

# Flood Risk Management (Scotland) Act 2009

Options appraisal for flood risk management:  
Guidance to support SEPA and the responsible  
authorities



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# 1. Introduction

## 1.1. Purpose

1.1.1. The Flood Risk Management (Scotland) Act 2009 sets out a new approach to managing flood risk in Scotland. It aims to ensure that actions are focused on areas where flood risk and the benefits of investment are greatest. It sets out responsibilities and arrangements to support collaborative working for SEPA, local authorities, Scottish Water and other responsible authorities. This will ensure that long-term and nationally focused outcomes are balanced with local knowledge and priorities.

1.1.2. Decision-making at all levels of flood risk management planning should be underpinned by effective appraisal. This document provides guidance for SEPA and the responsible authorities on the economic, social and environmental aspects of options appraisal for actions promoted under the Flood Risk Management (Scotland) Act 2009. It identifies methods for identifying and assessing positive and negative impacts and recommends a decision framework, based on the principles of sustainable flood risk management (Scottish Government 2011a, 2011b) and consistent with the HM Treasury Green Book (2011) and the Scottish Government (2012) guidance on appraisal and evaluation, part of the Scottish Public Finance Manual.

1.1.3. The guidance sets out core principles which can be applied consistently across flood risk management planning to support decision-making at national, catchment and local scales. It also reflects the importance of proportionality in the level of detail of each appraisal. As such, some parts of the guidance provide an additional level of detail principally relevant to the appraisal of schemes and works.

1.1.4. The guidance is aimed at those familiar with the principles of options appraisal. It builds on historic Defra and Scottish Government guidance for flood protection schemes and recognises that it is only one part of the solution, not the complete answer. The new approach emphasises the need to consider the social and environmental impacts alongside the economic impacts.

1.1.5. The guidance is not intended to be prescriptive or to cover every possible eventuality. Appropriate specialist advice should be sought where necessary.

## 1.2. Aim of options appraisal

1.2.1. The aim of appraisal is to identify and assess options that achieve flood risk management objectives whilst delivering other economic, social and environmental benefits. This helps to inform the decision-making process. Options appraisal should achieve the following aims:

**1.2.2. Sustainable solutions:**

A sustainable solution will take full account of economic, social and environmental impacts, and protect and enhance our natural and built environment for ourselves and for future generations. The solutions must be developed with consideration of catchment processes and characteristics, making all reasonable and practical efforts to enhance the natural ability of the landscape (rural and urban) to slow and store flood water. A sustainable flood risk management action should take account of interactions between flooding mechanisms and other interventions in the catchment or in the coastal area, and should avoid as far as possible tying future generations into inflexible and expensive solutions.

**1.2.3. Best use of public money:**

Demands for public funding always exceed the money available. When determining how to meet the objectives for managing flood risk, it is therefore necessary to aim for economic efficiency (where the total of all forms of benefit are maximised relative to the resources used). The appraisal should not be limited to the consideration of priced benefits and resources. It should, where appropriate, also include unpriced benefits, such as the enjoyment gained from walks by a river, as well as the unpriced costs, such as degradation of landscape.

**1.2.4. Accountability:**

A formal process of options appraisal can demonstrate that a wide range of options has been considered, and that the advantages and disadvantages of each have been fully and transparently considered. Appraisals also create an effective audit trail of decision-making.

**1.2.5. Robustness:**

Robust appraisals ensure that data being used to support decision-making are appropriate for the decision being made. They recognise the assumptions, uncertainties and limitations in data and methods, and test the sensitivity of results to these uncertainties. Good quality appraisals increase certainty and confidence in the final outcome.

## 2. Framework for appraisal

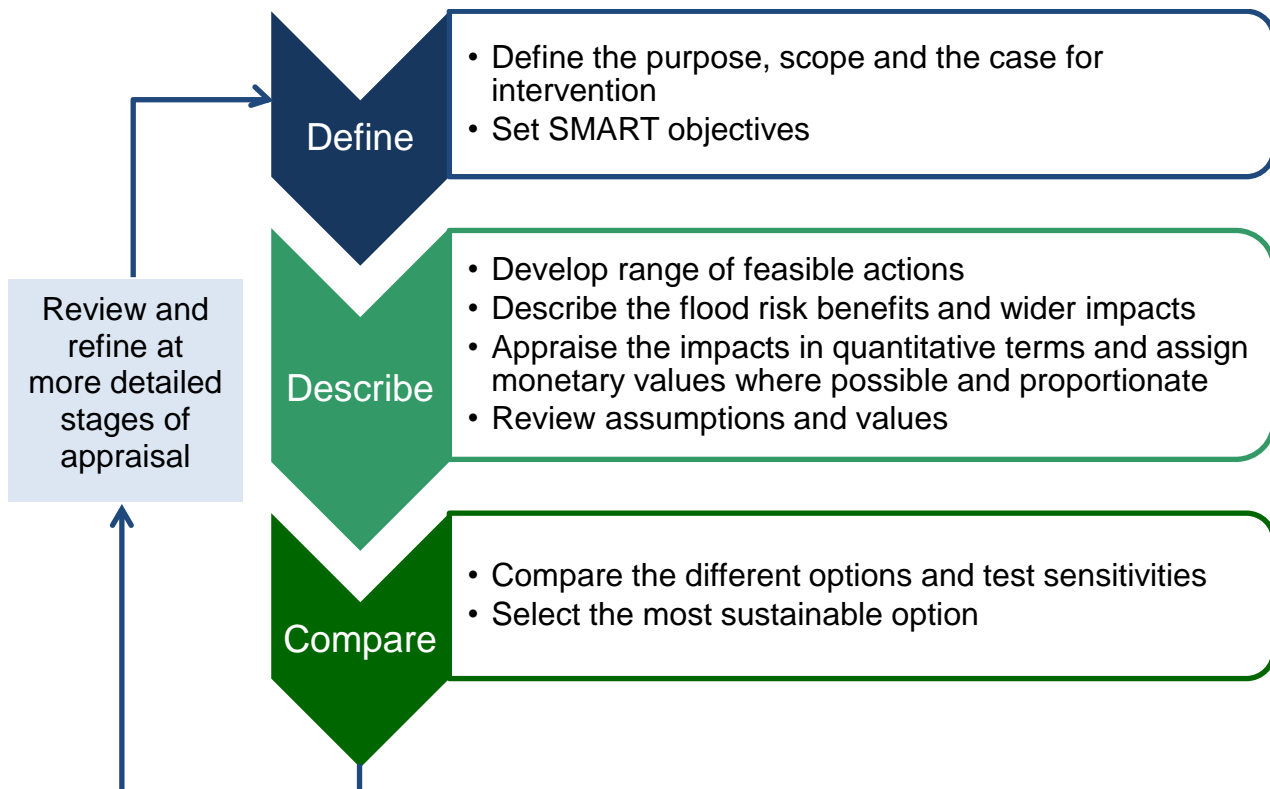
2.1.1. This guidance document provides additional detail to support the ministerial guidance on delivering sustainable flood risk management and the policy on principles of appraisal (Scottish Government 2011a, 2011b). It is designed to:

- Provide a framework for SEPA's strategic appraisal of flood risk management actions;
- Provide the principles for options appraisal that underpin the surface water management planning process;
- Provide guidance for feasibility and design stages appraisal of actions by the responsible authorities.

2.1.2. The process of option development, refinement and selection should be carried out within a logical appraisal framework (Figure 2.1). Ideally this should include defining the purpose of the assessment, setting objectives, identifying and appraising options, and selecting the most sustainable option.

2.1.3. The appraisal process should be iterative: it should explore the problem, generate options, and progressively refine the selection. This approach applies to strategic, feasibility and design stages of appraisals to aid and guide the selection of the most sustainable option.

**Figure 2.1: Summary of main stages in appraisal**



- 2.1.4. Appraisals should use the best and most up-to-date information available, which may include SEPA's strategic flood hazard and flood risk mapping<sup>1</sup> and any further flood risk studies already carried out at the catchment or local scale. The type of information required will depend on the purpose and scale of the appraisal. Where the available information is not appropriate for the purposes of the appraisal, new information will need to be acquired.
- 2.1.5. Key reference material for options appraisal is listed in Box 2.1. Note that Penning-Rowsell *et al.* (2013) is referred to as the 'Multi-Coloured Manual' (MCM) throughout this guidance. Reference is also made to SEPA (2015a) guidance for responsible authorities on flood hazard modelling and mapping, which underpins decision-making for flood risk management.
- 2.1.6. The guidance signposts to a number of other sources of information, particularly on the valuation of costs and benefits. Given the work being taken forward to implement the Flood Risk Management (Scotland) Act 2009 it is expected that the information base will continue to improve.

#### **Box 2.1: Reference material for options appraisal**

##### **Public sector appraisal guidance**

- HM Treasury (2011) The Green Book: appraisal and evaluation in Central Government. HM Treasury, London.  
<https://www.gov.uk/government/publications/the-green-book-appraisal-and-evaluation-in-central-government>
- Scottish Government (2012) Scottish public finance manual – appraisal and evaluation. Scottish Government, Edinburgh.  
<http://www.gov.scot/Topics/Government/Finance/spfm/appraisal>

##### **Scottish Government flood risk management guidance and policy**

- Scottish Government (2011a) Delivering sustainable flood risk management. Scottish Government, Edinburgh.  
<http://www.gov.scot/Publications/2011/06/15150211/0>
- Scottish Government (2011b) Sustainable flood risk management – principles of appraisal: a policy statement. Scottish Government, Edinburgh. <http://www.gov.scot/Publications/2011/07/20125533/0>
- Scottish Government (2014a) Benefit-cost analysis for surface water management plans [update to Section 6 in Surface Water Management Planning Guidance]. Scottish Government, Edinburgh.  
<http://www.gov.scot/Topics/Environment/Water/Flooding/FRMAct/guidance>

<sup>1</sup> <https://www.sepa.org.uk/environment/water/flooding/flood-maps/>

### **SEPA flood risk management guidance and methods**

- SEPA (2015a) Flood modelling guidance for responsible authorities. SEPA, Stirling.  
<http://www.sepa.org.uk/environment/water/flooding/developing-our-knowledge/>
- SEPA (2015b) Natural Flood Management Handbook. SEPA, Stirling.  
<http://www.sepa.org.uk/environment/water/flooding/developing-our-knowledge/>
- SEPA (In prep.) Flood risk management appraisal methodology. Version 2. Due for online publication in 2016 at:  
<http://www.sepa.org.uk/environment/water/flooding/FRM-strategies/frminfo/>

### **Detailed guidance on options appraisal:**

- Penning-Rowsell E, Priest S, Parker D, Morris J, Tunstall S, Viavattene C, Chatterton J and Owen D (2013) *Flood and Coastal Erosion Risk Management: A Manual for Economic Appraisal*. Routledge, Abingdon.



### **3. Stage one: defining the purpose**

#### **3.1. Define the purpose**

3.1.1. An appraisal should start with a clear description of the problems to be tackled. This will involve understanding existing flood risk and describing how this risk is likely to change over time.

3.1.2. Existing data and information can be used to describe the problem. Sources of data include SEPA's (national) strategic flood risk assessments, catchment and local scale flood models and maps, and local flood history. Source of models and historical flooding information are described in SEPA (2015a) flood risk modelling guidance. The data used should be fit for purpose and appropriate to the scale of the appraisal. Any significant uncertainties in the data or assumptions should be recorded.

3.1.3. All significant flood risk (economic, social and environmental) should be identified including the effects of climate change. Major constraints that may affect the choice of solution should also be stated.

#### **3.2. Set objectives**

3.2.1. One or more objectives should be set to define the purpose of the intervention. The objectives should be in line with wider government policy and plans and the HM Treasury Green Book (2011). They should be SMART (Specific, Measurable, Achievable, Relevant, Time-bound).

3.2.2. The following principles should underpin the setting of objectives:

- Main sources and impacts of flooding should be referenced;
- The baseline levels of flood risk should be included within the objectives to allow progress to be tracked;
- The objectives should be aspirational and not set limits on what is possible/ desirable. For example, it is not acceptable to state that the purpose is "to develop flood embankment with a 1% annual exceedance probability (AEP) (1 in 100 year return period) design standard"<sup>2</sup>.

3.2.3. There should be demonstrable links between objectives set out in a flood risk management plan and their contribution to tackling national, regional or local priorities, particularly in areas identified by SEPA as being potentially vulnerable to flooding. At a project level, objectives should clearly reflect the objectives set in the relevant flood risk management plan.

3.2.4. All objectives should be established in dialogue with partners and stakeholders and should not be biased to favour or to marginalise any group.

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<sup>2</sup> Scottish Government (2011a) guidance on Delivering Sustainable Flood Risk Management does not specify design standards.

3.2.5. When considering objectives, opportunities for delivering multiple outcomes should be considered early in the process.

## **4. Stage two: develop, describe and value**

### **4.1. Introduction**

4.1.1. This stage will identify a broad range of actions that could help to meet the objectives (Section 3.2) and eliminate unreasonable or unfeasible actions so that the effort focuses on appraising realistic, feasible options.

### **4.2. Identify a long list of actions**

4.2.1. Consideration must be given to a broad range of structural and non-structural actions, both individually and in combination across a catchment or coastal area. The actions may reduce the likelihood of flooding, reduce the damages should a flood occur, or avoid creating new flood risk (or exacerbating existing risk). A narrowly defined search may only identify the best action(s) from a poor set.

4.2.2. Standard lists of actions that can be used as a starting point are published by SEPA (2015b; In prep.).

4.2.3. The management of flood risk may impact on many aspects of the social, natural and historic environment. Wherever possible, SEPA and the responsible authorities should manage flood risk in ways that will improve the environment at the same time as reducing the risks to people and property. Opportunities to do more, while still cost-effectively reducing risk, should be promoted.

4.2.4. Consideration should also be given to the situation and physical aspects of the land and any existing flood risk management actions (including their residual life and standard of protection). Local scale actions should be developed in the context of wider objectives and actions set out in the Flood Risk Management Strategies.

4.2.5. A long-list of actions should therefore be identified with the following points in mind:

#### **4.2.6. Meeting the objective(s)**

- Consider all actions that could partially or completely address the risk of flooding that is predicted or has been observed.
- Consider actions which are effective at the property, neighbourhood or catchment scale or coastal area, as appropriate.
- Consider whether there are opportunities to combine actions that address flooding from different sources.

