide information on coastal flooding. SMPs have been carried out for the whole country. Strategy Plans are in progress;
- CFMPs and associated Strategy Plans. These have only recently begun, and the present coverage is small;
- The Indicative Floodplain Maps, complete for the whole country;
- Section 105 Surveys, providing detailed mapping for a small proportion of rivers;
- Other flood studies associated with individual schemes, etc.;
- A range of other documents including Catchment Management Plans, Local Environment Agency Plans, Biodiversity Action Plans, River Habitat Surveys, etc..

The first step will be to identify whether any additional studies are needed to obtain the required information on flood risk outlined above. Much work has already been carried out on aspects of floodplain management. Best use of existing information should be made including the identification of gaps where additional study is needed.

Additional studies may include the following, where suitable information is not already available:

- A flood study to identify flood flows, flood water levels, flood extents and the function of different parts of the floodplains (see Appendix B);
- A floodplain management study, which could include the following components:
  - Investigation of the impact of flood management measures on flooding, in order to determine the optimum measures. This type of investigation should be part of a Strategy Plan study, and is normally undertaken using hydrological and hydraulic models;
  - Investigation of the impacts of proposed developments on flooding, and identification of mitigation measures. This type of investigation is required under PPG25 for individual developments, but should be carried out at the Strategy Plan level using information on land use planning;
  - Social studies to identify particular local needs associated with floodplain residents, local institutions and other floodplain activities;
  - Environmental studies of the river and floodplains to identify the existing status of the environment and conservation opportunities.

The Local Plan is not a static document and is reviewed at regular intervals. The review should cover:

- New information on flood behaviour. This may arise from a large recent flood, new developments in the upstream catchment, or new information on climate change;
- Changes in roles and responsibilities of agencies involved in floodplain management;
- Changes in the aspirations of the community regarding future development.

### **3.6 The flood emergency system**

#### **3.6.1 Co-ordination of flood emergency response**

The current arrangements for dealing with flood emergencies are as follows:

- The Environment Agency provides a flood forecasting service for rivers;
- Defra co-ordinates the Storm Tide Warning Service for tidal surge forecasting;
- The Environment Agency provides a flood warning service which includes “Local Flood Warning Plans” containing information on local flood warning arrangements;
- Emergency planning is a County function although some local authorities have District emergency planning officers. The County Council produces a generic emergency plan;
- In addition, some areas have Inter-Agency Flood Emergency Plans. These may either be co-ordinated at County or District level;
- Flood emergency response is co-ordinated by the police and key stakeholders include the Health service, Fire and Rescue Service, Environment Agency, Coastguard, local authorities and voluntary services.

The arrangements for flood warning and emergency response are already adopted nationally, and this should continue. In addition, Inter-Agency Flood Emergency Plans should be developed for all communities, as recommended in *Learning to Live with Rivers* (ICE 2001, Section 6.9).

### 3.6.2 Flood warning systems

The national flood forecasting and warning services are well established and under constant development. The flood warning system is based on Flood Warning Codes, as follows:

- **Flood Watch: Flooding possible.** Be aware! Be prepared! Watch out!
- **Flood Warning: Flooding expected** affecting homes, businesses and main roads. Act now!
- **Severe Flood Warning: Severe flooding expected.** Imminent danger to life and property. Act now!

Warnings are issued to the emergency services, local authorities and the general public in flood risk areas. Information issued to those involved in flood response can include estimates of the severity of the flood in terms of maximum water levels and timing at particular points.

### 3.6.3 Flood emergency plan

A flood hazard analysis as outlined in Appendix C is needed to assess the flood hazard including flood extent, flood depth, flood flow velocities, rate of rise of flood water, warning time and flood duration. This information will assist in the planning of the emergency response. Particular concerns include:

- The order in which areas will flood, and timing
- Loss of key transport links
- The formation of “islands” where residents can be cut-off by floodwater.

The flood emergency plan provides a comprehensive guide to preparedness for, response to and recovery from flood emergencies. The plan should cover all floodplains including Main Rivers, coastal floodplains and critical Ordinary Watercourses. The target audience for the flood emergency plan should include:

- The agencies involved in responding to flood emergencies including local authorities and the emergency services
- The public at risk from flooding.

Different information will be required by each of these two groups and it may be advisable to split the plan into two parts, one for each group.

The plan should include:

- Flood risk areas and information on flood hazard for a range of flood probabilities;
- Property and utility hotspots in flood risk areas where particular measures or evacuation requirements are needed. These include vulnerable communities, caravan parks and key utilities;
- Flood warning arrangements;
- Flood preparedness including evacuation plans;
- Emergency response, including “trigger points” when certain actions should take place. An example of a trigger point is a certain water level reached at a particular location;

- Protection and reinstatement of essential infrastructure (sewerage, water supply, telephones, etc.);
- Flood clean-up and recovery. Assisting the community to recover from flooding can be long-term process taking many months;
- Collection and dissemination of information, including key contacts;
- Roles and responsibilities, including partnership activities with local communities, the role of voluntary organisations, etc.;
- Co-ordination arrangements and communications;
- Links with Local Authority Peacetime Emergency Plans;
- Contingency plans for maintaining activity in floodplain areas during the disruption of flooding and flood recovery.

The plan should be a “stand-alone” document co-ordinated by the County or District authority, depending on local emergency planning arrangements and the area covered by the plan. The plan should be co-ordinated with Environment Agency local Flood Directories to avoid duplication of effort and information. Consideration should also be given to education programmes to raise awareness of flood risk, as outlined in Section 3.11.

Further information on the preparation of a flood emergency plan is given in Appendix E.

The plan must be formally accepted and adopted by stakeholders including members of the general public who are directly involved (for example, flood wardens, etc.). It is recommended that a draft plan is exhibited within flood prone communities to raise awareness, obtain feedback and facilitate acceptance and ownership by the general public.

Awareness and education needs to be fostered regularly to maintain the effectiveness of community participation in the plan. It is recommended that flood emergency exercises should be held at the beginning of each flood risk season. For practical reasons these should be relatively low key but should involve all stakeholders sufficiently to ensure they are aware of their roles and responsibilities.

### **3.7 Information to be provided by Flood Management Plans**

Two categories of information are required from flood management plans: information for land use planning purposes and flood hazard information for emergency planning. The information required and the source (i.e. SMP, CFMP, and Strategy Plan) is summarised below.

#### **3.7.1 Information required for land use planning**

The following information is required for land use planning. The information should be provided specifically for the planning function in a separate section of flood management plans to make it easy for planners to access information, and avoid the need to study the plans in detail.

##### **Information from SMPs/CFMPs**

- A statement of flood management policies for each section of the floodplain;
- GIS layers showing:
  - Present flood risk areas (also available from Indicative Flood Maps);
  - Future flood risk areas;

- Any information on existing flood defences;
- The outline location and extent of proposed flood management measures;
- All other issues relevant to floodplain development including conservation, recreation, etc.

### **Information from Strategy Plans**

- GIS layers showing:
  - Floodplain function (flood conveyance, flood storage, etc.). This information is not currently supplied by flood management plans. ***It is recommended that information on floodplain function be provided as an output from Strategy Plans;***
  - Existing flood defences;
  - The detailed location and extent of proposed flood management measures;
  - All other issues relevant to floodplain development including conservation, recreation, etc.

Strategy Plans will only be available for floodplains where new flood mitigation measures are proposed. In addition, CFMPs will not be available for some time. It will therefore be necessary to obtain some or all of the above information from other sources, particularly previous studies. Where there are no suitable sources of information that are readily available, the local Environment Agency Development Control officer should be consulted on what guidance on flood management should be included in the Local Plan.

### **3.7.2 Emergency planning**

The following information is required for emergency planning. The information should be provided specifically for emergency planning in a separate section of flood management plans to make it easy for emergency planners to access information, and avoid the need to study the plans in detail.

#### **Information from SMPs/CFMPs**

- GIS layers showing:
  - Present flood risk areas (also available from Indicative Flood Maps);
  - Future flood risk areas;
  - Any information on existing flood defences.

#### **Information from Strategy Plans**

- GIS layers showing:
  - Floodplain function (flood conveyance, flood storage, etc.);
  - Existing flood defences;
  - Flood hazard:
    - Response/flood warning time;
    - Flood depth;
    - Flood duration;
    - Flow velocities;
    - Rate of rise of flood water.

Information on flood hazard is not currently supplied by flood management plans. ***It is recommended that information on flood hazard be provided as an output from Strategy Plans.*** Of the five headings under flood hazard, the most important for emergency planning are response/flood warning time, flood depth and flood duration.

Strategy Plans will only be available for floodplains where new flood mitigation measures are proposed. In addition, CFMPs will not be available for some time. It will therefore be necessary to obtain some or all of the above information from other sources, particularly previous studies. Where there are no suitable sources of information that are readily available, the local Environment Agency Flood Warning officer should be consulted on the information on flooding to include in the emergency plan.

### **3.8 Land use and flood risk**

#### **3.8.1 Introduction**

Local Plans should include policies for land use planning on floodplains, as outlined in Section 3.5.2 above. The policies should link with the requirements of PPG25. This section provides guidance on land use in flood risk areas.

The adopted land use for flood-prone land largely defines the resulting flood risk. Matching of land use to flood hazard maximises the benefits of using the floodplain and minimises the consequences of flooding.

PPG25 provides guidance on land use for different degrees of flood risk and this information has been used to prepare Table 3.1, which gives guidance on different land uses in different zones.

Defended floodplains are a special case. Whilst the overall degree of risk is reduced there is a serious hazard associated with overtopping or failure of defences, where flooding can occur quickly and without warning.

**Table 3.1 Land use in flood risk areas**

	<i>Degree of risk</i>				
	Little/none	Low to medium	High		
			Non-functional: Developed	Non-functional: Undeveloped/ sparse	Functional
Annual risk:					
Tidal:	< 1 in 1000	1 in 1000 to 1 in 200	> 1 in 200	> 1 in 200	> 1 in 200
<i>Land use</i> Non-tidal:	< 1 in 1000	1 in 1000 to 1 in 100	> 1 in 100	> 1 in 100	> 1 in 100
Open space/recreation	✓	✓	✓	✓	✓
Essential transport and utilities	✓	✓	✓(1)	✓(1)	✓(1)
Residential	✓	✓	✓(2)	(3)	
Commercial/industrial	✓	✓	✓(2)	(3)	
Caravan parks	✓	✓	✓(2)		
Public institutions	✓	✓			
Hospitals	✓				
Homes for the elderly	✓				
Schools	✓	✓(4)			
Police	✓				
Telephone exchanges	✓				
Emergency service	✓				

Notes:

- (1) Should be operational in a flood. Compensation works needed to avoid an increase in flood risk elsewhere.
- (2) Assuming appropriate flood defences are provided.
- (3) Limited developments permitted in certain circumstances as specified in PPG25.
- (4) But not main school buildings and access routes.

Figure 3.2 shows a cross section of a floodplain indicating the flood risk zones.

### 3.8.2 Land use by degree of risk and hazard

Specific advice on land uses depending on degree of risk and hazard is given below for the categories of land use given in Table 3.1.

#### Open space and recreation

Open space and recreation is entirely appropriate for high flood risk areas including functional floodplain. However great care must be taken to avoid obstructions to floodplain flow, for example:

- Fences and hedges should be avoided as they trap debris and become blocked;
- Associated facilities including pavilions and sports halls should be sited outside the functional floodplains. Such buildings should be allowed to flood to prevent loss of floodplain storage;
- Any landscaping associated with open space and recreation (for example, golf courses) should be carefully designed to avoid any worsening of flood conditions;
- Car parks should be avoided in the functional floodplain because of the risk of damage to vehicles, the risk of people being trapped in vehicles, and the risk of vehicles being swept away and possibly causing damage and blockages to flood flows elsewhere.

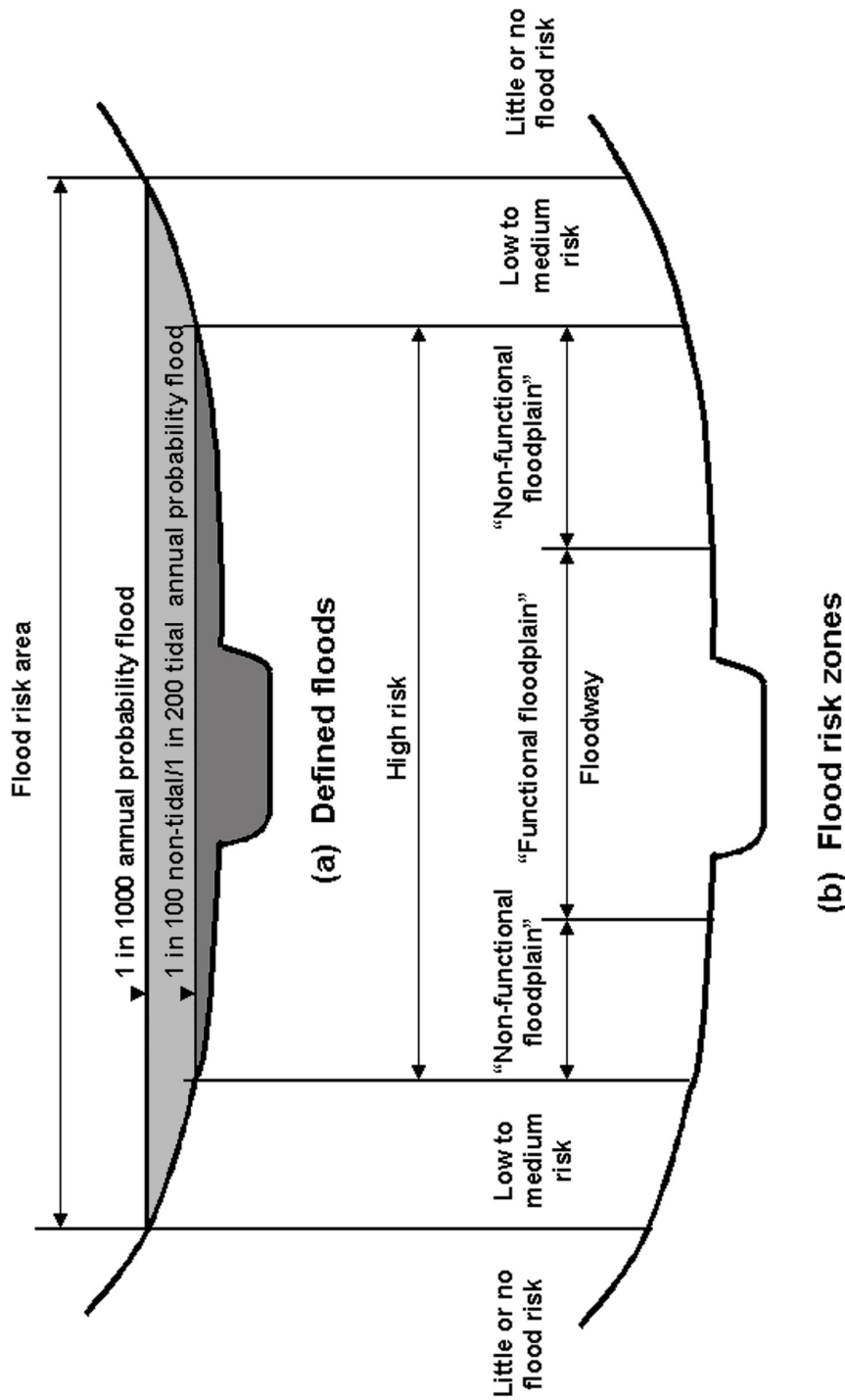


Figure 3.2 Flood zones across the floodplain



### Essential transport and utilities

Essential transport and utilities including railway stations, electricity sub-stations, etc. should be sited outside flood risk areas. It is however inevitable that some development associated with essential transport and utilities will occur in the high risk areas of floodplains, for example road crossings over rivers and electricity pylons. In such cases mitigation works will be needed to ensure that there is no increase in the flood risk elsewhere. For example, roads should be constructed on viaducts as far as possible. Where embanked sections are used, mitigation works including compensatory storage should be provided and studies carried out to demonstrate that there is no increase in flood risk.

### Residential

Residential development should only be permitted in high risk areas which are already developed if appropriate defences are provided (or already in existence) and the development is approved by the Environment Agency. Particular issues to consider with residential developments include:

- Where will people go if a flood occurs? Will evacuation be necessary?
- Safe evacuation routes if needed;
- The cost of repair, reinstatement and clean-up after a flood;
- Measures to limit flood damage including raised floor levels, flood proof construction, use of the ground floor for non-habitable uses (for example, car parking);
- Site planning, street layouts, housing density and house designs which minimise the risk to human safety and property damage;
- The vulnerability of occupants. For example, housing for the aged and those with impaired mobility should not be sited in high risk areas under any circumstances.

### Commercial and industrial

The siting of commercial buildings including shops and offices should be considered in relation to the potential damage to goods and property. Conflicts of interest may arise, for example where riverside locations for shops or other facilities have commercial and social benefits that outweigh the flood risk. Such issues should be resolved in the floodplain management plan.

Commercial and industrial developments involving the processing or storage of pollutants should be sited outside the flood-prone area to avoid the risk of pollution incidents during floods. These include petrochemical plants, garages, waste disposal industries, paint, herbicide and pesticide manufacturers, etc. Severe oil pollution occurred in Lewes during the Autumn 2000 floods.

### Caravan parks

Caravan parks present particular problems in relation to flooding, and specific advice is given in paragraph 70 of PPG25. It is generally suggested that caravan parks are treated in the same way as residential areas for the purposes of floodplain management.

### Public institutions

Public institutions including community buildings, prisons, etc. should be sited outside high flood risk areas. Those which are to be used as emergency refuge centres, for example selected community centres, should be sited outside the low to medium risk area.

### Hospitals and homes for the elderly

Hospitals and homes for the elderly should be sited outside flood risk areas. Where there are existing buildings which are in flood risk areas, particular attention should be given to flood preparedness and emergency response including evacuation plans.

### Schools

Schools should be outside flood risk areas as far as possible for safety reasons and also because of the considerable disruption that flood damage to a school could cause. However parts of schools could be sited in low to medium flood risk areas including playing fields, hard courts, car parks, etc. In addition, schools are sometimes used as emergency refuge centres, where a flood free location is essential.

As with hospitals, existing schools which are at risk from flooding will require particular arrangements for evacuation.

### Police and other emergency services

It is essential that the police and other emergency services are able to function at all times during a flood event. Facilities which are required during flood events including operation centres, fire stations and the accident and emergency centres at hospitals must be outside the flood risk area.

### Communications centres including telephone exchanges

Good communication is vital during a flood emergency. Centres which support communications during flood events must be outside the flood risk area. These include telephone exchanges and local radio stations.

## **3.9 Implications for buildings and infrastructure**

### **3.9.1 Introduction**

Local Plans should include policies for:

- Infrastructure design in flood risk areas;
- Development control in flood risk areas;
- Building controls in flood risk areas.

This section provides guidance on these policies.

### **3.9.2 Infrastructure design**

Infrastructure includes transport (roads, railways, etc.) and utilities (water supply, sewerage, sewer pumping stations, treatment works, electricity supply, gas supply and communications). It is important to ensure that flood risk is taken into account in the design of new works and the protection of existing works.

Essential services and transport links should be located outside flood risk areas or constructed above flood level. Existing essential services and transport links that are at risk of flooding should be protected as far as possible, and contingency plans prepared in case of flooding.

Any new works in flood risk areas should be designed to minimise the effects on flooding, minimise the impacts of floods on maintaining essential services, and facilitate emergency response and recovery.

### **3.9.3 Development and building controls**

Local authorities have control over development and building controls in flood risk areas. It is recommended that development and building controls are introduced as part of floodplain management policy. Building controls should be introduced for both new and existing buildings.

#### **Development control policy**

Controls on developments in floodplains should take account of the following:

- Sources of flooding (river, coast, local drainage, groundwater, etc.);
- Floodplain zone;
- Risk to life, health and property;
- Timing and rate of flooding;
- Availability of evacuation access during a flood;
- Impacts of the development on flood levels including changes to ground level, for example for new roads;
- Cumulative effects of developments including infill of spaces in existing developments;
- Appropriate freeboard for floor levels;
- Management of residual risks where flood defences are constructed.
- Compatibility of any proposed flood control works with the overall plan for floodplain development;
- Limiting runoff from the development site to pre-development or “natural” levels.

Proposed developments in defended areas will result in an increase in the value of defended assets. This in turn may justify an increase in the standard of protection, for example where development changes a sparsely developed area into a fully developed area. However it may not be possible to improve the defence standard, in which case the proposed developments should not be permitted.

#### **Building control policy**

Controls on new individual buildings and extensions to existing buildings should take account of the following:

- Design floor levels which are above the estimated flood level with a particular probability of occurrence;
- Suitability of proposed building materials;
- Impact of minor structures such as fencing on flooding.

Guidance on measures that can be applied to new buildings in flood risk areas is given in DTLR 2002 and guidance for minimum requirements is given in SEI/ASCE 2000.

