THE EFFECTIVENESS OF FLOOD MANAGEMENT

A case study of England

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1.0 INTRODUCTION

The Associated Programme on Flood Management (APFM) within the World Meteorological Organization (WMO) has been developing a series of flood management tool publications. One of these publications is focused upon understanding the "Effectiveness of Flood Management Measures in the context of Integrated Flood Management".

A first stage in this process is to collate information about flood management policies in different countries and the evidence used to ensure and measure their effectiveness. This report provides a contribution on the approaches and policies adopted in England.

1.1 Target audience

This report has been written as a contribution to the WMO initiative. It is understood that the report will be amalgamated into a wider report on the effectiveness of flood management. It is assumed that the reader has a very good understanding of the principles of flood management and the international terminology used. Where UK specific terms are used these are explained on first introduction.

2.0 OVERVIEW OF THE FLOOD RISK IN ENGLAND

England and Wales is characterised by a largely managed river and coastal network, with extensive flood defences (around 35,000 km) protecting many communities and with competing pressures to enhance ecosystem function whilst providing appropriate protection to people and the economy. The floodplains are varied in nature – ranging from small steep upland catchments through to river lowland and coastal floodplains. Around 5.2 million properties in England, or one in six properties, are in areas at risk of fluvial (river), coastal or pluvial (heavy rain) flooding. More than 5 million people live and work in the 2.4 million properties in the areas at risk from fluvial flooding and coastal flooding alone, one million of which are also at risk of pluvial flooding (over 15 per cent of the population). A further 2.6 million properties are susceptible to pluvial flooding alone (away from the fluvial and coastal floodplain). Flooding from groundwater also poses a threat in some areas; in general groundwater flooding impacts ecology and biodiversity and has limited impact on people or property.

The expected annual damages to residential and non-residential properties in England at risk of flooding from rivers and the sea is estimated at more than £1.2 billion (in England and Wales). This includes direct damage to property only; the true figure, including indirect (secondary) and intangible losses, would be significantly more. For example, many important infrastructure and public services are in flood risk areas. Over 55 per cent of water and sewage pumping stations/treatment works are in flood risk areas. The potential indirect impact of floods remain, to date, largely quantified in risk terms, including the knock-on effects of damage to important energy, water, communications and transport infrastructure as well as the disruption of basic public services such as schools and hospitals. Both flooding and erosion processes also play an important role in shaping the ecological function of coastal areas and watercourses.

For many years England has adopted a risk based approach to flood management, with formal benefit cost appraisal introduced in the early 1990's (MAFF, 1993) with progressively more comprehensive approaches introduced throughout the following decades (e.g. Sayers et al, 2002). Quantified analysis of costs and benefits has also played an increasingly important role in shaping flood policy in the England and Wales and continues to be used to explore the potential impact of future changes in policy, climate or socio-economics (Evans et al, 2004a&b, Environment Agency, 2009a&b, Defra, 2011a).

The present day or recently assessed risks within the UK are summarized in Table 1. The figures in Table 1 are based upon the National Flood Risk Assessment 2008 undertaken for England and Wales by the Environment Agency (Environment Agency, 2009a&b) and the subsequent flooding sector synthesis undertaken as part of the Climate Change Risk Assessment (Sayers et al, 2010, Ramsbottom et al, 2011).

Table 1 Present day flood risks within the UK

Nature of the risk	***Quantity***	***Basis***
Properties at risk of flooding		
Total number of properties in the UK at risk from **all sources** of flooding (annual probability 0.1% [1:1000] or greater).	6.0 million (m)	Pro-rata, based on 5.2 million in England and 360,000 in Wales.
Properties in the UK at risk **from river and coastal** flooding (annual probability 0.1% [1:1000] or greater).	2.8 m	2.4 million England; 220,000 Wales; 100,000 Scotland 60,000 N. Ireland
Estimated number of properties in the UK at risk **from surface water** flooding	4.2 m	3.8 million England; 230,000 Wales. About 1 million of these are also at risk from rivers and the sea
Estimated properties in the UK at **significant risk** from river and coastal flooding - annual probability >1.3% (1:75).	0.6 m	This takes account of protection provided by flood defences.
Estimated properties in the UK at **moderate risk** from river and coastal flooding - annual probability 1.3% to 0.5% (1:75 to 1:200).	0.9 m	This takes account of protection provided by flood defences.
Estimated properties in the UK at **low risk** from river and coastal flooding - annual probability 0.5% to 0.1% (1:200 to 1:1000).	1.3 m	This takes account of protection provided by flood defences.
People living in flood risk areas		
People in the UK at risk **from river and coastal** flooding (annual probability 0.1% [1:1000] or greater).	5.8 m	Pro-rata, based on 5 million people in England
Agricultural land at risk from flooding		
Agricultural land at risk **from river and coastal** flooding (all types)	1.87 million ha	England and Wales only. 13% of total agricultural land
Agricultural land at risk **from river and coastal** flooding (Grade 1)	188,400 ha	England and Wales only. 56% of total Grade 1: excellent quality agricultural land
Infrastructure		
Major roads in the floodplain	4600 km	England and Wales only. 10% of total
Water installations in the floodplain	950 km	England and Wales only. 60% of total
Energy generation capacity at significant risk of flooding	10 GW	England and Wales only. 15% of total
Police / Fire / Ambulance stations in the floodplain	5600	England and Wales only. 14% of total
Flood damages		
Expected Annual Damage to property from flooding (EAD),UK	£1,400 m	
Expected Annual Damage at risk from coastal erosion (EAD), UK	£14.4 m	
Economic losses – July 2007 floods	£3,200 m	Example of the overall costs of a major flood (Environment Agency, 2010a)

3.0 NATIONAL POLICIES FOR FLOOD RISK REDUCTION

3.1 Roles and responsibilities – Planning and implementing FCERM

Many organizations are responsible for delivering Flood and Coastal Erosion Risk Management (FCERM) in England. These include:

- **The Government of the day** - the Government sets out FCERM policy, led by the Department for the Environment Food and Rural Affairs (Defra). Other policy areas relevant to FCERM include planning policy and building regulations (Department for Communities and Local Government) and civil contingencies (Cabinet Office);

- **The Environment Agency** – Section 7 of the Flood and Water Management Act 2010 requires the Environment Agency to *develop, maintain, apply and monitor a strategy for flood and coastal erosion risk management in England*. As such the Agency has a duty to set out a strategy for FCERM and maintain a strategic overview of all sources of flooding and coastal erosion risks, the delivery of flood and coastal erosion risk management activities (on main rivers and the coast) and the regulation of reservoir safety. It also works in partnership with the Meteorological Office (Met Office) to provide flood forecasts and warnings through the national Flood Forecasting Centre;

- **The Lead Local Flood Authority (LLFAs)** – LLFAs lead the development of local flood risk management strategies and the delivery of these plans in partnership with others. In particular the local strategies must identify flood risks and include actions to alleviate flooding from surface water, groundwater and ordinary water courses;

- **Maritime Coastal Authorities (MCA)** – those local authorities that include a length of coast (Maritime Coastal Authorities) act as the local lead authority on coastal erosion risk management. Their functions include planning shoreline management activities with input from the Environment Agency and the delivery of coastal erosion risk management activities;

- **District Councils, Internal Drainage Boards and riparian land owners/managers** – all have a function in managing the risks of flooding from ordinary water courses (for example streams and drainage channels);

- **Water companies, reservoir owners, highways authorities and other organisations** - all have a FCERM function in managing their own assets or structures where the structure forms part of an FCERM system, or forms part of an important infrastructure service (e.g. water supply, energy, transport).

- **Insurance industry** - Flood insurance is provided by the private sector. The Association of British Insurers and its members are therefore vital in providing cover and handling claims for damages caused by a flood (discussed further in Section 3.4).

- **National Flood Forum** - A registered charity providing advice to those at risk and campaigning for better protection from flooding.

- **Various non-governmental organisations** (NGOs), e.g. World Wildlife Fund (WWF), Royal Society for the Protection of Birds, the National Trust, Wildlife and Rivers Trust and others provide a strong voice in shaping flood and erosion risk management actions.

- **Major land owners** - organisations that manage land, property, cultural heritage and the natural environment in England such as landowners, farmers (and the National Farmers Union), Natural England, Crown Estates, navigation authorities and the Forestry Commission.

In addition to these organisations, **Regional Flood and Coastal Committees** (RFCCs) advise on and approve the implementation of programmes of work for their areas. They also provide local democratic input to the decision process as the majority of membership is derived through election with a limited number of committee appointees.

3.2 Roles and responsibilities – Preparing for and responding to flood emergencies

An 'emergency' is defined in the Civil Contingencies Act 2004[1] as a situation or series of events that threatens or causes serious damage to human welfare, the environment or security in the United Kingdom. Extreme flood related risks fall into this category, and in fact, a widespread East Coast flood (as experienced in 1953) has been identified as one of the greatest potential risks faced by England (Cabinet Office, 2012).

In England, the primary responsibility for planning for and responding to any major emergency rests with local organisations, acting individually and collectively through **Local Resilience Forums**[2] (LRFs) and **Strategic Coordination Groups** (SCGs) located in the Strategic Co-ordination Centre (SCC). The chair of the Group, whether a police lead or Local Authority Chief Executive, is known as the **Gold Commander**.

There is a requirement for public and private organisations to work with and through their local forum to develop plans for maintaining critical services and business continuity during a flooding emergency and to respond to the wider challenges that will result.