#### **4.2.7. Delivering sustainable flood risk management**

- The actions should aim to deliver sustainable flood risk management (Scottish Government 2011a).
- Consider the impact that actions will have on flood risk now and in the future. Actions to manage flood risk should reflect the needs of future

generations and be adaptable to a changing climate and other drivers of changing flood risk (Sections 4.6.5 and 9.8).

- Consider actions which could deliver wider benefits such as better places for people to live (e.g. improved amenity or urban regeneration), improved environment (e.g. improvement in water quality) or improved biodiversity.
- Consider opportunities to improve existing actions e.g. change maintenance regimes or enhance/replace existing actions.

#### 4.2.8. **Working with stakeholders**

- Consider actions that could be delivered by the full range of stakeholder organisations.
- Actions may be added to or refined by the Local Flood Risk Management Partnerships, the Local Advisory Groups or through engagement with all stakeholders.

### 4.3. **Screening the long-list of actions**

4.3.1. Screening exercises may be required to reduce a long-list to a shorter list of actions. This will remove any that are clearly unfeasible, leaving a smaller number of actions for further appraisal. Any actions that are technically inappropriate (e.g. an offshore breakwater to deal with fluvial flooding risk) or technically impractical (e.g. a diversion channel over a hill where there are more sensible alternatives) and actions that have insurmountable constraints should be screened out. Complex and integrated solutions, however, should not be shied away from.

4.3.2. Sustainability must be a key consideration and actions that are clearly unsustainable should be rejected early. If necessary, broad positive and negative impacts can be identified for each of the actions. At this stage, technical details are not necessary and impacts do not need to be valued. Experience and informed judgment should be used to help eliminate actions.

4.3.3. There are various legal constraints on what actions can be progressed or, more specifically, the manner in which they are progressed. These mainly deal with the impact on people and the natural or built environment (see Box 4.1). Specific legal obligations should be clarified early in the appraisal process including consideration of how such obligations can be met.

4.3.4. A high level scoring or matrix analysis exercise may be helpful. The reasons for rejecting actions should be clearly stated and recorded. If in doubt, retain the action for further appraisal.

## Box 4.1: Examples of legal constraints and considerations

### Health and safety

Actions can introduce significant health and safety risks whether during construction, under maintenance or in use. Likewise actions can contribute to an overall reduction in risks to health and safety by reducing flood risk itself or by removing/replacing structures which are inherently hazardous to maintain (e.g. culvert trash screens).

The screening process needs to take a pragmatic approach with regard to actions and not exclude those actions which introduce additional risks during construction, under maintenance and in use, provided that those additional risks can be managed in line with legislation (e.g. Health and Safety at Work etc. Act 1974; Construction (Design and Management) Regulations 2007).

### Environmental and heritage protection

Many structural actions have the potential for negative impacts on the natural and/or built environment. Where these impacts are likely to be significant, a Strategic Environmental Assessment (SEA) / Environmental Impact Assessment (EIA) and a Habitats Regulations Appraisal maybe required<sup>3</sup>. Furthermore, a range of species, habitats and historic sites are protected by legislation to protect them from damage. It is essential to identify these environmental legislative requirements early in the appraisal process. Late consideration of environmental impacts and/or failure to adhere to environmental legislation can lead to damage to the environment, delays and legal challenges.

At the screening stage, the aim is to modify or remove any actions that raise insurmountable environmental problems, for example:

- An action is considered to have an adverse impact on the conservation objectives of a Natura site (Special Area of Conservation or Special Protection Area) such that the site integrity itself is compromised and mitigation will not prevent the adverse impact<sup>4</sup>;
- The action introduces an unacceptable risk of pollution to surface or groundwater that cannot be avoided or reduced.

This does not mean that actions with any adverse impacts on the environment should be screened out – only those with insurmountable problems. Opportunities should be sought throughout the appraisal process to prevent adverse impacts and to deliver wider benefits. Early engagement with stakeholders is recommended.

#### 4.4. Shortlist of actions: developing options

- 4.4.1. The screening exercise will have removed any unfeasible actions from the long-list, leaving a shortlist of actions for further assessment. This shortlist of actions should be used to build up viable options to meet the flood risk

<sup>3</sup> Scottish Government Environmental Assessment: <http://www.gov.scot/Topics/Environment/environmental-assessment> [accessed 16/11/2015]

<sup>4</sup> The only exceptions are if there are no alternative solutions and there are imperative reasons of overriding public interest for the plan or project to go ahead.

management objectives. The options should include the 'do nothing' and/or 'do minimum' options; other 'do something' options can be identified using an iterative process to build up viable solutions.

#### 4.5. The 'do nothing'/'do minimum' option

4.5.1. The starting point will be to develop a 'do nothing' or 'do minimum' option. This provides a consistent baseline against which the other options can be compared.

4.5.2. The 'do nothing' case describes the future situation with no further intervention – i.e. cease all current activities and walk away. Identifying the 'do nothing' option correctly is important to the analysis and needs careful consideration:

- Where there are no existing flood risk management actions, the 'do nothing' option is obvious; there is no intervention in natural processes;
- Where there is an existing scheme, the 'do nothing' option will be to walk away and abandon all associated maintenance and repair, allowing nature to take its course. For health and safety reasons, it may be necessary to take minimal steps to make any abandoned works safe and these costs should be taken into account. (Simply continuing with maintenance and repair of the existing structure then becomes one of the 'do something' options.);
- Where there is flood warning or forecasting scheme, the operation of this scheme would cease. Continuing with or altering the scheme would become a 'do something' option;
- Similarly, any activities to promote or subsidise property level protection would cease under the 'do nothing' option. It should be assumed that where property level protection exists, it may still be applied – however, without a flood warning scheme, property level protection is likely to be significantly less effective.

4.5.3. Where there is a statutory requirement to continue with activities then a 'do minimum' baseline should be used. This is the minimum amount of action needed to meet the legal requirement. Statutory requirements leading to a 'do minimum' baseline may be:

- Statutory duty to carry out clearance and repair works to bodies of water (Flood Risk Management (Scotland) Act 2009, Section 59);
- Provision of surface water drainage;
- Responsibility for civil protection.

Note that the 'do minimum' option entails costs and these should be taken into account.

4.5.4. Identifying a true 'do nothing' baseline can be difficult without individual models for a specific area. Therefore, for strategic appraisals, a 'do minimum' option may need to be used as the baseline.

#### 4.6. The 'do something' options

- 4.6.1. 'Do something' options will build on the 'do-minimum' option. The 'do something' options should be developed by looking for opportunities to use non-structural actions and best-practice actions that seek to enhance the (urban and rural) landscape's natural ability to slow and store flood water as well as considering more traditional engineering.
- 4.6.2. Options should be identified by combining and refining viable ways of meeting the flood risk management objectives. Adding complexity and more features might reduce flood risk but add to cost. The purpose of appraisal is to identify the best balance between the outcomes.
- 4.6.3. Ministerial guidance (Scottish Government 2011a) does not specify certain design standards – but it does expect all appraisals to include an option that protects to a 1% AEP plus allowances for climate change. Other incremental levels of protection should to be considered during option development. The approach should be risk-based, linking benefits to costs with the aim of maximising the reduction in overall risk.
- 4.6.4. There is always the possibility that during the lifetime of an action, a flood will occur that is more extreme than the design event. Consequently, arrangements to understand and deal with residual risks (for example, if design limits are exceeded by flood events) should be considered as part of option development.
- 4.6.5. In particular, pressures such as climate change, land use change and demographic change will lead to changes in flood risk in the future. Because of the uncertainties in projections of future flood risk, it is preferable wherever possible to design actions that can be adapted in future (a managed adaptive approach) rather than to design for climate change and other changes up front (a precautionary approach) (Box 4.2). However, this may not be possible for large one-off interventions where building in climate change and other future adaptations at the start may be the only feasible approach. Section 9.8 provides further guidance on how to take climate change and other drivers of future flood risk into account.

#### Box 4.2: Reference material for climate change adaptation

- Scottish Government (2014b) Climate ready Scotland: Scottish climate change adaptation programme. Scottish Government, Edinburgh. <http://www.gov.scot/Publications/2014/05/4669>
- Metropolitan Glasgow Strategic Drainage Partnership (2014) Climate change technical guidance. Metropolitan Glasgow Strategic Drainage Partnership, Glasgow. <https://www.mgsdp.org/CHttpHandler.ashx?id=25924&p=0>
- Centre for Expertise on Waters (2012) Coastal flooding in Scotland. A guidance document for coastal practitioners. James Hutton Institute, Aberdeen. [http://www.crew.ac.uk/files/publications/coastal\\_flooding\\_in\\_scotland.pdf](http://www.crew.ac.uk/files/publications/coastal_flooding_in_scotland.pdf)

## 5. Describe and value: appraising the options

### 5.1. Components for the appraisal

5.1.1. The options should go through a robust and transparent appraisal of costs and benefits, and positive and adverse impacts. The outputs should inform decision-making and provide evidence of a sound decision-making process.

5.1.2. The following components should be assessed:

- Estimates of flood risk management benefits (flood damages avoided) (Section 6, 7, 8 and 9)
- Wider positive and adverse impacts (Sections 7 and 8)
- Adaptability to climate change and other drivers of future flood risk (Section 9.8)
- Whole life costs (Section 10)
- Uncertainty in costs and benefits (Sections 10.8, 11.6 and 11.7)

### 5.2. Appraisal techniques

5.2.1. The flood risk impacts and wider impacts should be described, and where appropriate/possible, assessed in quantitative or monetary terms. There are advantages to estimating the impacts in monetary terms: these impacts can be readily compared with whole life costs to estimate the likely return on investment by calculating net present values (NPVs) and benefit-cost ratios (BCRs) (Box 5.1).

5.2.2. Some impacts, however, can be difficult to value in monetary terms and/or may require disproportionate effort (Section 5.5). It is therefore crucial that significant impacts that are not valued in monetary terms are always described, quantified (if possible) and brought into the appraisal through appraisal summary tables (Section 5.6). Understanding these impacts is critical to selecting sustainable options and they should not be omitted because they are difficult to value.

5.2.3. There are a range of techniques that can be used to appraise and help select the preferred option. The technique chosen will depend on the complexity of the problem being addressed, the detail and confidence in the assessment of flood risk, and the availability of data and methods for valuing different impacts.

5.2.4. Where the obligations *only* involve requirements that *must* be met, the technique of cost-effectiveness analysis would usually be appropriate to identify the most effective and sustainable method of meeting these requirements (see HM Treasury Green Book (2011) for a worked example). However, any wider benefits associated with such projects should be explored to see whether there is a case for doing more than the minimum requirement. There are likely to be only limited cases when cost-effectiveness analysis is appropriate to use in flood risk management options appraisal: therefore no further guidance is given here.



5.2.5. Appraisal techniques such as benefit-cost analysis (BCA) and multi-criteria analysis (MCA) provide metrics for comparing options. The appraisal should stimulate the selection of the most sustainable solution by analysing the consequences of all options. It may also help to identify ineffective or uneconomic options at an early stage.

5.2.6. There will be cases where it is not practical or possible to assign monetary values to all significant impacts for a benefit-cost analysis. In such cases, multi-criteria approaches (including scoring and weighting) can be used to complement or as an alternative to benefit-cost analysis.

5.2.7. If using benefit-cost analysis and multi-criteria analysis together in appraisal, it is important to ensure that they are robustly and consistently applied in order to: avoid double counting, make appropriate and consistent use of discounting; and ensure a common baseline.

### **Box 5.1: Techniques for comparing options**

#### **Net present value**

Net present value is the difference between the present value of a stream of costs and a stream of benefits. It is used to identify the net benefits of an option to demonstrate whether the economic benefits outweigh the costs and the magnitude of these benefits.

#### **Benefit-cost ratio**

Benefit-cost ratio (benefits divided by costs, where the costs include contributions) should be used to examine the relative return of an option for every pound spent. A benefit-cost analysis presumes that all components (costs, benefits, adverse impacts) of value are taken into account. Options are only economically worthwhile if the benefits exceed the costs (the ratio of benefits to costs is greater than one).

Furthermore, if all significant impacts are satisfactorily expressed in monetary terms, the option with the highest benefit-cost ratio will usually be the most appropriate choice. Appraisal summary tables (Section 5.6) should still be used in such cases to add to the transparency of the decision-making process (for example, to illustrate which impacts have been taken into account and how they have been described and valued in the benefit-cost analysis).

Appraisers should always give due consideration to any significant non-monetised impacts as these are important for identifying sustainable solutions. Options should not be rejected solely on the basis of economic criteria alone. For example, an option with a low benefit-cost ratio may be worth taking forward if it delivers strong non-monetary benefits.

#### **Incremental benefit-cost ratio**

Incremental benefit-cost ratio (the difference between the benefits provided by two options divided by the difference in costs) can be used to identify the additional benefits delivered by one option compared to another. It enables an understanding the opportunity cost – that is, whether there is an extra pound of

benefit for each additional pound of cost. For example, it can help examine whether the increased investment required to achieve a greater standard of protection is actually the most beneficial choice.

There may be a justifiable case for selecting an option which would provide a higher standard of protection than that offered by the option with the highest benefit-cost ratio, providing that the overall benefit-cost ratio represents good value for money when compared with other options.

### **Multi-criteria analysis**

Multi-criteria analysis (MCA) can be used to combine a mix of both monetary and non-monetary benefits. The extent to which each option meets the identified criteria is measured, and explicit weights are given to each of the criteria to reflect their relative importance. Using this technique, options can be ranked and a preferred option identified. Guidance on multi-criteria analysis forms part of HM Treasury Green Book supplementary guidance (Department for Communities and Local Government 2009).

### **Scoring and weighting**

Scoring and weighting (a type of multi-criteria analysis) can be used to estimate the monetary values of impacts where other approaches are not available or are not appropriate for the impacts predicted under the options being appraised. To use scoring and weighting, the impacts from at least one category (preferably several) need to have been quantified and valued in money terms. A scoring and weighting methodology is published by the Environment Agency (2010a).