Much can be done to improve the flood resistance of existing properties in flood risk areas. These include devices that can be attached to doors and windows, systems for waterproofing walls, sumps and pumps inside houses, modifications to buildings and fittings using flood resistant materials, and temporary defences that are erected away from the building structure. It is proposed to test and “kite-mark” these products. Local authorities should be aware of the results so that they can recommend appropriate actions that property owners could take. Information on improving the flood resistance of properties can be found in DTLR 2002 and Environment Agency 2001a.

### **3.10 Data and indicators**

Data are needed to improve understanding of flood behaviour and the magnitude of the flood risk. Without adequate data it is difficult to justify devoting more resources to floodplain management and also makes the objective allocation of limited resources between competing flood ‘problems’ impossible.

Appendix F provides recommendations for data to be collected covering flood behaviour, flood hazard and floodplain management. Much of the recommended data on flood behaviour are already collected by the Environment Agency.

In addition, substantial resources are required for the management of flood risk and flood hazard. Performance indicators are essential both to measure success and to ensure that resources allocated to floodplain management and flood emergency management activities are spent in an effective and equitable fashion. A set of simple, common and effective performance indicators is therefore needed.

Appendix F also provides recommendations for performance indicators. These include the number of planning districts which include floodplain management in the Local Plan and the number which have flood emergency plans. Indicators are also proposed for the number of properties and other assets protected to a defined standard.

### **3.11 Education, training and research**

The proposed approach to floodplain management involves the participation of a range of stakeholders and a change from past practice. It is recommended that the process involves an ongoing commitment to awareness raising, education and training both for floodplain managers and other stakeholders including the general public.

Sharing of information on floodplain management can be achieved by workshops and conferences, which should be organised at different levels as follows:

- National or regional awareness raising and training for local authority personnel, organised by the Local Government Agency and/or the Environment Agency;
- Local awareness raising and training for the general public, emergency service personnel, etc. organised by the County Council and/or local authority.

## 4. ROLES AND RESPONSIBILITIES

This section summarises the roles and responsibilities of stakeholders. A more detailed list is given in Appendix G. In addition, separate “Stakeholder sheets” are provided to give guidance for each group of stakeholders.

Stakeholders are divided into categories, and some stakeholders (particularly Local Authorities and the Environment Agency) appear under more than one category. This Section covers existing responsibilities but in some cases also indicates recommended future responsibilities.

### Those who live and/or work on floodplains

These include residents and businesses. As those most affected by flooding, they should be consulted in the preparation of land use and flood emergency plans. With the assistance of others, their responsibilities should include:

- Awareness of the flood risk
- Preparedness
- Knowing how to respond including evacuation arrangements
- Effective response including assistance with neighbours where possible
- Contribution to flood warden and other self help schemes.

It is particularly important that those who are protected by flood defences are aware of that there is still a flood risk. This is because flooding can occur very rapidly if a defence overtops or fails. Evacuation routes can be quickly blocked by floodwater and, in addition to the trauma of the situation, there is a significant risk to life and safety.

### Farmers and other landowners who own land in flood risk areas

This group includes owners of large areas of land, which may include watercourses and other drainage ditches which affect local drainage. In addition to the general responsibilities of all those who live and/or work on floodplains, they have particular responsibilities for the prevention of adverse drainage impacts and the maintenance of watercourses.

### Land use planning function

Local Planning Authorities (District Councils and Unitary Authorities) are responsible for land use planning, and are responsible for incorporating floodplain management into statutory plans. Those in local authorities with particular responsibility for planning include Chief Executives, elected members, planning officers and planning inspectors.

Local Planning Authorities are also responsible for the administration of Building Regulations and can influence the introduction of floodproofing measures for properties in the floodplains.

### River, drainage and coast managers

The three “operating authorities” for rivers and coasts are as follows:

- The Environment Agency, who is responsible for construction and maintenance of flood protection works on Main Rivers and coasts and maintenance of Main Rivers. Their flood defence responsibilities are undertaken by Flood Defence Committees;
- Local Authorities (District Councils and Unitary Authorities), who are responsible for flood protection and maintenance on Ordinary Watercourses and coast protection;

- Internal Drainage Boards (IDBs), who are responsible for flood protection and maintenance on watercourses in Drainage Districts.

The Environment Agency has a general supervisory duty for flood defence matters. It should be noted that powers related to carrying out flood defence works by operating authorities are permissive and not statutory.

In addition to the above, Water Companies are responsible for stormwater drainage systems including flooding. A particular problem for water companies is foul floodwater from combined sewers.

In the recommended approach to floodplain management outlined in Section 3.5 and 3.6, Local Authorities would have the co-ordinating role in the management of floodplains and Flood Emergency Plans. They would also be involved in commissioning flood studies in collaboration with the Environment Agency

#### Emergency planning, response and recovery

Organisations are involved in emergency planning, response and recovery include:

- Emergency Planning officers in Unitary Authorities, County Councils and some District Councils;
- The police, who are involved in flood emergency planning and co-ordinate the emergency response. They are also responsible for public safety;
- The Fire and Rescue service, who are involved in flood emergency planning and emergency response including rescue and pumping out;
- Local Authorities, who are involved in flood emergency planning and response (for example, road diversions and provision of rest centres). In addition, Local Authorities bear the brunt of post-flood clearing up and recovery of the local community. This includes the assembly and dissemination of information;
- The Environment Agency, who produce flood forecasts, issue flood warnings, and assist in flood emergencies;
- The Meteorological Office, who provide forecasts for tidal surges and provide weather information to the Environment Agency;
- The Health Service, who provide health support to those affected by floods;
- The voluntary sector, who provide assistance in flood emergencies and flood recovery;
- The media, who have an important role in the dissemination of flood warnings and other information. They also assist with awareness raising by reporting on flood problems.

#### Those involved with conservation and environmental enhancement

Organisations who are concerned with conservation and enhancement of the environment include:

- English Nature and other organisations who provide advice on conservation matters;
- Other conservation organisations, some of whom are directly responsible for managing conservation areas on floodplains;
- The Environment Agency, who have a duty to conserve and enhance the environment. Their activities include environmental improvements on coasts, rivers and floodplains, and environmentally sensitive maintenance.

### Policy makers and other supervisory organisations

Defra and the Welsh Office are responsible for Flood Defence Policy in England and Wales respectively. They also provide funding for flood defence.

ODPM are responsible for policy on land use planning including guidance on development and flood risk.

The Building Regulations Advisory Committee are responsible for Building Regulations and would therefore take forward recommendations for floodproof construction of buildings in floodplains.

### Those who have assets on floodplains (transport, utilities)

Organisations who have assets on the floodplains in addition to residents and businesses include:

- Highway Authorities (County and District) who are responsible for maintenance and construction of roads;
- The Highways Agency, who is responsible for maintenance and construction of trunk roads and motorways;
- Railtrack, who is responsible for maintenance and construction of railways;
- Utilities, who are responsible for the provision and maintenance of services including electricity, gas, water, sewerage and communications.

All these organisations are subject to planning requirements when undertaking works in the floodplains.

### Business interests

Companies that have an interest in floodplains include:

- Developers, who wish to undertake new development in the floodplains;
- Insurance companies, who include flood risk in their insurance cover. The ABI, which is the representative body for insurance companies, provides advice to insurance companies on flooding matters;
- Mortgage lenders, who lend money for the purchase of property. Their representative body is the Council of Mortgage Lenders.

New developments require planning permission, and developers are required to demonstrate the impacts that their proposals will have including impact on flood risk. This applies whether or not the developments conform with Local Plans. The provision of flood insurance for developments in flood risk areas is a matter for insurance companies.

### Other stakeholders

Other stakeholders include professional bodies who are involved in technical aspects of flooding and are particularly involved in the studies needed for flood management. These include SMPs, CFMPs, Strategy Plans, scheme studies and other Flood Studies.

A matrix showing areas of common interest between stakeholders and the interdependencies between different activities is shown in Table 4.1.

**Table 4.1 Floodplain management: Responsibility matrix**

Stakeholders	Activity													
	Land use planning	Flood management policy	Flood defence: Coasts	Flood defence: Main River	Flood defence: Drainage Districts	Flood defence: Ordinary watercourses	Flood plain structures	Flood forecasting	Flood warning dissemination	Flood awareness	Flood preparedness	Emergency response	Post-flood clean-up and recovery	Improved knowledge
Flood-prone community	X													
Land owners in floodplains	X													
Environment Agency		X	X	X		X	X	X		X	X	X	X	
FDCs			X	X		X	X			X	X	X		
Local Authorities	X		X			X	X			X	X	X	X	
IDBs					X		X			X	X	X	X	
Police								X			X	X		
Fire Service											X	X		
Health Service											X	X		
Voluntary organisations											X	X		
Media									X	X	X	X		
Conservation bodies	X				X	X								X
Defra					X	X								X
ODPM	X								X					X
LGA / ADA/ ABI														
Railtrack / highway authorities							X						X	
Utilities							X						X	
Developers							X						X	
Insurance companies							X						X	
Professional bodies														X



## 5. LEGISLATION, ADMINISTRATION AND LIABILITY

The objective of the floodplain management guidance with regard to legislation is to develop guidance which is as far as possible compatible with existing legislation. Where legislation could be improved to the benefit of floodplain management, these opportunities are identified together with recommendations for suitable improvements.

### 5.1 Existing legislation

#### Land use planning and development

Legislation covering the present system of plan-led development is contained in the Town and Country Planning Act 1990 (as amended in 1991). The resulting development plans (existing Structure, Local and Unitary Development Plans) set out the main considerations on which planning applications must be decided. These plans are prepared and administered by local planning authorities.

In addition, Planning Policy Guidance Note 12 *Development Plans* (PPG12) explains the statutory provisions and provides guidance to local authorities and others on the preparation of Development Plans. Other Planning Policy Guidance Notes cover a range of policy areas, of which PPG25 on Development and Flood Risk is particularly relevant to floodplain management.

With regard to decisions on planning applications, flooding is one of many considerations. Whilst the Environment Agency is a statutory consultee, final decisions are made by the planning authorities taking account of all considerations.

It should be noted that the current planning system is likely to change. A DTLR (now ODPM) Planning Green Paper was produced in December 2001 which recommends:

- Replacement of Structure, Local and Unitary Development Plans by Local Development Framework;
  - Replacement of Regional Planning Guidance by Regional Spatial Strategies.
- (DTLR 2001b).

The Local Development Frameworks would include statements of core policies and detailed action plans for smaller local areas of change.

#### Flood management

Legislation covering land drainage and flood management is included in the Water Resources Act 1991, the Land Drainage Act 1991 (amended 1994) and the Environment Act (1995). These set out the responsibilities of operating authorities (the Environment Agency, Internal Drainage Boards and local authorities) for land drainage and flood defence.

Powers are generally permissive and not statutory. This means that operating authorities are not obliged to provide flood defence and are therefore not committed to the investment that would be needed to provide flood defence on a statutory basis. Central Government funding historically has fallen short of identified defence requirements and is also not provided to defend new developments. Central funding therefore cannot be guaranteed to address the defence needs of existing developments – indeed, with climate change and sea level rise considerations, a precautionary approach is recommended.

Flood defence is increasingly being carried out within a framework of plans, as outlined in Section 2.2. These plans do not however have statutory status. They are used by operating authorities to guide future flood defence planning but can only be implemented with the support of local authorities.

### Emergency response

Local authorities have powers to respond to emergencies under the Local Government Act 1972, and Emergency Plans are prepared by Unitary, County and District Councils. However there is a recognition that flooding differs from other emergencies in that the areas where it is likely to occur are generally known, and some warning can be given. Hence some local authorities have prepared Flood Emergency Plans although there is no statutory obligation for them to do so.

## **5.2 Future legislation and guidance**

The proposed approach to floodplain management can be carried out within the present legislative framework. This has been demonstrated by local authorities that have implemented floodplain management measures. However, as noted in Section 5.1, the current planning system is likely to change. In addition, experience gained using PPG25 may lead to a future update of this Planning Policy Guidance as a result of lessons learnt during implementation.

The legislative framework within which floodplain management is implemented is therefore subject to change. Based on information available to date, the way in which floodplain management could be accommodated within the system recommended in the Planning Green Paper is as follows:

- Floodplain management policies to be included within the Local Development Framework. These would be based on the flood management policies identified in SMPs and CFMPs, but would also include policies on land use, development, infrastructure and building controls in flood risk areas;
- An action plan for the floodplain within the Local Development Framework. This would be based on the recommendations of CFMPs, SMPs and Strategy Plans.

The action plan should also take account of any other relevant plans, which may include Coastal Habitat Management Plans (ChaMPs) and Water Level Management Plans (WLMPs). If information from other plans is to be considered for inclusion in land use planning, it must be presented in a format that can be easily understood and used by planners.

If it is decided to implement the recommendations for floodplain management identified in this project, guidance on how to do it should be made available to stakeholders. This could be done in the following way:

- Guidance on floodplain management for local authorities would initially be provided as an output from Stage 2 of this project. If floodplain management becomes part of Government planning policy in the future, it might be appropriate to include it in an update of PPG25;

- Guidance on the outputs required from CFMPs, SMPs and Strategy Plans should be included in updates of the appropriate guidance documents for preparing these plans, produced by Defra and the Environment Agency;
- Guidance on flood emergency planning would initially be provided as an output from Stage 2 of this project.

### **5.3 Administrative requirements and funding**

In order to formally include the management of floodplains in land use planning and prepare flood emergency plans, funding and associated resources would be needed to:

- Collect information, including studies where required
- Prepare documentation in a suitable format
- Monitor performance indicators to measure success.

The amount of funding will vary depending on the level of flood risk and existing activities in different districts. In the “good practice sites” at Worcester and Lewes many of the essential activities for floodplain management and flood emergency planning are already taking place and additional funding needs would be relatively small. In other districts the needs will be greater although some activities, for example, floodplain mapping, are undertaken nationally by the Environment Agency.

It is anticipated that the savings from a co-ordinated approach to floodplain management and flood emergency planning will far outweigh the costs in terms of savings in flood damages and response and recovery costs.



## 6. STAGE 2 RECOMMENDATIONS

The specific actions required to implement Stage 2 are as follows:

### **Initial planning**

- Select a suitable district for the implementation of Stage 2. It is advisable to select a location where an SMP or CFMP and Strategy Plan exist;
- Hold an initial workshop with stakeholders in order to explain the overall process, find out local arrangements for co-ordination, seek agreement to participate, and invite comments and other feedback;
- Agree a programme for implementation of Stage 2, including objectives and timescales.

### **Local Plan preparation**

- Assemble the information to be included in Local Plans as set out in Section 3.5.2 and Appendix D;
- Carry out additional studies where the necessary information is not available. As Stage 2 is concerned with implementing a procedure, the need for additional studies should be kept to a minimum;
- Prepare a version of the Local Plan which contains floodplain management policies and measures;
- Undertake consultation on the floodplain management component of the Plan;
- Modify the Plan and record lessons learnt;
- It is recognised that this work is unlikely to fit with the timescale of local planning. However, if possible, the floodplain management component of the Local Plan should be implemented as an Addendum to the Local Plan.

### **Flood emergency planning**

- Review existing emergency planning arrangements and identify the work needed to implement a Flood Emergency Plan;
- Collect any additional information needed to prepare the Plan;
- Prepare a draft Flood Emergency Plan in consultation with stakeholders as set out in Section 3.6.3 and Appendix E;
- Undertake consultation on the Plan;
- Modify the Plan and record lessons learnt;
- Work with stakeholders to implement the Plan.

### **Final Report**

- Prepare a final version of a Guide for the management of floodplains to reduce flood risks incorporating lessons learnt;
- Prepare a brochure on the Guide for distribution to all County, District and Unitary authorities, Environment Agency Regional and Area offices, and Internal Drainage Boards;
- Present the findings of the project to relevant stakeholders including local authority members and staff, emergency planning officers, the Environment Agency, Internal Drainage Boards, the emergency services and other stakeholders, possibly arranged in collaboration with the LGA.

It is essential that all the above work is carried out in close collaboration with the local authority. In particular, it is expected that such activities as public consultation will be carried out by the local authority based on their normal consultation procedures.

### **Stakeholder sheets**

The purpose of stakeholder sheets is to provide specific advice to particular stakeholders.

The stakeholder sheets can be used as separate documents for distribution to stakeholders.

- Those who live and/or work on floodplains
- Farmers and other landowners who own land in flood risk areas
- Land use planners
- River and coast managers (Environment Agency, Local Authority engineers, IDBs)
- Emergency services
- Those involved with conservation and environmental enhancement
- Those who have assets on floodplains (transport, utilities)
- Business interests (developers, insurance)
- General information for the general public who use floodplains, the media, politicians, etc.

## **Floodplains: Guidance for those who live and/or work on floodplains**

### ***Areas that are liable to flooding***

Flood maps show main flood risk areas on rivers or coasts and can be accessed via:

- The Internet on [www.environment-agency.gov.uk/floods](http://www.environment-agency.gov.uk/floods)
- Your local Environment Agency office.

Flooding can occur outside these areas, particularly during very large floods or where the floodwater does not come from rivers or the sea, for example when sewer systems overflow or water runs off hillsides.

### ***How frequently can flooding occur?***

The flood maps show approximate flood limits for floods which have:

- a 1 in 100 chance of occurring every year on non-tidal rivers
- a 1 in 200 chance of occurring every year on tidal rivers, estuaries and coasts.

The closer the location is to rivers and coasts, the more frequent the flooding is likely to be. In frequently flooded and/or recently flooded areas, local people will have knowledge of flooding.

### ***Preparing for floods***

#### Flood warning and evacuation

- Register with your local flood warning scheme if one exists. You will then receive flood warnings either by telephone or from a flood warden or other personnel;
- Obtain a copy of your local Flood Directory from the Environment Agency and/or the local flood emergency plan from your local authority;
- Keep these documents in an easily accessible and safe place;
- If in doubt, contact Floodline on 0845 988 1188;
- Make sure you know what the flood warning arrangements are and how to respond when a flood warning is issued;
- Make sure you know evacuation arrangements and routes.

#### Safeguarding your property

- Identify and prepare measures to protect property and contents from flood damage, including the use of protection devices and plans to move items (including cars) out of the area which might flood.

#### Working with the community

- Join local community groups. Self-help and neighbour support are very important in flood emergencies;
- Maintain flood awareness by regular meetings and events in your community;
- Consider becoming a flood warden if you would be able to help others during a flood emergency.

### ***When a flood occurs:***

- When a flood warning is received, pass it to neighbours where you can;
- Try to obtain up to date flood information by radio, other residents or other pre-determined means;

- Implement plans to protect property and contents;
- Evacuate property if required to do so. Make sure everyone in your property is evacuated;
- Assist neighbours if you are able to, particularly vulnerable groups (e.g. children and the elderly).

If you are able to provide information to your local authority about the flood and the warnings and help you received, this will improve planning and preparation for future floods.

***What help is available?***

- Advice on how to protect your property is available from the Environment Agency;
- Advice on finance and insurance is available from insurance companies or the ABI;
- The Police co-ordinate the emergency response and organise the evacuation of properties, where necessary;
- The Fire and Rescue Service will rescue trapped people and help to pump water out of properties;
- The local authority will provide:
  - Rest centres for evacuees;
  - Temporary accommodation for those unable to arrange anything themselves;
  - Assistance with evacuation;
  - Assistance with clearing up;
  - Advice and assistance on recovering from a flood disaster.

***ENSURE THAT YOU HAVE TELEPHONE NUMBERS FOR THESE ORGANISATIONS***

***ALL THESE ORGANISATIONS HAVE LIMITED RESOURCES. THE MORE YOU CAN HELP YOURSELF AND YOUR NEIGHBOURS, THE BETTER***

After a flood you will be faced by the task of clearing up and repairing your property. Advice on the repair and restoration of your property is available from the Environment Agency.

***You can help to reduce flooding by:***

- Commenting on flood management aspects of the local authority draft land use plan for your area, and how it relates to your community;
- Commenting on the local authority draft flood emergency plan for your area, and how it relates to your community;
- If there is a small watercourse or drainage channel on any boundary of your property, make sure it is maintained so that it does not impede the discharge of floodwater. Larger watercourses are maintained by the Environment Agency – make sure you know who is responsible for the watercourse.

***IF YOU HAVE EXPERIENCE OF FLOODING IN YOUR AREA, YOUR COMMENTS WILL BE PARTICULARLY IMPORTANT***



## **Floodplains: Guidance for farmers and other landowners who own land in flood risk areas**

### ***Areas that are liable to flooding***

Be aware of the parts of your property that are liable to flood

Flood maps show main flood risk areas on rivers or coasts and can be accessed via:

- The Internet on [www.environment-agency.gov.uk/floods](http://www.environment-agency.gov.uk/floods)
- Your local Environment Agency office.

Flooding can occur outside these areas, particularly during very large floods or where the floodwater does not come from rivers or the sea, for example when sewer systems overflow or water runs off hillsides.