[1] http://www.legislation.gov.uk/ukpga/2004/36/contents

[2] A list of LRFs can be found on the UK Resilience website - http://www.cabinetoffice.gov.uk/content/local-resilience-forums

The principle of subsidiarity within Government policy emphasises the importance of local decision making supported, where necessary, by co-ordination at a higher level. Three broad types (or levels) of emergency have been identified which are likely to require direct central government engagement. Details can be found within the Concept of Operations[3] (or CONOPS) but these levels broadly include:

- **Significant emergency (Level 1)** - requires central government involvement or support, primarily from a lead government department (LGD), alongside the work of the emergency services, local authorities and other organisations. There is, however, no actual or potential requirement for fast, inter-departmental/agency, decision making which might necessitate the activation of the collective central government response.

- **Serious emergency (Level 2)** - is one which has, or threatens, a wide and prolonged impact requiring sustained central government co-ordination and support from a number of departments and agencies. The central government response to such an emergency would be coordinated from the **Cabinet Office Briefing Rooms** (COBR), under the leadership of the lead government department.

- **Catastrophic emergency (Level 3) –** is one which has an exceptionally high and potentially widespread impact and requires immediate central government direction and support, such as a major natural disaster, 9/11 scale terrorist attack in the UK, or a Chernobyl-scale industrial accident. Characteristics might include a top-down response in circumstances where the local response had been overwhelmed, or the use of emergency powers where required to direct the response or requisition assets and resources. The Prime Minister would lead the national response from COBR.

  At this level of emergency COBR would be activated in order to facilitate rapid co-ordination of the central government response and effective decision-making. In practice, the actual response to a specific emergency would need to take into account the nature of the challenge and other circumstances at the time. Ministers and senior officials, as appropriate, from relevant UK government departments and agencies, along with representatives from other organisations, as necessary, are brought together in COBR to ensure a common appreciation of the situation and to facilitate effective and timely decision making. Where COBR is activated in response to a no-notice incident, its default strategic objectives are to:

  - protect human life (and, as far as possible, property and the environment); and alleviate suffering;

[3] http://webarchive.nationalarchives.gov.uk/+/http://www.cabinetoffice.gov.uk/media/349120/conops-2010.pdf accessed 31 January 2013

- support the continuity of everyday activity and the restoration of disrupted services at the earliest opportunity; and
- uphold the rule of law and the democratic process.

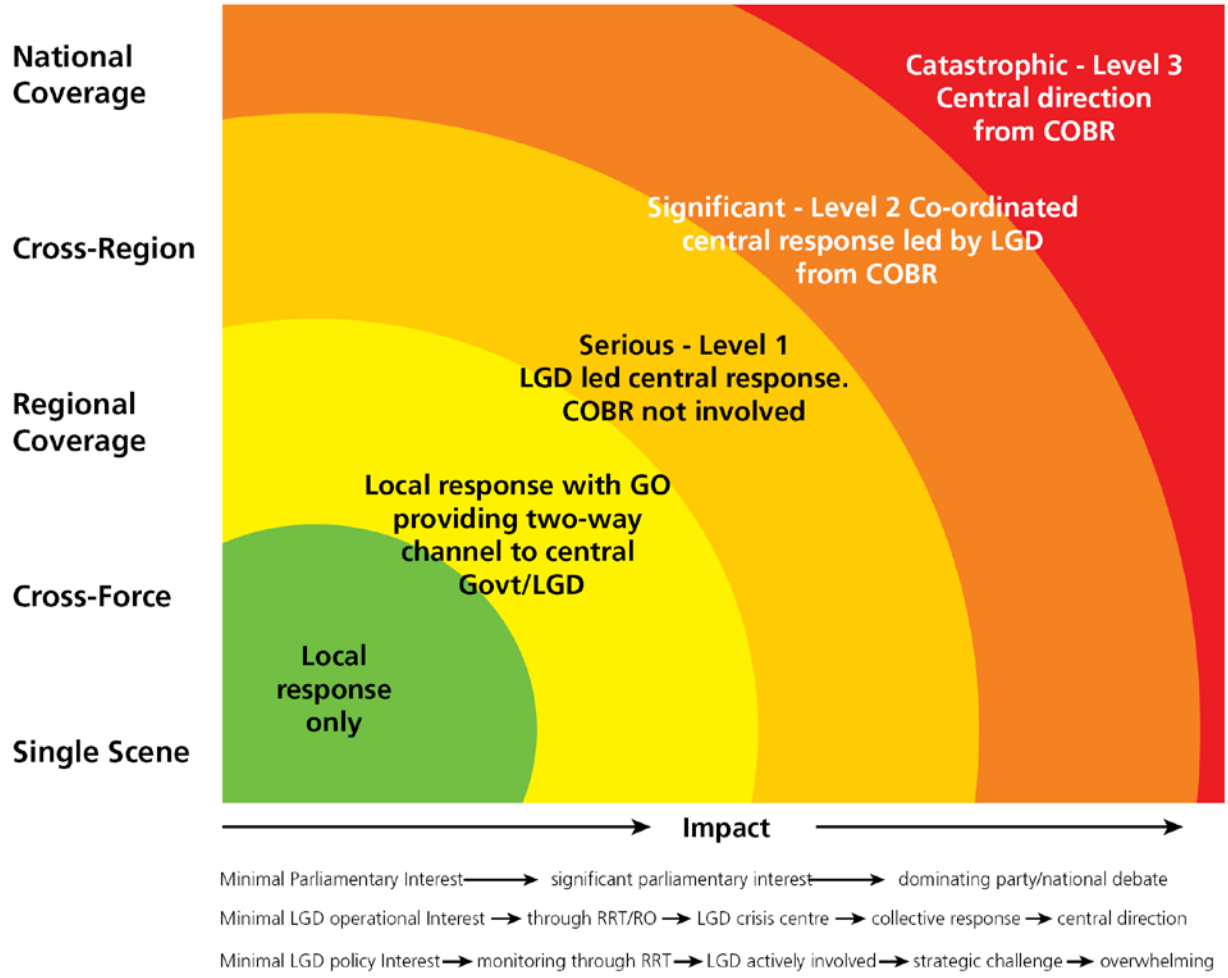


Figure 3-1 Emergency levels (Defra, undated)

3.3 Relevant policies

A number of policy documents govern the way flood risk management is implemented and investment choices are made. The most important governs the way in which (i) the Environment Agency will act to discharge its duties, and (ii) how the planning authorities will act. The primary policy documents that relate to these two aspects include:

Overarching strategy for flood risk management - Following major flooding in 2000 and the Foresight Future Flooding Studies (Evans et al, 2004a&b) Defra published is overarching strategy *Making Space for Water - MSfW* (Defra, 2005). MSfW sets a holistic approach to managing flood and coastal erosion risks in England based on a consideration of all sources of flooding and portfolio of responses. After the severe 2007 summer floods, the Defra released *Future Water* (Defra, 2008a), which is the government's strategy by 2030 to manage surface water with better coordination and with planning and promoting sustainable drainage above ground. This strategy introduces Surface Water Management Plans as a tool to improve the coordination of drainage stakeholders. Both of these documents have now been reflected within the Environment Agency strategy for Flood and Coastal Risk Management (Environment Agency, 2011).

Development and planning controls – The UK Government issue Planning Policy Statements (PPS) and Planning Policy Guidance (PPG) to explain statutory provisions and guide local planning authorities and others. The plethora of planning guidance is currently in the process being streamlined through the National Planning Policy Framework[4] (27 March 2012). This is a key part of Government reforms to make the planning system less complex and more accessible, to protect the environment and to promote sustainable growth and following the introduction of the Localism Act 2011[5] that transferred many planning powers from central to local government.

Planning Policy Statement 25 (PPS25): Development and Flood Risk (CLG, 2010) provides the supporting guidance in association with flood risk. In particular PPS25 aims are to ensure that flood risk is taken into account at all stages in the planning process to avoid inappropriate development in areas at risk of flooding, and to direct development away from areas of highest risk. This reflects the general planning principle of the sequential test (that seeks to identify, allocate or develop certain types or locations of land before others – for example, brownfield land before greenfield sites, town centres before out of centre and non-flood prone before flood prone). Where new development is required to take place within the floodplain, the local authority can still go ahead by arguing an exceptional need. In this case the planners must still ensure the development is safe, does not increasing flood risk elsewhere, and, where possible, reduces flood risk overall.

The individual regulations and guidance documents of most relevance to flood risk management are summarized in Table 2 and 3 below.

[4] https://www.gov.uk/government/policies/making-the-planning-system-work-more-efficiently-and-effectively accessed 1 Feb 2013

[5] http://www.legislation.gov.uk/ukpga/2011/20/contents/enacted accessed 1 Feb 2013

Table 2 European scale Directives that impact flood risk management in England (Sayers et al, 2011)

England is a member of the European Commission and as such a number of European Directives are important in shaping flood risk management activities. These include:	
Habitats and Species Directive Birds Directive Ramsar Convention	Places a requirement upon member states (including the UK) to ensure the network of internationally important habitats are maintained. Where likely to be lost, compensatory habitat must be provided.
Floods Directive	Places a requirement upon member states to undertake a Preliminary Flood Risk Assessment (national coverage) to identify those areas at significant risk from flooding (from any source), communicate these to the public and development a Flood Risk Management Plan for these areas.
Water Framework Directive	Places a requirement upon member states to ensure all water bodies obtain a good ecological status. The only exceptions are those water bodies designated (by the member state) as 'heavily modified' – i.e. a significant operational port where good ecological status cannot be achieved. There is therefore always a driver to maintain, and where possible improve, water quality.
INSPIRE Directive	Places a requirement upon member states to provide public data in an interoperable format – with appropriate metadata and access standards. This is an important basis for sharing and reusing data (note: data does not need to be provided free of charge).