## **5.3. Principles for valuing costs and benefits**

5.3.1. Options appraisal should use economic values rather than financial values. Economic values take the view of the nation as a whole (one person's loss can be another person's gain) and exclude taxes on goods and services such as VAT. They are therefore different to financial values, which take the view of the individual and include VAT as well as other taxes on goods and services. In economic valuation, goods that are damaged or lost by households and businesses are valued at their remaining value (typically at half-life) and not the replacement cost.

5.3.2. Principles of valuing costs and benefits are described in Appendix 1. Key points are:

- Inflation should be ignored in undertaking the analysis;
- Real prices (i.e. 'today's' prices) should be used for all streams of benefits and costs. (Values with different base dates will require adjusting);
- Any 'negative costs' should be regarded as benefits;
- Any 'negative benefits' should be regarded as costs;
- 'Transfer payments' should be excluded from the benefit-cost analysis;
- The discount rates recommended by the HM Treasury Green Book (2011) should be used for all streams of benefits and costs.

#### **5.4. Setting boundaries for the appraisal**

- 5.4.1. Appraisers need to determine the spatial extent of the appraisal and the appraisal period. These boundaries should be set taking into account the consequences of the options. It may not be possible to assess all such consequences and a reasoned decision must therefore be made as to how far the process should be pursued.
- 5.4.2. A conceptual model of the key flooding processes can help understand the interaction of different actions across catchments or coastlines and, in turn, determine the spatial extent of the appraisal. See SEPA (2015a) modelling guidance for further information on conceptual models and spatial extents.
- 5.4.3. Options may have an impact beyond the immediate area and, in addition, the factors outside the immediate area can influence the effectiveness of an option. For example, urbanisation of the upstream catchment could increase flood risk downstream. The assumptions made about external conditions should be realistic, not simply convenient. Any significant impacts beyond the project boundary should be included or the project boundary adjusted to incorporate these impacts.
- 5.4.4. The costs and benefits of all options should be evaluated over the same period, based on the life (with maintenance) of the longest-lived option under consideration. Any costs for maintenance, repair or replacement of shorter-lived components (required for the integrity of the wider solution until the end of its lifespan) should be factored in.
- 5.4.5. The presumption is that for most appraisals, a 100-year timeframe will be appropriate to enable comparison of options. Using a shorter timeframe (such as 50 years) would mean that costs or benefits that occur after 50 years are not taken into account and this could affect which option is identified as preferred. For example, short time horizons can bias the appraisal against options that cost a lot now but which are less expensive to maintain, or which provide significant benefits and/or may be more sustainable over a longer timeframe. Longer timeframes also better allow for environmental or adaptation benefits to be included in appraisals.

#### **5.5. A proportionate approach**

- 5.5.1. The level of detail in appraisal should be proportional to the stage of appraisal (be it strategic, feasibility or design) and to the level of detail needed to differentiate between options. For flood risk management options involving a small amount of expenditure, a detailed benefit-cost analysis may not be justified.
- 5.5.2. At the early stages of appraisal, readily available data are usually sufficient. As the appraisal proceeds, data are usually refined to become more specific and accurate as needed to support decision-making. It is important

that the effort applied at each step is proportionate to the time and resources available and that additional data are only collected where required.

- 5.5.3. Less detail is needed where the choices among options are clear, whereas more detail is likely to be required where there are complex issues and where differentiation is more difficult. A simplified analysis, where there are valid grounds for such an approach, should still be rigorous.
- 5.5.4. Appraisers must therefore decide on the appropriate level of detail and the streams of benefits and costs to be included. One of the skills needed for a good options appraisal is deciding when enough information has been collected to make a robust and defensible decision. This is usually where collecting more information will not make a significant difference to the decision. It is essential to demonstrate this clearly and openly to those that may be affected by the decision.
- 5.5.5. Data collection and modelling can be one of the most expensive parts of a benefit-cost analysis. Appraisals should seek to build on existing modelling work, for example, SEPA's strategic flood hazard and risk modelling, Scottish Water's assessment of flood risk from sewerage systems (carried out under Section 16 of the Flood Risk Management (Scotland) Act 2009), and modelling and surveys held by local authorities. Where existing modelling work (or surveys) are to be used for a new appraisal, appraisers must ensure that: (i) the scale and purpose of the modelling is appropriate for the new appraisal; and (ii) changes in the catchment and available data would not affect the results of the appraisal. Any new modelling work should be carried out to a suitable level of accuracy for the type of appraisal. See SEPA (2015a) modelling guidance for further guidance on the use of existing models and development of new models.
- 5.5.6. For feasibility and design stages, the appraisal should be sufficiently extensive to show with reasonable confidence whether it is worth adopting any of the 'do something' options. Ideally, the first streams of benefits and costs to be included should be those contributing the greatest proportion of the total. While it is not always possible to determine in advance which will be the largest, there are two areas which should generally be considered first; these are:
- Benefits and costs that have the highest probability of occurrence;
  - Benefits and costs that accrue earliest in the timeframe of the appraisal.
- 5.5.7. The cost of carrying out the appraisal will vary depending on the types of impacts that are appraised and the precision required. For recreational benefits, it may cost as much to appraise these for a small scheme (or area) as a large one. The assessment cost also depends on the extent to which available data sources can be used, such as depth-damage data for residential (and some non-residential) properties (Section 6.2). Furthermore, if the flood mechanisms and topography are complex, appraisal costs will increase.

5.5.8. Further guidance is provided in Box 5.2.

### **Box 5.2: How to determine a proportionate approach: additional considerations**

#### **How uncertain are estimates of flood hazard and flood risk?**

Flood models use simplifications and assumptions to represent complex natural systems and this leads to inherent uncertainty, which must be acknowledged when making decisions based on model results. SEPA (2015a) provides guidance on where uncertainty may arise in flood modelling and how it may be managed through the modelling process so that it can inform appropriate decisions.

Understanding the uncertainty in flood modelling is crucial to ensuring a proportionate and robust appraisal. There is little advantage in spending time looking at flood damages in detail if the flood models that have predicted those impacts are coarse. Furthermore, the data used to estimate damages should be appropriate given the type and tolerance of the flood model. For example, depth-dependent property damage data (Section 6.2) are not appropriate to use if flood depth estimates are highly uncertain. (Weighted damages, which do not require depth information, are more appropriate to use in these situations. See the MCM for more detail.)

There will also be uncertainties in the receptor data used to estimate flood damages. The MCM contains some health warning for particular data and advises where sensitivity analysis (Section 11.7) might be particularly important.

#### **Are the impacts significant?**

If the economic impact on a receptor is likely to be around 10% or more of property damages (which can be estimated reasonably quickly), then it is worth spending time to assess the impact in more detail. It is also often worth considering non-residential property damages in detail as they can account for a large proportion of damages, even if they make up a relatively small proportion of affected properties. This is because standard depth and damage information for non-residential properties can often significantly over or under estimate damages, due to the highly individualised nature of these types of properties and their exposure to flooding.

#### **Do the impacts differ across the options being appraised?**

Where impacts are very similar across all or most options, there is unlikely to be much value in considering these impacts in a lot of detail. Instead, the effort should focus on assessing those impacts that vary across options to enable decision-makers to differentiate between options.

#### **How much time is required to describe, quantify or value the impacts?**

It can take a considerable amount of time to estimate the monetary damages of some impacts. Where those impacts are relatively small, it is essential to consider how significant the impacts are likely to be before starting to collect data or estimate damages. Those impacts that may require disproportionate effort to monetise should be described, and quantified if appropriate. If the choice of preferred option turns out to be reliant on differences between options in any one

category, it may be possible to monetise these impacts later in the appraisal process to bring them into the benefit-cost analysis.

The most likely significant impacts are usually the drivers for action (often damages to residential and non-residential properties or damages to critical infrastructure) and these should be identified at the outset. If a robust benefit-cost ratio is achieved on the basis of protection to properties alone, in many cases there may be little advantage to trying to estimate the monetary benefits to transport or of indirect impacts, given their complexity. Instead, these impacts should just be described.

#### **Are suitable approaches available to value the impacts?**

Some significant impacts, particularly related to social and environmental criteria, may be difficult to value in monetary terms. Where valuing these impacts would incur disproportionate time or costs, or where techniques are not readily available, these impacts must at the least be described, and if appropriate, quantified. These impacts must still be taken into account during decision-making.

### **5.6. Appraisal summary tables**

5.6.1. Appraisal summary tables should be used as a framework for systematically describing, valuing and, where possible, monetising the positive and negative impacts of options. The tables should provide a comprehensive assessment of the impacts of all options. They should also make transparent which impacts have been valued in monetary terms (and how these monetary values have been developed) and which have not. Assumptions should be clearly stated and any uncertainties associated with the description, quantification and valuation of impacts should also be recorded. For an example, see templates developed by the Environment Agency (2010b).

## **6. Assessing economic impacts**

### **6.1. Introduction**

6.1.1. Flooding can have a wide range of economic impacts, including damages to property and contents, costs to emergency services, damages to infrastructure and agricultural land and impacts on land use. This section provides guidance to appraisers on assessing damages to specific receptors and enables appraisers to calculate the benefits of damages avoided (Section 9). Further and more detailed guidance can be found in the MCM.

6.1.2. It is not necessary to assess damages to all receptors in every appraisal. Appraisers should select the level of detail proportionate to the type and scale of appraisal, be it at a strategic, catchment or local level (Section 5.5). The process should be iterative: the calculated values and assumptions should be reviewed to make sure the results are representative.

6.1.3. Prior to assessing economic impacts, appraisers should decide on whether the appraisal will be desk-based or whether it will require a survey of topographic threshold levels and a site walkover survey. This will be determined by the acceptable level of confidence in the outputs (see Section 5.5).

### **6.2. Residential and non-residential property**

6.2.1. Flood damages to properties can be estimated given the flood extent, the number of properties and the frequency of flooding. Better estimates will be obtained with additional information on the types of properties and the depth and duration of floods.

6.2.2. The MCM contains some standard data on the economic losses to be expected for residential and non-residential properties. These losses include damages to the building fabric and contents and the costs of drying out and cleaning up. For residential properties, the MCM also contains standard data on losses from vehicle damages and evacuation costs (e.g. temporary accommodation, additional travel and time costs, loss of earnings). Adjustment factors, which take account of the additional losses from saline flooding, are available.

6.2.3. An alternative to standard data is to commission a site survey. This is expensive, however, and is rarely justified unless the property concerned is atypical (such as a large industrial or commercial property, hospital or listed building) and the use of standard data would likely give misleading results. Further guidance on site surveys can be found in the MCM.

6.2.4. Iterative checking of damages is an important quality assurance tool, particularly given the inherent uncertainty in estimates of damages for non-residential properties and capping values (Section 6.2.7).

6.2.5. Where a flood has occurred recently, a record of the damages incurred (if available) can provide a useful context for the evaluation of losses and also used at a later stage to check calculations. (However, information can be incomplete and actual damages will rarely be available for the required range of events. Where losses are recorded, these will often be in financial rather than economic terms (Section 5.3) and values will have to be converted.)

6.2.6. Permanent buildings at risk of total loss from flooding should usually be valued at their current market value, excluding any adjustment in value for the flood risk (Section 6.2.8). Generally, property will be assumed to be written off if it is flooded on average more than once every three years unless it is flood resistant or flood resilient. This is because there is unlikely to be sufficient time for the property to be repaired and return to full use following the previous flood before the next flood occurs. As a result, repairing the property would be a waste of money.

6.2.7. Where a property is flooded more frequently than once every three years, it is assumed that the cumulative present value damages do not exceed the risk-free market value of the property. Damages to a property should therefore be capped at the risk-free market value (Section 6.2.8).

6.2.8. It is important to use risk-free market values for write-offs (Section 6.2.6) and capping (Section 6.2.7) because the actual market value of an at-risk property could be lower as where the risk is known, there may be lower demand for the property (see the MCM). Historical values should be uplifted to present values (Appendix 1 Section A1.2).

- For residential properties, the Registers of Scotland (<https://www.ros.gov.uk>) publish data on house prices. Regional market values by property type can be used as an estimate of the risk-free market value. This approach may be particularly suited to strategic and feasibility stages of appraisals. An alternative, where feasible, is to develop a local proxy for risk-free market value (based on property prices in nearby and similar properties or adjacent neighbourhoods). Where at-risk property prices are depressed, the prices of adjacent properties or streets may also be affected. Developing local risk-free market values therefore requires local knowledge and may be more suitable for design stage of appraisal. Sensitivity analysis can be used to examine the choice of capping values.
- For non-residential properties, the MCM recommends using rateable values together with a conversion factor (see MCM for details) as a proxy for market values. Rateable values are available from the Scottish Assessors Association (<http://www.saa.gov.uk>). If this approach is used, appraisers should check that the resulting estimates of market values are appropriate for the type and scale of appraisal, as rateable values are not always proportionate to market values.

6.2.9. When appraising relocation of properties, particular consideration should be given to the appropriateness of capping values. This is because the



costs of relocation are rarely less than the market value of the property, so relocation may not compare favourably in economic appraisal. In these cases, it is worth comparing the damages both with and without capping. Also, social impacts (Section 7) of relocation may be significant and should be fully explored.

6.2.10. Market values sometimes need adjustment. For example, for properties such as pubs and restaurants, the market value includes a significant factor for customer goodwill. This 'goodwill' element is a transfer, not an economic loss (Appendix 1 Section A1.4). In other circumstances, if there is an excess supply of, say, some types of commercial property, such property would not be replaced if lost and no economic loss would be incurred. It is also important to avoid double counting any waterside amenity element of market value. Furthermore, in the case of loss through abandonment, it should be assumed that the contents of the buildings are removed before the building is lost. Consequently, the value of all removable fixtures and fittings should be excluded from the damages.

### **6.3. Distributional Impacts analysis for residential properties**

6.3.1. A Distributional Impacts analysis can be used to adjust the benefits of reducing flood risk to individuals, depending on aspects such as their socio-economic group. (The rationale being that an extra pound will give more benefit to a person who has lower income than to someone who has higher income.)

6.3.2. Distributional Impacts should be applied where it is necessary and practical to do so (HM Treasury 2011). Determining if it is 'necessary and practical', depends on a number of circumstances, including (i) whether a community at flood risk can be identified with reliable data and categorised according to their prosperity or social class; (ii) whether the assessment will contribute to an appraisal that demonstrates equity and fairness to people; and (iii) whether the time and effort in undertaking the assessment is proportional to the scale of the overall appraisal.