### ***How frequently can flooding occur?***

The flood maps show approximate flood limits for floods which have:

- a 1 in 100 chance of occurring every year on non-tidal rivers
- a 1 in 200 chance of occurring every year on tidal rivers, estuaries and coasts.

The closer the location is to rivers and coasts, the more frequent the flooding is likely to be. In frequently flooded and/or recently flooded areas, local people will have knowledge of flooding.

### ***Defending your land against flooding***

- Any flood defences will require permission from the Environment Agency\*. This is because flood defence works can affect the flood risk elsewhere;
- If you are considering building flood defences, talk to the Environment Agency\* first. There may already be plans to defend your property.

\* Or Internal Drainage Board if you are in a Drainage District.

### ***Existing flood defences***

- If you have private flood defences on your property already, you are responsible for maintaining them;
- Make sure private flood defences are maintained.

### ***Land drainage***

- Landowners should not increase the amount of drainage water that runs off their land. Any changes to the drainage system should include measures to control the rate of runoff;
- If there are any watercourses or drainage channels that either run through or along any boundary of your property, make sure it is maintained so that it does not impede the discharge of floodwater. Larger watercourses are maintained by the Environment Agency – make sure you know who is responsible for the watercourse.

***Flooding of un-occupied properties***

- Identify and prepare measures to protect property and contents from flood damage, including the use of protection devices and plans to move items (including cars) out of the area which might flood;
- Advice on how to protect your property from flooding, and how to repair and restore properties after a flood, is available from the Environment Agency.

***Flooding of occupied properties***

- If people are at risk of flooding, refer to the sheet.

**Floodplains: Guidance for those who live and/or work on floodplains**

***You can help to reduce flooding by:***

- Commenting on flood management aspects of the local authority draft land use plan for your area;
- Commenting on the local authority draft flood emergency plan for your area.

***IF YOU HAVE EXPERIENCE OF FLOODING IN YOUR AREA, YOUR COMMENTS WILL BE PARTICULARLY IMPORTANT***

## **Floodplains: Guidance for the planning function of local authorities.**

This guidance is intended for all those involved with the planning function of local authorities including:

- Chief Executives
- Elected members
- Planning officers
- Planning inspectors.

The land use planning function should:

- Include flood risk areas in land use plans;
- Include draft flood management policies, flood management measures and floodplain land use in draft land use plans, using information provided by the Environment Agency;
- Finalise flood management policies, flood management measures and floodplain land use following consultation with floodplain residents, businesses and others. Inform the Environment Agency of any changes to the draft proposals;
- The policies should include acceptable types of land use in different zones of the floodplains, as defined in Figure 3.2;
- Show floodplain zones on land use planning maps;
- Show proposed flood management measures on land use planning maps;
- Ensure that new developments comply with the flood management policies and floodplain land use plans. In particular, new developments should facilitate flood emergency activities including access during emergencies.

### ***Areas that are liable to flooding***

Flood maps show main flood risk areas on rivers or coasts and can be accessed via:

- The Internet on [www.environment-agency.gov.uk/floods](http://www.environment-agency.gov.uk/floods)
- Your local Environment Agency office.

Flooding can occur outside these areas, particularly during very large floods or where the floodwater does not come from rivers or the sea, for example when sewer systems overflow or water runs off hillsides. In particular you should:

- Estimate the floodplain extent on other watercourses not shown on the maps where flooding is a problem. These flood extents should be shown on land use planning maps;
- Identify any other areas which are known to flood.

### ***How frequently can flooding occur?***

The flood maps show approximate flood limits for floods which have:

- a 1 in 100 chance of occurring every year on non-tidal rivers
- a 1 in 200 chance of occurring every year on tidal rivers, estuaries and coasts.

The closer the location is to rivers and coasts, the more frequent the flooding is likely to be. In frequently flooded and/or recently flooded areas, local people will have knowledge of flooding.

### ***Flood management policies***

- Develop policies for land use on the floodplains in collaboration with the Environment Agency;
- Policies on development in flood risk areas should be based on PPG25;
- Floodplains should be zoned into:
  - Areas where flood flow occurs: Developments that impede flood flows should not be permitted in these areas;
  - Areas where flood storage occurs: Developments that reduce flood storage should not be permitted in these areas;
  - Areas where the floodplain is constricted by development: The long term aim should be to gradually remove development from these areas.

### ***Flood management measures***

- Flood management measures reduce flood risk and mitigate the impacts of flooding;
- They include structural measures (for example, flood embankments) and non-structural measures (for example, flood warning schemes);
- Details of proposed flood management measures for the planning district can be obtained from the Environment Agency. These are outlined in SMPs and CFMPs and set out in detail in the local river or coastal strategy plans where these have been prepared.

## **Floodplain management responsibilities of river and coast managers**

(Environment Agency, Local Authority engineers, IDBs)

### ***The Environment Agency***

#### Flood defence and flood management

- Producing maps of the floodplains;
- Maintenance and improvement works on the larger rivers (termed “Main Rivers”) and coasts;
- Provision and maintenance of flood defences on Main Rivers and coasts;
- Planning consultee on land use plans and planning applications;
- Advice to the general public and others on all flooding matters.

#### Flood emergencies

- Forecasting of floods;
- Issuing of flood warnings to the general public, the emergency services and other relevant organisations. Flood warnings may also be disseminated by others, for example flood wardens, depending on local arrangements;
- Assistance in flood emergencies, particularly with regard to strengthening defences and clearing blockages.

#### Conservation

- Development of schemes to conserve and enhance the natural environment. These are often carried out as part of flood defence schemes;
- Advice to the general public and others on conservation matters.

Regional and Local Flood Defence Committees are responsible for the flood defence duties of the Environment Agency.

### ***Local Authorities (District Councils, Unitary Authorities, London Boroughs)***

#### Flood defence

- Maintenance, improvement works and flood defences on the smaller rivers and streams (termed “Ordinary Watercourses”) and coasts. This includes Critical Ordinary Watercourses;
- Works to protect the coast from erosion and other damage.

#### Flood emergencies

- Working with the emergency services to plan for flood emergencies;
- **Preparation of a draft flood emergency plan** in collaboration with the County Council (where appropriate) and the emergency services;
- **Finalise the flood emergency plan** in collaboration with the County Council (where appropriate), following consultation with floodplain residents, businesses and others;
- Disseminating Environment Agency flood warnings to relevant staff;
- Responding to flood emergencies including:
  - Assisting flood affected people particularly the elderly and other vulnerable groups;
  - Working with the police to close flooded roads and arrange road diversions where Local Authorities have highway responsibilities;
  - Providing rest centres and temporary accommodation;
  - Co-ordinating the activities of the voluntary sector;

- Providing temporary mortuaries where required during emergencies.
- Clearing up after a flood;
- Assisting the local community to recover from floods;
- Provision of information to flood affected communities;
- Improve the flood emergency plan and prepare for the next flood;
- Maintain flood awareness of floodplain communities by public meetings and newsletters.

***Internal Drainage Boards (IDBs)***

- Maintenance and flood protection for watercourses in Drainage Districts;
- Planning consultee on land use plans and planning applications in Drainage Districts.

It should be noted that the flood management powers of Operating Authorities (the Environment Agency, Local Authorities and Internal Drainage Boards) are generally permissive and not statutory. In particular, they are not legally required to provide flood defences and/or flood warning systems.

## **Floodplains: Guidance for the emergency services**

### Areas that are liable to flooding

Flood maps show main flood risk areas on rivers or coasts and can be accessed via:

- The Internet on [www.environment-agency.gov.uk/floods](http://www.environment-agency.gov.uk/floods)
- Your local Environment Agency office.

Flooding can occur outside these areas, particularly during very large floods or where the floodwater does not come from rivers or the sea, for example when sewer systems overflow or water runs off hillsides.

### How frequently can flooding occur?

The flood maps show approximate flood limits for floods which have:

- a 1 in 100 chance of occurring every year on non-tidal rivers
- a 1 in 200 chance of occurring every year on tidal rivers, estuaries and coasts.

The closer the location is to rivers and coasts, the more frequent the flooding is likely to be. In frequently flooded and/or recently flooded areas, local people will have knowledge of flooding.

### Who and what is at risk of flooding

- The location of residential, commercial and industrial properties at risk of flooding can be determined by overlaying flood maps on street maps;
- The location of vulnerable communities who may require particular help in floods, for example the elderly, should be determined in consultation with local authorities.

### ***Responsibilities of the Police***

- Working with local authorities to plan for flood emergencies;
- Trigger conditions for activation of the flood emergency plan;
- Control and co-ordination of the emergency response including communications;
- Public safety;
- Working with highways authorities to close flooded roads and arrange diversions.
- Evacuation, with particular assistance to the elderly, disabled and other vulnerable groups;
- Protection of property from looting, etc.;
- Implementation of contingency plans if, for example, road accesses becomes blocked or key services fail;
- Maintenance of flood response capability by regular updates and emergency exercises;
- Allocation of duties and training of staff.

### ***Responsibilities of the Fire and Rescue Service***

- Working with the police and others to plan for flood emergencies;
- Rescue of people trapped by floods;
- Pumping out of flood affected properties;
- Allocation of duties and training of staff;
- Identification and allocation of resources including boats and other rescue equipment.

### ***Responsibilities of the Health Service***

- Providing health support to those affected by floods including making vehicles and facilities available during flood emergencies;

- Research into health impacts of flooding.

***Involvement of the media***

- Assist with the dissemination of flood warnings;
- Raising the awareness of the general public to flood risk and the impacts of flooding;
- Provision of information on flooding including, for example, details of road closures.

***Involvement of the voluntary sector***

- Assistance in flood emergencies and recovery
- Activities of the voluntary sector should be co-ordinated by local authorities.



## **Floodplains: Guidance for those involved with conservation and environmental enhancement**

Those who are involved in conservation and environmental enhancement should:

- Know the areas at risk from flooding;
- Know what the important conservation and environmental features are in the areas of the floodplain where they have particular interests or responsibilities;
- Understand the impacts of flooding in these areas;
- Contribute to floodplain management aspects of local land use plans with advice on conserving and enhancing the natural environment of the floodplain;
- Conserve, enhance and manage the natural environment of the floodplain;
- Manage conservation areas so that they do not increase flood risk.

### ***Areas that are liable to flooding***

Flood maps show main flood risk areas on rivers or coasts and can be accessed via:

- The Internet on [www.environment-agency.gov.uk/floods](http://www.environment-agency.gov.uk/floods)
- Your local Environment Agency office.

### ***How frequently can flooding occur?***

The flood maps show approximate flood limits for floods which have:

- a 1 in 100 chance of occurring every year on non-tidal rivers
- a 1 in 200 chance of occurring every year on tidal rivers, estuaries and coasts.

The closer the location is to rivers and coasts, the more frequent the flooding is likely to be. In frequently flooded and/or recently flooded areas, local people will have knowledge of flooding.

### ***Impacts of flooding***

The impacts of flooding in conservation areas can be both positive and negative and include:

- Damage caused by the flow of water across the floodplains
- Deposition of sediment
- Recharge by fresh floodwater (from rivers) and saline water (from the sea)
- Impacts of polluted floodwater.

As flooding is a natural process, flooding is part of the natural regime of the floodplain. As a general principle therefore, the flood regime in conservation areas should not be changed by the introduction of flood management measures. There may be exceptions to this principle for particular sites.

### ***Contribution to floodplain management***

- Advice on conservation and environmental features on the floodplains and how they should be managed;
- Comment on the proposals contained in the draft local land use plans with respect to environmental impacts on floodplains, and advise on recommended changes;
- Advice on the environmental opportunities and enhancements arising from proposed new developments and flood management measures on the floodplains.

### ***Management of conservation areas***

In order to minimise the impact of conservation areas on flooding, management of the areas should:

- Ensure that flood flow paths on floodplains are maintained
- Manage vegetation including cutting avoid blockage of the floodplain
- Avoid changes in the land profile that increase flood risk
- Ensure that hedges and other structures (including fences, etc.) do not block flow paths and increase flood risk.

## **Floodplains: Guidance for those who have assets on floodplains (transport, utilities)**

Those who have assets on floodplains should:

- Know where the floodplains are;
- **As far as possible, keep key facilities such as electrical sub-stations out of flood risk areas;**
- Know the likely flood levels in relation to the assets, and the likelihood of flooding;
- Understand the impacts of flooding on the assets;
- Prepare contingency plans for closure/failure during floods and implement if necessary in flood emergencies;
- Repair damaged facilities after floods and, where possible, move key facilities out of flood risk areas;
- Maintain assets to avoid increasing flood risk;
- Be consulted on floodplain management aspects of draft land use plans and contribute to the final plans.

### **Areas that are liable to flooding**

Flood maps show main flood risk areas on rivers or coasts and can be accessed via:

- The Internet on [www.environment-agency.gov.uk/floods](http://www.environment-agency.gov.uk/floods)
- Your local Environment Agency office.

Flooding can occur outside these areas, particularly during very large floods or where the floodwater does not come from rivers or the sea, for example when sewer systems overflow or water runs off hillsides.

### ***How frequently can flooding occur?***

The flood maps show approximate flood limits for floods which have:

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The closer the location is to rivers and coasts, the more frequent the flooding is likely to be. In frequently flooded and/or recently flooded areas, local people will have knowledge of flooding.

### ***Flood levels***

Data on flood levels are not available from flood risk maps, but may be obtainable from the following sources:

- The Environment Agency
- Flood studies associated with new works, for example new road crossings of the floodplain.

Levels should be associated with a frequency of occurrence and allowances should be made for higher levels that might occur.

### ***Impacts of flooding***

The impacts of flooding include:

- Inundation of roads and railways, leading to closure
- Inundation of facilities on floodplains including water treatment works, electricity substations, etc., leading to closure
- Damage to embankments and other foundations
- Blockage and backing up of drainage systems
- Blockage of flood openings in embankments by debris
- Water, sediment and pollution damage to plant and electrical equipment.

### ***Maintenance of assets***

Assets in floodplains should be designed and maintained to avoid increasing flood risk, including:

- Avoid small flood openings in embankments as they are liable to blockage;
- Design flood openings that are in line with the flood flow;
- Avoid fences across flood flow paths as they accumulate debris and cause blockage (unless the fences are specifically designed to collapse during floods);
- Design and maintain drainage systems to manage local runoff during floods.

## **Floodplains: Guidance for developers and insurance companies**

Developers should:

- Know where floodplains are;
- Know the frequency of flooding and flood levels at proposed development sites;
- Know the local floodplain management policies. These will be based on Planning Policy Guidance contained in PPG25, and will be set out in the local land use plan;
- Undertake a Flood Risk Assessment as required by PPG25;
- Design developments suited to flood risk areas;
- Make appropriate arrangements for the long-term management of the development, including flood management (for example, maintaining flood flow routes and defences) and local drainage;

Insurance companies should:

- Know the risk of flooding for any developments they are proposing to insure;
- Advise the developer of insurance conditions and likely costs during the planning stage of the development.

### ***Areas that are liable to flooding***

Flood maps show main flood risk areas on rivers or coasts and can be accessed via:

- The Internet on [www.environment-agency.gov.uk/floods](http://www.environment-agency.gov.uk/floods)
- Your local Environment Agency office.

Flooding can occur outside these areas, particularly during very large floods or where the floodwater does not come from rivers or the sea, for example when sewer systems overflow or water runs off hillsides.

### ***How frequently can flooding occur?***

The flood maps show approximate flood limits for floods which have:

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The closer the location is to rivers and coasts, the more frequent the flooding is likely to be. In frequently flooded and/or recently flooded areas, local people will have knowledge of flooding.

### ***Flood levels***

Data on flood levels are not available from flood risk maps, but may be obtainable from the following sources:

- The Environment Agency
- Flood studies specifically undertaken by the developer.

Levels should be associated with a frequency of occurrence and allowances should be made for higher levels that might occur.

***Developments in flood risk areas should:***

- Have a very small flood risk to buildings that is acceptable to insurance companies;
- Not worsen flood risk elsewhere. This should be demonstrated in the flood risk study required by PPG25;
- Facilitate any required access by emergency services during flood emergencies including the need for evacuation;
- Have drainage systems that manage local runoff during flood events. Note that “Sustainable Urban Drainage Systems (SUDS)” that involve infiltration of runoff into the ground are unlikely to be effective on floodplains during floods.

## **Floodplains: General information for the public**

Floodplains are areas of special concern because they are often:

- Highly developed including residential, commercial, amenity and agricultural areas
- At risk of suffering from a severe natural hazard (i.e. flooding).

The general public should be aware of:

- The location of floodplains
- The likelihood of flooding
- How they are affected by the flood risk.

Floodplains must be managed to minimise the overall flood risk to people and property. This is done by:

- Planning of land use on the floodplains taking the flood risk into account
- Flood emergency planning, where plans are made for the emergency response needed in times of flood.

These activities are co-ordinated by the local authority and undertaken with assistance from the Environment Agency, emergency services and others.

### ***Areas that are liable to flooding***

Flood maps show main flood risk areas on rivers or coasts and can be accessed via:

- The Internet on [www.environment-agency.gov.uk/floods](http://www.environment-agency.gov.uk/floods)
- Your local Environment Agency office.

Flooding can occur outside these areas, particularly during very large floods or where the floodwater does not come from rivers or the sea, for example when sewer systems overflow or water runs off hillsides.

### ***How frequently can flooding occur?***

The flood maps show approximate flood limits for floods which have:

- a 1 in 100 chance of occurring every year on non-tidal rivers
- a 1 in 200 chance of occurring every year on tidal rivers, estuaries and coasts.

The closer the location is to rivers and coasts, the more frequent the flooding is likely to be. In frequently flooded and/or recently flooded areas, local people will have knowledge of flooding.

### ***How flooding affects the general public***

- Transport disruption caused by the closure of roads and railway lines;
- Service disruption, including possible failure of electricity supply systems, telephones, etc.;
- Employment disruption for those who work in floodplains;
- Business disruption, including temporary loss of local businesses and effects on local tourism, etc.;
- Disruption to sports facilities and other local amenities.





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# APPENDICES



# Appendix A

## Floodplain management measures

This Appendix provides general background information on the various categories of floodplain management measures and on individual measures themselves, including their advantages and potential disadvantages.

For convenience, the various measures have been described in isolation. However, a fundamental principle of good floodplain management is that management measures **should not be considered in isolation**. Rather, they need to be considered collectively on a risk management basis in order to provide the best combination of measures for managing flood risk on floodplains taking account of:

- their interactions
- their suitability and effectiveness
- economic effectiveness
- social impacts
- ecological impacts.

### A.1 Structural measures

Common structural measures used to mitigate flooding include:

- Embankments and walls, including spillways to control flooding
- Bypass or diversion channels
- Increasing the channel conveyance capacity
- Flood storage and detention basins
- Pumping
- River maintenance
- Operation of dams
- Tidal flood barriers/barrages
- Flood proofing of buildings.

#### A.1.1 Flood embankments and walls

Flood embankments and walls are often the cheapest way to protect existing development in flood-prone areas. The height or crest level is determined by factors that include:

- Flood levels
- Required standard of protection
- Economics, as defined in the project appraisal process
- Physical limitations of the site. Flood walls are normally used in restricted locations.

There is a risk that embankments and walls may fail, and there is an ongoing need for maintenance and repair. In addition, embankments and walls will be overtopped during events which exceed their design standard. This emphasises the importance of flood emergency plans for areas protected by embankments and walls, which should include details of the emergency response if defences fail or are overtopped.

When embankments and walls are used for flood mitigation, the following events, conditions and precautions need to be observed:

- The likelihood of catastrophic damage and unacceptable hazard levels when overtopping or failure occurs (including rate of rise and velocity of floodwater);
- It is advisable to provide spillways in embankment systems to control overtopping and reduce the risks of breaching and uncontrolled high velocity overflows in developed areas where lives are at risk;
- Maintenance of the crest level, grass cover and other protection, and spillways;
- Flood emergency plans for overtopping or failure of defences are in place including evacuation plans, particularly where escape routes can be severed (as in a ring embankment, or where the protected area can fill rapidly once overtopping starts);
- The community receives on-going education to ensure that people are aware of the risk of overtopping or failure of defences, informed about flood emergency plans, and do not lapse into the common belief that embankments and walls “provide total protection against all floods”;
- Embankments and walls prevent flood flow in the protected areas and reduce floodplain storage. Thus there is a risk of increasing flood levels elsewhere unless suitable mitigation measures are taken (for example, increasing the conveyance capacity of the adjacent river and unprotected floodplain);
- Drainage of local runoff water that collects within the protected area needs to be taken into account. Pumps and sumps may be required to remove this water during floods. If they fail, flooding may occur in the protected area;
- Freeboard is needed to take account of the effects of uncertainty in flood level prediction, wave action, subsidence, etc.

In areas where permanent embankments and walls would not be acceptable for visual or environmental reasons, an alternative would be to use demountable flood walls. These require permanent foundations but the actual wall units are only erected on receipt of a flood warning. Whilst these offer a potentially attractive solution, they require:

- An adequate period of flood warning to permit assembly of the walls
- Adequate manpower to be available whenever required.