Table 3 National scale regulations that impact flood risk management in England (Sayers et al, 2011)

National scale regulations	
Direction of travel A commitment to sustainable development (see The Brundtland Report, World Commission on the Environment, 1987) Sustainable Flood Risk Management – Making Space for Water (Defra)	Sustainable development is defined as that which meets the needs of the present without compromising the ability of future generations to meet their own needs. Sustainable development is not just concerned with balancing economic, social and environmental interests; it seeks to enhance all three components, or as a minimum, to ensure that there are no overall adverse effects. Compensatory activity may thus be needed to offset an unavoidable impact. For example, new inter-tidal habitat will be created to replace that unavoidably lost by engineering works. Defra's Making Space for Water document outlines the direction of travel and seeks to support the implementation of a more comprehensive risk-based approach to managing flood and coastal erosion risks in England.
Acts Civil Contingencies Act Flood and Water Management Act Water Resources Act Wildlife and Countryside Act UK Biodiversity Action Plan Ancient Monuments and Archaeological Areas Act	A series of Acts provide the high level framework within which flood risk management takes places (and translate the European Directives to UK law). In a particular they: • Provide the Environment Agency with a strategic overview of all flood and erosion issues to be taken with a lead delivery role for pre-event planning to be taken by the local authorities and during event planning to be taken by Local Resilience Forums (led by the Police) • Promote outcomes that: – Protect, and where possible enhance, water resources – Enhance and restore ecosystems to contribute to biodiversity and maximise the environmental benefits of natural floods – Avoid adversely affecting human health; to maintain/enhance safety – Avoid imposing a significant constraint on future choices – Support and inform the land use planning process – Avoid adversely affecting existing land uses – Maintain, and if possible enhance, ecological functions/processes
Guidance to planners (sample) PPG2 (Planning Policy Guidance) Green Belts PPS9 (Planning Policy Statement) Biodiversity and Geological Conservation PPG15 Planning and the Historic Environment; PPG16 Archaeology and Planning PPG17 Sport and Recreation PPS 25 Development Planning	A series of planning notes provide advice to planning authorities as to: • The type of development that may be appropriate and where (taking into account based on exposure to flood hazards) • The need to protect, and where possible enhance, the historic environment etc.

3.4 Insurance and compensation arrangements within England

3.4.1 Private sector losses

Insurance remains a private sector provision, with no state funded compensation for flood victims. Under an agreement with the government (set out in June 2006, the so-called *Statement of Principles*[6]), the insurance industry (through the ABI – Association of British Insurers) made a commitment to continue to provide insurance cover for all properties, even those at significant risk, in return for action by government to identify and manage risks. This agreement comes to an end in June 2013 and at the time of writing no agreement has been reached on how flood insurance will be provided to those properties at greatest risks beyond that date. The ABI have proposed a ring fenced fund, contributed to by all insurers and underwritten by government, in order to provide insurance to those at highest risk. It has been suggested that the Government however does not wish to provide public money to support the insurance industry and maintains that a fully free market solution offers the best way forward[7].

3.4.2 Public sector losses

Compensation of flood losses as well as additional costs incurred in managing a flood event by the local authority and emergency services is underwritten nationally through the Bellwin Scheme[8]. The Bellwin Scheme provides financial assistance to local authorities dealing with emergencies.

[6] http://www.abi.org.uk/Publications/24956.pdf

[7] http://www.nce.co.uk/news/water/deadlock-over-flood-insurance/8641560.article accessed 1 March 2013

[8] https://www.gov.uk/government/publications/bellwin-scheme-2012-to-2013-guidance

4.0 STRATEGIES FOR INTEGRATED FLOOD MANAGEMENT

4.1 Overview

The goals of sustainable development provide the overarching framework within which flood risk is managed within England (Defra, 2011b). Integrated flood risk management is an implied rather that stated goal. The approach adopted is to manage flood risk through various means (reducing the likelihood of flooding and reducing consequences when a flood occurs). It is hoped that integrated flood risk management is therefore achieved by implementing a range of management activities and working in partnership with a range of stakeholders (including, crucially, planners). In many cases this works well and is made possible through the strategic overview role that the Environment Agency has for all flood issues.

4.2 Design standards, outcomes and legal requirements

4.2.1 Design standards of protection

The power to undertake flood risk management activities is permissive and the Environment Agency has the power to choice which projects are given priority (subject to Treasury rules and other legislation) and the standard of protection afforded by any particular scheme. For the majority of England therefore there are no set standards of protection to be achieved. This reflects four underpinning concepts within the Environment Agency's decision making process:

- a consistent framework of decision making is more important, and useful, than the application of consistent (i.e. uniform) standards of protections;
- an underlying decision making process that is based on a trade-off of benefits and costs;
- investment is limited and that decisions as to where and when to invest should be based on risk (recognizing that a standards based approach can lead to inefficient investments), and;
- a realization that risk is best managed through a portfolio of measures, and as such a presumption of 'protection' is not necessarily the best means of achieving a reduction in risk within the context of a broader goal of sustainability.

The only expectation to rule is within the Thames Estuary where sets design standards for the Thames through central London (upstream of the Thames Barrier) as 1:1000 year return period and lower levels in the outer estuary were defined following the devastating floods experienced in 1953 (Waverley, 1954). A more detailed discussion of the flood risk within the Thames Estuary is provided in Box 1.

There are however indicative standards of protection that provide some guidance on the level of protection that is likely to be considered appropriate for a given land use. These are summarized in Table 4. It should be noted however that these are a guide only and do not imply a right to a given standard of protection. In the latest appraisal guidance (Environment Agency, 2010b) no discussion of the indicative standards is provided, leaving the appropriate standards to be determined on a risk basis.

Dams and reservoirs are currently managed in a different way; where the principles of ALARP (as Low as Reasonable Practicable) are applied and only in exceptional cases (where the benefits to society are considered disproportionate to the costs of the reducing the risk further) are higher risk levels tolerated.

Table 4 Indicative standards of protection (MAFF, 1999)

Land Use Band	Comment	Indicative Standard of Protection (years return period)	
		(Fluvial)	(Coastal)
A	Typically large urban areas at risk from flooding	50 - 200	100 - 300
B	Typically less extensive urban areas with some high grade agricultural land	25 - 100	50 – 200
C	Typically large areas of high grade agricultural land at risk from flooding and impeded drainage with some properties also at risk from flooding	5 - 50	10 – 100
D	Typically mixed agricultural land with occasional, often agricultural related properties at risk from flooding. Agricultural land may be prone to flooding or waterlogging.	1.25 - 10	2.5 - 20
E	Typically low grade agricultural land, often grass, at risk from flooding or impeded land drainage, with isolated agricultural properties at risk from flooding	<2.5	<5

Important Note: There is no legal right to protection and the decisions as to where and when to invest are made by the Environment Agency using risk based approaches (following Treasury and Defra guidance). This means that the indicative standards outlined above may or may not be achieved – they are only included here to provide an indication of the typical standards in England.

4.2.2 Target condition grades for flood defences

The Environment Agency routinely assesses the structural condition of their flood defence assets and records the condition using a 1 to 5 grading (Table 5).

Table 5 Structural condition grades (Environment Agency, 2006)

Grade	Description of condition	Extent of defects
1	Very good	Cosmetic defects that will have no effect on performance
2	Good	Minor defects that will not reduce overall performance of asset.
3	Fair	Defects that could reduce performance of asset.
4	Poor	Defects that would significantly reduce performance of asset.
5	Very Poor	Severe defects resulting in complete performance failure.

The target condition grade (regardless of the associated risks) is set by the Environment Agency as a Condition Grade of 3 (reflecting a 'fair' condition). Any asset in a condition worse than the target condition is either considered no longer a flood defence or action is taken to improve its condition.

4.2.3 Legal obligations

The lack of design standards does not imply an absence of legal requirements. For example, The Construction, Design and Management Regulations place a requirement to design engineering works that can be constructed and maintained safely. Various environmental regulations govern the impact on the local habitat, noise, pollution etc. The flood risk management option selected should always meet these legal obligations.

4.2.4 Outcome measures

A suite of outcome measures for flood and coastal erosion risk management has been published by Defra and will be kept under review to improve the monitoring of outcomes in return for Government's investment in flood and erosion risk at a programme level. Outcome measures and targets are intended to operate at the programme level and influence the prioritisation of projects for public investment rather than the appraisal of individual projects and policy options.

Six measures have been established for the 4 year period from April 2011 to March 2015 to monitor the outcome from England's capital investment in flood and coastal erosion risk management. These are summarized in Table 6.

Table 6 Outcome measures for flood and coastal risk management in England[9]

OM no.	Outcome Measure (OM) definition
OM 1	Overall benefit to cost ratio of capital projects in the national capital programme to manage flood and coastal erosion risk. (This include capital flood and erosion risk management projects led by the Environment Agency, local authorities and internal drainage boards receiving Defra grain in aid) Benefits per £1 of Government investment.
OM 1a	
OM 2	Households moved from one category of flood risk to a lower category of risk. (Only households that are at direct risk of flood damage and have been built or converted into housing before January 2012 are counted in this measure.)
OM 3	Households better protected against coastal erosion. (Households that are at direct risk of damage from coastal erosion and have been built or converted into housing before January 2012 are counted.)
OM 4	Statutory environmental commitments met through flood and coastal erosion risk management
OM 4a	Hectares of water-dependent habitat created or improved to help meet the objectives of the Water Framework Directive
OM 4b	Hectares of inter-tidal habitat created to help meet the objectives of the Water Framework Directive for areas protected under the EU Habitats or Birds Directive
OM 4c	Kilometres of river protected under the EU Habitats or Birds Directive improved to help meet the objectives of the Water Framework Directive
OM 5	The proportion of households and businesses in the highest risk areas that receive the Floodline Warnings Direct
OM 6	The proportion of residential units within planning decisions where the application has been refused or has been amended in line with Agency advice

[9]http://www.Defra.gov.uk/environment/flooding/funding-outcomes-insurance/measuring-performance/

Box 1 Flood defences in the Thames Estuary (adapted from Tarrant and Sayers, 2012a)