6.3.3. In addition, appraisers should consider whether they feel that in not undertaking the assessment, an option will still have an adverse differential impact on a particular group. In this case, a decision not to adjust explicitly for distributional impacts will need to be justified.

6.3.4. A Distributional Impacts analysis is achieved by applying Distributional Impacts factors to adjust the damages to residential properties. The subsequent values arising from the appraisal may then be treated in the conventional manner. Further advice and application of Distribution Impacts analysis to flood risk management is set out in Defra (2004) and the MCM.

### **6.4. Indirect impacts on non-residential properties**

6.4.1. If a shop or factory is flooded, the company will lose sales and its customers may be inconvenienced. Therefore there are two forms of indirect

losses: losses to the consumer and losses to the supplier. In general, the loss to the consumer is the economic loss; the loss to the supplier is usually financial rather than economic.

6.4.2. If consumers can buy the same goods at the same cost from an alternative supplier immediately, there is no loss to them. If they have to make do with inferior goods or incur higher costs, there may then be an economic loss. However, it will only be appropriate to describe or quantify this in special circumstances; for example, where long-term loss of a rural retail outlet is likely to involve significant extra travel.

6.4.3. Losses to the supplier may occur due to businesses being unable to obtain supplies or to distribute finished products. If other shops or factories can supply products or provide distribution of products, this is simply a transfer unless those other shops or factories incur higher costs (Appendix A, section A1.4). The sales lost by one company are gained by another. The only exception is when those purchases are made up by additional UK imports or lost exports. Indirect losses do not normally arise from disruption to commercial and retail activity because there are typically many alternative outlets offering the same services immediately. This need only be considered in exceptional circumstances, for example when highly specialised products are involved. A description of any significant impacts may be sufficient, although if desired indirect effects can be quantified using business multipliers (see Environment Agency 2010b).

6.4.4. There may also be indirect impacts due to closure of businesses. Where a business is expected to close rather than relocate, there may be some knock on effects on trade as well as social impacts. These damages do not need to be quantified, but any potential significant effects should be described.

## 6.5. **Temporary and semi-permanent structures**

6.5.1. For temporary and semi-permanent structures, the real economic value of losses may be very different from current market values. For example, the economic value of a caravan on a particular site is equivalent to the cost of moving it there and establishing the site, not the value of the unit itself, which could be retained if it were relocated elsewhere.

6.5.2. For the 'do nothing' case, it should normally be assumed that a caravan could be relocated. The economic loss would then be limited to the cost of removal together with the loss of installed infrastructure, depreciated as appropriate. Where a site is to be protected, the 'do something' damages should be calculated in the normal way, taking into account the seasonal nature of occupation. Similar considerations will apply to other temporary or relatively short-life structures, such as most amusement park rides.

6.5.3. 'Park homes' (residential mobile homes), however, may be treated differently to other types of caravan as they cannot be easily moved and may

be written off at flood depths of over 60cm. Further guidance is published in the MCM.

6.5.4. In specific cases, a caravan park may provide important support to another feature (such as tourism) or the revenue of another operation (such as an associated harbour). Moving the caravan park may not be possible within the local area and may therefore have significant impact on the sustainability of other values in the area. It is important that the overall interaction of features are identified and recorded. Information of this type may be particularly significant in drawing comparison between options.

6.5.5. In assessing economic damages, caravans, mobile homes, chalets or other temporary buildings or structures should be considered as depreciating assets worth, on average, only half their replacement cost.

## 6.6. **Emergency costs**

6.6.1. A range of organisations may incur emergency costs in tackling flooding and in the recovery process, including: police authorities, ambulance services, fire services, local authorities, voluntary services and the armed forces. The costs are above and beyond the normal operating costs for these organisations. Estimates for these costs are generally calculated as a proportional factor of property damages. See the MCM for further guidance.

## 6.7. **Infrastructure**

6.7.1. Infrastructure includes structures and assets associated with:

- Provision of energy;
- Provision, treatment and removal of water and removal of waste water;
- Waste management and recycling;
- Transport;
- Healthcare;
- Education and community facilities.

6.7.2. The impacts on both national infrastructure and on infrastructure of local or regional importance should be considered. In accounting for infrastructure losses, the following should be considered:

- Number and type of infrastructure affected;
- The area served by the infrastructure;
- Spare capacity of existing and alternative infrastructure;
- Opportunities to divert or redirect services;
- Permanent loss of infrastructure.

Disruption from and damage to transport infrastructure (notably main road and rail routes) is considered in Section 6.8.

6.7.3. The damages to infrastructure can be direct (physical damages to the content and or fabric of the infrastructure) and indirect (the implications of the loss of services).

6.7.4. For certain infrastructure (e.g. schools, village halls, sewage treatment works), direct damages to the building itself can be calculated using the non-residential property depth-damage data published in the MCM (Section 6.2). However, generalised depth-damage data can be misleading for some infrastructure as it can be highly individualised and site surveys may be required, particularly for hospitals. Types of infrastructure that may require site surveys are identified in the MCM.

6.7.5. The loss of services provided by the infrastructure should be considered, bearing in mind that potential impacts may well extend beyond the area directly affected by flooding. There may also be knock-on social effects, such as health impacts or community disruption. Methods exist for estimating the monetary economic value of loss of services such as power supply. For the purposes of flood risk management appraisal, however, a qualitative or quantitative assessment of any significant impacts will usually be sufficient. Further guidance is published in the MCM.

6.7.6. Embankments constructed primarily as flood defences have a functional value only in terms of the protection that they provide. Including a value for such assets is likely to lead to double counting. However, they may also have a marginal use value for recreation, which may be taken into account (Section 7.5).

## 6.8. **Transport**

6.8.1. Flood damage to transport infrastructure and disruption of transport networks can result in significant losses.

6.8.2. When assessing direct damage to transport infrastructure, the appraisal should consider the type of infrastructure, its relative importance (e.g. local or national), and the duration and permanency of any impacts. European average road damage costs may be found in Annex 3 Table 18 of Doll and Sieber (2011); other damages are published by in the MCM. Locally derived repair costs may be used if deemed more appropriate.

6.8.3. Road disruption, although may be significant, is difficult to estimate as it is location specific. It will not generally be worth evaluating these unless:

- A major through-road is closed during a flood of at least 10% AEP (1 in 10 year flood event); or
- Diversions are very long or non-existent; or
- Road disruption is a key driver for managing flooding.

6.8.4. If flooding is expected with 20% AEP (1 in 5 year event) or greater, and a significant part of the network carrying through-traffic is affected, the benefits of reducing disruption can be large, both in total and as a proportion of all benefits. Traffic that usually uses the roads will have to divert (if possible), and may have to travel further, and/or for longer, incurring both resource and time costs. Since the speed of traffic depends on volume, the normal traffic on the diversion routes will also travel more slowly, again increasing such costs.

- 6.8.5. One problem is that of identifying the diversion routes. Another is that the progressive development of flooding may induce a cascade of traffic diversions as one road after another is closed. Further, standard volume-speed relationships are not intended for highly congested traffic, and their application out of context can give misleading results.
- 6.8.6. Methods and guidance are available to help calculate the difference in the resource and time costs of using the road network under different flooding conditions, and to address the special problems of calculating the costs of flood-induced traffic disruption. The MCM provides guidance on how to take account of the costs of road traffic disruption.
- 6.8.7. Disruption to rail networks can also give rise to substantial economic costs. The MCM provides guidance on how the economic costs of rail delays can be calculated.
- 6.8.8. Transport by air and water may be also affected by flooding. If impacts are likely to be significant, then these should be captured at least in qualitative form. Whether it is appropriate to quantify or monetise these impacts will depend the type of decision to be made and the available data. The following information may be useful:
- The number, length and type of transport affected;
  - The number of passengers and/or freight carried;
  - Whether there are alternative routes (either by the same transport type or other means).
- 6.8.9. Impacts on transport from flooding may also give rise to knock-on effects, such as 'social' impacts (e.g. health impacts or community disruption). These effects should be considered within appropriate categories. Any effects due to flooding of evacuation routes or infrastructure used in emergencies (e.g. airports or heliports) will also need to be captured.

## 6.9. **Agriculture**

- 6.9.1. Flooding and actions to manage flood risk can impact significantly on agriculture and agricultural production. The MCM and Defra (2008a) contain guidance on how to take account of impacts on agriculture. The guidance advises on the approach for valuing the following scenarios:
- Where land is abandoned or no longer fit for agricultural use for the foreseeable future;
  - Where there are occasional losses of output as a result of flooding;
  - Where agricultural output per hectare either falls or rises (a more permanent change in output than the occasional losses in the previous scenario).

Note that different flood management options might have different impacts on agricultural land depending on the type of output – for example, a flood warning scheme would be expected to provide greater benefits to pastoral land rather than to arable land.

6.9.2. Where land is lost from agriculture, Defra recommends that the loss should be considered as the market value of the land less the present value of Single (Farm) Payments.

6.9.3. Where occasional losses of agricultural output are expected, appraisers may find the following datasets useful for calculating damages:

- Centre for Ecology and Hydrology (2011) Land Cover Map 2007;
- James Hutton Institute (1982) Land capability for agriculture.

Appraisers should consider whether changes in land use over time may affect the flood damage estimates.

6.9.4. Additional guidance on the appraisal of flood risk management for agriculture is also provided in the MCM. Appraisers should seek further guidance from the Scottish Government when valuing impacts on agricultural land for:

- High level strategic assessments;
- Large scale schemes of more than 10,000 ha;
- Less favoured areas where there could be impacts on farming communities and local economies.

#### 6.10. **Future land use: development and regeneration**

6.10.1. The impact of flooding on land uses other should also be considered – for example, impacts on development or regeneration.

6.10.2. Any benefits arising from providing flood protection to potential new land use development (including the intensification of existing land uses), should normally be excluded from the appraisal. The primary reason for this exclusion is to preclude Government funding of works which would enable land to be developed for private gain. Where land has been identified for development and agreements are in place, or where construction has commenced, then damage to the proposed development can be taken into account in the appraisal. Brownfield sites should be valued on damages to their current use, except where agreed local development plans or full planning permission are in place. Whether the future development would increase risks should also be considered.

## 7. Assessing social impacts

### 7.1. Introduction

7.1.1. Flooding can have a wide variety of social impacts, such as impacts on human health and wellbeing (e.g. risk to life, exposure to contaminated water, long term stress and anxiety), loss of irreplaceable items and loss of community. Reference material for understanding the social impacts of flooding is listed in Box 7.1.

7.1.2. Social impacts arise as a consequence of actions to manage flood risk. For example: provision of flood warning can help to reduce worry about future flooding (Werritty *et al.* 2007); some engineered and natural flood management actions can create recreational opportunities.

7.1.3. Engagement with affected communities can help provide insight into the negative and positive impacts of options by drawing on local knowledge. Local authority social services, community groups and the voluntary sector may also be able to help describe and quantify the impacts.

#### Box 7.1: Reference material for understanding the social impacts of flooding

- Kazmierczak A, Cavan G, Connelly A and Lindley S (2015) Mapping Flood Disadvantage in Scotland 2015. Scottish Government, Edinburgh.
  - Main report: <http://www.gov.scot/Publications/2015/12/9621>
  - Methodology report: <http://www.gov.scot/Publications/2015/12/9277>
  - Research findings: <http://www.gov.scot/Publications/2015/12/1746>
  - Maps: <https://www.arcgis.com/home/item.html?id=2061e4a5ba134fe3ba3afb58de2c3079>
- Houston D, Werritty A, Basset D, Geddes A, Hoolachan A and McMilan M (2011) Pluvial (rain-related) flooding in urban areas: the invisible hazard. Joseph Rowntree Foundation, York. <https://www.jrf.org.uk/report/pluvial-rain-related-flooding-urban-areas-invisible-hazard>
- Werritty A, Houston D, Ball T, Tavendale A & Black A (2007) Exploring the social impacts of flooding and flood risk in Scotland. Scottish Executive Social Research, Edinburgh. <http://www.gov.scot/Publications/2007/04/02121350/0>

### 7.2. Risk to life

7.2.1. Whilst deaths from the flooding in the UK have fortunately been rare, it is still sensible to assess whether floods in a particular situation pose a high risk to life. Reducing risk to life, therefore, may be a key consideration when comparing options.

7.2.2. Risk to life is assessed using a function of depth and velocity. Defra (2008b) published a method that can be used to calculate the potential

number of casualties and also to assign a monetary value to loss of life. Care should be taken to ensure that there is sufficient confidence in the flood hazard data before making this assessment.

- 7.2.3. There may be significant risk to life due to local flood characteristics arising from wave overtopping. This is not considered in the Defra (2008b) method and so should be considered on a case-by-case basis.

### 7.3. **Flood impacts on human health**

- 7.3.1. The short and long-term health impacts of flooding may be significant, especially for vulnerable households, but can be difficult to quantify in monetary terms.

- 7.3.2. Guidance provided by Defra (2004) indicates that the value of avoiding the health impacts of flooding is of the order of £200 per year per household. This value (uplifted to present day values) can be used for more strategic appraisals. For more detailed (feasibility and design) appraisals, where information on baseline and 'do something' standard of protection is known, Defra's (2004) risk reduction matrix may be used instead.

- 7.3.3. The values published by Defra (2004), however, should be used with caution as they capture only part of the intangible health benefits of reducing flood risk and are likely to be an underestimate. This is an evolving topic of research and new values may become available (See discussion in the MCM).

### 7.4. **Social vulnerability to flooding**

- 7.4.1. Different people will vary in the degree to which their health and wellbeing would be negatively affected if they are exposed to flooding. A body of research has identified a range of factors (e.g. age, health, income, home ownership, housing type, green space) that can influence flood vulnerability (e.g. Kazmierczak *et al.* 2015; Lindley and O'Neill 2013; Houston *et al.* 2011; Tapsell *et al.* 2002).

- 7.4.2. Recent research commissioned by the Scottish Government has examined social vulnerability to flooding in Scotland (Kazmierczak *et al.* 2015). The research has produced maps of social vulnerability and flood disadvantage: these are available as GIS files and can be used to help understand the nature of the flooding problem and to support and evaluate flood risk management decisions.