In summary, whilst embankments and walls provide an effective flood management measure for existing flood problems, they should be supplemented by flood emergency measures.

### **A.1.2 Bypass or diversion channels**

Bypass or diversion channels redirect a portion of flood flow away from areas at risk, and reduce flood levels along the channel downstream of the diversion off take.

Opportunities for the construction of diversion channels are limited by the topography of the area, ecological considerations and the availability of land. Diversion channels may create new flood risk areas along the diversion channel itself. In addition, diversion channels reduce flood attenuation and can increase flood flows and therefore flood risk at locations downstream of the diversion channel.

Further advice on the design of river diversions is given in Fisher and Ramsbottom, 2001.

### **A.1.3 Increasing the channel conveyance capacity**

The capacity of a river channel to discharge floodwater can be increased by widening, deepening or realigning the channel, and by clearing the channel banks and bed of obstructions to flow.

Such “improvements” can increase the velocity and possibly the depth of flow. It is essential (duty of care) that signage be erected to warn the public of any untoward hazard associated with increasing the channel conveyance capacity.

In urban situations, particularly where drainage channels have degraded over time, channel improvements can provide the community with other positive benefits, such as enhanced visual aesthetics (by landscaping) and providing recreation facilities, such as linear parks. A particular example of a method of increasing the conveyance capacity which provides enhancement opportunities is the creation of a “two-stage” channel. In this case the existing river channel is retained for low and medium flows, and floodplains are created parallel to the river channel to accommodate flood flows.

Increasing the channel conveyance capacity can, like diversion channels, reduce flood attenuation and increase the flood risk downstream. Other disadvantages include the cost of maintenance of oversized channels, where sediment deposition may occur. In the past, channel “improvements” have resulted in the destruction of riparian habitat and the visual impact of replacing naturally varying channel sections with a section of more uniform geometry. Modern design methods concentrate on conserving and enhancing the natural environment and retaining natural features wherever possible (HR Wallingford, 2001).

### **A.1.4 Flood storage and detention basins**

A flood storage basin is an artificial basin specifically designed for the temporary storage of excess flood water, thus limiting the flow that passes downstream. Floodwater is released gradually after the flood has passed. Storage basins require controls to limit the amount of water passing downstream.

Flood storage basins may be classified as “on-line”, where the river channel passes through the storage area, and “off-line”, where the river channel bypasses the storage area. In addition, flood storage basins can be “wet”, where the storage area contains water under dry weather conditions, or “dry”, where the storage area is free of water under dry weather conditions.

Further details of storage basins are given in Hall et al 1993.

Flood storage basins provide opportunities for environmental enhancement but they have a number of disadvantages that need to be carefully evaluated:

- They require a substantial area of land to achieve the necessary storage. As a result they are often not viable for large rivers;
- Where used for multiple purposes, for example as playing fields during dry conditions, public safety aspects during flooding need to be considered;
- Long duration or multi-peak storms, where the basin is partly or completely filled from a previous peak, can reduce the effectiveness of the storage basin. Once the basin is full, attenuation of the flood discharge is small;

- When the basin is full and overtopping occurs, there is a risk of breaching and the resulting downstream hazard;
- Flood storage basins can trap sediment, and require regular maintenance for sediment removal. There may also be adverse impacts downstream associated with this loss of sediment.

### **A.1.5 Pumping**

Pumping is used to maintain water levels in many low lying catchments in the UK, particularly agricultural areas in the East of England. The systems are designed to discharge floodwater and reduce the risk of surface water flooding. Pumping is normally used in conjunction with embankments to prevent back flow of water from the receiving watercourse (or the sea for coastal installations).

Pumping is an effective flood mitigation measure for relatively small catchments where the flood volumes are not too great. The drainage system in the catchment leading to the pumping station must have adequate capacity for flood flows.

### **A.1.6 River maintenance**

River maintenance is used to reduce flood risk by a number of measures including:

- Dredging
- Weed cutting
- Bank clearance
- Removal of obstructions and rubbish including structure/screen blockages.

Whilst the removal of obstructions is a routine maintenance item, dredging and vegetation management are specific measures used to maintain a particular standard of flood protection. These measures may be used to reduce the risk of frequent flooding. On the River Thames for example, river maintenance helps to provide an in-channel capacity for about the 1 in 10 annual probability flood.

### **A.1.7 Operation of dams**

Reservoirs, even if full, can significantly reduce downstream flood discharges. As the flood wave passes through a reservoir, the reservoir progressively fills to the point of overflow, and then provides temporary storage above the spillway crest level for floodwaters subsequently passing through the reservoir.

The ability of a reservoir to mitigate floods depends largely on the surface area of the dam at spillway level and its spillway capacity. The larger the surface area and the smaller the spillway capacity, the greater the reduction in downstream discharges. This effect is most beneficial immediately downstream of the dam and the benefits reduce as the floodwave travels downstream.

In the UK, most reservoirs are used for water supply and the scope for flood management is very limited. However as part of catchment flood management planning, the impacts of any proposed dams on flooding should be taken into account.



### **A.1.8 Tidal flood barriers/barrages**

Tidal flood barriers and barrages are located on tidal rivers and estuaries, and are designed to prevent tidal flooding upstream of the structure. Barrages impound the river upstream and require sluice gates for the river discharge and locks for navigation. They have a significant impact on the river regime including floods, sediment and water quality. In contrast, barriers are only closed during extreme high tides and therefore the impact on river regime is small.

Both barriers and barrages are normally combined with flood walls and banks in order to provide a complete defence system.

### **A.1.9 Flood proofing of buildings**

Flood proofing refers to:

- The design and construction of buildings with appropriate water-resistant materials such that flood damage to the structure of the building and contents is minimised when the building is flooded;
- The use of temporary barriers and other measures to reduce flood damage when a flood actually occurs. Traditionally sandbags have been used but more efficient products have been developed.

Flood proofing may be applied to both new construction and existing buildings.

In areas that flood regularly where residents are aware of the impacts, some buildings are already “flood proofed” using such measures as stone floors and walls, raised electricity supply, etc.

The decision to adopt flood proofing as a formal mitigation measure is best made from within the framework of a building control policy within land use plans. Although flood proofing can reduce damage to flood-affected buildings, the occupiers still suffer the social disruption of flooding.

Issues to consider in flood proofing the structure of a building include:

- Design to withstand water immersion, differential water pressure on walls, debris and flotation forces;
- Use of methods of construction and certain types of materials which are better able to withstand immersion than others. For example plasterboard and chipboard are generally irreparable after immersion, whereas some bricks and plastics can withstand immersion without damage and only require cleaning when the flood subsides;
- Impact of polluted water, particularly by sewage from urban flooding;
- Raising floor levels above the flood level.

The most effective flood proofing measure is to raise the floor level above flood level. However this involves additional cost in raising ground levels which can be very significant, particularly for large commercial buildings. Raised floor levels will also reduce the amount of available flood plain storage as water which would otherwise flood buildings is now unable to do so. This must be taken into account in the overall assessment of the impact of the development on flooding.

## **A.2 Non-structural measures**

Non-structural measures (i.e. those which do not require engineering or building work) include:

- Development control, which includes:
  - Avoidance of inappropriate developments on floodplains
  - Protection of new developments
  - Floodplain zoning, to link land use with the flooding function of different parts of the floodplain.
- Flood insurance
- Flood emergency planning:
  - Raising the awareness of flood risk and preparedness of individuals and organisations to respond to a flood emergency. This includes the floodplain population, floodplain managers and the emergency services
  - Flood warning
  - Emergency response
  - Clean-up after a flood
  - Recovery from flooding.

### **A.2.1 Development control**

Development control is concerned with whether or not developments should be constructed in flood risk areas and, where developments are permitted, the conditions attached to the development of defined areas. Such controls are aimed at reducing the risk of buildings and other assets being flooded, reducing the resulting damage when above floor flooding occurs, and avoiding increases in flood risk elsewhere. Typical development control requirements include for example, identification of the parts of a site where building may and may not be permitted, and minimum floor levels. Careful and creative strategic site planning can reduce hazard and facilitate evacuation when required.

Guidance on whether or not development should be permitted is given in Planning Policy Guidance Note 25 (PPG25), which indicates types of acceptable development in parts of the floodplains with different degrees of flood risk.

The Environment Agency in its role as a statutory consultee will state specific requirements related to the floodplain and the type of additional data and analysis that might be required. These requirements may include:

- Assessment of the impacts of the development on flood levels elsewhere
- Specific comments on the proposed development to minimise the impact of floods
- Identification of suitable evacuation routes
- Environmental requirements.

The safety of people during a flood event is of fundamental importance in the development of flood risk areas. Evacuation can be very hazardous if safe evacuation routes are not available. Developments should either include safe locations for people, for example in the upper floors of buildings, and/or safe evacuation routes. Provisions for the safety of people during floods should be agreed with the emergency services.

Flood hazard may vary significantly across the site because of topography. For example, higher areas further away from the river or coast will be flooded to shallower depths and may

experience lower flow velocities than lower areas closer to the source of flooding. By locating buildings in the higher parts of the site, their effect on flooding will be reduced, potential flood damage will be lessened and risks to people will be less.

Fences and hedges are a particular issue of concern because they can significantly obstruct flood flow and increase flood levels. During a flood, open mesh fences and hedges tend to become clogged with debris and act as solid obstructions to flow. One possibility might be to use lightweight fences which collapse under a certain pressure of flow.

#### Floodplain zoning

The division of flood-prone land into appropriate land uses is an effective and sustainable means of limiting flood damage to future developments. Local land use plans should identify appropriate zones and related development constraints in each zone.

Floodplain zoning should be based on objective criteria related to social, economic and ecological issues, as well as flood risk. Examples of such criteria include:

- Areas of active floodplain (where flood flow occurs) and passive floodplain (where storage occurs);
- Flood hazard;
- Potential for future development to adversely affect flood behaviour at existing developments, particularly the cumulative effects of future development;
- Availability of adequate evacuation routes during floods;
- Certain land uses to be kept out of flood risk areas, for example accommodation for the elderly.

#### Voluntary purchase

In certain high hazard areas of the floodplain it may be impractical or uneconomic to mitigate flood hazard to existing properties at risk, and flood insurance may not be available for such properties.

In these circumstances it may be appropriate to cease occupation of such properties in order to free both residents and potential rescuers from the hazard of future floods. Properties would be bought and buildings removed or demolished as part of local development planning. Property should be purchased at an equitable price and only when voluntarily offered. Such areas should be re-zoned to a flood-compatible use, such as recreation or parkland.

### **A.2.2 Flood insurance**

Flood insurance has for many years been provided in the UK as part of the standard property insurance cover package. Insurance fills the gap between the total amount of potential flood damage each year and the amount which is prevented by flood defences and other flood management measures.

Recent floods on the UK, particularly Easter 1998 and Autumn 2000, have raised the awareness of insurers to the high potential losses associated with flooding. It is therefore likely that arrangements for flood insurance cover will change in the future, with residents and businesses being required to take a greater proportion of the risk.

It is recommended that the insurance industry has a greater involvement in flood management. Suggestions include:

- Consultee on guidelines for flood risk aspects of Local Plans and Flood Emergency Plans;
- Consultee on Local Plans ;
- Consultee on major developments, working with local authorities and developers to develop schemes where the flood risk is acceptable to insurers.

Clearly these suggestions have a resource implication for the insurance industry.

### **A.2.3 Flood emergency measures**

Flood emergency measures include:

- Flood forecasting
- Flood warning
- Planning for flood emergencies
- Flood response during flood emergency including the relief of evacuees
- Recovery after the flood.

All of these flood emergency measures are incorporated in the Flood Emergency Plan, an outline of which is given in Appendix E.

The importance of flood emergency planning has become apparent in recent years, particularly following the Easter 1998 floods where in some areas the floods exceeded the standards of protection provided by defences and areas flooded that had not flooded before. The development and implementation of effective flood emergency plans is the only means of reducing the damage and hazard associated with this residual risk.

Preparedness measures include:

- Raising awareness of flood risk
- Flood warning arrangements and advice to residents, businesses and other stakeholders on how they should respond
- Preparatory measures by residents and businesses to protect properties and contents
- Arrangements for public safety including evacuation plans where required.

These measures will reduce both the intangible as well as the tangible costs of flooding. They may be the only economically justifiable management measure where a few people are subjected to a high degree of flood risk.

One challenge with flood emergency planning is to maintain an adequate level of flood awareness during the extended periods when moderate to severe flooding does not occur, particularly in the face of population turnover. A continuing awareness programme must be put in place to inform new residents, maintain the level of awareness of old residents and to cater to changing circumstances of, for example, flood behaviour and new developments.

In addition to their role in flood emergency planning, the flood-prone community must be made aware—and remain aware—of their role in the overall floodplain management strategy for their area, including the defence of their town and the evacuation of themselves (and possibly personal goods and possessions).

Sustaining an appropriate level of flood awareness involves a continuous effort by the local authority, community groups and the emergency services. The cost of such efforts can be regarded as a “maintenance cost” of the flood emergency plan.

Irrespective of the available warning time, generally there is widespread variation in flood awareness, both between households and communities. In a very flood-aware community flood-affected residents may move all their goods and possessions to a safe location with little fuss or bother, even down to removing internal doors. The principal factor determining the degree of flood awareness of a community is usually the frequency of moderate to large floods in the recent history of the area. The more recent and frequent the flooding, the greater the awareness.

### **A.3 Freeboard and other safety provisions**

There is considerable uncertainty associated with flood prediction and management. The reasons for this include uncertainty in predictions of flood flows, flood levels and wave heights, and the impacts of climate change (including greater storminess and sea level rise). In addition, there is even greater uncertainty in flood emergencies, where the extent of the flood and response of individuals is difficult to predict.

Particular problems associated with the prediction of flood levels include:

- Uncertainties in estimates of flood levels due to lack of data, and uncertainties and simplifications in the models used to predict flood discharges and flood levels;
- Differences in water levels across the floodplain because of “local factors” not included in hydraulic models;
- The cumulative effect of subsequent development;
- Increases in water level as a result of wave action including both wind induced waves and the effects of vehicles moving through flooded areas.

Where possible, safety provisions should be included in floodplain management measures. Examples include:

- Freeboard on flood embankment and wall levels;
- Freeboard on raised floor levels;
- Additional capacity in other structural measures including flood storage, diversion channels, etc.;
- Failsafe procedures in flood emergency planning, for example a check by the emergency services that all buildings that should be evacuated have been.



## Appendix B

### The flood study

#### B.1 Introduction

A flood study is a comprehensive technical investigation of flooding behaviour that defines the extent and depth of floodwaters for floods of various magnitudes. A flood study constitutes the principal technical foundation from which flood risk can be taken into account in planning, and flood emergency plans can be formulated.

A large number of flood studies have been carried out in England and Wales and information on flood behaviour is already known in many areas. Flood studies have generally been carried out for the following purposes:

- To define the extent and depth of flooding. These include the Section 105 Surveys, primarily concerned with areas of new development, and the Indicative Floodplain Map, which provides a flood risk map for England and Wales using information from a number of sources;
- To identify flood management measures and undertake hydraulic design. This is now carried out within a framework of Shoreline Management Plans (SMPs), Catchment Flood Management Plans (CFMPs), Strategy Plans and scheme appraisal, although there have been many flood studies carried out over the years for individual flood protection schemes.

SMPs and CFMPs are intended to determine the general policy for flood management for whole river catchments or coastal cells. They include a high level appraisal of options to confirm that the policy is feasible. Strategy Plans identify the schemes for a part of a catchment or coastal cell which together achieve the flood management policy set out in the high level plans. Scheme appraisal then considers the individual schemes identified in the Strategy Plan.

The main outputs of studies to define the extent and depth of flooding are as follows:

- Flood maps, generally showing the 1 in 100 annual probability flood limit in non-tidal areas and the 1 in 200 annual probability flood limit in tidal areas;
- In some cases flood outlines for a range of return periods have been produced, typically ranging from the 1 in 5 annual probability flood to the 1 in 200 annual probability flood;
- Information from many of these studies can be used to derive flood hazard information including flood depth, flow velocities and rate of rise of flood water, but this information is not a direct output at present;
- Many flood mapping studies do not take account of existing flood defences.

The main outputs of studies to identify flood management measures and undertake hydraulic design include:

- Information on existing flood risk including flood extent and depth for a range of annual probabilities of flooding;
- Preferred flood management options, which normally consist of structural measures but may also include non-structural measures;
- Project appraisal, which includes an assessment of flood damage with and without the flood management options in order to determine benefit-cost ratios;

- Information from many of these studies can be used to derive flood hazard information including flow velocities and rate of rise of flood water, but this information is not a direct output at present.

Thus flood studies generally provide adequate information for floodplain management planning but the information on flood hazard is incomplete. However much information on flood hazard can be derived from historic information and information collected for flood warning purposes.

Components of flood studies are listed below:

Coastal flood mapping:

- Derivation of design conditions including combinations of tidal water levels and wave heights;
- Hydraulic analysis to determine the extent of flooding.

River flood mapping

- Hydrological analysis to estimate flood discharges for floods of a range of magnitudes;
- Hydraulic analysis to determine the extent of flooding.

Additional components needed for the appraisal of flood management options:

- Identification of flood management options;
- Economic appraisal of options, based on the methods given in FCDPAG3 (MAFF 1999b);
- Risk assessment, based on the methods given in FCDPAG4 (MAFF 2000a);
- Environmental appraisal of options, based on the methods given in FCDPAG5 (MAFF 2000b);
- Social impacts of flooding. One possible approach is contained in Defra/Environment Agency (2002b).

The most appropriate level of study for floodplain management is the Strategy Plan. This is because:

- It covers all schemes related to a particular town or other flood risk area
- It requires flood extents and depths for the appraisal process.

Guidance on this approach is given in FCDPAG2 (MAFF 2001a). However, floodplain management planning should be based on whatever flood study information is available to minimise the need for additional work.

## **B.2 Coastal flooding**

Flooding on the coast is caused by extreme high tidal water levels, often in combination with waves. In addition, extreme waves can cause overtopping and local flooding on the coast.

Tidal defences are often designed for extreme tidal water levels with a particular probability of occurrence. The 1 in 200 annual probability event is normally used in tidal areas in England and Wales. In addition, a freeboard allowance is made to cover uncertainties in predictions, wave action and wind “set-up”.



In some areas the highest flood water levels are caused by combinations of tidal and fluvial (river) flows. In such cases, a joint probability analysis is needed to determine appropriate design water levels. This analysis can be relatively simple where the “interaction zone” between tidal water levels and fluvial flows is short. More rigorous approaches include:

- Running models using long time series of historic tide and river flow data, and undertaking statistical analysis of the predicted water levels to estimate extreme levels at each location;
- “Monte Carlo” or similar joint probability analysis, which involve running a large number of scenarios on a model and undertaking statistical analysis of the results (MAFF 2000a).

### **B.2.1 Extreme high tidal water levels**

Statistics of tidal water levels are available at tide gauges around the coast. In addition, predictions of astronomical tidal water levels are available into the future. Extreme high tides are caused by a combination of astronomical tidal water levels and a surge component, caused by weather conditions, particularly variations in air pressure. If a large tidal surge coincides with a high astronomical tide, very extreme high water levels can result.

There are generally two approaches to predicting future extreme high water levels on the coasts:

- Extreme data analysis of historical high water levels at tide gauges. These automatically contain both astronomical and surge components;
- Joint probability analysis of data on astronomic tides and surge “residuals” (i.e. the difference between actual and astronomical water level).

In both cases sea level rise must be taken into account. Guidance on expected rates of sea level rise are given in MAFF 1999b, Section 4.6.

Tidal water levels are often required for locations other than tide gauges. In addition, where a tide gauge record is very short, data from other sites are needed to extend the record. The best way of predicting tidal water levels away from tide gauges is by coastal computational hydraulic modelling. Such models take the coastal bathymetry into account, and generally include at least one and preferably two tide gauge sites, for calibration purposes.

An alternative approach to predicting tide levels at sites away from tide gauges is by correlation with the nearest tide gauges to the site. This requires some local high tide water levels for specific events which can then be compared with corresponding levels at the tide gauges. Correlation may also be used to extent short tidal records using longer data sets from other gauges.

### **B.2.2 Wave heights**

Wave heights are estimated based on the analysis of long-term deep water wave data. In-shore wave heights are predicted using coastal computational models which include the coastal bathymetry. The impact of breaking waves and the associated overtopping is investigated using local computational models. Physical models are also used for the design of coastal flood defence schemes where the geometry is complex.

Where combinations of tidal water levels and wave heights are needed, joint probability analysis should be applied to determine appropriate combinations.

### **B.2.3 Hydraulic analysis**

Hydraulic analysis is needed not only to predict water levels and waves heights at coastal locations, as indicated above, but also to predict the extent and depth of flooding. Flooding may occur from overtopping of defences, breaching of defences, or a combination of the two.