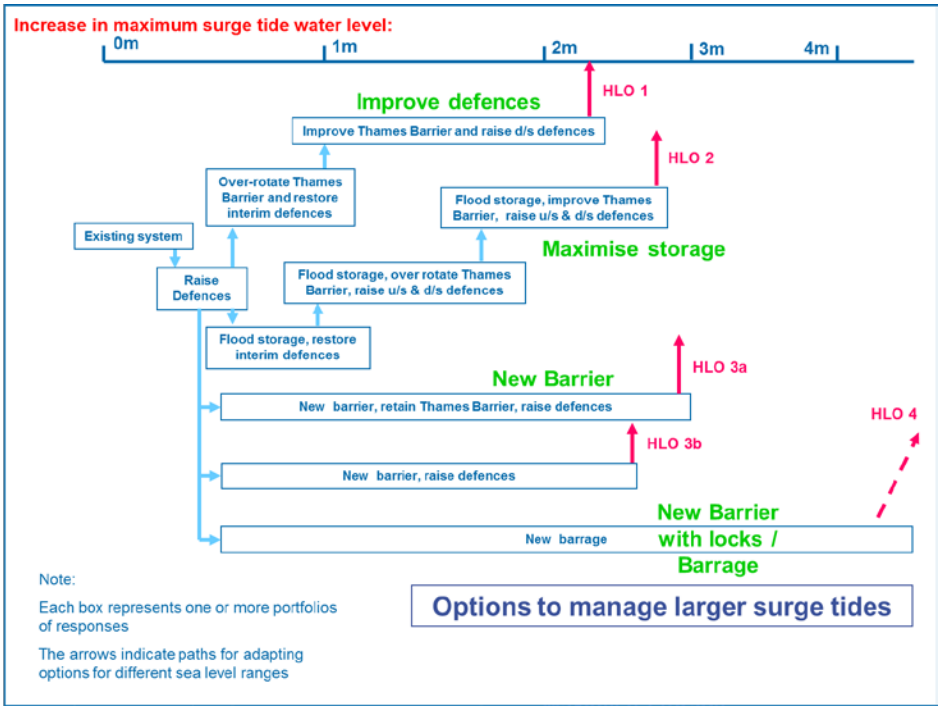
During the 19th Century it was seen that the levels of exceptional surge tides in the Thames Estuary were increasing, and after two record tides of 1874 and 1875 Parliament acted by passing the Metroplois Management (Thames River Prevention of Floods) Amendment Act 1879 (Gilbert and Horner 1984). The Act set a statutory level for the flood defences in London. Following the 1928 event, the last major event to flood central London, the defences were raised again under the powers of a new Land Drainage Act passed in 1930. Following the devastating North Sea surge of 1953, and 58 deaths on Canvey Island in the outer Thames Estuary after the defences were breached, the issue gained new prominence. This catastrophic flood (that affected much of the East Coast of the UK as well as the Netherlands, Belgium and Germany) provoked an urgent interest in *protecting* London from tidal surges. In 1954, the Government appointed, Waverley Committee, reported on the disaster and studies into the natural phenomena which cause surge tides and possible new flood defence options commenced. Eventually the government Chief Scientist, Sir Herman Bondi, recommended, in 1966, that the best solution was a *"tidal surge barrier and raising the height of the river bank, backed up with a good system of flood warnings"*. In 1972, legislation was provided through the Thames Barrier and Flood Prevention Act, to design and construct the system of River Thames tidal defences seen today. This approach is characteristic of a "flood defence" led management paradigm; where events occur and defences are raised in response. This reactive approach is evident in the stratification of different materials used to construct the tidal defences as they exist today.

Historically a flood defence approach has led to "reactive" raising of the defences in response to major events within the Thames Estuary – Courtesy Thames Estuary 2100 Project.

The Thames barrier was inaugurated by the Queen in 1983, three decades on from the 1953 floods. The Barrier, its associated gates and defences were designed to protect London from the 1:1000 year combined tidal/fluvial flood event in the year 2030. This design standard included an allowance of 8mm yr-1 to account for the rate of change in mean sea level measured from the gauged record by the engineers and designers in the 1970s. In addition this 8mm yr-1 also allowed for and the known rate of local subsidence associated the rapid rate of groundwater abstraction which occurred during the

industrial revolution and regional isostatic sinking following the last glaciation. The final crest level chosen during the design included a further freeboard allowance taking the actual standard to what is currently estimated to be approximately 1:10000 year return period.

In 2002, the Thames Estuary 2100 project (TE2100) was established with the aim of developing a long-term tidal flood risk management plan for London and the Thames Estuary (Environment Agency 2009). The project, led by the Environment Agency, included a detailed assessment and appraisal of the options available to manage flood risk; their economic costs, benefits and environmental impacts. It set out the strategic direction for managing flood risk in discrete policy areas across the estuary, and contained recommendations on what actions will needed in the short (next 15 years), medium (the following 35 years) and long term (to 2100). The Plan was based upon current guidance on climate change, but extended this to ensure the plan was adaptable to changes in predictions for sea level rise and climate change over the century.



Decision pipelines were used to show decision points within the strategy. The decision pipelines were also used to highlight the flexibility of different choices. (Thames Estuary 2100 Project, Environment Agency 2009).

References

Environment Agency (2009). Thames Estuary 2100 Flood Risk Management Plan. Technical Report, September 2009. Published by the Environment Agency.

Gilbert, S. and Horner 1984. The Thames Barrier. Thomas Telford. 1984. ISBN 0 7277 0249 1

End of Box 1

4.3 Range of activities to manage flood risk

The Environment Agency and Government have set out that they will work with individuals, communities and organisations to reduce the threat of flooding and coastal erosion (Environment Agency, 2011). The range of activities is summarized in Figure 4-1 and includes:

- Understanding the risks of flooding and coastal erosion, working together to put in place long-term plans to manage these risks and making sure that other plans take account of them; avoiding inappropriate development in areas of flood and coastal erosion risk and being careful to manage land elsewhere to avoid increasing risks;

- building, maintaining and improving flood and coastal erosion management infrastructure and systems to reduce the likelihood of harm to people and damage to the economy, environment and society;

- increasing public awareness of the risk that remains and engaging with people at risk to encourage them to take action to manage the risks that they face and to make their property more resilient;

- improving the detection, forecasting and issue of warnings of flooding, planning for and coordinating a rapid response to flood emergencies and promoting faster recovery from flooding.

Figure 4-1 Activities to managing flood and coastal erosion risks (Environment Agency, 2010)

4.4 Hierarchy of plans

Flood risk management contributes to all levels of decision making (Figure 4-2), including:

- **National policy planning.** Sets out the framework within which flood risk management plans are developed (Environment Agency, 2011).
- **River basin and coastal cell management planning.** Catchment Flood Management Plans (CFMPs) are developed at a scale of hydrological catchments (watersheds) and Shoreline Management Plans (SMPs) are development on a scale of sediment process cells. Both set high level policies (maintain the standard, do nothing, set back, etc.) that are constrained/facilitated by the national policies. Both plans seek to reconcile policies within sector specific plans in the context of flood and erosion management. For example Coastal Habitat Management Plans provide management policy for the coastal habitats within a large region of the coast; System Asset Management Plans outline proposed maintenance of the existing defence system; Regional Structure Plans layout future development aspirations.
- **Localised management strategies.** Surface Water Management Plans (inland) and Coastal Defence Strategy Plans (coast) build upon the CFMP and SMP where they exist and set out more localised management policies, long term goals and management actions in outline.

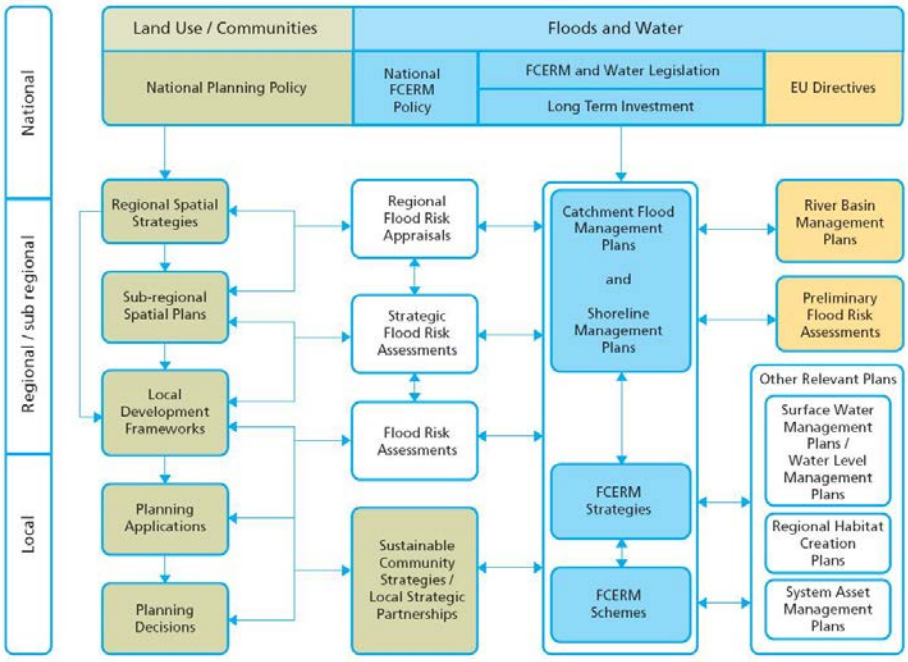


Figure 4-2 Relationship between high level plans, strategies, schemes and other planning initiatives (Defra, 2009)

Although the framework is well-structured in concept and many elements exist in practice, three primary difficulties exist:

- **Vertical integration and alignment**. Various levels within the hierarchy are under development simultaneously. This demands an iterative and updating process and often there is lag between changing policy and changing action on the ground.