### 7.5. **Recreation**

- 7.5.1. Some flood risk management options may affect the value of a river or the coast for recreational uses. For strategic appraisals, an assessment of impacts on recreation is likely to be qualitative. At more detailed (feasibility and design) stages of appraisal and where there are significant gains or losses, impacts on recreation should be included in the benefit-cost analysis



as far as possible. Where only marginal changes in recreation or amenity are likely, such valuations will seldom be worthwhile. Further advice on considering such impacts is provided in the MCM.

7.5.2. Note that where recreational value is a significant part of the total benefits, a contingent valuation study may be necessary to derive a site-specific value of enjoyment. These studies, however, can be complex.

## **8. Assessing environmental impacts**

### **8.1. Introduction**

8.1.1. Flooding can have both positive and negative impacts on the environment. Floods are fundamental to the ecology of floodplains and wetlands and the development of river features. But flooding can also have negative environmental impacts: some species and habitats can be damaged by sediment, pollutants or salt in flood water or by the action and movement of flood water itself.

8.1.2. Actions to manage flood risk can have environmental impacts, for example, through changes in land use, alterations to channel morphology, impacts on habitats and species, and impacts on greenhouse gas emissions. Sensitively designed flood risk management actions can make a significant contribution to the environment and appraisers should look for opportunities to deliver multiple benefits.

8.1.3. Early consideration of environmental and heritage protection (Box 4.1) will allow appraisers to identify any negative impacts, take steps to avoid, minimise or mitigate for those impacts, and include the costs of these steps in the appraisal. Furthermore, it can help to identify opportunities to contribute to environmental enhancement.

### **8.2. Assessing impacts on environmental receptors**

8.2.1. Many options, whether 'do something' or 'do nothing', will have significant environmental consequences. In some cases, protecting one site may have consequences for another and a decision will have to be made on their relative values. In other cases, environmental losses may be unavoidable, for example, in reducing the risk of loss of life. An auditable record of the assessment and decision-making process will therefore be required.

8.2.2. Appraisers should assess both the positive and negative impacts of options on the environment: this includes the impacts as a result of changes to flood hazard and from wider impacts. This guidance identifies aspects of the environment that might be impacted (grouped by the topics commonly used for SEA and EIA to assist with integrating statutory impact assessment into the decision-making process). It is not exhaustive and references are provided to other sources of information (Box 8.1)

8.2.3. Consultation with Scottish Natural Heritage, SEPA, Historic Environment Scotland and other stakeholders is recommended at an early stage to help maximise potential benefits and avoid or minimise adverse impacts.

## Box 8.1: Reference material for assessing environmental impacts

### State of Scotland's environment

- Scotland's environment web <http://www.environment.scotland.gov.uk>: contains a wide range of information and data on the state of Scotland's environment, including pressures and trends, which can be used to help inform appraisal.

### Guidance for valuing environmental impacts

- The 'Multi Coloured Manual' (MCM) (Penning-Rowsell *et al.* 2013): guidance on assessing environmental impacts of flood risk management actions.
- Supplementary HM Treasury Green Book guidance (and references therein) covering the consideration of environmental impacts in policy appraisal: <https://www.gov.uk/government/publications/green-book-supplementary-guidance-environment>

## 8.3. Frameworks for assessing impacts

8.3.1. Using a framework to consider the impacts of actions on the environment can help ensure that all significant impacts are identified and brought into the appraisal. The key purpose is to ensure that these impacts are considered as part of decision-making.

8.3.2. One framework is the ecosystem services framework (UK National Ecosystem Assessment (2011, 2014)). The ecosystem service approach involves valuing the environment according to the range of goods and services it provides to people. Where an option alters the quantity or quality of ecosystem services provided, the impact of the changes should be comprehensively assessed and, where possible and proportionate, quantified and or valued (this may be in monetary terms).

8.3.3. It is recognised that there can be considerable complexity in understanding and assessing the causal links between a policy or intervention, its effects on ecosystems and related services and then valuing the effects. Integrated working with policy, science and economics disciplines will be essential in implementing this approach in practice. The critical importance of the links to scientific analysis, which form the basis for valuing ecosystem services, needs to be recognised.

## 8.4. Valuing environmental impacts

8.4.1. Appraisers should decide whether it is proportionate to attempt to put a monetary value on environmental impacts. For many appraisals, the use of non-monetised assessments is likely to be sufficient to support decision-making. There are a variety of techniques available that allow these impacts to be considered for example by assigning categorical data, counts, scores, or other qualitative data.

8.4.2. Where environmental costs and benefits are valued in monetary terms, these impacts can be brought into a benefit-cost analysis. As many aspects of the environment are not traded in markets and therefore remain unpriced, the relative economic worth of these goods or services may be assessed using quantitative non-market valuation techniques (such as willingness to pay or contingent valuation). The type of valuation technique chosen will depend on the purpose of the appraisal, the aspect to be valued, as well as the quantity and quality of data available. Some valuation methods may be more suited to capturing the values of certain environmental aspects than others. HM Treasury Green Book (2011) and supplementary guidance (and references therein) provide further information on valuation methods.

## 8.5. **Water environment**

8.5.1. Actions to manage flood risk can impact both positively and negatively on the water environment. Given the emphasis on delivering multiple benefits, appraisals should consider the impact on water quality and on coastal/channel morphology, including the potential for contributing to objectives set out in River Basin Management Plans (developed for the EC Water Framework Directive under the Water Environment and Water Services (Scotland) Act 2003). Information on the current chemical and morphology status and objectives for water bodies is available on the SEPA website.

8.5.2. Actions that help to minimise urban and rural pollution can help to protect drinking water quality and bathing water quality. Data are available from the Drinking Water Quality Regulator<sup>5</sup> and SEPA<sup>6</sup>.

## 8.6. **Biodiversity, flora and fauna**

8.6.1. Flooding can have positive and negative impacts on biodiversity, flora and fauna. Some types of habitats and species are dependent on periodical flooding. Damage, however, may result from extended water submersion, from the release of sediment or pollutants (e.g. from sewage or from flooding to sites regulated under the Pollution Prevention and Control (Scotland) Regulations 2012), or from exposure to salt water due to coastal flooding. Therefore, appraisals should consider how any changes to flood hazard will impact on habitats and species.

8.6.2. Actions can also impact on biodiversity, flora and fauna, for example through the footprint of the action, through disturbance during construction / operation / maintenance, through impacts on supporting habitats, or through changes to natural processes. These positive and negative impacts should be considered in appraisal.

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<sup>5</sup> Drinking Water Quality Regulator <http://dwqr.scot/>

<sup>6</sup> SEPA: Bathing Waters: <http://apps.sepa.org.uk/bathingwaters/Index.aspx> [accessed 26/10/2015]

8.6.3. Appraisals should consider the impacts on protected sites and species, and also on wider biodiversity and habitat connectivity, for example:

- Impacts on internationally protected sites. Particular reference should be given to impacts on Natura sites. Habitats Regulations Appraisal may be required (see Box 4.1);
- Impacts on nationally protected sites and species including: Sites of Special Scientific Interest (SSSIs); Nature Marine Protected Areas; Species listed in Schedule 1 (birds), Schedule 5 (other animals), and Schedule 8 (plants) of the Wildlife and Countryside Act 1981;
- Impacts on species or habitats listed in the Scottish Biodiversity List<sup>7</sup>;
- Impacts on species or habitats listed in Local Biodiversity Action plans;
- Impacts on habitat connectivity.

Further information on protected sites and species and links to data can be found on the Scottish Natural Heritage website<sup>8</sup>.

## 8.7. Air and soil

8.7.1. Appraisers should consider whether the options are likely to have significant effects on air quality, both in the short and long-term. For example, green infrastructure may provide benefits to air quality (Forest Research 2010).

8.7.2. Appraisals should also consider the impacts of options on soil and geodiversity<sup>9</sup> (including rocks, minerals and landforms). Soil quality can be affected by pollution, vegetation cover, erosion, acidification, compaction and soil sealing.

## 8.8. Climatic factors

8.8.1. Part 4 of the Climate Change (Scotland) Act 2009 places duties on public bodies relating to climate change. The duties in the Act (Section 44) require that a public body must, in exercising its functions, act:

- In the way best calculated to contribute to delivery of the Act's emissions reduction targets;
- In the way best calculated to deliver any statutory adaptation programme; and
- In a way that it considers most sustainable.

The Scottish Government (2011c) has produced guidance for public bodies on how to put their duties into practice.

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<sup>7</sup> Biodiversity Scotland <http://www.biodiversityscotland.gov.uk/advice-and-resources/scottish-biodiversity-list/> [accessed 26/10/2015]

<sup>8</sup> Scottish Natural Heritage: Protecting Scotland's nature: <http://www.snh.gov.uk/protecting-scotlands-nature/>; Habitats networks and spatial ecology <http://www.snh.gov.uk/land-and-sea/managing-the-land/spatial-ecology/> [accessed 26/10/2015]

<sup>9</sup> Scottish Natural Heritage: Safeguarding geodiversity <http://www.snh.gov.uk/protecting-scotlands-nature/safeguarding-geodiversity/> [accessed 26/10/2015].

8.8.2. Appraisals should consider the impacts of greenhouse gas emissions associated with different options. This should include the greenhouse gas emissions that are associated with implementing and maintaining the option (e.g. construction and land use change) and those associated with recovery from flooding.

8.8.3. Qualitative comparisons of greenhouse gas emissions may be sufficient for strategic and feasibility appraisals, whereas for more detailed design it may be appropriate to quantify and even value greenhouse gas emissions. When determining whether to describe or quantify greenhouse gas emissions, appraisers should consider whether the difference in emissions between options is likely to be significant (e.g. when comparing two options that differ greatly in the quantity of concrete such as a concrete versus earth embankment). Supplementary guidance to the HM Treasury Green Book provides rules for valuing energy usage and greenhouse gas emissions (DECC 2014).

8.8.4. Guidance on assessing the impacts of and adapting to climate change is provided in Sections 4.6.5 and 9.8.

## 8.9. **Landscape**

8.9.1. The assessment of environmental impacts should include the consideration of impacts on landscape; encompassing all the external environment including cities, towns, villages and the wider countryside. It is a combination of the visual dimension with other factors including geology, topography, soils, cultural heritage, land use, ecology, and architecture that together determine its overall character. It is therefore part of our natural, social, and cultural heritage resource base in both urban and rural areas. Landscape is dynamic, continually evolving in response to natural and man-induced processes. There may be significant overlaps with social impacts such as sense of belonging and sense of place.

8.9.2. Scottish Natural Heritage has published a range of guidance and tools on how to manage and assess landscape change<sup>10</sup>. The Landscape Institute (2013) publish guidelines on assessing the landscape and the visual impacts of development projects. Appraisers should also consider engaging with local communities when assessing impacts on the landscape.

## 8.10. **Cultural heritage**

8.10.1. Cultural heritage includes historic buildings, parks, gardens and landscapes, palaeo-environmental and geo-archaeological remains (as indicators of past climates, vegetational and landscape change) and archaeological remains (including wrecks). It can be impacted by flooding and also by actions to manage flood risk.

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<sup>10</sup> Scottish Natural Heritage: Looking after our landscapes <http://www.snh.gov.uk/protecting-scotlands-nature/looking-after-landscapes/> [accessed 26/10/2015]

8.10.2. Some cultural heritage sites have specific protection under legislation and policy, including:

- UNESCO World Heritage Sites;
- Listed Buildings;
- Scheduled Monuments;
- Inventory of Gardens and Designed Landscapes;
- Battlefields;
- Historic Marine Protected Areas;

Information and further advice can be sought from Historic Environment Scotland.

8.10.3. Appraisal of impacts on cultural heritage should consider impacts on:

- The physical asset;
- Its setting;
- Its inter-relationships with other historical assets;
- Areas where there may not be any known physical assets but where there is potential for archaeological finds (including where any works could disrupt or damage hidden archaeology, including wetland archaeology);
- The importance of the asset for the community.

8.10.4. The Scottish historic environment policy (Historic Scotland 2011) sets out a framework and principles to help assess, protect and minimise damage to the historic environment.

8.10.5. Flood damages to listed buildings may be captured as part of the depth-damage assessment of residential and non-residential properties so care should be taken not to double count these impacts. This assessment, however, may not capture the full range of impacts on listed buildings:

- Damages to contents and building fabric may be underestimated (depending on the specific building characteristics and usage);
- The importance of the asset from a social perspective is not recognised.

8.10.6. In many cases a qualitative or quantitative approach will be an appropriate way to capture impacts. However, where impacts to cultural heritage are likely to be significant and will affect decision-making, the appraisers should consider whether it is worthwhile deriving a proxy or contingent economic value for the impacts on the asset. There may also be benefits transfer values available that can be used to monetise impacts on cultural heritage. Consultation with appropriate specialists is recommended if using these approaches.

## **9. Estimating flood risk management benefits**

### **9.1. Introduction**

9.1.1. Guidance is provided here on how to estimate the flood risk management benefits of different options.

9.1.2. A summary of the key steps is shown in Figure 9.1. These are:

- Establish the expected flood hazard for each option;
- Describe, quantify and, where appropriate, monetise the expected damages for the baseline and the 'do something' options;
- Construct loss-probability curves for monetary damages;
- Estimate flood risk benefits (damages avoided) for 'do something' options.

### **9.2. Expected flood hazard**

9.2.1. The baseline ('do nothing' or 'do minimum') flood hazard needs to be established, along with the expected flood hazard for the 'do something' options, for a range of exceedance probabilities (see Section 9.5). Flood hazard can include the consideration of the depth, extent, velocity and duration. Appraisers will need to select the most appropriate components of flood hazard to assess, based on the type of appraisal and the site in question. SEPA (2015a) provides more guidance on modelling the flood hazard for strategic, feasibility and design studies.

9.2.2. Changes in flood hazard both upstream and downstream of the action and/or along the adjacent coastal areas must also be assessed (see Section 5.4 for consideration of spatial boundaries).

9.2.3. Not all 'do something' options will lead to a change in flood hazard. Non-structural actions such as flood warning or property level protection typically alter the impacts of flooding rather than flood hazard itself (Section 9.3.5).