Flood models are generally based on a volume of flood water from calculations of overtopping caused by high water levels and/or waves, or the volume of water that enters a breach during a number of tide cycles (after which the breach is assumed to be repaired). There are a range of models available to predict flooding, as follows:

- A simple basin model, in which the flood risk area is divided into “reservoirs”, and each reservoir is assumed to have a horizontal flood water level. Flow between reservoirs is calculated using weir flow formulae;
- More complex models, in which the rate of breach formation is included in the model, and a two dimensional time based model is used to simulate the propagation of flood water.

The outputs of the flood models are:

- Flood water levels;
- Flood depths. These may either be derived manually by overlaying the flood water level surface on a topographic map of the floodplain or electronically using georeferenced water level data and a Digital Terrain Model (DTM).

## **B.3 River flooding**

River flooding is caused by rainfall runoff from storms over the river catchment. A hydrological analysis is used to predict flood flows, and hydraulic calculations are used to predict flood water levels and flood extents along the river.

### **B.3.1 Hydrological analysis**

The rate of discharge of floodwater varies throughout the course of a flood event. Flood hydrographs (plots of flow against time) generally have a relatively rapid rate of increase in discharge on the rising limb up to the peak discharge, followed by a slower decline in discharge on the falling limb. Hydrograph shapes can vary significantly, particularly where hydrographs combine from tributaries or there are multiple storms in a catchment.

Before floodwater levels and depths can be determined it is necessary to know the peak flood discharge. In addition, the shape and volume of the hydrograph is also important to estimate duration of flooding (for flood hazard) and the impacts of flood storage.

Two techniques are commonly used:

- Statistical method;
- Rainfall-runoff method.

These two methods form the basis of the Flood Estimation Handbook (FEH, NERC 1999), which is the standard approach to hydrological estimation used in the UK. Background to these two approaches is given below.

### **Statistical method**

The statistical method determines the peak flood discharge at any location of interest for a range of flood probabilities of occurrence. The statistical method as presented in the FEH is a relatively rapid means of estimating peak flood discharges.

The analysis is based on peak flood discharge data from river gauging stations. Rating curves (relationship between flow and water level) have been developed for each gauging station. These are generally based on the performance of standard gauging structures where they exist, actual flow gaugings, or a combination of the two. Most gauging structures are drowned at high flows and supplementary flow gauging is needed in these circumstances.

Gauging stations generally have a continuous record of water level, and the rating curve is used to estimate the flow corresponding to observed flood water levels. A statistical analysis of high flow data is then used to predict flood flows for floods of different probabilities. One practical problem with the use of rating curves is that flood flows often exceed the channel capacity at the gauging site and bypassing occurs. The flow that bypasses the site is not gauged and is not taken into account in the rating curve.

Hydraulic analysis or modelling can be used to extend the rating curve into the range of water levels characteristic of larger floods. These analyses are approximate and, as a consequence, estimates of peak flood discharge may have an uncertainty of up to 20% or more.

Because of the generally short periods of record at most gauging stations (typically 20 to 50 years), there is always some uncertainty in the estimates of peak discharges obtained from a flood frequency analysis. These uncertainties are statistical and additional to inaccuracies arising from unreliable rating curves.

### **Rainfall-runoff method**

The rainfall-runoff method not only provides estimates of peak flood flows but also flood hydrographs shapes. The method provides a mathematical representation of the various catchment processes that transform rainfall into runoff. The FEH provides guidance on deriving suitable rainfall events for application in the method. The method then simulates the associated discharge hydrograph at the outfall of the catchment area to which the rainfall is applied.

The two main catchment processes that affect the size and shape of discharge hydrograph are the proportion of rainfall that runs off the land surface into the river system, and storage effects as the runoff travels down the catchment. Rainfall-runoff models can only approximate these processes. To improve the estimates of discharge hydrographs, it is necessary to calibrate the model for flood events for which both rainfall and discharge data have been recorded.

Calibration of rainfall-runoff models suffers from the same uncertainties in flood flow measurement at gauging sites as described above for the statistical method. In addition, there is uncertainty in the accuracy of rainfall data at rain gauges and the extent to which rain gauge data are representative of the actual storms that occur, taking into account spatial and temporal variations.

The flood hydrograph shape is affected by combinations of flows from tributaries, and attenuation effects as the hydrograph passes down the catchment. A distributed model should be used where these effects are significant, and also for large catchments where the assumption used in the rainfall-runoff method of uniform design rainfall across the catchment is unrealistic.

### **Comparison of statistical and rainfall-runoff methods**

Where good peak flood flow records exist at a gauging station with a reasonable length of record, the statistical method provides a rapid and reasonably accurate estimate of peak flood discharges. Actual flood hydrographs can be determined by the inspection of recorded hydrographs.

However there is considerable uncertainty in the accuracy of high flow data. Generally, rainfall records are longer than river flow records. Hence, rainfall data has a greater degree of statistical reliability than discharge data. Rainfall-runoff models can also simulate the effects of different developments on flood discharge hydrographs, for example urbanisation and new reservoirs.

Wherever possible both methods should be applied and the results compared.

### **Distributed catchment models**

Distributed catchment models are used where:

- It is necessary to simulate combined hydrographs from several tributaries;
- Attenuation of the flood hydrograph and effects of flood storage in the river valley are significant.

A distributed catchment model consists of:

- A number of rainfall-runoff models representing “sub-catchments” (or sub-divisions of the catchment). Generally each sub-catchment should be an area of relatively uniform geomorphology, climate and land use;
- A hydraulic flow routing model, which simulates combinations of hydrographs, attenuation and flood storage.

The model is used to predict flood flows at locations of interest in the catchment. Further advice on the application of catchment models of this type is given in Defra/Environment Agency 2002.

## **B.3.2 Hydraulic analysis**

Once the peak discharges (and the discharge hydrographs if necessary) of flood events of interest have been estimated, flood water levels and flood extent along the reach of river under consideration can be determined. This is normally done using a computational hydraulic river model.

### **Hydraulic modelling**

Computational hydraulic models simulate:

- The flow of water along river channels and floodplains taking into account frictional resistance and other energy losses;
- Transfer of flow between river channels and floodplains, including flow over embankments;

- The impacts of hydraulic structures on flows and water levels, including weirs, control gates, pumping stations, bridges and culverts;
- Reservoirs and flood storage areas;
- Operation of structures.

The models require data including:

- Survey cross sections of the river channels;
- Topographical data for floodplains;
- Surveyed crest levels on embankments and flood walls;
- Dimensions and levels of structures;
- Estimates of the frictional resistance of the river channel and floodplains;
- Flood water levels and extents from historic floods, for model calibration purposes;
- Inflow data from the hydrological analysis, including flows for calibration events;
- Downstream model boundary data, which normally consists of a rating curve. For a model where the downstream model limit is tidal, tidal water levels should be used.

The model is calibrated by adjusting parameters in the model (normally frictional resistance, and discharge coefficients for embankments and structures) to obtain agreement between recorded and simulated water levels during a severe flood. Effort devoted to obtaining as much historical data as possible on the selected floods for model calibration is time well spent. In addition to the Environment Agency, other sources of information include residents who have lived in the area for a long time, newspapers and council records. The calibrated model needs to be verified against other flood events as no two floods are identical and the floods cannot be perfectly reproduced by the model.

The model is then used to simulate floods of a range of probabilities of occurrence. The model outputs of flood depth are used in combination with a DTM to estimate flooded extents for each event.

#### **B.4 Floodplain zoning**

Model results can be used to assist with zoning of the floodplains for planning purposes. Current planning guidance (PPG25) recommends zoning according to the probability of flooding. Table 3.1 (Section 3.8.1) shows the recommended types of land use for zones with different probabilities of flooding.

These zones can be derived directly from the results of flood studies by plotting the estimated flood limits for the flood risk given in table 3.1 (i.e. 1 in 100 and 1 in 1000 annual probabilities of flooding in non-tidal areas; 1 in 200 and 1 in 1000 annual probabilities of flooding in tidal areas).

However additional floodplain zones should also be identified, as follows:

- Zones where there are significant flows during flood events (this area together with the river channel is sometimes referred to as the “floodway”). Any development in these areas will cause a direct impediment to flood flows and increase flood risk upstream. Development which impedes flood flow should not be permitted in these areas;
- Zones where storage of flood water occurs but flow velocities are very low. The main concern in these zones is to maintain flood storage volume for the full range of flood levels. Therefore not only should the full volume of storage be maintained, but the water surface area at each level should also be maintained. Developments in these zones should

either not reduce flood storage, or provide compensatory flood storage in the development area with the same flooded area to level profile;

If the flood storage volume is reduced, flood risk will increase downstream. Whilst the increases for individual developments are often small, there is concern that the cumulative effect of several developments will significantly increase flood risk.

## **B.5 Flood hazard**

Flood studies in the UK have been primarily concerned with predicting the depth and extent of flooding. Other criteria to estimate flood hazard have generally not been produced as study outputs. However the results may be used to estimate flood hazard, and this is discussed in Section C.2.7.

## **B.6 Future changes to the flood levels**

Flood levels are generally predicted based on an analysis of historic flood information. However these may change in the future for the following reasons:

- Climate variability: the climate is not static. Historic data recorded during a relatively dry period will provide lower extreme flood predictions than those obtained from data recorded during wetter periods;
- Climate change. This refers to permanent changes in the climate beyond natural variability. For example, there is evidence that the global temperature is increasing and mean sea level is also increasing. There is also considerable speculation that climate change will affect weather patterns leading to increasing storminess and consequently an increase in flood severity;
- Land use change. Land use changes in a river catchment will affect runoff and therefore flood flows. Particular causes of changes in runoff include urbanisation and changes in agricultural practices.

The consequences of increases in sea levels and more severe flood behaviour should be assessed as part of a flood study, and Defra give guidance on the figures that should be used (MAFF 1999b for sea level rise; MAFF 2000a Section 2.3.5 for river flows).

## **B.7 Appraisal of flood management measures**

Having determined flood water levels and flood extent, it is then necessary to define the magnitude of the flood risk and the options for reducing the risk.

The magnitude of the flood risk is expressed in terms of economic damages (FCDPAG3, Defra 1999b). It may also be expressed in terms of population at risk and social vulnerability (Defra/Environment Agency 2002).

Options for mitigating the risk are selected, based on the range of measures described in Appendix A. It is likely that a combination of measures will be needed, and a typical combination might consist of the following:

*Structural measures:*

- Flood embankments for part of the floodplain, with pumps for local drainage;
- River maintenance, to reduce the flood risk particularly for undefended areas;

- Flood proofing of new buildings in the flood risk area;
- Measures to flood proof existing buildings.

*Non-structural measures*

- Zoning of the floodplain, with different types of development permitted in each zone;
- Agreement with insurers on insurance arrangements for new developments in flood risk areas;
- A flood forecasting and warning system;
- Raising the awareness of the flood-prone community of the risks, particularly those in the defended area;
- Flood emergency planning.

However before any major structural works can proceed, an appraisal is needed to justify the works. A range of options, each consisting of a number of measures, is appraised and the preferred option is selected. The current method of appraisal is based on an economic (benefit/cost) analysis given in FCDPAG3 (MAFF 1999b).

Environmental impacts are also assessed (FCDPAG5, MAFF 2000b). Impacts on population and social vulnerability currently do not form part of the formal appraisal process although methods are under development which could be applied in the future (Defra/Environment Agency 2002).

The measures which comprise the preferred option will be described in the Strategy Plan. These should be included in statutory development plans.





# Appendix C

## Flood hazard

Flood hazard varies both in time and place across the floodplain. Floodwaters flow swift and deep at some locations; in other places, they are shallow and slow moving. The variation of hazard and flood behaviour across the floodplain needs to be understood by flood-prone communities, floodplain managers and flood emergency staff.

This Appendix describes flood hazard and gives guidance on how flood hazard can be assessed for different parts of the floodplain.

### C.1 Factors affecting flood hazard

Factors that affect the hazard and disruption caused by a flood can be grouped into the four broad categories:

- Flood behaviour (including severity of flood, risk of failure of defences, response time, rate of rise, depth, flow velocity, duration, water quality);
- Public safety issues (including evacuation routes and time for evacuation);
- Population at risk (including number and vulnerability of people, flood awareness);
- Land use;
- Emergency management (including flood forecasting, flood warning, flood response, evacuation and recovery).

Note that emergency planning is covered in Appendix E.

### C.2 Flood behaviour

#### C.2.1 Flood severity

The severity or size of a flood is generally the principal determinant of hazard. Not only does it affect aspects of flooding behaviour that individually influence hazard (e.g. depths, velocities, rates of rise), it also determines the number of people at risk. It is impossible to predict when flooding will occur or the size of the flood. Furthermore there is no guarantee that, if a severe flood has occurred recently, another perhaps larger flood will not occur in the near future.

The impact of the flood will be worsened if flood defences fail. This would result in severe local flooding that can occur very rapidly and without warning, thus increasing the flood hazard.

#### C.2.2 Response time

The speed with which a flood occurs following heavy rainfall is also a major contributory factor to hazard, and is sometimes referred to as the “response time” for a particular river catchment. In large river catchments the response time is relatively slow and the available warning time is relatively long. In small steep catchments, the response time is very short and there is often very little available warning time.

On the coasts it is possible to predict tidal surges many hours in advance, permitting warnings of possible flooding to be issued. However if a defence fails the time taken for flooding to occur can be very quick thus creating a very high level of hazard. In addition, coastal flooding often occurs during very bad weather conditions over the flood risk area, exacerbating the hazard. Coastal flooding generally occurs at high tide, and therefore flood-prone communities will have some knowledge of when flooding might occur and can be warned of this in advance.

### **C.2.3 Rate of rise of floodwater**

Situations where floodwaters rise rapidly are potentially far more dangerous than situations where flood levels increase slowly. Typically, the rate of rise of floodwaters is more rapid in small, steep catchments and/or small urban catchments than in their larger, flatter counterparts. It is also rapid in situations where defences fail or are overtopped.

### **C.2.4 Floodwater depth and velocity**

The threat to life and structural damage caused by floods depends largely upon the velocity of flow and depth of floodwaters. These, in turn, depend upon both the size of the flood and the hydraulic characteristics of the river or coast and its floodplain.

The following guidance is given to indicate the type of information needed in a flood hazard assessment:

- Wading by able-bodied adults becomes difficult and dangerous when the depth of still water exceeds 1.2 m, when the velocity of shallow water exceeds 0.8 m/s, and for various combinations of depth and velocity between these limits;
- In assessing the safety of wading, factors other than depth and velocity need to be taken into account such as evenness of the ground surface or presence of depressions, potholes, fences, major stormwater drains, water-borne debris and water temperature;
- Small, light, low motor vehicles crossing rapidly flowing causeways can become unstable when water depths exceed 0.3 m. Evacuation by larger, higher cars is generally only possible and safe when water depths are less than 0.4 m. Large emergency vehicles, for example fire engines, may operate in depths of up to one metre;
- As the depth of floodwater increases, caravans and buildings of light construction will begin to float. In these circumstances the buildings can be severely damaged when they settle unevenly in receding floodwaters. If the flood velocity is significant, buildings can be destroyed and cars and caravans can be swept away. In certain areas, the build up of debris and the impact of floating objects can cause significant structural damage to buildings and bridges;
- The build up of debris can in turn block bridges, culverts and other flood flow routes, thereby increasing flood levels and flood damage;
- At velocities in excess of 2 m/s, the stability of foundations and poles can be affected by scour. As grass and earth surfaces begin to erode, scour holes can develop;
- At depths in excess of 2 m, lightly framed buildings can be damaged by water pressure, flotation and debris impact, even at low velocities. Where buildings are “floodproofed”, and there is a higher level of water outside than inside, the maximum differential pressure that brickwork walls can resist is of the order of one metre.

### **C.2.5 Duration of flooding**

The duration of flooding or length of time a community, town or single dwelling (e.g. farm house) is cut off by floodwaters can have a significant effect on the costs and disruption associated with flooding. In the UK, rescues from isolated properties are generally relatively rapid, but the stress of having to leave a flooded property for a long period adds significantly to the overall trauma of flooding. The duration of flooding also has a significant impact on damage. The longer the duration the more severe the damage can become and the greater the length of the recovery and repair period.

The duration of flooding on rivers generally correlates with the rate of rise of floodwater, typically being longer for slow rates of rise (larger, flatter catchments) and shorter for rapid rates of rise (smaller, steeper catchments). On the coasts the duration of flooding is to some extent influenced by the tide but in many cases depends on the time it takes to remove floodwater from the affected areas.

### **C.2.6 Floodwater quality**

The temperature of floodwater contributes to the overall hazard. Floodwater is generally cold and in winter can be close to freezing, presenting a significant additional hazard.

In addition, flood water is often of relatively poor quality. It may be polluted by sewage from foul sewers (particularly during floods caused by urban drainage overflows), oil or chemicals from flooded industrial plants, and any number of other pollutants washed off the floodplains. Sediment is deposited where velocities are low, particularly inside properties, and is often polluted.

Not only does pollution add to the misery of flooding, it also increases damage and adds to the amount of effort needed for post-flood clean-up and recovery.

### **C.2.7 Use of models to estimate flood hazard**

Model studies carried out for both flood mapping and flood management predict flood water levels and flood extent. Information needed for the assessment of flood hazard is generally not needed for these studies and is therefore not a standard output. However, the model results can be used for flood hazard estimation in the following ways:

- Flood response (and associated warning) time on rivers is best estimated from time of travel of flood hydrographs between gauging sites. Where gauging sites do not exist, models can be used to estimate warning times by correlating the timing of rainfall or flows at particular locations with the predicted time of flooding;
- Flood response times on coasts are more difficult to predict because of uncertainty over the locations where defences will overtop or breach, and model results may be of little assistance in flood warning;
- Rate of rise of flood water can be estimated using level hydrographs from models for different locations on the floodplains;
- Depth of flooding for different probabilities of flooding can be obtained directly from model results by comparing flood water levels and ground levels. The Modelling and Decision Support Framework for catchment flood management planning (Defra/Environment Agency 2002) provides this information directly for individual properties;

- The average flow velocity at each model section is calculated by the model, and this will give an indication of floodplain flow velocities. Ideally the cross sections should identify flood flow paths and limit hydraulic calculation of flows to these areas to obtain a better estimate of flow velocity;
- Flood duration can be estimated from model output hydrographs for floodplain cells.

### **C.3 Public safety**

Public safety is of primary concern during floods. As far as possible the public should be advised to move to a safe location and stay there until a flood recedes. Residents should be advised to move upstairs in multi-storey properties where only the ground floor will be flooded. Alternatively, residents could move to high ground on receipt of a flood warning and before the arrival of floodwaters, thus avoiding the need to be evacuated. Residents should also be made aware of the hazards of attempting to walk in floodwater, particularly if it is deep or fast flowing.

Evacuation is a very hazardous operation during floods and is best avoided if at all possible. However, there are many cases where evacuation is needed, particularly from such buildings as bungalows and caravans where residents have no escape once a flood occurs. In addition, there are locations where the emergency services will require the early evacuation of residents, for example those who live on islands in large rivers where the flood duration is long and rescue once the floodwaters have risen would be very hazardous.

#### **C.3.1 Evacuation problems**

The levels of damage and disruption caused by a flood are influenced by the difficulty of evacuating flood-affected people and property. Evacuation may be difficult because of:

- The number of people requiring assistance;
- The depth and velocity of floodwaters;
- Wading problems, which can be exacerbated by, for example, uneven ground, fences, debris and localised high velocities;
- Distance to flood-free ground;
- Loss of trafficability on evacuation routes because of rising floodwaters;
- Bottlenecks on evacuation routes (i.e. roads cannot cope with the increased volume of traffic and the number of people that have to be evacuated);
- Unavailability of suitable evacuation equipment such as boats, lorries and helicopters.

#### **C.3.2 Effective flood access**

The availability of effective access routes from flood-prone areas and developments can directly influence the resulting hazard when a flood occurs.

“Effective access” means a high level exit route that remains trafficable for sufficient time to evacuate the population at risk (i.e. evacuation can be undertaken solely by motor vehicle). In some urban situations, access to flood-prone residents can be lost relatively early in the flood, for example where:

- Evacuation routes lead downhill onto and across the floodplain. Access to the evacuation route and trafficability can be lost early in the flood because of rising floodwaters;
- Cul de sac residential developments built on rising land that only have downhill road access. Vehicular access is likely to be lost early in the flood although it may be possible to evacuate residents by walking to high land behind the development;

- Roadways may become overland flow paths for severe stormwater flooding. This will reduce their trafficability and could affect evacuation.

Thus there is considerable benefit to be gained from taking possible evacuation needs into account in designing regional and local road networks for flood-prone areas.

Access is generally divided into two categories: pedestrian and vehicular. The provision of road access trafficable in all conditions will obviously assist in reducing the flood hazard and enhance the effectiveness of the emergency response.