- **Horizontal/sectoral integration.** The weakest level of planning in the UK is at river basin and coastal zone. In part this reflects the use of other plans to implicitly provide a river basin and coastal zone plan, but the absence of a formal basin or coastal zone plan sometimes leaves a disconnect between flood planning and broader spatial planning/environment planning.

- **Planning and Development decisions**. Physical flood control works require planning permission from the local planning authority for all but the most basic of actions. For these minor actions the Environment Agency has the power to act directly. For development planning the Planning Authority must consult the Environment Agency on flood risk issues. They are not obliged to follow the advice provided but must take it into account.

The goal of better horizontal integration has been in place for some time but remains difficult to achieve in practice; and many barriers continue to persist in turning integrated strategies into coordinated action. Some good progress has however been made in terms of embedding flood risk consideration into guidance that underpins other sectorial plans, for example building codes and development control. Less progress however has been made on integrating more broadly with (i) Spatial planning (outside of basic zoning within the development control guidance PPS25); (ii) biodiversity planning, and; (iii) energy (hydropower) and water resource planning.

4.5 Managing flood defence assets

By far the largest annual expenditure is directed toweards the management of existing flood defence assets or the construction of new defences. An asset in this sense is described as any feature that is actively managed to reduce the chance of flooding, including:

- A linear asset – e.g. a raised defence (levee or dyke)

- A point asset – e.g. a pump, gate or culvert trash screen

- The watercourse – e.g. the vegetation and sediment within a channel

- The coastline - e.g. a groyne, beach or backshore

Then Environment Agency operate a structured asset management programme based on a cyclic process of review and investment (Figure 4-3).

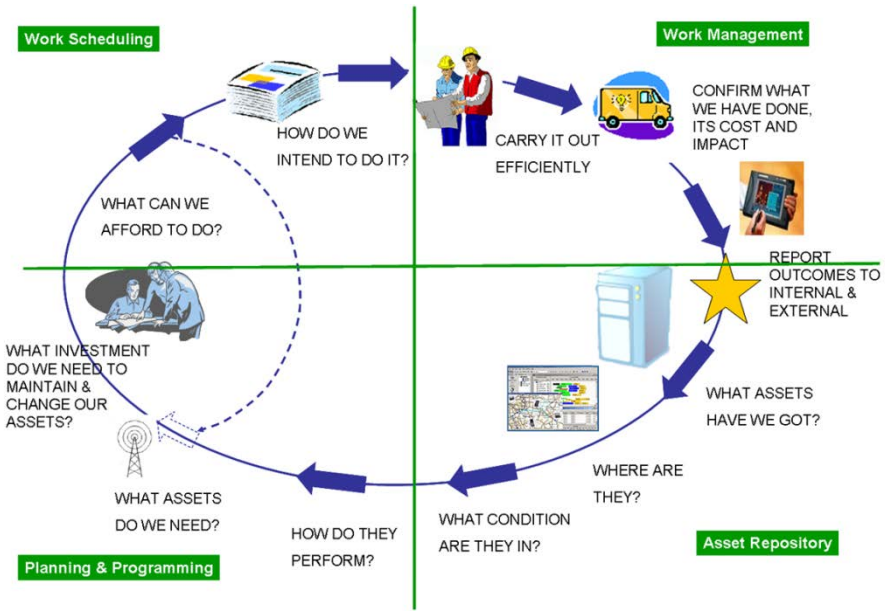


Figure 4-3 Asset management lifecycle (Environment Agency, 2010c)

Through this cycle common databases provide a means of accessing data and progressively evolving data quality (supporting a 'collect once, use many times' policy). The importance of such a system, and the difficulty in achieving it in practice across multiple stakeholders, can not be under-estimated. Within England, for example, the National Flood and Coastal Defence Database (NFCDD) provides a common home for asset data – regardless of ownership – but significant difficulties associated with access and data quality have been encountered. This is currently being extended and replaced with a broader Asset Information Management System (AIMS). Although not without technical and organisational difficulties an NFCDD (or its equivalent) is a fundamental component of any asset management system without which, data collection and analysis activities are easily repeated and effort wasted.

Given the varied and aging nature of the flood defence assets in England this process is however a difficult task. A number of good practice attributes have emerged over recent years and these are summarised in Table 7.

Table 7 Best practice principles in support of asset management (Sayers et al, 2010a)

Best practice principles in support of asset management tools	
Appropriateness	Appropriate level of data collection and analysis reflecting the level of risk associated with an asset and the uncertainty within the decision being made.
Understanding	Improving understanding of assets and their likely performance.
Transparency	Transparency of analysis enabling audit and justification
Structure	Structured knowledge capture encapsulated through fault tree, breach potential etc.
Tiered assessment and decision making	In terms of both data and modelling approaches.
Collect once use many times	Reusing data through the hierarchy of decision making stages and supporting tools – from national policy to local detail.
Simple use and practical	There is a significant challenge is converting good science in practical tools. Therefore, even though the underlying analysis may be complex, the user experience must be well-constructed and intuitive.

4.6 Protecting critical infrastructure

Recent follow events in England have highlighted the vulnerability of important infrastructure (water supply, energy, waste, transport etc.) to flooding and the cascade of impacts that can follow in the event of disruption. In recent years the Environment Agency has sought to identify the most critical of these and work alongside the owners to increase resilience.

5.0 Investment planning

The aim of the programme of flood risk management is to deliver maximum benefit and obtain best value for money while also meeting any necessary legal requirements and policy goals. This is achieved which the context of a hierarchy of investment planning activities, namely:

- **National Government** – Comprehensive Spending Review – looking across government functions and determining priorities and departmental budgets at a national scale. These take place on a variable cycle – typically between 2 to 4 years and consecutive review periods may or may not overlap.

- **National Agencies** – The Environment Agency provides a contribution to the Comprehensive Spending Review through the provision of their evidence on cost and outcomes of flood and coastal management. Information can be at a programme and project level or at the national long term scale. The Long Term Investment Strategy (LTIS) is based on a national analysis of benefits and costs of flood risk management activities. The LTIS published in 2009[10] considered a range of investment scenarios (increased and decreased) and estimates the outcomes (additional or reduced) that would be achieved. Through the LTIS it has been estimated a return of 1 to 7 is currently achieved on flood risk expenditure at a national scale.

- **Regional Agencies and Local Authorities** – Promote local and regional projects and seek national and local funding support.

5.1 Who pays

Increasingly the UK Government is trying to introduce the concept of the beneficiary pays. This attempts to secure funding for flood risk management from those that benefit from the activities, in particular commercial organisations with direct frontage to the river or with operations within the floodplain. The new Partnership Funding policy has been introduced recently to encourage local contribution, support local development and implementation of projects and to encourage a closer link between beneficiaries and contributors. Funding for flood risk management is therefore drawn from three primary sources:

- **National tax payer funds** risk management activities based on a national view of the economic return.

- **Local levies** are raised and distributed through the Regional Flood Committee and prioritised based on regional needs.

- **Private contributions** from developers, NGO, individual land owners, etc. which are prioritised based on local issues. Local contributions to funding are sought but these have historically been limited. The only significant exception to this is the local protection funded and implemented by

[10] http://www.environment-agency.gov.uk/research/library/publications/108673.aspx accessed 1 March 2013

major utilities (for local protection to power stations, water distribution, etc.) and at a smaller scale, the actions taken by property developers and individual homeowners to flood proof properties.

At present however general tax payers continue to fund the majority of activities. Going forward however the contribution from the private sector is set to increase and a recent announcement from Defra suggests that the private contribution for 2013/14 is expected to be £148m.

5.2 Return on investment

The return on national investment in flood and coastal erosion risk management has been estimated as 1:8. This compares favourably with other demands on public money. Into the future it is expected that spending on flood defence assets will need to increase from around £570 million pa on asset maintenance and construction (2010-2011) to around £1,040 million by 2035, plus inflation[11].

[11] http://a0768b4a8a31e106d8b0-50dc802554eb38a24458b98ff72d550b.r19.cf3.rackcdn.com/geho0609bqdf-e-e.pdf

6.0 DECISION MAKING AND APPRAISAL APPROACHES

6.1 Framework of thinking

Understanding flood risk and how best to manage it over a range of time and space scales underpins the approach promoted by the Environment Agency. Traditional planning activities have all too often adopted a time and spatial scale that is simply too short (often no more than 20-30 years) and too small (a single community or reach) to promote innovative strategic thinking. In past such approaches have been perceived to be constrained by immediate demands that often are seen to promote the continuation of the status quo and undermine the strategic nature of the plans developed.

An important step forwards as therefore been to focus on the system behavior, described by the sources, pathways and receptors of risk (Figure 6-1) and to take a whole life view (Sayers et al, 2002). Determining the time and space scales of interest and, in particular, understanding how activities will transition from the short to long term and vice versa (i.e. how will the demands of today be met in a way that is supportive of achieving longer term goals), for example:

- ***Long term and large scale*** (the basis of strategic planning) - by adopting a time scale of 75-100 years or more and a space scale that spans whole catchments, basins or even nations, the constraints of the existing structures (organisational and physical) can be challenged and new innovative and ambitious approaches sought. Adopting such an approach enables the strategic direction to be set, unencumbered by local and present day political issues. Such an approach was successfully applied through the Foresight Future Flooding Studies (Evans et al, 2004a&b) and is now a routine component of the planning in the England and Wales through the Long Term Investment Strategy (Environment Agency, 2009).

- ***Short and medium term and system scale*** (critical for action planning) - Under certain circumstances such as post-flood recovery, it may be necessary to move immediately to restore elements of a flood damage reduction system damaged by a flood event. Failure to repair levees or damaged flood walls in the face of the potential for similar floods in the immediate future could result in catastrophic losses should a flood occur. However, in moving forward with such short or medium term actions, every effort must be made to take into account how the short term plans might best fit with potential long-term actions and plans that would foreclose future option should be avoided. To the maximum extent possible, real estate acquisitions and recovery work should provide flexibility for future flood risk management activity. Where pre-flood planning has taken place, it may be possible in a post-flood recovery situation, to move immediately to initiation of longer-term flood risk management options such as conversion or frequently damaged lands into natural flood storage areas.