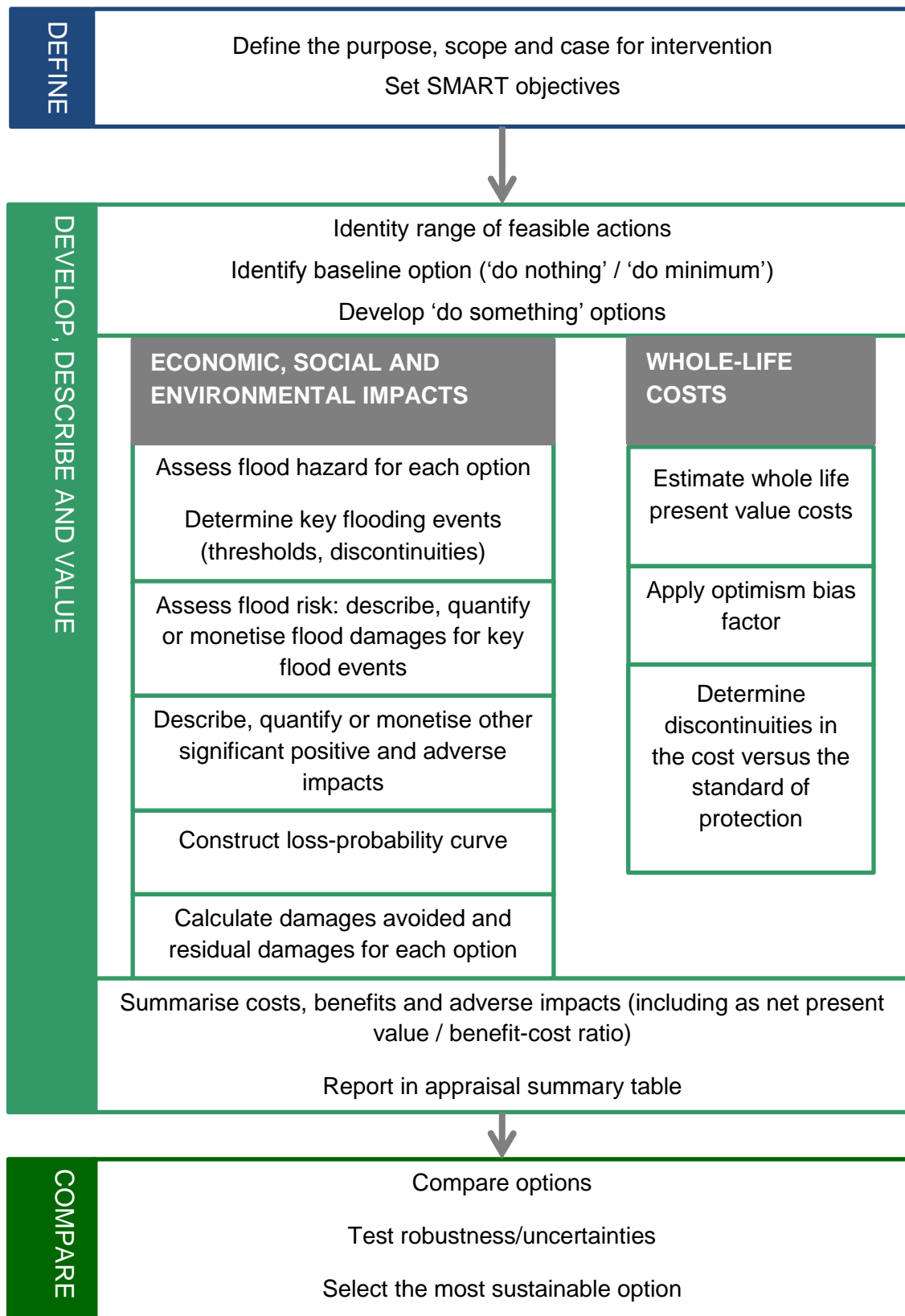
### **9.3. Changes in flood damages**

9.3.1. Having established any changes to flood hazard, the appraisal should then estimate the change in flood damages under the 'do something' options compared to the baseline. This will need to be assessed for a number of exceedance probabilities (return periods) for each option.

9.3.2. The benefits of flood risk management are estimated as the flood damages avoided by the 'do something' option compared to the baseline option. For monetary benefits, these are usually presented as the expected value of annual average damages avoided. For non-monetary benefits, this information needs to be presented and summarised in a descriptive or quantitative way.



**Figure 9.1: Flow chart for flood risk management appraisal**



- 9.3.3. The appraisal must also consider where flood hazard might lead to an altered flood risk upstream and downstream of the action and/or along the coast (Section 9.2.2). Any remedial action required to address an increase in flood risk elsewhere should be considered as a cost (see Appendix 1, Section A1.3).
- 9.3.4. Where flood damages can be expressed in monetary terms, then flood damages for a selection of return periods can be used to construct loss-probability curves (Section 9.5). For non-monetised impacts, damages should be described and, if possible, quantified and reported for different exceedance probabilities where appropriate.
- 9.3.5. Where non-structural actions, such as property level protection or flood warning, lead to changes in flood impacts rather than flood hazard, the benefits may be captured by altering the expected losses for a range of exceedance probabilities. (See, for example, the strategic assessment of flood risk management benefits of property level protection by JBA (2014)). Further guidance is provided in the MCM. Where large components of the benefits may be expressed in non-monetary terms rather than monetary terms, multi criteria approaches may be particularly useful.

#### **9.4. The upper limit to damages**

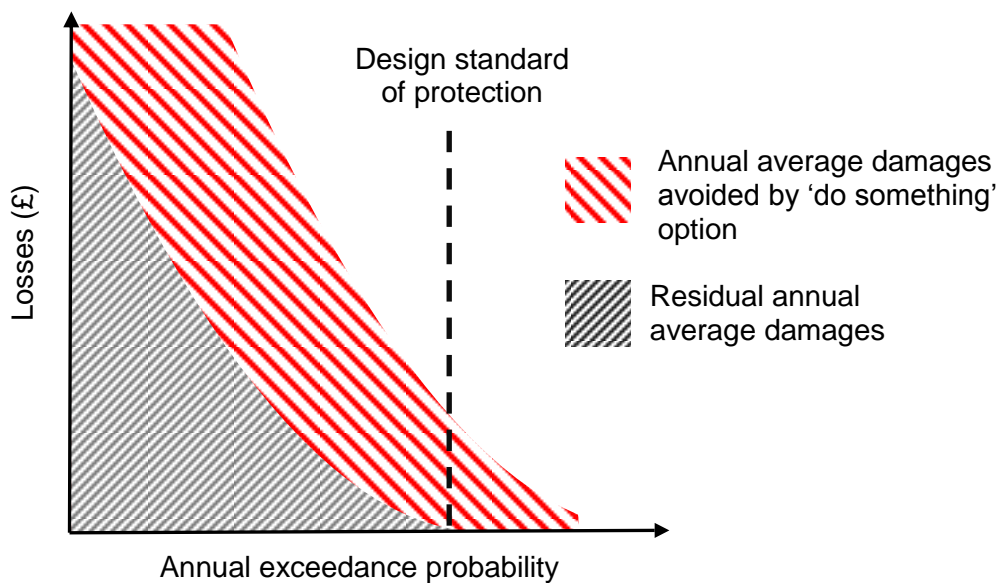
- 9.4.1. Care should be exercised where the total present value of damages exceeds the current write-off value of the receptor. For residential and non-residential properties, this is discussed in Section 6.2.
- 9.4.2. In the case of other receptors, such as roads, railway lines, pipelines or cables, there is the potential for very large values to be generated for long-term disruption. Theoretically, it would be reasonable to assume that the maximum economic benefit to the receptor will be equal to the economic cost, depreciated to allow for the age of the existing receptor, of reconstructing an equivalent facility at a higher level, or on an alternative alignment, which avoids the flood risk. However, appraisers should avoid investing disproportionate time in estimating a capping limit for these damages, particular as the costs of relocating these types of receptors are likely to be extremely high and rarely less than the expected damages.

#### **9.5. Constructing loss-probability curves for monetary damages**

- 9.5.1. Loss-probability curves are used to determine the difference in monetary damages between the baseline and a 'do something' option. The value of annual flood damages is calculated as the probability of a range of events multiplied by the damage caused for such an event.

9.5.2. In practice, the benefits are measured by the difference in the areas under loss-probability curves for the baseline and 'do something' options. This difference in area is the expected value of the damages avoided each year over the life of the option (Figure 9.2) – i.e. the annual average benefits. These are discounted over the life of the option to give the present value of the benefits.

**Figure 9.2: Determination of annual average damages avoided**

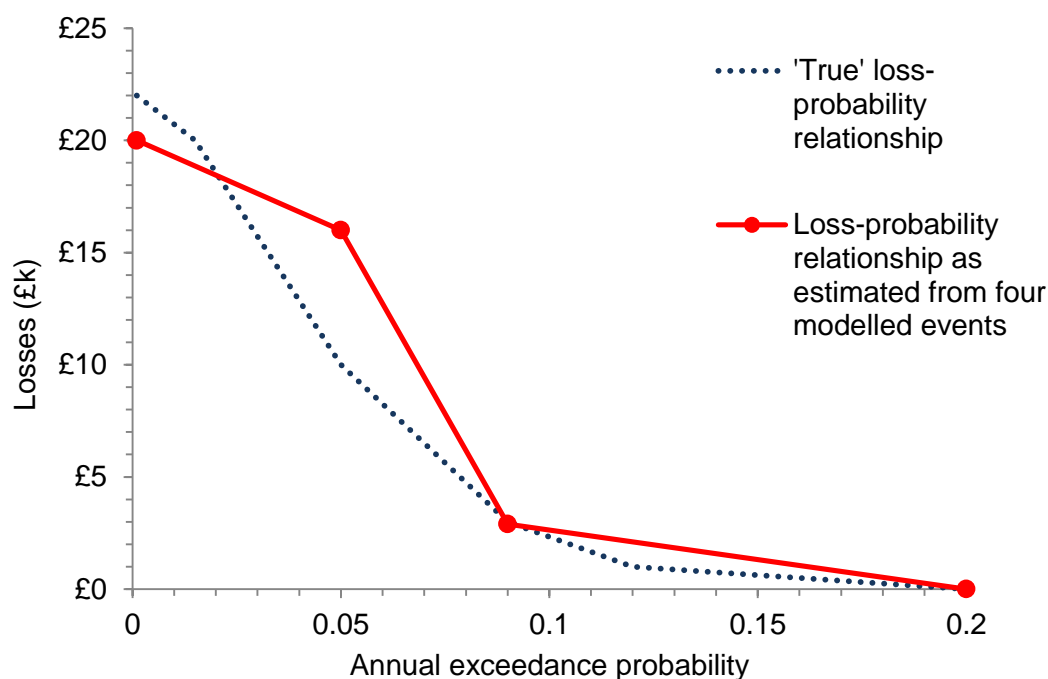


9.5.3. The loss-probability curve is generally calculated using only a very small sample of all possible flood events that might be considered. The overall shape of the curve and the area under it is derived by drawing straight lines between the calculated points. This can, potentially, result in wrong estimates of the area under the curve. In Figure 9.3, the choice of flood events when compared to the 'true relationship has resulted in a significant overestimate of the overall losses.

9.5.4. Determining how many and which flood events to include is a sampling problem. The aim is to obtain a reasonably close approximation to the loss-probability curve representing an infinite number of flood events if these were to be modelled.

9.5.5. The ideal events to use are those located at the points on the curve where there is a disproportional change in loss compared to the change in probability (i.e. a significant change in the gradient of the loss-probability curve) – these points are known as discontinuities. The easiest way to ensure discontinuities are captured or approximated is to appraise a range of flood events. Computer processing power to deal with multiple modelling scenarios and outputs makes this much easier now than in the past.

**Figure 9.3: Accuracy of estimation of the loss-probability curve**



9.5.6. Judiciously chosen events at appropriate points of discontinuity will generally produce a more realistic result than a larger number at standard intervals. To select the appropriate flood events:

- Firstly, it is important to locate the probability of the threshold flood event: that is, the most likely flood that does not cause any damage. It may be relevant to include events below the threshold event if the option is likely to increase flooding elsewhere (e.g. flooding to agricultural land). This can be determined by reviewing hydraulic outputs.
- Secondly, engineering judgment should be used to assess where the discontinuities are likely to be. For example, discontinuities can be expected when an existing natural or man-made structure is overtopped, or a culvert or bridge reaches its capacity.
- Thirdly, the greatest proportion of benefits generally arises from the floods with highest probability. Consequently, the sampling should usually be biased towards these events.

9.5.7. In terms of good practice:

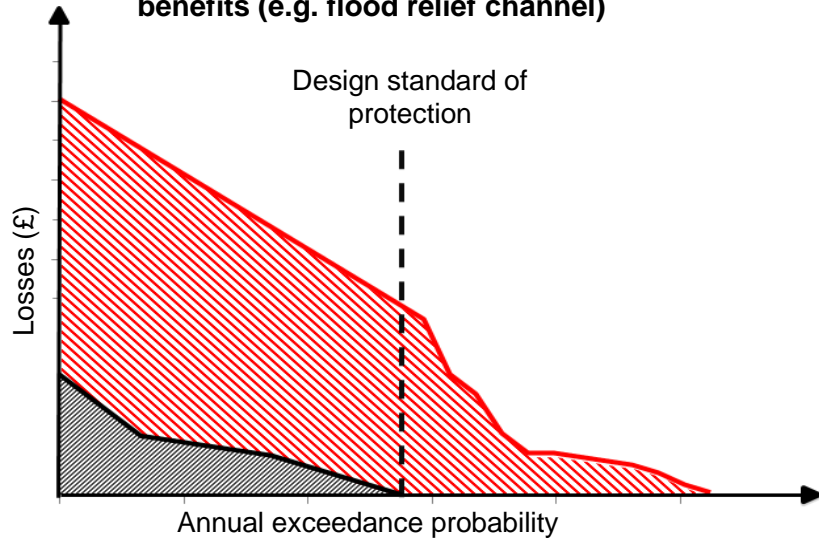
- The benefits should be calculated using a minimum of three events (preferably five) and the choice of those events should be considered carefully;
- One of these events should normally be the threshold flood event;
- One of these events should be beyond the standard of protection to establish the impact of above-design standard benefits (Section 9.6). This is particularly important if the design is to a low standard of protection, otherwise the benefits will be underestimated.