The suitability of access routes needs to be investigated for a range of flood events. Arrangements and evacuation routes which are suitable for flood events up to a specified standard may become unsafe or inoperable for more severe floods. In potentially hazardous situations, pedestrian access routes at least should be provided which can be used in extreme flood events. Without such access, the danger to the entrapped and their rescuers may be unacceptable.

A potentially hazardous situation develops when rising floodwaters isolate an area of land, leaving an island in a sea of floodwater. The degree of hazard depends on the depth, velocity and rate of rise of floodwaters between the island and possible places of refuge. Vehicle access may be cut rapidly. Rescue by boat, helicopter or large vehicle may be necessary, so putting the rescuers' lives at risk. Although such a situation may not develop for "normal" floods, a check should be made to see whether rare flood events cause islands to develop, or even worse, to subsequently be submerged.

#### **C.4 Population at risk**

The degree of hazard and social disruption varies with the size of the population at risk. The larger the population at risk, the greater the effort that will be needed to ensure public safety.

##### **C.4.1 Flood awareness**

A flood aware population is more likely to be effective in moving to a safe location and protecting possessions. Flood awareness is largely related to past experience of flooding and greatly influences the time taken by flood-affected people to respond effectively to flood warnings. In communities with a high degree of flood awareness, the response to flood warnings can be relatively prompt, efficient and effective.

The promotion of flood awareness by public education campaigns is an essential component of flood emergency planning.

##### **C.4.2 Warning time**

Flood hazard can be reduced the longer the available warning time, as people will have more time to prepare and move to safety. However, a flood will still cause significant damage and substantial community disruption.

The available flood warning time is linked to catchment response time on rivers, and the timing of high tides where severe conditions are predicted on coasts. In large catchments, flood warnings can be based on rates of rise and peak water levels at upstream gauges. In

smaller, more responsive catchments, flood warnings need to be based on rainfall measurements. In the smallest catchments, warnings need to be made on predictions of likely rainfall made before the rainfall occurs, based on weather radar and meteorological forecasting models.

The effective warning time, or actual time available for emergency response activities, is always less than the available warning time. This is because of the time needed to alert people to the imminence of flooding and the time needed to come to terms with this information and take the necessary action. Warnings are issued by a variety of means including Automatic Voice Messaging, the media, loud-hailer and word-of-mouth, particularly by flood wardens.

## **C.5 Land use**

Land use also influences hazard. There are considerably greater difficulties in evacuating a hospital or a retirement home than an industrial area. Conversely, the flooding of industrial areas might result in the escape of toxic industrial products.

### **C.5.1 Historic areas**

There are a number of particular problems associated with flooding of historic urban areas. These include:

- Old arch bridges which constrict the flood flow, raising upstream water levels. These are also prone to blockage by debris, further raising water levels;
- A legacy of old drainage infrastructure which is liable to blockage;
- The dense pattern of building coverage and narrow streets and alleyways, which significantly increase flood levels and velocities;
- The high cost of damage associated with old buildings;
- The need for careful drying out and restoration, which can take much longer than for modern buildings.

## **C.6 Degree of hazard**

The degree of hazard varies across the floodplain in response to the above factors. As part of the floodplain management process, it is necessary to determine hazard. This is of considerable significance to the appropriateness or otherwise of various land uses.

This document recognises four degrees of hazard.

**Low:** There are no significant public safety problems. If necessary, children and elderly people could wade to safety with little difficulty; maximum flood depths and velocities along evacuation routes are low; distances to safe flood-free ground are short. There is ample time for flood forecasting, flood warning and evacuation (if required); evacuation routes remain trafficable for at least twice as long as the time required for evacuation.

**Medium:** Fit adults can wade to safety, but children and the elderly may have difficulty. Where evacuation is required, evacuation routes are longer; maximum flood depths and velocities are greater. Evacuation by cars is only possible in the early stages of flooding, after which 4WD vehicles or lorries are required. Evacuation routes remain trafficable for at least 1.5 times as long as the necessary evacuation time.

**High:** Fit adults have difficulty in wading to safety. Where evacuation is required, wading evacuation routes are longer again; maximum flood depths and velocities are greater (up to 1.0 m and 1.5 m/s respectively). Motor vehicle evacuation is possible only by 4WD vehicles or trucks and only in the early stages of flooding. Boats or helicopters may be required. Evacuation routes remain trafficable only up to the minimum evacuation time.

**Extreme:** Boats or helicopters are required for evacuation; wading is not an option because of the rate of rise and depth and velocity of floodwaters. Maximum flood depths and velocities are over 1.0 m and over 1.5 m/s respectively. There may be very little (if any) warning time before the flood arrives.

## **C.7 Estimation of hazard**

An appropriate procedure for estimating flood hazard needs to involve an assessment of all the components summarised in Section C.2. The two principal factors that affect the safety and stability of pedestrians wading through floodwaters and motor vehicles traversing flooded roads are the depth and velocity of the floodwaters.

Pedestrians can be swept away by sliding due to a loss of grip between their shoes and the roadway or by falling over under the pressure of floodwater. Motor vehicles are swept away because of loss of friction between their tyres and the roadway caused by flotation, or the pressure of floodwater.

Whilst some work on stability estimation procedures are available, there is currently no definitive guide to the combinations of depth and velocity that cause loss of stability. A comprehensive testing program of people, vehicles and structures is needed before definitive design guidelines can be presented. Any study on the effects on people needs to consider not only the physical issues of flooding but also the psychological effects.

### **C.7.1 Hazard graphs**

The emergency services should undertake hazard analyses as part of the preparation of a flood emergency plan. This requires results from a flood study and an assessment of all factors affecting hazard, such as flood behaviour, flood awareness and possible public safety problems. Even a relatively crude analysis will identify the main hazards to consider in a flood emergency, and will provide valuable guidance on the deployment of emergency vehicles, etc.

Figures C.1 and C.2 provide a simple graphical means of making a preliminary estimate of hazard along proposed evacuation routes based on the depth and velocity of floodwaters (Fig. C.1) and on the relative evacuation time (Fig. C.2). These are based on work undertaken in Australia where there is a greater emphasis on evacuation than in the UK. The following points should be noted:

- The four degrees of hazard shown on Figure C.1 correspond to the hazard descriptions of Section C.6. Also shown on Figure C.1 are depth and velocity combinations for small, low motor vehicles and 4WD (4 wheel drive) vehicles. These are based on Keller & Mitsch (1993) and are used here for demonstration purposes only;
- “Relative evacuation time” is the ratio of the time available for evacuation (as determined by flood behaviour and topography) to the minimum time required for orderly evacuation,

which depends largely on the number and age of people involved. The time available for evacuation is measured from when the order to evacuate is given until evacuation routes become untrafficable because of rising floodwaters. Thus, a relative evacuation time of 1.0 means that the available evacuation time (as determined by flood behaviour) just balances the required time for evacuation. A relative evacuation time of less than 1.0 means that not enough time is available for an orderly and controlled evacuation.

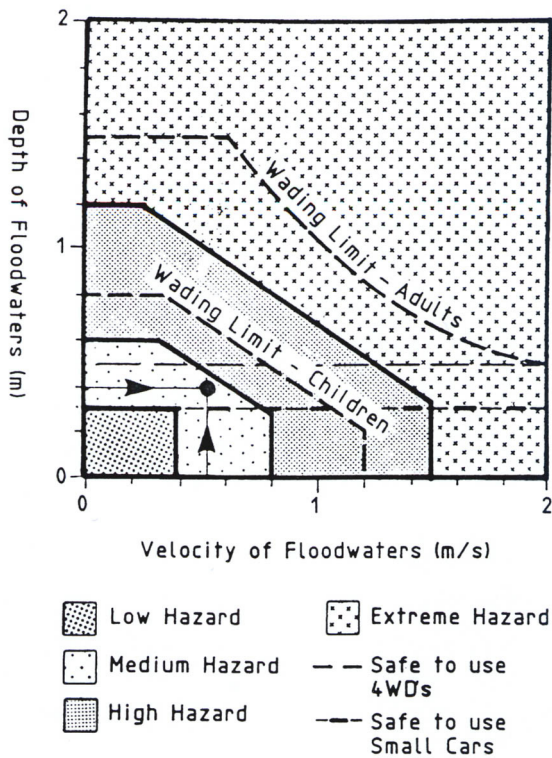
Clearly Figure C2 only applies where evacuation is required and may be limited to relatively small areas in the UK

To use Figure C.2, from the “Initial hazard estimate” axis draw a vertical line to the appropriate isoline of relative evacuation time. The “adjusted hazard estimate” is given by the hazard region where the end of the line falls. This procedure does not allow an initial hazard estimate to be reduced in severity. For example, consider the degree of hazard associated with wading through water 0.3 m deep and flowing at 0.5 m/s. According to Figure C.1, the degree of hazard is medium (i.e. fit adults can wade to safety over distances of up to say 200 m, but children and the elderly will have difficulty). If the relative evacuation time is unity (1.0), then according to Figure C,2, the initial estimate of hazard (medium) should be upgraded to high.

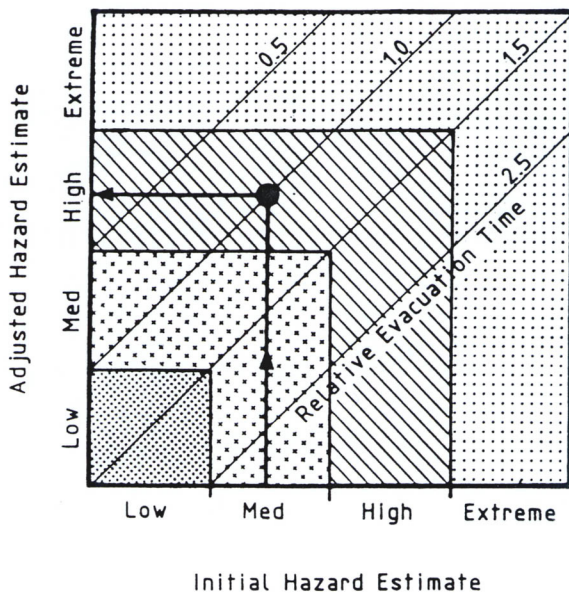
### **C.8 Hazard maps**

Mapping of flood hazards will assist in the preparation of flood emergency plans. In preparing such maps, hazard zones should be defined in broad terms which are consistent with the detail of data used to estimate the hazard. Any excessively detailed variation of hazard should be “smoothed” out.





**Figure C.1 Estimation of hazard along evacuation routes**



**Figure C.2 Effect of relative evacuation time on hazard rating.**

Note: the adjusted hazard assessment is not to be a lower hazard than the original assessment

Courtesy: Floodplain Management in Australia: Best Practice Principles and Guidelines. SCARM Report 73, CSIRO Publishing, 2000.



## **Appendix D**

### **Information on flood risks to be included in Local Plans**

This appendix provides guidance on the information on flood risk that should be included in Local Plans. The intention is to manage floodplains to achieve the best compromise between conflicting demands which include land use, minimising flood damage and disruption, and environmental concerns.

The range and detail of the information to be included in the Local Plan will depend on the magnitude of flood risk in the area concerned. For example, where a District only has a very small floodplain area, the amount of effort required to include floodplain management in the Local Plan should be correspondingly small.

#### **D.1 Summary of information**

The suggested information on flood risk to be included in the Local Plan is as follows:

- Maps
- Areas at risk from flooding
- Existing flood defences and other flood management measures
- Flood management policies
- Proposed flood management measures
- Other floodplain issues (conservation, recreation, etc.)
- Link with the flood emergency plan
- Assessment of options.

#### **D.2 Maps**

The spatial information on flood risk is summarised below. These should preferably be added directly to the proposals map.

- Flood risk areas and probability of flooding (Section D.3)
- Floodplain functions and corresponding zones (Section D.3)
- Existing flood defences and standard of protection (Section D.4)
- Areas covered by flood warning schemes, and approximate warning times (Section D.4)
- Proposed flood management measures (Section D.6)
- Other issues, opportunities and constraints, for example floodplain conservation areas (Section D.7).

#### **D.3 Areas at risk from flooding**

The areas at risk from flooding should be clearly illustrated on a map (or maps) of the planning district. The maps should also indicate the probability of flooding and sources of information. Sources of information on flood risk areas will include:

- Flood studies for the area;
- Indicative Floodplain Maps for England and Wales produced by the Environment Agency. These show the estimated 1 in 100 annual probability flood (non-tidal areas), 1 in 200 annual probability flood (tidal areas), and 1 in 1000 annual probability flood (all areas, to be available in 2002/2003).

In addition to the basic flood outlines, the following information should be shown on the map(s) to facilitate floodplain zoning:

- “Floodways”, as defined in Section B.4
- Areas of the floodplain where storage of floodwater occurs, as described in Section B.4.

Different land use policies will be needed for these different parts of the floodplains as discussed in Section D.5 below.

Some flood studies produce flood outlines for a range of different floods. These data should be plotted as an overlay to the proposals map where available, as they provide valuable information on the frequency of flooding in different parts of the floodplains. They will also indicate the order in which properties become flooded, which in turn will assist emergency services in emergency planning.

It is also advisable to estimate any changes which might occur in the future as a result of land use and climate change. This should be based on information from CFMPs (where available) and SMPs, which both contain estimates of future flood risk areas.

#### **D.4 Existing flood defences and other flood management measures**

Existing flood defences and other structural measures should be listed in the plan and shown on the proposals map. The estimated standard of protection should also be provided both in the text and on the map.

Information on non-structural measures should also be included in the plan. Information to be shown on maps should include areas covered by flood warning schemes, and the approximate available warning time for different areas.

Information on the location of flood defences and the standard of protection may be difficult to obtain because:

- Flood defences are not all owned by one organisation. Owners include the Environment Agency, local authorities and private landowners;
- Flood defences have often been provided as parts of schemes intended to provide a certain standard of protection when the scheme was designed. Changes in river catchments, new flood data and improvements in design methods will have changed the effective standard of protection provided, and the present standard is often not known.

The Environment Agency is compiling a National Flood and Coastal Defence Database (NFCDD), which is intended to include all known information on existing defences.

#### **D.5 Flood management policies**

The policies that guide the plan and assist with individual planning decisions with regard to flood risk should be contained in the plan. These should include policies on:

- Flood management, from CFMPs and SMPs
- Development, based on PPG25
- Development in different zones of the floodplain
- Infrastructure design in flood risk areas
- Development control
- Building controls.

PPG25 provides detailed Planning Policy Guidance for development in flood risk areas. Whilst it is recognised that such development will continue to take place, detailed advice is given on how to taking account of flooding when planning new development.

Table 3.1 in Section 3.8.1 indicates acceptable types of land use for different parts of the floodplains, based on PPG25. It is based on the 1 in 100 annual probability flood (non-tidal areas), 1 in 200 annual probability flood (tidal areas), and 1 in 1000 annual probability flood (all areas).

In addition, it is also strongly advised that policies for land use be developed for different zones of the floodplain. A good example is the approach adopted by the City of Worcester, where policies have been developed for the following floodplain zones:

- The “floodway”, as defined in Section B.4, where the aim is to preserve the floodplain function. Developments which obstruct floodplain flow are not permitted;
- Zones where floodwater is stored, where the aim is to preserve the storage function but more flexibility is permitted in types of development;
- Strategic “pinch points” in the floodplains where no development is permitted and there is a long term aim to return these areas to natural floodplain;
- Small watercourses, where there are policies aimed at minimising flood risk and safeguarding the drainage function;
- In addition, there are policies for preserving and enhancing amenity and environmental benefits.

## **D.6 Proposed flood management measures**

Present and future flood risks for coastal cells and river catchments are identified in CFMPs/SMPs. These high level plans are used to develop overall flood management policies for these areas, and identify options which could achieve these policies. For example, if the policy is to provide a certain standard of flood protection for all urban areas, the CFMP/SMP must identify feasible options for achieving this policy. Each option will consist of a package of measures.

The high levels plans feed into Strategy Plans, which cover a length of coastline protected by one or more flood defence systems, or part of a river catchment. Strategy Plans are used to plan individual flood management schemes, and therefore flood management measures must be developed in sufficient detail to ensure that options are feasible and viable.

Strategy Plans are the appropriate level for identifying the specific flood management measures to be included in the Local Plan. Details of both structural and non-structural floodplain management measures are given in Appendix A.

Floodplain management planning should take account of the fact that structural measures modify flood behaviour. Although they may reduce flood discharges and levels in one area, such works can increase flood discharges and levels elsewhere. Although the Environment Agency requires that mitigation measures be provided to mitigate such increases, this is not always possible.

## **D.7 Other issues, opportunities and constraints**

The designation of land use including amenity and environmentally important areas is covered by land use planning. However there are a number of issues that are specifically related to flooding, including the following:

- The management of land to minimise impact on flooding. This might include the way in which vegetation is managed during the flood season to reduce flow resistance, or the alignment and design of fences which might otherwise accumulate debris and impede flood flow;
- The provision of suitable signage indicating the flood risk and designating evacuation routes.

In addition, structural flood defence works provide opportunities for environmental enhancement. For example, flood detention basins can also improve water quality and environmentally sensitive river improvements can incorporate wetlands, reed beds and other features.

## **D.8 Link with the flood emergency plan**

Flood management measures will never address the complete flood risk and there will always be a residual flood risk in all parts of the floodplain. This is because there is always the risk of a flood which will exceed the flood defence standard, and there will always be undefended areas because the provision of defences is either not viable or affordable.

A Flood Emergency Plan to address residual flood risk is essential. This covers flood warning arrangements, preparedness for floods, response to flood emergencies and recovery from flooding, and is described in more detail in Appendix E. Such a plan should be complementary to the flood management measures contained in the Local Plan.

Specific links between Local Plans and Flood Emergency Plans include the following:

- Information: Local Plans will contain information on flood risk areas and land use which can be used directly in flood emergency planning;
- Community awareness: The consultation process for land use planning (including the floodplain) will help to raise the awareness of flood risk amongst the general public. Flood-prone communities should be made particularly aware of the consultation process associated with planning in flood risk areas. This should be directly linked to flood emergency planning so that individuals and communities are made as aware as possible of their responsibilities before, during and after floods. A programme of regular re-education of people living in flood-prone areas is also needed to maintain this awareness;
- Planning issues: The policies and measures in the Local Plan should be consistent with the requirements of flood emergency planning. For example, vulnerable developments such as old peoples' homes should not be permitted in flood risk areas. In addition, access for the emergency services during flood emergencies must be taken into account in land use planning.

Local authorities have a key role in both floodplain planning and emergency response, although these activities are generally carried out by different departments. Any ways in which internal co-ordination can be improved will lead to more co-ordinated management of the floodplain.

## **D.9 Assessment of options**

The formulation of a plan for floodplain areas involves consideration of various options concerning land use and the mitigation of flooding, together with an assessment of the social, economic and environmental consequences of proposed land uses and mitigation measures.

There are often conflicting objectives and assessment can be difficult because of the different nature of the underlying issues. For example, a development plan which is preferred by the local community may lead to an increase in flood risk elsewhere. An alternative plan which may be environmentally preferable and provides a reduced risk of flooding may be less desirable from the community viewpoint.

One possible approach to comparing options is to use a multi-criteria matrix method. A matrix is prepared in which the columns consist of the various management options and the rows consist of the various floodplain management objectives and issues.

How well the various management options meet the objectives and issues is assessed and the information entered into the matrix. Where possible, the advantages and disadvantages of each option should be quantified. This can be done relatively easily in terms of the costs of flood mitigation measures and the associated reduction in flood damage. In other areas, such as the environment and community desires, a quantitative estimate is difficult. A qualitative estimate of the advantages and disadvantages of the option needs to be made and entered into the matrix, for example, ranking outcomes on a scale of (say) 1 (best) to 5 (worst).

Once the matrix has been prepared, it provides a framework for comparing the various options. This process facilitates the comparison of options, both individually and collectively, leading to a balanced decision regarding the “best” option(s). This process will also help to identify and resolve conflicts in a structured way.

It is likely that this process will lead to changes in the components which contribute to the Local Plan. For example, changes may be required in proposed flood defence measures to accommodate other features of the Plan, and this information should be used to update the associated flood Strategy Plan.

## **D.10 Specific issues of concern**

The following issues should be considered in the preparation of the Local Plan. Further work is needed to identify whether they should be covered by policies in the Local Plan and, if so, what those policies should be.

### **D.10.1 Future planning considerations**

Planning for future flood management measures involves a realistic appraisal of desired and realisable future land uses. If future land use is not considered and appropriately incorporated in the plan, the benefits of measures implemented today may be overrun by the impacts of future development.

The planning horizon for flood defences is typically 50 years whereas land use plans typically cover 10 years. In order to encompass the possibility of large-scale land use change and urban redevelopment, the planning horizon for floodplain management should be at least 30 years and preferably 50 years.

This would require a way of extending the land use planning horizon. A methodology to achieve this objective for CFMPs is given in Defra/Environment Agency 2002.