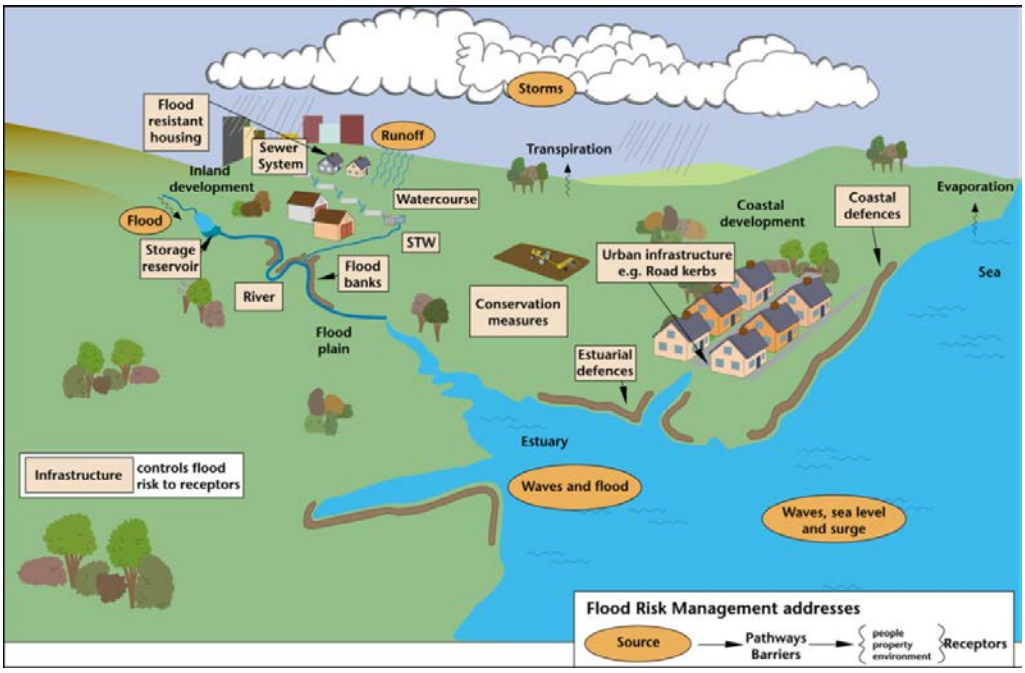


Figure 6-1 Developing a whole systems view based on the Source, Pathways and Receptors of risk (illustration courtesy Mervyn Bramley)

6.2 The appraisal process

6.2.1 Basis of appraisal process

In most cases, there is no legal requirement on Government to reduce risk and therefore the case for further investment in flood risk management must be weighed against other calls upon public funds and the greatest returns identified. The overarching framework of appraisal is provided by the HM Treasury Green Book (HM Treasury, 2003). In translating these guidelines for flood risk management a number of important principles are recognized:

- **National economic benefits**– the focus of flood risk management investment by central government is on national economic return. This means that taxes and other transfer payments should be excluded from the appraisal of costs and benefits, as their net economic impact to society is zero.

- **Discounting** - is used to bring all future costs and benefits to a present value. This is intended to avoid speculation of future inflation rates or valuation changes.

Table 8 Declining long-term test discount rate

Period of years	0 - 30	31 - 75	76 - 125	126 - 200	201 - 300	301 and over
Discount rate	3.5%	3.0%	2.5%	2.0%	1.5%	1.0%

- **Optimism bias** - Corrections for optimism bias are applied to the costs and works duration in line. This reflects experience from past projects where costs are routinely under-estimated at the appraisal stage (HM Treasury Green Book supplementary guidance, HM Treasury (2009).

- **Beneficiary pays** - Costs and benefits should be disaggregated showing the extent to which interested parties experience either an economic benefit or burden from different options. Disaggregation is also important in order to identify potential contributors and indicate the fairness of decisions to different groups (Defra, 2006a).

- **Distributional impacts** - in considering options that impact different sections of society Treasury guidance allows weights or equity multipliers to be applied. Such modifications are not made until benefits and costs have been disaggregated, to avoid double counting and to show the effect of the adjustment.

- **Whole life costs and appraisal timeframe** - To reflect the nature of the investment over a long period of time, including future maintenance and adaptations, the whole life costs should be included in the assessment. A timeframe for appraisal is usually about 100 years.

6.2.2 Framework of project appraisal

Appraisal is about gathering information and comparing options in a consistent way in order to: (i) support good decision-making; (ii) avoid bad decisions, and (iii) maximize the chance that the chosen approach turns out to have been the right choice.

The degree of detail considered and resources used should be proportionate to the complexity the problem and information required to make a robust decision (taking about of uncertainty about present day and future benefits and costs). In some instance legal requirements (for example the need to protect vulnerable habitats) may influence the options should be fully considered throughout the appraisal process.

A structured appraisal is a necessary prerequisite to justify Government investment in flood and coastal erosion risk management and Defra guidance (Defra, 2009) sets out three basic stages in the appraisal process:

1 - Define the issue and set objectives (define the issue and consider the case for government intervention. Set SMART objectives if there is a case).

2 - Develop, Describe and Value (develop a full range of possible options, describe the options, and then value the positive and negative impacts of each of the options).

3 - Compare and Select (compare options in a systematic way and select the most effective and deliverable solution.)

The methods and approaches applied at each of these steps are described in more detail below.

Defining the issue and setting objectives

The FCERM Project Appraisal (Defra, 2009) identifies a number of key requirements in setting objective the project objectives, these include:

State objectives - The objectives need to be stated clearly and linked to the problem. Some of these objectives may already be stated in high level plans such as CFMPs and SMPs and strategies if prepared.

Make sure the objectives are not restrictive - The objectives must relate to the problem but must not presuppose a solution or exclude potential opportunities for multiple benefits that may be linked with the project.

Links to environmental assessment and stakeholder engagement - The outcomes of environmental assessment and stakeholder engagement must feed into the definition of objectives to enable justification of any environmental and social enhancements that could be implemented.

Make sure that the objectives can stand up to scrutiny and can be understood all – including the scope of the project and what is trying to be achieved.

Agreeing objectives - The objectives should be set and agreed by the project team with input from stakeholders.

Set the quality criteria for the project - Any objectives that relate to the appraisal process should be included as quality criteria. The quality criteria will be used at the end of the appraisal to assess whether the appraisal has achieved what is required.

Developing and valuing options

Defra guidance (Defra, 2009) promotes good practice in developing options and assessing the impacts associated with alternative courses of action. These include:

Considering a range of options - A wide range of options, including structural and non-structural solutions and those that can be adapted for future risks, should be considered both individually and in combination. This builds upon the UK Foresight Future Flooding Study (ref) reinforced the idea that to manage risk effectively requires multiple actions to be taken and that no single measure provides a complete solution.

Identifying a baseline option – In all appraisal the performance of a 'do something' option is assessed against the counterfactual of a doing nothing – the so-called 'do-nothing' option. The do nothing option is always considered so it provides a consistent baseline against which to compare the benefits of possible interventions.

Assessing and valuing impacts - The impacts (both positive and negative) of any option must be clearly described and quantified. Where possible, impacts are valued in monetary terms. The valuation is based on risk-free market prices where possible, unless it is impractical or disproportionately expensive to do so. The monaterisation provides a common currency of risk and a consistent way of comparing

value for money of different options. Various standard approaches are provided to help quantify impacts in monetary terms, including:

- ***Valuing land and property*** - The basic principle applied is present day risk-free market values are considered to present for the duration of the Appraisal period, This helps ensure consistency across the valuation of different aspects even though it may not reflect the values that some assets may acquire in the future. For example this means that brown field sites and other undeveloped areas should be valued on the basis of the damages that flooding or erosion would cause to the current use, not on their development potential. The reason for this is to preclude Government funding of works which would enable land to be developed for private gain. An exception to this is if there is full planning permission in place in which case the valuation would be on the basis of the proposed land use. However, the developer would be expected to contribute in full towards the costs of reducing flood or coastal erosion risk to an acceptable level for the land concerned.

  The so-called Multi-Coloured Manual (FHRC, 2005) provides details approaches on the valuation of full range of impacts, including residential and commercial property damages presented in the form of flood depth v damage relationships for a variety of property types.

  The valuation of agricultural land is based on the net loss to the UK economy (Defra, 2008b). The approach factors out subsides provided by under the European Union the Common Agricultural Policy (CAP) along with other national subsistence and incentives payments (as these are only considered transfer payments). The detail of the approach to the valuation of agricultural land and output for appraisal purposes is provided within the Multi-Coloured Manual (FHRC, 2005) with supporting guidance provided by Defra (Defra, 2008b).

- ***Valuing ecosystem services*** - Where practical the environmental impacts should be assessed using an ecosystem services approach (Defra, 2007a&b). This means valuing the environment according to the range of goods and services it provides and how these benefits might be different under different options. Where possible any change should be valued in monetary terms. The detail of the approach to the valuation eco-systems is provided within the Multi-Coloured Manual (FHRC, 2005) with supporting guidance provided by Environment Agency (Environment Agency, 2010d).

- ***Valuing flood warning benefits*** - The flood warning service in England is provided by the Environment Agency as part of a combined local and national service. The method of evaluation is detailed in the Multi-Coloured Manual (FHRC, 2005) and includes consideration of the chance that:

  - a correct forecast of the flood will be issued;
  - an individual is warned in sufficient time to take action;
  - the individual will be available to respond to that warning;
  - the individual will be physically able to respond effectively;
  - the individual will respond effectively.