## 9.6. Above-design-standard benefits

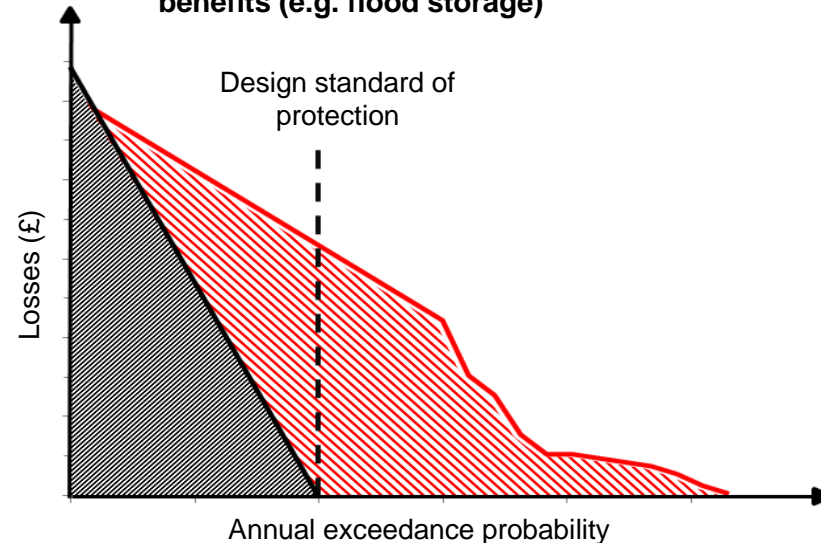
- 9.6.1. Not all actions will have a specified standard of protection but, where they do, the notional standard of protection (design standard) will usually be defined in terms of the onset of significant losses. However, some actions will have an effect on the losses from all floods, even the most extreme, and all of these impacts should be taken into account.
- 9.6.2. It may not always be practical to model the extent of flooding for extreme events (particularly for strategic appraisals). However, failure to take extreme events into account may result in an underestimation of the benefits of an option. In the absence of modelled results, it may be possible to draw logical inferences as to how the action will respond to these extreme events. From this, the potential shape of the loss-probability curve may be estimated.
- 9.6.3. It is important to ensure that the range of events considered is appropriate for fair comparison of all options.
- 9.6.4. Options that increase the capacity of a river channel will result in less water flowing out of the bank for all events with the scheme than without. Consequently, the losses from any particular event with the option should never exceed those without and will normally be less. Two examples are illustrated in Figures 9.4(a) and 9.4(b). In both cases the shaded areas represent the total average annual benefits.
- 9.6.5. For other options, such as those involving walls and embankments that may be overtopped, losses in less probable events can in some cases be more severe than if no action existed. The duration of flooding may be increased, or the velocities of flow resulting from a failure may be greater than from the natural rate of rise of the flood (Figure 9.4(c)). In this case the negative benefits above the design standard should be included to derive the net annual average benefits.
- 9.6.6. For some options, above-design-standard benefits can be a significant proportion of total benefits. They will also have an impact on the incremental benefits of different design standard options. For instance, part of the incremental benefits of a nominal 1% AEP scheme may already be realised in the benefits of the 2% AEP scheme. This illustrates the importance of considering the full range of benefits in all decision-making.

**Figure 9.4: Estimation of above-design-standard benefits**

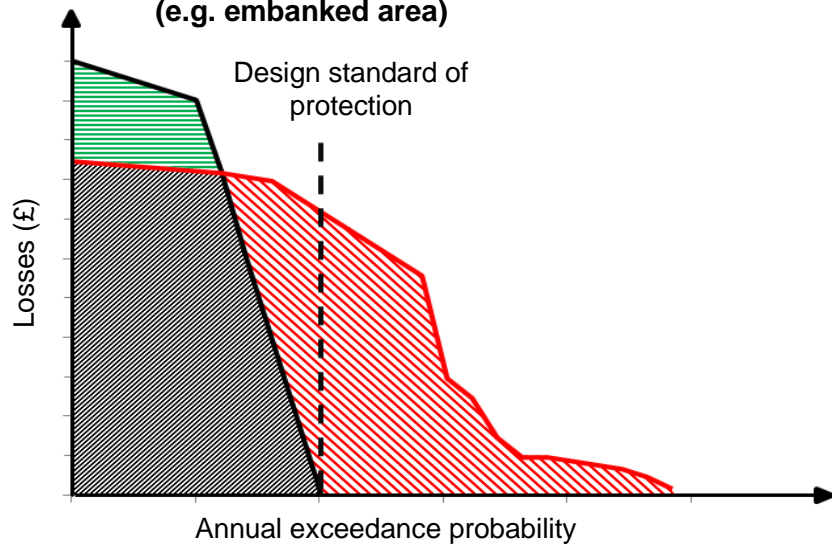
**(a) Option with significant above-design-standard benefits (e.g. flood relief channel)**








**(b) Option with reduced above-design-standard benefits (e.g. flood storage)**



**(c) Option with negative benefits in extreme event (e.g. embanked area)**



-  Loss-probability curve under the baseline option
-  Loss-probability curve under 'do something' option
-  Annual average damages avoided under 'do something' option
-  Residual annual average damages
-  'With-scheme' losses to be deducted from annual average damages avoided by 'do something' option

## 9.7. Freeboard

9.7.1. Freeboard is a factor of safety in flood protection design (usually expressed as height above flood level), which is used to compensate for factors related to the uncertainty in estimating flood hazard (e.g. wave action, localised hydraulic effects).

9.7.2. Freeboard does not change the assumed threshold of flooding used in the appraisal: the benefits of an option should be based on the calculated design standard. For example, if a defence is constructed on the basis of a 1% AEP (100-year) standard of protection, but with an additional crest height to allow for uncertainty in the hydrology and hydraulic analysis, the only benefits to accrue should be those appropriate to the 1% AEP standard.

## 9.8. Future flood risk

9.8.1. Considering flood risk management options against future change in flood risk is essential to be able to select sustainable actions that will stand the test of time and enable adaptation in the future (Section 4.5.5). Drivers of future flood risk include climate change, land use and demographic change<sup>11</sup>.

9.8.2. Climate change in particular poses serious challenges and risks for managing flooding in Scotland. The impacts of climate change include the potential increase in intensity, severity and frequency of rainfall events affecting flooding in fluvial catchments and urban surface water systems. Sea levels are projected to rise, and there may also be a change in the severity and frequency of storm surge and wave events with associated impacts on flood risk (see, for example, Sayers *et al.* 2015).

9.8.3. The appraisal process should seek to fully understand risk in a changing climate and should be in accordance with the Scottish Government's guidance on Public Bodies Climate Change Duties (2011c) and the objectives of the Scottish Climate Change Adaptation Programme (Scottish Government 2014b).

9.8.4. The likely effects of the changing climate should be consistently taken into account in appraisals using up-to-date evidence. There is, however, a relatively large degree of uncertainty in climate predictions that makes it difficult to accurately model and assess risk. It is therefore important that uncertainty is understood, managed and accounted for in the determination of the future scenario(s); so, awareness and use of a probabilistic approach to future assessment of risk might be applied.

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<sup>11</sup> National Records of Scotland Household Projections: <http://www.nrscotland.gov.uk/statistics-and-data/statistics/statistics-by-theme/households/household-projections>

9.8.5. An important consideration when choosing the future scenario(s) is the level of confidence in the overall appraisal, and what degree of confidence is therefore required to make a decision. For example, a more conservative future scenario (e.g. a peak flow which is 'highly unlikely to be exceeded') may be more appropriate to use if the uncertainty in the overall appraisal is relatively high.

9.8.6. When choosing the future scenario(s), other considerations should include the vulnerability of receptors (including the potential change in receptor numbers and density over the time period) and the uncertainty in defining future flood hazard. A proportionate approach should therefore be taken when considering future climate change: where the receptor vulnerability is likely to be high, a more extreme (precautionary) scenario might be considered (e.g. a High emissions scenario) and a more conservative predictive curve used to consider future change in peak flow.

9.8.7. Possible approaches for taking climate change into account in appraisal are described below. Where suitable data is available, future changes in receptors (see Section 9.8.1) can be considered alongside the changes to flood hazard to provide a 'truer' assessment of flood risk.

#### **a) Use existing flood models**

By extrapolating flows, it is possible to estimate how frequently a modelled flood event might occur in the future under climate change. Existing flood damage data can then be used to estimate future flood damages.

#### **b) Model changes in hazard and risk**

Where changes are anticipated in the expected probabilities of flooding over the life of the option, it is possible to calculate a number of different annual average damages corresponding to the different conditions (e.g. 2050s, 2080s). SEPA (2015a) highlights the probabilistic and regional approach, the range of potential peak flow uplifts for a range of scenarios and sets out the scenarios SEPA used in its flood maps.

These estimated benefits can be used in the following ways, depending on the type of study:

- Annual average damages can be calculated for appropriate years, and values interpolated for intervening periods. Benefit-cost ratios can be estimated both with and without climate change.
- A near-future climate change scenario can be factored in the appraisal from the start (as confidence in near-future climate change scenarios is greater than for more distant scenarios).

#### **c) Sensitivity analysis**

For high level strategic studies, sensitivity analyses (Section 11.7) may provide a proportionate approach to initially consider the future impacts of



climate change. The analysis should make best use of available data acknowledging the associated limitations and uncertainties.

Key flood risk indicators (e.g. number of properties at risk) can be estimated as snapshots under the climate change scenarios (for example, 2050s and 2080s) and compared with the current day flood risk estimate. This can help to identify the sensitivities of different areas to help inform selection of actions. The impacts of climate change should then be fully considered in more detailed studies.

## **10. Estimating whole life costs**

### **10.1. Introduction**

10.1.1. Whole life costs are the total costs of an option over its whole life. They takes account of design costs, initial capital costs (including mitigation), operation, maintenance and repair, and (where significant) disposal. They do not include costs already incurred such as investment in preceding studies or defences – these are defined as ‘sunk’ costs, and cannot be recovered whatever decision is taken now.

### **10.2. Cost estimates**

10.2.1. The approach to estimating whole life costs should be risk based and proportionate: in some cases, professional judgement may be sufficient, whereas in others, a more detailed estimate may be required.

10.2.2. The precision of cost estimates will depend on the stage in the flood risk management planning process. Where appropriate, and particularly for strategic and feasibility studies and early stages of design, costs may be quoted as estimate ranges rather than single point estimate figures.

10.2.3. Appraisers should select the best and most appropriate source of information, including the sources listed in Box 10.1 and costs from previous studies and works (e.g. estimates from local authority departments), recent tenders, published articles and estimating price books. The source of the cost estimates should be recorded.

10.2.4. For detailed design, aspects to be considered should include site conditions, location, size, complexity, risks and risk profiles, uncertainties, programming and timing constraints, availability of resources, and construction methodology. Maintenance estimates should allow for storm damage repairs and, where significant, decommissioning costs, in addition to regular planned maintenance/repair/replacement activities.

10.2.5. Where less common items constitute a significant part of the overall cost, it is often necessary to obtain quotations and estimates obtained from operators with commercial experience in that sector in order to make a careful assessment of costs.

10.2.6. Where additional sums are likely to be required for particular areas of work, for example for dealing with poor ground conditions, these should be included but general contingencies should be estimated as part of the process of deriving the optimism bias adjustment (Section 10.8).

10.2.7. As no illegal operations should have been included in the options (Section 4.3), infraction costs (from infraction proceedings, penalties, or fines) should not be included.

Box 10.1: Sources of information for estimating whole life costs	
Type of estimate	Examples
Expert judgement	<ul style="list-style-type: none"> <li>Local authority or Scottish Water officers; consultants</li> </ul>
Strategic estimates	<ul style="list-style-type: none"> <li>JBA (2013) Costs of flood risk management actions. JBA, Skipton. Report commissioned by SEPA (contact: <a href="mailto:flooding@sepa.org.uk">flooding@sepa.org.uk</a>).</li> <li>JBA (2014) Assessing the flood risk management benefits of property level protection. Technical and economic appraisal report. JBA, Skipton. <a href="http://www.gov.scot/Resource/0046/00466212.pdf">http://www.gov.scot/Resource/0046/00466212.pdf</a></li> <li>SEPA (2015b) Natural Flood Management Handbook, SEPA, Stirling. <a href="http://www.sepa.org.uk/environment/water/flooding/developing-our-knowledge/">http://www.sepa.org.uk/environment/water/flooding/developing-our-knowledge/</a></li> </ul>
Previous studies and works	<ul style="list-style-type: none"> <li>Local authority or Scottish Water officers; consultants</li> </ul>
Detailed estimates	<ul style="list-style-type: none"> <li>AECOM (Eds.) (2015) <i>SPON's Civil Engineering and Highway Works Price Book 2016</i>. CRC Press.</li> <li>SEPA (2012) Flood warning improvement project – Phase 3: Work package resource assessment.</li> </ul>

### 10.3. Price indices

10.3.1. Whole life costs are expressed in present value terms. The base year used for pricing should always be stated. When data are not available for that particular year, it will be necessary to use appropriate indices to convert historical prices to the same base (Section 10.3.2; Appendix 1 Section A1.2).

10.3.2. For feasibility studies, costs and benefits can generally be indexed using the HM Treasury Gross Domestic Product (GDP) deflator series<sup>12</sup> as this gives an overall picture of the economy and not just prices. Historic prices (Section 10.3.1) should also be brought up to current values using the GDP deflator series. For detailed design, the Office for National Statistics construction price and cost indices<sup>13</sup> are appropriate for most uses.

10.3.3. Particular components may constitute a large proportion of a project cost or the cost of those components may be expected to vary in real terms over time. In such cases, sensitivity analysis (Section 11.7) should be used to explore the implications for option choice.

<sup>12</sup> <https://www.gov.uk/government/collections/gdp-deflators-at-market-prices-and-money-gdp> [accessed 27/11/2015]

<sup>13</sup> <https://www.gov.uk/government/collections/price-and-cost-indices> [accessed 27/11/2015]

#### 10.4. **Discontinuities in costs**

10.4.1. Costs, as with benefits, may increase in a discontinuous fashion (Section 9.5). For example, this could occur where the form of construction needs to change to accommodate a higher water level for an increased standard of protection. The points at which these steps occur should be examined in detail to assess the standards of protection where benefits may increase without increased costs.