### **D.10.2 Cumulative effects**

A common problem on many floodplains is the cumulative effect of development. As developments are built, each may have a small effect on flood behaviour individually but become significant cumulatively. Common examples include:

- The cumulative adverse effects are the progressive blocking of floodways and flow paths by individual developments;
- The ad hoc filling of floodplain areas thus reducing the flood storage capacity of the floodplain;
- The increase in the at-risk population living and working in the more hazardous areas of the floodplain.

SMPs and CFMPs provide a total catchment/coastal cell approach which allows cumulative effects to be evaluated before they occur. This involves identifying the location and encroachment of “allowed development”, undertaking hydraulic studies to assess the impact of cumulative development in these areas, and the formulation of planning, building and development controls to ensure that future developments conform to the adopted plan. Development can have adverse impacts elsewhere in river catchments, and there is also a need to include mitigation measures in the plans to prevent this happening.

Developments which conform to the plan should generally be allowed to proceed. Developments which do not conform should not be allowed to proceed unless compensatory measures are both fully investigated and implemented.

### **D.10.3 Protection of infrastructure**

Essential infrastructure services, such as water supply, sewerage, telephone and electric power need to be protected during the onset of a flood. The ready restoration of these services after a flood will facilitate clean-up and recovery, thereby minimising social disruption to the community. The telephone network is of particular importance for communication during a flood and protection should be a high priority.

Examples of protection methods include building temporary banks around sewage treatment plants, water treatment plants and electricity substations. Alternatively, design and fabrication to allow the uncoupling and removal of electric motors from pumps in flood-prone sections of



the sewerage and water supply systems will facilitate the reactivation of these systems after the flood.

If new or upgraded infrastructure facilities are proposed, they should be located in flood-free areas or flood proofed or ensure that services can be easily restored after a flood.

#### **D.10.4 Larger floods**

When planning for future floods, the implications of the full range of floods that could occur must be considered. Structural flood management measures are designed to provide protection for floods with a specific probability of occurrence. These will clearly not be adequate for larger floods, and both the Local Plan and the Flood Emergency Plan must consider the implications of larger floods.

A particular concern is that of embankments and walls, which are likely to be overtopped during extreme floods and may breach. This in turn will lead to very hazardous conditions in the defended areas. Whilst the Flood Emergency Plan should advise on preparing for and responding to such emergencies, the flood management measures in the Local Plan should include the possibility of spillways in embankments and walls to control inundation and minimise flood hazard in areas where the consequences of flooding would be high.

#### **D.10.5 Islands**

The formation of islands on the floodplain during a flood is always potentially hazardous and is **to be avoided**. People trapped on the island may be safe for small floods, but are at high risk in extreme floods. The development of land that becomes isolated prior to inundation increases the load on emergency services during flood events. Furthermore, the rescue of people from islands may place rescuers at undue risk.

#### **D.10.6 Detention basins**

Flood detention basins are used as a means of controlling the peak discharge from newly urbanised areas. There is a potential hazard to downstream areas associated with the overtopping and breaching of detention basin embankments. In addition, recent research has shown that the design criteria used for detention basins do not always achieve their flood mitigation objectives (HR Wallingford 2001). Those involved in land use planning and development control should be aware of these shortcomings and the impacts they can have on flood risk.



# Appendix E

## Flood emergency planning

Flood emergency planning refers to the preparation of formal plans of action to deal with the threat, onset, occurrence and aftermath of a flood. This Appendix provides guidance on issues to consider and the preparation of Flood Emergency Plans.

### E.1 Background

There are four components of flood emergency management, as follows:

- Flood warning
- Preparedness
- Response
- Recovery.

Emergency measures to deal with the actual occurrence of flooding are essential to complement flood mitigation activities covered by information on flood risk management in Local Plans. Emergency measures address the residual risk associated with all floods (i.e. the difference between the magnitude of the flood and the standard of protection provided by flood defences). In many cases emergency measures may be the only feasible way to deal with existing risk where structural measures are either impractical or not economically justified. Even minor floods require some management responses, even if they are only providing information to the community.

#### E.1.1 Flood warning

Flood forecasting is the process of predicting the severity of flooding at different locations. This includes the area of land affected, the likely level of floodwater, and timing of the flood. Flood warning refers to the process of alerting the occupants of flood prone areas of the immediacy and severity of the flood risk.

Although the flood forecasting and flood warning are separate (it is possible to forecast floods without issuing any warnings), an appropriate forecasting system is essential to an efficient and effective warning system.

The Environment Agency provides a flood forecasting service for rivers in which a variety of techniques are used to forecast floods. These include water level correlations at different points in a catchment, hydrological and hydraulic modelling, and the use of weather radar to estimate rainfall. The Agency uses the flood forecasts to formulate warnings for areas prone to flooding.

On the coasts the Storm Tide Warning Service monitors tidal water levels and forecasts the impacts of tidal surges. These forecasts are used to provide flood warnings to coastal communities that might be affected.

Forecasts are subject to considerable uncertainties. As the event which is likely to cause flooding gets closer the accuracy of the forecast will increase but the warning time will reduce. There is therefore a degree of unreliability in flood warnings. The unreliability must

not become too great as it will significantly affect confidence in the warnings, and hence the quality of the response.

Flood warnings are disseminated in several ways and by a variety of agencies. The Environment Agency has primary responsibility for dissemination, and disseminates warnings to the media, emergency services, local authorities and floodplain residents (by Automatic Voice Messaging and other means). Further dissemination is undertaken by local authorities and community groups. The value of personal face to face warnings in this process is very important as it provides a point of human contact at a very stressful time.

The process of formulating flood warnings should include:

- Maintaining flood intelligence records indicating what effects occur at particular levels of flooding as measured at nominated stream gauges, including road closures, inundation of built-up areas, and flooding of buildings. This information enables advice on likely flooding to be given before the flood occurs;
- Defining who should receive warnings at different flood levels as the flood develops. These include local authorities, emergency services, residents, businesses, farmers, caravan parks, tourists, etc.;
- Identifying the information needs of different groups and designing effective flood warning messages;
- The means by which warnings and advice will be transmitted to different groups. Ideally there should be contingency plans in case the preferred method of communication fails, and the receiver should routinely confirm the receipt of messages;
- Deciding who will undertake warning tasks and what local networks are needed, for example flood wardens and community groups.

### **E.1.2 Flood preparedness**

Flood preparedness refers to knowing what to do in advance of a flood, knowing what to do when a flood occurs and how to do it effectively during the onset of a flood. Flood preparedness is required by all stakeholders in flood emergencies including the flood-prone population, floodplain management authorities and emergency services. Preparedness of the emergency services includes training of staff in responding to flood warnings, evacuation, rescue, other flood emergency tasks, and ensuring the provision and reliability of equipment to be used in a flood.

With regard to the flood-prone population, preparedness including flood awareness is particularly important. Not only does this lead to reduced damage to possessions compared with people who are not prepared, but also they are more likely to understand the need for evacuation and which route to utilise if evacuation becomes necessary.

Investment is needed by local authorities to foster and maintain flood awareness and preparedness in the local population. However, this can only be done effectively with the cooperation and whole-hearted support of the local authority and local community. This commitment should be considered as a “maintenance cost” of flood emergency planning.

Raising and maintaining flood awareness is not easy. The natural turnover of properties and residents in flood prone areas results in people who have experienced floods being replaced by those who may have no experience in flooding. In the often long periods between severe floods, flood awareness erodes and may even disappear. This is especially so for communities

protected by embankments, which generally provide protection from all but the more serious and infrequent floods. Ultimately, however, a flood that overtops the embankments is likely to occur.

Local authorities can enhance flood awareness through, for example, regular public education programs via newspaper articles, videos, pamphlets, meetings and messages accompanying rate notices. The Environment Agency is very active in raising the awareness of flooding nationally.

Another means of raising and maintaining awareness is to undertake flood emergency exercises, although this can be time consuming for the many professionals and others involved.

### **E.1.3 Flood response**

Flood response refers to the operations that may be initiated to reduce the hazard of an actual flood after a flood warning has been issued. These include road control, building up of defences, evacuation, rescue and providing information and advice to communities affected by flooding.

Road control may be undertaken by the police or local road authority, depending on local agreements. It involves closing roads which are liable to flood, planning and implementing detours, signposting, and disseminating information on road closures. Where flooding is a regular occurrence, flip down signs can be used to warn road users of flooding.

The Environment Agency and local authorities may build up defences using sand bags or other means, although sand bags have a number of disadvantages and are not used by some local authorities. Local authorities also provide labour, equipment and facilities for conducting a range of response tasks, including for example lifting or moving furniture for the elderly and disabled. Local authorities also provide temporary accommodation and food for evacuees.

Flood emergency plans need to be based on a thorough understanding of likely flooding behaviour. Strategies to guide flood response activities appropriate for one level of flooding may become hazardous or otherwise inappropriate at higher water levels during more extreme floods.

### **E.1.4 Flood recovery**

Flood recovery refers to clean-up, welfare, restoration of services and other forms of assistance provided by local authorities and voluntary organisations after a flood. Recovery functions may be divided into those which deal with human welfare and those relating to infrastructure and facilities. The local Flood Emergency Plan should contain details of initial cleanup and recovery operations.

It is particularly important to restore essential services that have been affected by flooding as this will assist the recovery process. In addition, services to consumers outside the floodplains may have been affected. Essential services include electricity supply, water supply, sewerage, telephones, police stations, fire service control, ambulance control and hospitals.

The integrity of these services will be maintained if they are located in flood-free locations. The relevant organisations should aim to move essential services that are currently in flood risk areas as the opportunity arises, for example when replacement is needed. Alternatively services can be floodproofed although this will not guarantee that they will not be affected by flooding.

Flood recovery includes:

#### **Short term**

- Rest and information centres
- Support to the vulnerable
- Provision of cleaning materials, skips and dustcarts
- Provision of waste disposal sites
- Advice on insurance and money matters
- Cleaning and re-opening roads
- Building safety and environmental health checks
- Provision of information to affected residents.

#### **Medium term**

- Establish recovery strategy
- Drying out and repairs to properties
- Recovery of businesses
- Temporary housing
- Road repairs
- Provision of information to affected residents
- Fund raising to support flood victims.

#### **Long term**

- It may take over a year for residents and businesses to return to flood affected properties
- Provision of information to affected residents
- Lessons learnt and preparation for future floods
- Re-evaluate defences. This might lead to improving the defences or, where improvement is not a practical option, considering alternative measures such as improved flood warning
- Review planning status. It may be advisable, for example, not to permit any further development in the flood risk area.

## **E.2 Preparation and content of Flood Emergency Plans**

Ideally the agency responsible for preparing Flood Emergency Plans should also be responsible for collecting and compiling flood intelligence, and for coordinating response activities. Having such broad responsibilities encourages the agency to develop expertise in managing floods. In practice the most suitable agency for preparing Flood Emergency Plans are County Councils, District Councils or Unitary Authorities because of their broad responsibilities, even though the police co-ordinate the emergency response. The choice of local authority will depend on local emergency planning arrangements and the area covered by the plan.

County emergency plans exist to deal with any type of emergency that may occur. These are generic plans which detail procedures for dealing with emergencies, and identify roles and

responsibilities. However the emergencies dealt with by such plans are generally unpredictable, for example an air crash or major pollution incident.

Flooding differs from these types of emergency in that the area affected can be predicted, and warnings can be provided of an impending flood. In addition, flooding is a widespread natural phenomena which occurs every year in different parts of the country. Hence a separate Flood Emergency Plan is required which can be more specific than a generic emergency plan.

It is recommended that Flood Emergency Plans are prepared at local level for all significant communities in England and Wales (ICE, 2001). However, county emergency plans also have a role in the following:

- Coordination of responses for floods occurring simultaneously in several districts within the county
- Coordination of the provision of extra resources required at local level
- Control arrangements for widespread emergencies
- Exchange of regional level information including severe weather warnings, provision of information to the media, etc.

There may also be a need to co-ordinate responses across County boundaries in some catchments.

Local Flood Emergency Plans may include:

- Aims of the plan, including the target audience
- Basic information on flooding:
  - The flood risk are
  - Population and assets at risk
  - Flood hazard
  - Evacuation routes
  - Flood warning arrangements
- Roles and responsibilities
- Contact details
- Actions for different groups:
  - Local authorities and the emergency services
  - Residents
- Advice sheets
- Detailed information for sectors of the floodplains.

Flood Emergency Plans should be updated annually and dated, so that users will know how up to date the plan is. This is necessary to take account of changes in contact details and any other changed circumstances, for example lessons learnt from recent floods.

### **E.3 Aims of the plan and target audience**

The aims of the plan are to:

- Provide a plan for responding to flood emergencies
- Define roles and responsibilities for all stakeholders
- Communicate roles and responsibilities to stakeholders.

Stakeholders should be involved in the development of the plan to ensure that the plan takes their views and ideas into account, and to ensure they are aware of their roles and responsibilities.

The two main categories of stakeholder are broadly those who live and/or work in flood prone areas, and those involved in responding to floods. The information required by these groups will be different, and it is recommended that the flood emergency plan is divided as follows:

- Information for those involved with the emergency response
- Information for those who live and/or work in flood prone areas.

Although these two sections form part of the same plan, it should be possible to separate them and distribute them separately to their respective target audiences. In addition, a separate single plastic covered sheet should be provided to those who live and/or work in flood-prone areas, which gives key information and contact details. This sheet should be kept in a safe and accessible place by recipients for use in times of flood.

#### **E.4 Basic information on flooding**

The plan should contain the following information:

- The flood risk area;
- Information on the population and assets at risk, needed by those involved in co-ordinating the emergency response;
- Information on flood hazard;
- Areas where evacuation may be needed, and evacuation routes;
- Flood warning arrangements. This includes a brief description of the Environment Agency's Flood Warning Service, the meanings of flood warnings, and the ways in which warnings are disseminated within the community.

#### **E.5 Roles and responsibilities**

The roles and responsibilities of all stakeholders should be clearly stated. Those who affected by flooding need to know from whom they can expect assistance, and have the required contact details. In view of the risk that telephone systems may fail, representatives of the emergency services should be present in the flood risk areas as soon as possible after the flood warning is received, with appropriate communications equipment.

Flood emergency planning involves the coordinated activities of:

- The Environment Agency, who provide flood warnings and assist in flood emergencies;
- The police, who co-ordinate the emergency response and are also responsible for public safety;
- Local authorities, who assist with the emergency response, have a major role in clean-up and recovery, provide information to those affected by flooding, and co-ordinate the activities of voluntary organisations;
- The fire and rescue service, who rescue those stranded by floods and deal with pumping out and pollution;
- The health service, who provide health support to those affected by floods;
- The media, who provide information;
- Voluntary organisations, who assist with flood recovery;



- Community groups and residents associations, who encourage self-help and support amongst flood-prone communities.
- Flood wardens.

Individuals should only become flood wardens if they are able to undertake the duties when a flood occurs. Many floodplain residents will be preoccupied and therefore unable to undertake flood warden duties. Each flood warden is allocated a group of properties, and they are responsible for making sure everyone is aware of the flood. In addition, wardens may facilitate the evacuation of individuals, particularly families with children, the elderly and other vulnerable groups. Flood wardens must be identifiable and known to the local community.

## **E.6 Actions for different groups**

The flood emergency plan should state the actions to be taken by each of the main stakeholder groups for each component of emergency planning (i.e. preparedness, response and recovery). The formulation and issue of flood warnings is the responsibility of the Environment Agency. The following lists summarise some of the main responsibilities for the two main stakeholder groups.

### **E.6.1 Local authorities and the emergency services**

#### **E.6.1.1 Preparedness**

- Preparation of the Flood Emergency Plan
- Issue of the Flood Emergency Plan to all stakeholders
- Allocation of duties and training of staff
- Identification and allocation of resources
- Maintenance of flood response capability by regular updates and emergency exercises
- Maintain flood awareness of floodplain communities by public meetings and newsletters.

#### **E.6.1.2 Flood response**

- Trigger conditions for activation of the plan
- Control and co-ordination of the response, led by the police
- Communication and liaison arrangements
- Assistance with warning dissemination, for example within local authorities
- Road control
- Evacuation and rescue, with particular assistance to the elderly, disabled and other vulnerable groups
- Protection of property
- Implementation of contingency plans if, for example, road access becomes blocked or key services fail
- Exchange of information with the Environment Agency, the media and the general public, particularly those affected by the flood.

#### **E.6.1.3 Flood recovery**

- Pumping out
- Clean-up and repairs of public facilities including roads
- Rest centres, temporary accommodation and assistance with a wide range of flood recovery activities

- Collect information from the flood from those affected and others
- Improve the flood emergency plan and prepare for the next flood.

## **E.6.2 Those who live and/or work on floodplains**

### **E.6.2.1 Preparedness**

- Register with the flood warning scheme
- Receive a copy of the Flood Emergency Plan
- Know what the flood warning arrangements are and how to respond when a flood warning is issued
- If evacuation becomes necessary, know evacuation arrangements and routes
- Identify and prepare measures to protect property and contents from flood damage, including the use of protection devices and plans to move items (including cars) out of the area which might flood
- Join local community groups as self-help and neighbour support are very important in flood emergencies
- Maintain flood awareness by regular meetings and events
- Consider becoming a flood warden if resources are available during a flood emergency.

### **E.6.2.2 Flood response**

- Receive flood warning and pass to neighbours where appropriate
- Obtain up to date flood information by radio, other residents or other pre-determined means
- Implement plans to protect property and contents
- Evacuate property if required to do so.

### **E.6.2.3 Flood recovery**

- Clean-up
- Restoration of property and contents
- Provide feedback on flood to local authority in order to improve planning and preparation for future events.

## **E.7 Advice sheets**

Flood emergency plans should include advice sheets for particular aspects of flooding. These should be “standalone” single sheets for separate issue if required. Advice sheets might include:

- How to protect properties and contents. This would give key advice, but also refer to web sites and other more detailed sources of information (particularly from Environment Agency 2001a and DTLR 2002);
- Guidance on electrical safety in floods;
- Guidance on other health and safety issues, for example building safety and polluted water;
- Restoration of damaged properties. This would give key advice, but also refer to web sites and other more detailed sources of information (particularly from Environment Agency 2001b, CIRIA at [www.ciria.org.uk/flooding](http://www.ciria.org.uk/flooding), and BRE 1997).

## **E.8 Detailed information for sectors of the floodplains**

A Flood Emergency Plan includes detailed information on the flood risk area to facilitate street by street implementation of the plan. Information for each sector of the floodplain might include:

- Population at risk
- Number of properties
- Institutions (schools, etc.)
- Key service installations
- Information on vulnerable communities, for example flats for the elderly
- Frequency and mode of flooding
- Guidance on evacuation and rescue procedures.



# Appendix F

## Data and performance indicators

This Appendix briefly reviews the need to collect, store and use appropriate data in order to improve floodplain management. There is a need to collect consistent data on a common basis which is suitable for a national database. It would be desirable to include data in the National Flood and Coastal Defence Database (NFCDD) rather than create a new database.

### F.1 The need for data

Data are needed to improve understanding of flood behaviour and the magnitude of the flood risk. A reliable and adequate database is an essential foundation of effective management. The poor availability and unreliability of flood damage data and management data makes the economic justification for devoting more resources to floodplain management difficult. It also makes the objective allocation of limited resources between competing flood ‘problems’ impossible.

An adequate database is also essential to the definition and measurement of appropriate performance indicators to monitor the success and effectiveness of floodplain management activities. The existence of a national database of flood damage and floodplain management data will foster better floodplain management. It would also facilitate comparison of problem areas, both between and within districts and regions.

### F.2 Data to be collected

Data should be collected of the following two types:

- Data which arise from the theoretical assessments of flooding made in flood studies
- Data from actual floods.

The theoretical data will be relatively easy to obtain because it comes directly from flood studies. Comparison of these data will identify the effectiveness of the flood study and floodplain management process, and lead to improvements based on actual experience.

Data that could be collected encompasses the three broad areas of flood behaviour, flood hazard and floodplain management measures.

#### F.2.1 Flood behaviour data

Flood behaviour data include:

- Peak river flood discharges for a range of floods
- Peak flood water levels at key locations on rivers and coasts for a range of floods
- Areas of inundation for a range of floods
- Rate of rise of floodwaters (for hazard appraisal)
- Estimated velocity of floodwaters (for hazard appraisal).

Much of these data are already routinely collected by the Environment Agency.

## **F.2.2 Flood hazard data**

Flood hazard data include:

- Number of people in flood risk areas for a range of flood events
- Number of people requiring evacuation or other assistance
- Number and type of properties at risk of flooding for a range of flood events
- Average depths of flooding and flood damages for a range of flood events
- Number of people evacuated from their homes, and period of evacuation

There are currently no national records of the number of people evacuated from their homes, and the period of evacuation. However some local authorities have kept records. For example, statistics for the Autumn 2000 floods in Lewes are as follows:

Number of residential properties vacated	397
Number of residential properties still vacant one year after flood	58

Number of commercial properties vacated	147
Number of commercial properties still vacant one year after flood	32

- Cost of the emergency response and clean-up. There are generally no data on this but ongoing research on the Autumn 2000 floods suggests that these costs are considerable.