- ***Valuing intangible impacts and loss of life*** – The primary goal of flood risk management is to protect from loss of life. Although in the past some flood events have caused significant loss of life

(most notably the 1953 coastal surge), loss of life due to flooding in the England is rare. This does not mean however that it is ignored. The assessment of loss of life remains a central common of the appraisal. The methods to assess loss of life (and serious injury) rely upon an understanding of the demographics as well as the flood depth and velocity (Defra, 2006b). The value of a statistical life is provided by the UK Treasury Green Book (Treasury, 2003) and ensures consistency across all functions roads, rail, health etc. The economic value of a statistical life is maintained by the Treasury.

- ***Valuing climate change mitigation*** - The impact of greenhouse gas emissions should be valued according to Government guidance, currently based on Defra guidance on the social cost of carbon.

- ***Valuing non monetarised impacts*** - Impacts which are not valued in monetary terms are described, quantified and brought into the appraisal through summary tables. It is recognized that such impacts are often important and should not be ignored simply because they cannot easily be valued in monetary terms. Such parameters are maintained in native terms (e.g. hectares of habitats, number of hospitals etc.) and incorporated into the appraisal using multi criteria techniques, such as weighting and scoring, to aid the systematic comparison of options. This is not seen as an alternative to quantified cost benefit analysis but an extension of it.

Climate change impacts and adaptation - The impacts of climate change should be consistently taken into account (see Section 7 for more detail).

Compare the options and select the preferred approach

The information gathered through the process of assessing and valuing the benefits and costs associated with alternative options is used to compare one option with another and select the preferred approach. The approach of comparison is laid out in (Defra, 2009) and is based on:

Transparent decision-making – As flood risk management expenditure has to compete with other areas of public expenditure, and individual projects need to compete for funding with other possible FCERM interventions around the country a transparent and consistent basis to the decision making is vital.

Economic viability and financial affordability - Projects are only economically worthwhile if the benefits exceed the costs (i.e. the ratio of benefits to costs is greater than 1). This does not mean the project will however be funded, as this will reflect the availability of funds (affordability).

Promoting partnership funding - The disaggregation of costs and benefits should be used to enable the affected groups and impacts to be viewed transparently and aid the decision making process. Where contributions from beneficiaries are available, a further measure of economic efficiency, which complements the benefit-cost ratio, may also be used to evaluate such projects. The suggested additional metric is NPV / Cg[12]. This metric is important because it can present the effects of private expenditure in managing risk, and highlight any increases to marginal benefit cost ratio and net present value for wider society.

[12]Where Net Present Value (NPV) = (total present value of benefits minus the total present value of costs) and Cg= Costs to Government only. Please refer to operating authority guidance on approach.

Basis of selection – No one approach is given as the definitive means of selecting the preferred approach. It is recognized within Defra guidance that decision making should be balanced and should make use of an appropriate combination of approaches (e.g. NPV, BCR and multi criteria approaches or other similar or relevant metrics) to arrive at a preferred option, and not necessarily depend on a single metric.

In practice, however, the following approach prevails (as outlined in Defra, 2009):

- ***Cost-benefit analysis*** **-** If all significant impacts of options are satisfactorily expressed in monetary terms, the option with the highest BCR will usually be the most appropriate choice. This however often leads to a 'do minimum' approach where for a small level of investment a relatively large benefit is accrued, was still leaving a significant level of flood risk unmanaged. In deciding whether or not it is worthwhile investing more to reduce the risk a distinction is made between managing the a national or regional programme of investments or a flood risk at a single location. For example:

    - *Applying the incremental rule at a single site:* In this case consideration is given to (i) the standard of protection provided by the leading option and (ii) the additional cost and the additional benefits that would be accrued by moving to the next highest cost option.
    - *Applying the incremental rule at a national or regional programme:* At a programme level the additional benefit accrued at one site given one extra pound of expenditure is compared to the additional benefits that could be gained by investing the additional resources in an alternative project in another geographical area. Thus, there may be a justifiable case for selecting an option at a particular site that would provide a higher level of protection than that offered by the option with the highest benefit-cost ratio, providing that the extra expenditure represent good value for money, when compared with other investments. The role of assessment of the iBCR (incremental BCR) helps ensure that the investment cannot be more effectively spent elsewhere in the FCERM programme.

    This process is summarized by the so called decision rule (Figure 6-2).

- ***Cost-effectiveness analysis*** – In some instances decisions are based on cost-effectiveness rather than benefit-cost. For example, where:

    - There is a legal requirement to achieve a certain outcome and that outcome cannot be met through a project with a positive cost benefit ratio; or
    - An option has been justified through the normal appraisal process and an intervention (such as investment in a like-for-like replacement of a sluice gate) is necessary to continue to deliver that function.
    - If the condition of a functional asset (i.e. one that contributes to flood protection) has fallen below the national condition grade target (currently condition grade 3 – i.e. 'fair' condition) actions will be taken to improve the condition of the asset on a lowest acceptable cost basis.

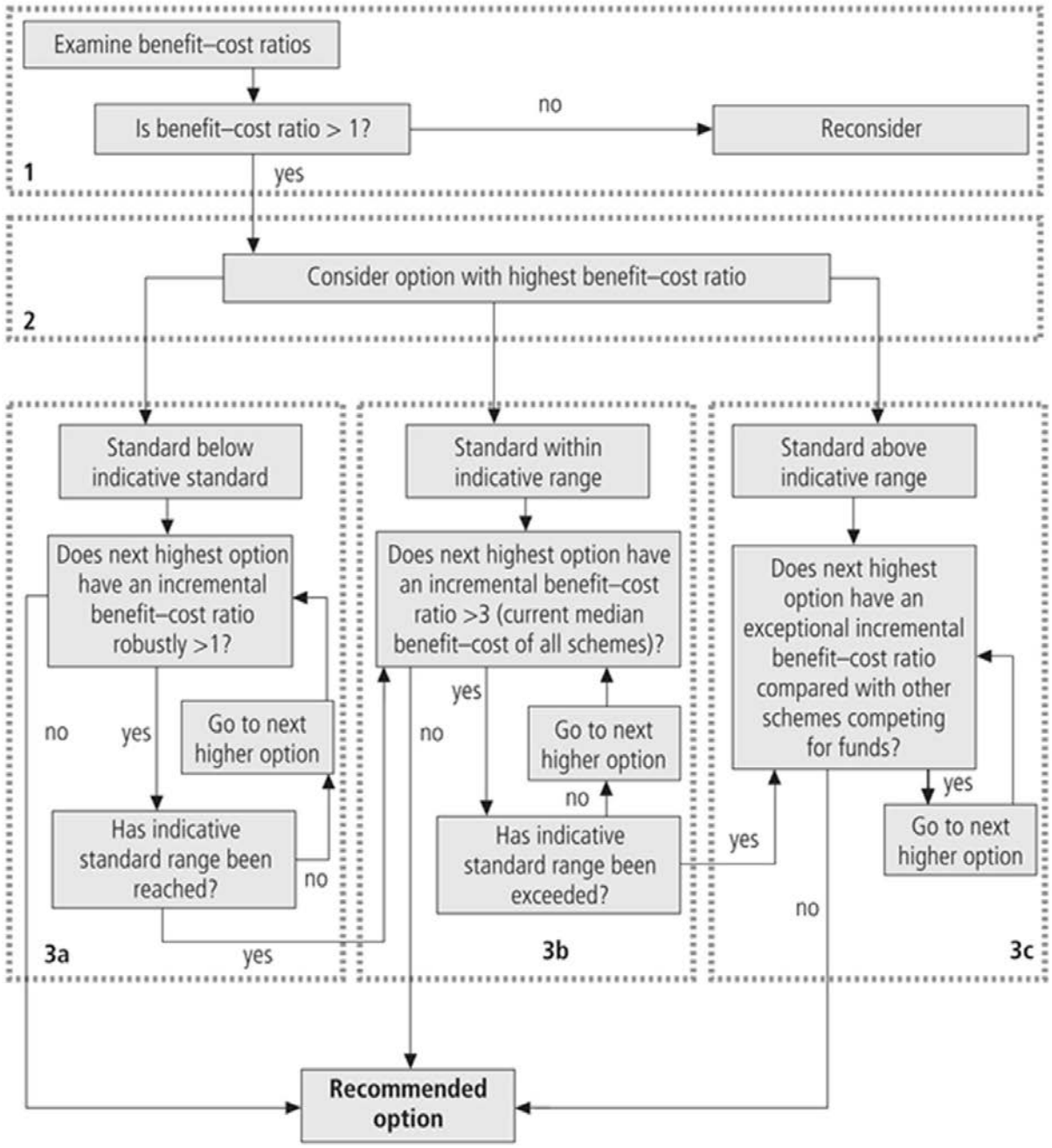


Figure 6-2 Decision rule - The process of selecting the preferred management option

7.0 CLIMATE CHANGE ADAPTATION POLICIES IN FLOOD MANAGEMENT

7.1 Existing guidance

The uncertainty in the future climate is currently accounted for in flood risk management decisions by testing the performance of the preferred option using published allowances for climates change (Table 9). If the preferred choice performs satisfactorily this is considered the best choice.

Table 9 Recommended national precautionary sensitivity ranges (CLG, 2010)

Parameter	**Year**			
	1990-2025	2025-2055	2055-2085	2085-2115
Peak rainfall intensity	+5%	+10%	+20%	+30%
Peak river flow	+10%	+20%		
Offshore wind speed	+5%		+10%	
Extreme wave height	+5%		+10%	

This however is a rather static future of future change. Increasingly it is accepted that recognizing uncertainty is a key requirement for appropriately designing adaptive capacity and resilience into flood risk management choices. Only by quantifying and acknowledging uncertainty are we better placed to decide how best to manage it (Sayers et al, 2012b).