## **F.2.3 Floodplain management data**

Floodplain management data include:

- Number of Local Plans which contain recommended flood risk management provisions and the approximate proportion of the national assets at risk of flooding covered by the plans;
- Effectiveness and costs of various floodplain management measures.

## **F.3 Data collection responsibilities**

Data on river flows and water levels are collected by the Environment Agency. Data on tidal water levels are collected by the Proudman Oceanographic Laboratory (POL). Data on flooded areas are generally collected by the Environment Agency, often with the assistance of local authorities.

Data on flood hazard and floodplain management would most effectively be collected by local authorities, in consultation with the emergency services and the flood prone community where appropriate. In particular, the local authority is in the best position to undertake the essential activity of collecting and recording actual data after a flood event.

## **F.4 Performance indicators**

Substantial resources are required for the management of flood risk and flood hazard. Performance indicators are essential to ensure that resources allocated to floodplain management and flood emergency management activities are spent in an effective and equitable fashion and to measure the success of floodplain management programs.

A set of simple, common and effective performance indicators is needed which can be readily accessed on the national database. Such performance indicators need to measure the long-term trends in programme outcomes rather than short-term outputs. An example of a long-term programme outcome is the proportion of flood-prone urban areas where flood risk is covered in Local Plans with floodplain management plans in place. This is a more meaningful measure of success in meeting basic programme objectives than, for example, the number of flood studies started in the last 12 months, which is simply a measure of activity or programme output. Furthermore, adopted performance indicators need to be relatively simple and easy to measure.

Defra and the Environment Agency are looking at the development of performance indicators. The performance indicators listed in the following sections are suggestions that may be appropriate for incorporation in wider performance indicators when published in the future.

### **F.4.1 Performance indicators for urban planning districts**

Appropriate performance indicators to measure long-term outcomes of floodplain management programmes in planning districts where land use is predominantly urban include the proportion of:

- Flood-prone urban areas and towns where flood risk is adequately covered in Local Plans
- Flood-prone urban areas and towns with completed flood emergency plans in place
- Flood-prone urban areas and towns with a plan for implementing post-flood recovery activities, including the post-flood repair and reactivation of infrastructure
- Flood-prone urban areas and towns with dedicated flood forecasting and warning systems in place.

Urban performance indicators may also include the ratio of:

- The current number of urban properties susceptible to flooding by a flood event(s) of nominated severity(s) to the number of properties susceptible in a nominated base year. This would measure the degree of success achieved in protecting urban properties;
- The current value of average annual potential or actual flood damage to the value in a nominated base year.

Some more limited but useful performance indicators can be defined to measure specific programme outcomes such as the success of flood emergency activities in actual flood events and the reduction in potential damage associated with specific management measures.

#### **F.4.2 Performance indicators for rural planning districts**

Appropriate performance indicators to measure the long-term outcomes of floodplain management programmes in rural districts include the proportion of:

- Flood-prone rural areas where flood risk is adequately covered in Local Plans;
- Flood-prone rural areas with flood forecasting and warning systems in place;
- The area and type of farming activity susceptible to mainstream flooding by a flood event(s) of a nominated severity(s) to the area and type of farming activity in a nominated base year;
- Current value of average annual potential or actual flood damage to the value in a nominated base year.

#### **F.4.3 Social and environmental performance indicators**

Appropriate social and environmental performance indicators need to be defined to measure the outcomes of urban and rural floodplain management strategies on social and environmental objectives. Social indicators could relate to the reductions in the intangible costs of flooding. Environmental indicators could relate to the environmental costs, benefits and sustainability of management measures.

There has been very little previous work carried out on the development of social and environmental performance indicators and further research is necessary before recommendations can be made.



## Appendix G

### Stakeholders and their roles

<i>Stakeholder</i>	<i>General responsibilities</i>	<i>Responsibility in flood plain management</i>
<b>Those who live and/or work on floodplains</b>		
Householders/business owners, farmers, other landowners  Note: Whilst this list primarily refers to those who live and work on floodplains, others outside the floodplains are affected by loss of services, business disruption, etc.	<ul style="list-style-type: none"> <li>• Property ownership.</li> <li>• Land management.</li> <li>• Drainage of land and management of flows from adjoining land.</li> </ul>	<ul style="list-style-type: none"> <li>• Self help.</li> <li>• Prevent adverse drainage impacts.</li> <li>• Private flood defences.</li> <li>• Riparian owners with land adjacent to Ordinary Watercourses are responsible for maintenance including banks, paths and prevention of erosion.</li> <li>• Awareness, preparedness, response to flood emergencies.</li> <li>• Flood wardens.</li> <li>• Residents and businesses need to be engaged in preparing emergency plans.</li> </ul>
Local residents associations and community groups	<ul style="list-style-type: none"> <li>• Raising awareness</li> <li>• Community co-ordination</li> </ul>	<ul style="list-style-type: none"> <li>• Neighbour support</li> <li>• Distribution of information</li> <li>• Recruitment of flood wardens</li> </ul>
<b>Land use planning function</b>		
Local Planning Authorities (District Councils and Unitary Authorities).	<ul style="list-style-type: none"> <li>• Land Use Planning.</li> <li>• Administration of Building Regulations.</li> </ul>	<ul style="list-style-type: none"> <li>• Need to incorporate floodplain management into statutory land use plans</li> </ul>
<b>River, drainage and coast managers ('Operating Authorities')</b>		
Environment Agency	<ul style="list-style-type: none"> <li>• Implementing Government policy.</li> <li>• General supervision over all matters relating to flood defence.</li> <li>• Main Rivers and coasts.</li> <li>• Maintenance of Main Rivers including debris removal.</li> </ul>	<ul style="list-style-type: none"> <li>• Floodplain mapping.</li> <li>• Maintenance and improvement works on rivers and coasts.</li> <li>• Provision and maintenance of flood defences on Main Rivers and coasts.</li> <li>• Planning consultee.</li> <li>• Advice on all flooding matters</li> </ul>
Regional and Local Flood Defence Committees	<ul style="list-style-type: none"> <li>• Agency flood defence responsibilities.</li> </ul>	<ul style="list-style-type: none"> <li>• Priorities for flood defence works.</li> </ul>

Local Authorities (District Councils, Unitary Authorities, London Boroughs).	<ul style="list-style-type: none"> <li>• General duties of care.</li> <li>• Ordinary Watercourses.</li> <li>• Coast protection.</li> <li>• Amenity and recreation.</li> </ul>	<ul style="list-style-type: none"> <li>• Maintenance, improvement works and flood defences on Ordinary Watercourses and coasts.</li> <li>• Coast protection works.</li> </ul>
Internal Drainage Boards (IDBs)	<ul style="list-style-type: none"> <li>• Drainage of land in Drainage Districts.</li> </ul>	<ul style="list-style-type: none"> <li>• Maintenance and flood protection for watercourses in Drainage Districts.</li> <li>• Planning consultee</li> </ul>
Water companies	<ul style="list-style-type: none"> <li>• Stormwater drainage.</li> <li>• Combined systems.</li> </ul>	<ul style="list-style-type: none"> <li>• Maintenance and works on adopted drainage systems (including SUDS).</li> <li>• Sewer flooding including foul flooding.</li> </ul>
<b>Emergency planning, response and flood recovery</b>		
Environment Agency	<ul style="list-style-type: none"> <li>• Flood warning.</li> <li>• Emergency response.</li> </ul>	<ul style="list-style-type: none"> <li>• Flood forecasting.</li> <li>• Issue flood warnings.</li> <li>• Assistance in flood emergencies.</li> <li>• Monitor and repair flood defences</li> <li>• Clear blockages</li> </ul>
Met Office	<ul style="list-style-type: none"> <li>• Weather forecasting.</li> </ul>	<ul style="list-style-type: none"> <li>• Forecasting of extreme weather and tidal surges.</li> </ul>
Police	<ul style="list-style-type: none"> <li>• Law and order.</li> </ul>	<ul style="list-style-type: none"> <li>• Flood emergency planning.</li> <li>• Co-ordinate emergency response.</li> <li>• Interpretation of EA flood warnings</li> <li>• Public safety.</li> <li>• Evacuation.</li> </ul>
Local Authorities (including County, Unitary and District).	<ul style="list-style-type: none"> <li>• Emergency planning.</li> <li>• Emergency response.</li> <li>• Clearing up.</li> </ul>	<ul style="list-style-type: none"> <li>• Flood emergency planning.</li> <li>• Flood emergency response including road diversions, rest centres and clearing watercourses..</li> <li>• Welfare of flood victims.</li> <li>• Co-ordination of voluntary organisations.</li> <li>• Clearing up and recovery.</li> <li>• Interpretation of EA flood warnings.</li> <li>• Provision of information.</li> </ul>
Fire Service	<ul style="list-style-type: none"> <li>• Emergency response particularly fires, road accidents, etc.</li> </ul>	<ul style="list-style-type: none"> <li>• Flood emergency planning.</li> <li>• Emergency response including rescue.</li> <li>• Pumping out.</li> <li>• Dealing with pollution</li> </ul>
Health Service	<ul style="list-style-type: none"> <li>• Public health.</li> </ul>	<ul style="list-style-type: none"> <li>• Health support to those affected by floods.</li> <li>• R&amp;D into health impacts of flooding.</li> </ul>

Media	<ul style="list-style-type: none"> <li>• News reporting and communication.</li> </ul>	<ul style="list-style-type: none"> <li>• Flood warning.</li> <li>• Awareness raising.</li> <li>• Information.</li> <li>• Public reassurance.</li> </ul>
Voluntary sector		<ul style="list-style-type: none"> <li>• Assistance in flood emergencies and recovery.</li> </ul>
<b>Those involved with conservation and environmental enhancement</b>		
Conservation bodies	<ul style="list-style-type: none"> <li>• Conservation and environmental enhancement.</li> </ul>	<ul style="list-style-type: none"> <li>• Management of conservation areas.</li> <li>• Advice on conservation matters in flood risk areas.</li> </ul>
Environment Agency	<ul style="list-style-type: none"> <li>• Conservation and environmental enhancement.</li> </ul>	<ul style="list-style-type: none"> <li>• Schemes for environmental enhancement.</li> <li>• Advice on conservation matters.</li> </ul>
<b>Policy makers and other supervisory organisations</b>		
Defra (National Assembly of Wales in Wales)	<ul style="list-style-type: none"> <li>• Policy.</li> <li>• Strategic guidance.</li> <li>• Provision of funding.</li> </ul>	<ul style="list-style-type: none"> <li>• Flood defence policy.</li> <li>• Grant aid of flood defence schemes.</li> <li>• Research.</li> </ul>
ODPM	<ul style="list-style-type: none"> <li>• Town and Country Planning.</li> <li>• Policy on land use. Planning.</li> </ul>	<ul style="list-style-type: none"> <li>• Guidance on development and flood risk.</li> </ul>
Local Government Association (LGA)	<ul style="list-style-type: none"> <li>• Local authority co-ordination.</li> </ul>	<ul style="list-style-type: none"> <li>• Co-ordination on flooding matters.</li> </ul>
Association of Drainage Authorities (ADA)	<ul style="list-style-type: none"> <li>• IDB co-ordination.</li> </ul>	<ul style="list-style-type: none"> <li>• Co-ordination on flooding matters.</li> </ul>
Building Regulations Advisory Committee	<ul style="list-style-type: none"> <li>• Building Regulations.</li> </ul>	<ul style="list-style-type: none"> <li>• Regulations for flood proofing of buildings.</li> </ul>
<b>Those who have assets on floodplains (transport, utilities)</b>		
Highway Authorities (County and District)	<ul style="list-style-type: none"> <li>• Roads.</li> </ul>	<ul style="list-style-type: none"> <li>• Highway drainage.</li> <li>• Maintenance of floodplain structures.</li> </ul>
Railtrack	<ul style="list-style-type: none"> <li>• Railways.</li> </ul>	<ul style="list-style-type: none"> <li>• Railway drainage.</li> <li>• Maintenance of floodplain structures.</li> </ul>
Highways Agency	<ul style="list-style-type: none"> <li>• Trunk roads and motorways.</li> </ul>	<ul style="list-style-type: none"> <li>• Highway drainage.</li> <li>• Maintenance of floodplain structures.</li> </ul>
British Waterways Board	<ul style="list-style-type: none"> <li>• Canals</li> <li>• Navigable waterways</li> </ul>	<ul style="list-style-type: none"> <li>• Protect structures</li> <li>• Manage floodwater within BWB systems</li> </ul>

Utilities	<ul style="list-style-type: none"> <li>• Services (electricity, gas, water supply, sewerage, communications, etc.).</li> </ul>	<ul style="list-style-type: none"> <li>• Provision of services.</li> <li>• Maintenance of services.</li> <li>• Safety of services.</li> <li>• Information on service disruption</li> <li>• Alternative services during disruption</li> <li>• Clean up/repair.</li> </ul>
<b>Business interests</b>		
Developers	<ul style="list-style-type: none"> <li>• New developments</li> </ul>	<ul style="list-style-type: none"> <li>• Developments conform with flood management requirements.</li> <li>• Flood Risk Assessment for new developments.</li> <li>• Contributions to floodplain management.</li> <li>• Improve floodplain where compensatory works needed.</li> </ul>
Insurance companies	<ul style="list-style-type: none"> <li>• Insurance of properties and other assets.</li> <li>• Encourage action by Clients to reduce risk.</li> </ul>	<ul style="list-style-type: none"> <li>• Provision of insurance.</li> <li>• Conditions for provision of insurance.</li> <li>• Financial rewards for reduced risk.</li> <li>• Need emergency response.</li> </ul>
ABI	<ul style="list-style-type: none"> <li>• Representative body for insurance companies.</li> </ul>	<ul style="list-style-type: none"> <li>• Co-ordination on flooding matters.</li> <li>• Fairness of cover.</li> </ul>
<b>Other stakeholders</b>		
Professional bodies	<ul style="list-style-type: none"> <li>• Professional standards.</li> <li>• Technical advances.</li> </ul>	<ul style="list-style-type: none"> <li>• Promote good practice.</li> </ul>

Sources of information: *Land drainage and flood defence responsibilities*, 3<sup>rd</sup> Edition, Institution of Civil Engineers, 1996  
*Learning to live with rivers*, Institution of Civil Engineers, 2001

## **ABBREVIATIONS**

AAD	Annual Average Damages
ABI	Association of British Insurers
AVM	Automatic Voice Messaging
CFMP	Catchment Flood Management Plan
CHaMP	Coastal Habitat Management Plan
Defra	Department for Environment, Food and Rural Affairs
DTLR	Department for Transport, Local Government and the Regions
DTM	Digital Terrain Model
FCDPAG	Flood and Coastal Defence Project Appraisal Guidance
IFM	Indicative Flood Map
MAFF	Ministry of Agriculture Fisheries and Food (now part of Defra)
NFCDD	National Flood and Coastal Defence Database
ODPM	Office of the Deputy Prime Minister
PPG	Planning Policy Guidance Note
SMP	Shoreline Management Plan
UDP	Unitary Development Plan
WLMP	Water Level Management Plan



## **GLOSSARY**

### **Astronomical tide**

The variation in sea level caused by the gravitational effects of (principally) the moon and sun.

### **Average annual damage (AAD)**

The total damage caused by all floods over a long time divided by the number of years in that period. (It is assumed that the population and development situation of interest does not change over the period of analysis).

### **Bathymetry**

The configuration of the sea, estuary or river bed, as measured by depth contours.

### **Brownfield site**

A site for which new development is proposed that has been developed in the past. Brownfield sites often have particular problems, for example contaminated ground and polluted groundwater.

### **Catchment**

The area of land draining to a specific location. It includes the catchments of tributaries as well as the main river.

### **Catchment Flood Management Plan**

High level plan for managing floods in river catchments.

### **Consequence**

The consequence of flooding is the impact of the flood including economic damages and social impacts.

### **Conveyance**

The ability of a watercourse or other flow path to carry (or convey) water.

### **Critical Ordinary Watercourses**

Ordinary Watercourses which the Environment Agency and other operating authorities agree are critical because they have the potential to put at risk from flooding large numbers of people and property.

### **Discharge**

The rate of flow of water, as measured in terms of volume per unit time, for example cubic metres per second ( $m^3/s$ ).

### **Effective warning time**

The time available for the evacuation of people and their goods and possessions before the onset of flooding.

### **Flood emergency**

A condition or situation caused by flooding that requires urgent action or assistance.

**Flood emergency plan**

An agreed set of roles, responsibilities, functions, actions and management arrangements to deal with flood events.

**Flash flooding**

Sudden and unexpected flooding caused by local heavy rainfall or rainfall in another area.

**Flood hazard**

The impact of a flood on the safety of people, including the potential for loss of life and injury. The degree of hazard varies with the severity of flooding and is affected by flood behaviour (extent, depth, velocity, duration, amount of warning and rate of rise of floodwaters), topography, population at risk and emergency management.

**Floodline**

The name of the Environment Agency's flood awareness and flood warning campaign.

**Flood management**

The management of floods. This includes physically "managing" flood water, for example by providing storage areas, and other measures to reduce the flood impact, for example flood warning schemes.

**Flood management plans**

A term used in this document to collectively describe Shoreline Management Plans, Catchment Flood Management Plans and Strategy Plans.

**Floodplain**

Area of land adjacent to a river, estuary or coast which is subject to inundation by flooding.

**Floodplain management measures**

The full range of measures available to prevent or reduce flood hazard and disruption.

**Floodplain management option**

A set of possible measures for the management of a particular area of the floodplain.

**Floodproofing**

A combination of measures incorporated in the design, construction and alteration of individual flood-prone buildings or structures to reduce or eliminate flood damage.

**Flood recovery**

Flood recovery refers to clean-up, welfare, restoration of services and other forms of assistance provided by local authorities and voluntary organisations after a flood.

**Flood risk**

Flood risk is defined as:

$$(\text{Probability of flooding}) \times (\text{Consequence of flooding})$$

Flood risk is normally measured in terms of economic damages for a particular probability of flooding, or Annual Average Damages based on the full range of floods that could occur.



**Flood storage areas**

Those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood.

**Flood study**

A comprehensive technical investigation of flood behaviour.

**Floodway**

A zones of a floodplain where there are significant flows during flood events.

**Fluvial**

Relating to rivers.

**Freeboard**

The height above a defined flood level typically used to provide a factor of safety in, for example, the setting of floor levels and embankment crest levels.

**Greenfield Site**

A site for which new development is proposed that has not been developed in the past.

**Hydrograph**

A graph that shows for a particular location, the variation with time of discharge (discharge hydrograph) or water level (stage hydrograph) during the course of a flood.

**Indicative Flood Map**

Floodplain maps which cover the coastline, estuaries and the larger rivers. These maps show the estimated flood limit with a 1 in 100 chance of occurring in any year on rivers and 1 in 200 chance on coasts.

**Local Plan**

Statutory land use plan covering a local authority district, prepared by District Councils.

**Main River**

Rivers for which the Environment Agency has control powers for maintenance, improvement and construction of new works. These comprise the larger rivers in England and Wales.

**Ordinary Watercourse**

A watercourse in England and Wales that is not a Main River. These are generally the smaller rivers and streams in England and Wales.

**Peak discharge**

The maximum discharge occurring during a flood event past a given point on a river system.

**Probability**

The probability of flooding is the chance of a flood occurring, and may be expressed as the chance of a particular flood occurring in any one-year (for example, the flood with a 1 in 200 chance of occurring in any year).

**Regional Planning Guidance**

Regional Planning Guidance, which provides a strategic planning framework in each of the eight English regions. In London there is a spatial development strategy.

**Residual flood risk**

The remaining level of flood risk that a community is exposed to after floodplain management measures to reduce risk have been implemented.

**Riparian owner**

The proprietor of land on the banks or under the bed of a natural watercourse.

**Runoff**

The amount of rainfall that drains into the surface drainage network to become stream flow.

**Section 105 Survey**

Section 105 Surveys, which is a national programme of detailed flood mapping required under Section 105(2) of the Water Resources Act 1991.

**Shoreline Management Plan**

High level plan for managing floods and coastal erosion in coastal cells, or relatively self contained lengths of coastline.

**Stage**

Equivalent to “water level”. Both are measured relative to a specified datum.

**Stage hydrograph**

A graph which shows how the water level at a particular location changes with time during a flood. The stage hydrograph must be referenced to a particular datum.

**Stakeholder**

Individual or organisation who are directly affected by a particular phenomena or activity, for example flood management. Stakeholders in flood management include those affected by flooding and those involved in flood mitigation.

**Strategy Plan**

Flood management plans for sub-divisions of river catchments or coastal cells, which identify appropriate schemes to implement the policies set out in CFMPs and SMPs respectively.

**Structure Plan**

Statutory land use plan covering a County, and prepared by County Councils.

**Unitary Development Plan**

Statutory land use plan prepared by unitary authorities.

**Watercourse**

A river, stream or ditch (but not public sewer).