7.2 Emerging approach

The acceptance that future conditions may change (perhaps significantly) from those that exist today, or existed when a structure was first designed, underlines the need for a continuous process of monitoring and intervention, which is essential to the success of any infrastructure project. The risk-based adaptation decision making framework proposed by Willows and Connell (2003), shown in Figure 7-1, which establishes adaptive management as a continuous process of defining objectives, assessing risks, appraising options, implementation and monitoring is now making its way into flood risk management. Conditions of uncertainty and change imply a commitment to on-going study of and intervention in the system in question, in the context of constantly evolving objectives.

Accepting the need to directly recognise uncertainty is having a profound impact on strategy development; forcing the traditional linear design model to be replaced with adaptive strategies. These approaches are contrasted in Table 10.

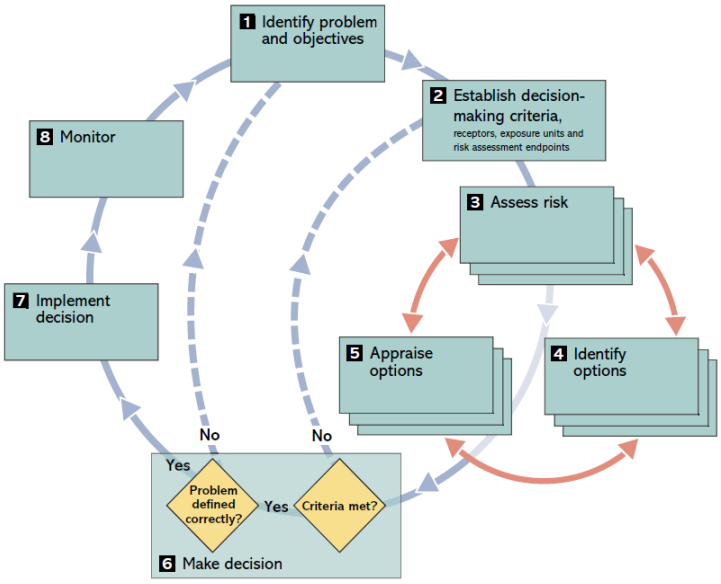


Figure 7-1 Framework for adaptation decision making proposed by Willows and Connell (2003)

Table 10 Uncertainty is having a profound impact on strategy development (Sayers et al, 2011 adapted from Hutter and McFadden, 2009)

Stages of strategy development	Traditional (certain) model of strategy development and decision making	Adaptive (uncertain) model of strategy development and decision making
Deciding what to do	Pre-defined system of goals, objectives and desired outcomes. Defined set of activities and resource demands.	Emerging pattern of goals, objectives and desired outcomes. Flexible configuration of resources and priorities.
Deciding how to do it	Sequential process of planning, programming and implementation. Top-down strategy development.	Continuous alignment of plans, programmes and implementation activities with the changing world. Continuous reconciliation of the bottom-up initiatives and top-down strategies.
Understanding the external and internal influences	Stable system of decision making. Predictable (deterministic) future change – climate, demographics, deterioration, preferences etc.	Changing decision processes and priorities. Unknown future change - climate, demographics, deterioration, preferences etc.

The current FCERM AG guidance (Environment Agency, 2009) includes many references to the need to take an adaptive approach, but does not provide explicit guidance on how to build this into appraisal at all stages. The Supplementary Guidance to the Green Book[13] provides a simple example to describe in concept how decision trees can be used to help make the best choice – but this simple example provides limited practical insights to help address adaptability in more complex settings.

To address this issue the Environment Agency are currently developing supplementary to support FCERM practitioners in developing projects and plans that can be readily adapted to accommodate future change and justifying the choices made through an appraisal process that is able to explicitly account for the benefits and costs associated with embedding adaptive capacity. This work builds upon a number of academic publications (e.g. Sayers et al, 2012b) and exemplar projects such as the Thames Estuary 2100 Strategy that provides a first example of an adaptive plan developed within a heavily constrained by floodplain (Box 1). It is hoped that the emerging guidance will help adapting thinking become central of all strategies and projects.

The three principles that will be central to this Environment Agency guidance (due for publication in 2013) are introduced below.

7.2.1 Promoting long term sustainability

All publicly funded plans and projects are required to promote long term sustainability and balance economic, environmental and social challenges and opportunities. It is often the case however that the objectives respond to current circumstances rather the potential future states. This can mean that the solutions developed and implemented are tuned to present day conditions, but are not sustainable given potential future changes in climate or the local economy for example. To support better adaption planning, the objectives and strategies developed must promote sustainability over the whole appraisal period under a range of alternative future storylines.

7.2.2 Promoting adaptation

Embedding the desire to enhance adaptation within the objectives of the plan or project is fundamental to achieving it. This means using the objective setting process to promote:

- Using responses that do not foreclose future options or unnecessarily constrain future choice
- Using responses that are effective under the widest set of all plausible future uncertainties
- Enabling the appropriate modification of policies, plans and projects as the reality of the future becomes known.

7.2.3 Promoting resilience

Resilient systems have a number of attributes that closely relate to the goal of managing future uncertainty. In particular, concepts of resilience help promote plans and projects that:

- Are able to withstand a range of threats, including ones that are readily foreseeable and do not 'fail' catastrophically when exposed to events more severe than those foreseen

[13] http://archive.Defra.gov.uk/environment/climate/documents/adaptation-guidance.pdf accessed 1 March 2013

- Are able to capitalise upon a range of opportunities both now and in the future
- Are able to recover (rapidly) from a disruptive event.

8.0 Exploring potential future risks

In 1996 Defra undertook a study to explore the change in the national flood and coastal risks under climate change (Defra, 2001). In 2004 a more comprehensive was undertaken including scenarios of future changes in demographics, climate and futures as part of the Foresight programme sponsored by the Office of Science and Technology, the so-called Foresight Future Flooding Project (Evans et al, 2004a&b).

More recently in 2010/11 Defra undertook a wide ranging climate risk assessment, covering a range of sectors not only flood risk management. This explored the changes in flood risk that build upon the National Flood Risk Assessment and the Long Term Investment Strategy (Figure 8-1).

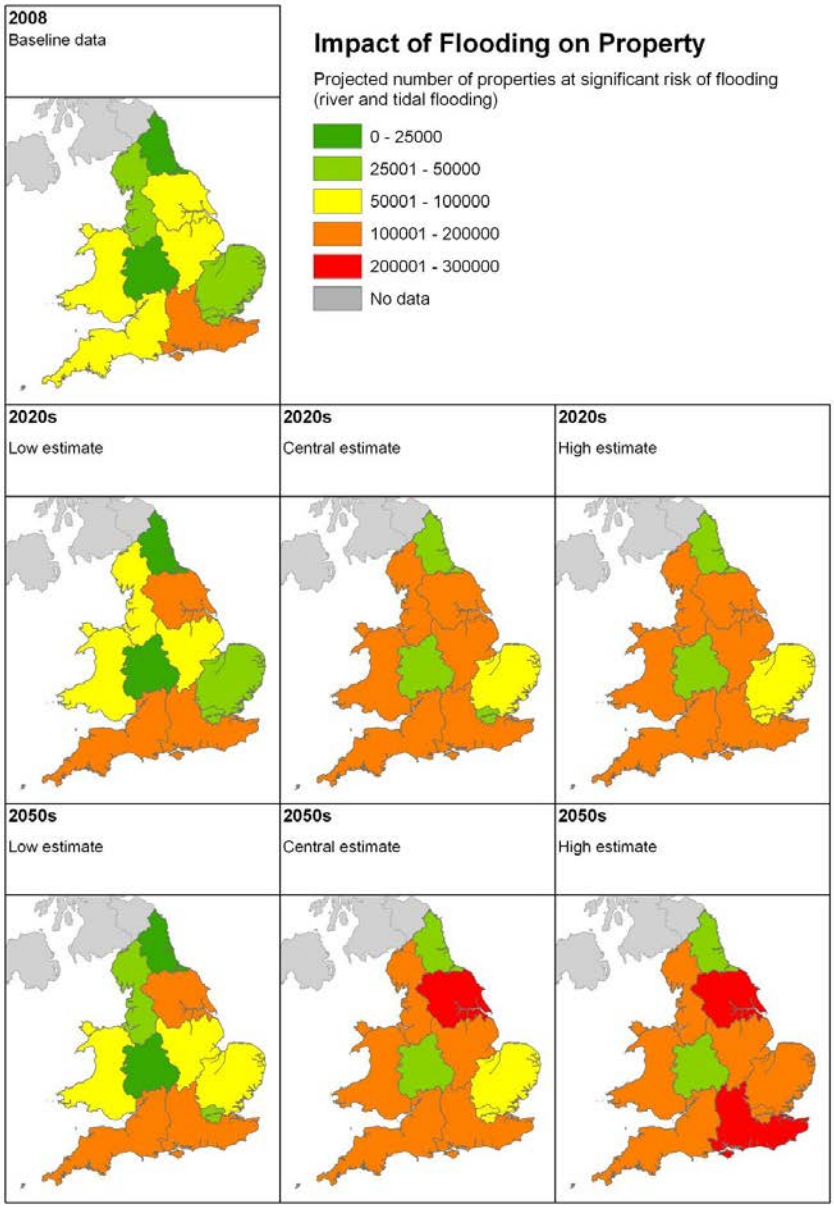


Figure 8-1 Impact of climate change on the number of properties flooded (Defra, 2011a)

9.0 CONCLUSIONS

This report has highlighted the framework within which flood risk management is undertaken in England and the effectiveness of this framework in delivering flood risk management benefits. The strategic overview role of the Environment Agency is highlighted as a key aspect of this approach together system based and longer term thinking. The approaches to appraisal are set out together with current return of investment achieved.

The flood risks within every country, watershed and community are different. However, it is hoped that many elements of the approaches adopted in England may provide useful guidance for others.

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