#### 10.5. **Residual values**

10.5.1. Even where an appraisal covers the full expected period of use of flood risk management asset, some assets could have residual value, in an alternative use, in a second-hand market, or as scrap. The HM Treasury Green Book (2011) recommends that these values should be included, and tested for sensitivity, as it may be difficult to estimate the future residual value at the present time.

10.5.2. For the purposes of flood risk management, the residual values should be taken into account in appraisal only where this is required to ensure a fair comparison of different options. The residual value of most assets is likely to be very small, particularly once discounting is applied. Consider, therefore, whether any residual value is going to be significant in terms of the whole life cost and hence whether it is worthwhile spending time calculating it.

#### 10.6. **Mitigation costs**

10.6.1. It may be possible to eliminate or reduce some negative impacts through design or by mitigation. In these circumstances, the cost of mitigation should be included as part of the option costs. The residual impact (the impact that remains following mitigation) will need to be described, quantified and, where appropriate, valued as damages. If mitigation is not possible and actions are required to compensate then these costs should also be included in the option costs.

#### 10.7. **Contributions from others**

10.7.1. The full cost of the project, regardless of who pays for it, should be reflected in the project costs. Any private contributions to the cost should not be deducted. Generally, any windfall contributions (e.g. from developers) only affect the distribution of costs and not the total resources required for the project.

10.7.2. If the benefits associated with the contribution can be reliably separated and excluded from the appraisal, then it would be reasonable to also exclude the contribution. However, it is preferable to include all benefits and costs in the appraisal (particularly when other contributions may also

stem from public money). In this way the benefit-cost analysis will demonstrate whether the option as a whole is justified.

## 10.8. **Optimism bias**

10.8.1. There is a widely recognised, general tendency for early estimates of costs, benefits and time-scales to be overly optimistic when compared with final outturn values. This is termed optimism bias. An explicit consideration of optimism bias is required through (i) the application of suitable uplift factors to early best estimates of options costs, and (ii) sensitivity analysis of predicted benefits (and project time-scales).

10.8.2. The HM Treasury (2013) has published supplementary green book guidance on optimism bias. It provides benchmark optimism bias factors for different project types, including standard and non-standard civil engineering. Higher optimism bias factors may be required at early stages in the appraisal process; the optimism bias factor can be reduced according to the extent to which the contributory factors have been managed.

10.8.3. Historic guidance for flood and coastal defence projects is available from Defra (2003): it contains additional descriptions of the risk components and recommends broadly similar starting values for optimism bias to those recommended by HM Treasury.

10.8.4. For large complex projects, HM Treasury (2015) provides further guidance concerning the allowance of contingency in early project cost estimates.

## **11. Stage three: compare and select the most sustainable option**

### **11.1. Introduction**

11.1.1. Flood risk management decisions should be underpinned by an appraisal of economic, social and environmental impacts, whole life costs, and proper consideration of risk and uncertainty. By balancing these issues, the most sustainable solution should be identified.

11.1.2. The decision must be made in a clear, justifiable and transparent manner based on appropriate and robust information, such that it can be clearly and readily understood by those affected. A well-designed appraisal summary table will assist with this.

### **11.2. The decision process**

11.2.1. When deciding on which option(s) to implement, there are several questions which should be borne in mind:

- Does the option meet the objectives?
- Does the option represent best value for money?
- Does the option deliver multiple benefits? What are the adverse impacts?
- What are the uncertainties and robustness in the appraisal? What are the risks in implementation?

11.2.2. It is important that all impacts (both positive and negative) of an option are taken into account during decision-making. It is therefore necessary to weigh up those impacts that have not been valued in monetary terms and consider whether they are significant enough to change the preferred option from that which would be chosen based on the economic criteria alone.

11.2.3. Decision-making can make use of a combination of approaches (Section 5.2) and not depend on a single metric.

### **11.3. Meeting the objectives**

11.3.1. All options under consideration should meet the agreed objective(s). Information on economic damages and damages avoided as well as quantitative or qualitative information e.g. reduction in risk to life, reduction in damages to environment and cultural heritage) should be used, where relevant, to assess the extent to which the options meet the objective.

### **11.4. Best value for money**

11.4.1. Flood risk management aims to maximise the return on investment. Benefit-cost ratio can be used to identify the option that delivers the best value for money but this must be supported by full and evidenced considerations of non-monetised impacts.

- 11.4.2. Where there is a choice between options offering different standards of protection, the incremental benefit-cost ratio can be used to identify whether the increased investment in a greater standard of protection is actually the most beneficial choice (Section 5.2). Where the incremental benefit-cost ratio of an option is greater than one, it indicates that the additional standard of protection delivers value for money.
- 11.4.3. Where the decision process leads to a preferred option that is not the optimum in terms of benefit-cost ratio, this should be clearly indicated in the appraisal report and a rationale given.
- 11.4.4. Because of the limitations inherent in comparing schemes by use of a single indicator, it is good practice to plot the changes in the different streams of benefits and costs over time (see Box 11.1). This will provide information on economic sustainability.
- 11.4.5. Value for money should not to be confused with the affordability of an option. Affordability is a separate matter relating to availability of funds. An awareness of potential funding mechanisms, however, is likely to be of relevance when making strategic decisions as it will dictate the path of progression for schemes and other actions.

#### **11.5. Wider impacts and delivery of multiple benefits**

- 11.5.1. As emphasised throughout this guidance, the consideration of wider impacts and the delivery of multiple benefits should be an integral part of decision-making. Potentially viable options should not be dismissed just because some of the benefits may be difficult to value. Options delivering the best solution in environmental and social terms should be considered unless they are justifiably unviable.
- 11.5.2. Partnership working and the early engagement of stakeholders can help to identify opportunities to deliver multiple benefits.
- 11.5.3. The results of any statutory environmental assessment (see Section 4.3) will need to be taken account in decision-making. Options may need to be revised or mitigation applied to avoid or minimise significant negative environmental impacts.

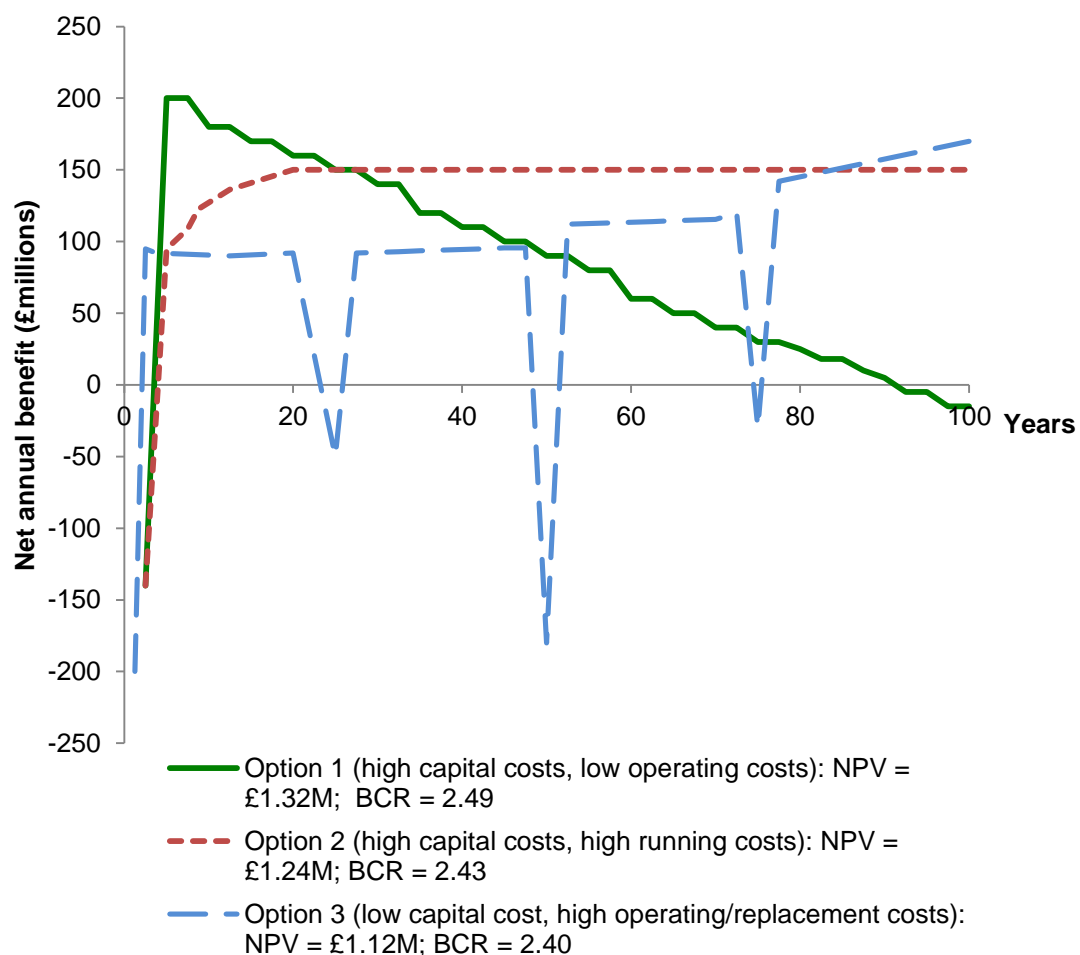
### Box 11.1: Economic sustainability

The economic sustainability of different options can be examined by plotting the distribution of net annual benefits over time (i.e. the difference between expected annual benefits and costs for each year of the scheme life).

Figure 11.1 shows three options with very different distributions of net annual benefits but very similar benefit-cost ratios (BCRs) and net present values (NPVs). Option 1 has (marginally) both the highest benefit-cost ratio and NPV. However, unlike the other two options, the net annual benefits of option 1 are negative in the long run. With option 2 there are some significant initial costs and the benefits are not immediately realised in full, but in the long-term stable benefits are achieved. Option 3, shows increasing benefits over time but also high recurrent costs.

In such a case it would not be appropriate to attach significant weight to the relatively minor differences in benefit-cost ratio or net present value but rather to examine the wider area of economic sustainability. This will help to when considering the impacts of decisions for both current and future generations (Section 1.2.2).

**Figure 11.1: Comparison of options with different expenditure profiles**





## 11.6. **Uncertainties and risks**

11.6.1. Uncertainties and risks will exist at all stages of appraisal including estimates of flood hazard and risk (Box 5.2), estimates of costs and benefits, effectiveness of actions and technical limitations. Section 1 of 'Delivering sustainable flood risk management' (Scottish Government 2011a) provides an overview of managing uncertainty.

11.6.2. The uncertainties in appraisal and the risk profiles of different options should be clearly presented, as these can play a major part in decision-making. The results of sensitivity analysis (Section 11.7) can help to determine the level of risk.

## 11.7. **Sensitivity analysis and robustness testing**

11.7.1. The purpose of sensitivity analysis and robustness testing is to determine whether, within reasonable bounds of confidence and based on the assumptions made:

- The option is economically worthwhile;
- The economic return is likely to be achieved;
- The option choice is robust.

11.7.2. It is important to focus on differences between options as this will help identify which factors are influencing the choice of one option over another. (For major projects, it is particularly important to identify switching points where a change in the assumptions would alter the choice.) Informed judgments can then be made of the relative likelihood of the different outcomes to determine and justify the preferred option.

11.7.3. Having determined the most important factors, assessments of uncertainty should be made on the basis of experience and judgment. As a general guide, a range of possibilities should be considered for items such as:

- Hydraulic modelling or Lidar tolerances;
- Threshold of flooding (many schemes will be sensitive to assumptions about the level, and hence frequency, at which flood damage commences);
- Calculation of extremes and their probabilities;
- Residual flood risk;
- Any single large damage sources;
- Changes to major beneficiaries (for example consider how the damages would change if a major business in the benefit area ceased trading or relocated);
- Any weightings used in the appraisal (for example, social weightings – see Section 6.3);
- Future flood risk (Section 9.8);
- Costs (whole-life capital, maintenance and management) based on the key costs elements and sensitivity to project risk (e.g. changes in costs of key materials or resources).

- 11.7.4. It can be useful to quantify the impacts of uncertainties on the benefit-cost ratios, particularly where the scale of the uncertainty is much larger than tangible difference between options. If, for example, the benefit-cost ratio is highest for an option where there is significant uncertainty, there may be a need to work to resolve the uncertainty. Any remaining uncertainty should be clearly understood in the decision-making process.
- 11.7.5. Where it is not possible to quantify the uncertainty associated with each variable, it should be possible to assess the relative scales of the uncertainties compared with the other options.
- 11.7.6. All major risks should be considered both singly and in combination.

## **12. Post project evaluation**

- 12.1. Post project evaluations demonstrate whether past investment has been worthwhile and has achieved its objectives. The exercise can be considerably eased if the fully documented original appraisal is readily available to evaluators. For example, it will be possible to compare actual performance against the sensitivity analysis in the benefit-cost analysis. This will enable a check on the areas of greatest uncertainty, to see whether variations in practice are within predicted limits.
- 12.2. In undertaking benefit-cost analysis as part of post project evaluation of flood risk management options, it can be difficult to identify realised benefits, which are based on the avoidance of losses which would have occurred had the project not been implemented. Hence, it is difficult to determine whether the actual benefits are equal to those predicted. It will usually, therefore, be necessary to judge success on the accuracy of related predictions such as the costs of construction and maintenance, rates of environmental enhancement or measures of residual damage.

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## 14. Glossary

Term	Definition
Action	An action may consist of a single intervention (e.g. build a storage reservoir) or could be two or more interventions, where the presence of one is essential to the success of another (e.g. demountable defences and flood warning system).
Above-design-standard benefits	The benefits from reductions in flood losses from flood events which exceed the design standard of protection, expressed as an annual average benefit.
Annual Average Damages (AAD)	Depending on its size or severity, each flood will cause a different amount of damage to a flood prone area and we can calculate the cost of this damage. Annual Average Damages for an area are the average costs per year that would occur from flooding over a very long period of time.
Annual exceedance probability (AEP)	Probability that a flood event of specified magnitude will be equalled or exceeded in any year (also see 'return period').
Appraisal	The process of defining objectives, examining options and weighing up the costs, benefits, risks and uncertainties before a decision is made.
Benefits	Positive quantifiable and unquantifiable changes that an action will produce.
Benefit-cost ratio	The ratio of the present value of benefits to the present value of the costs. If the ratio is greater than one then the project is deemed to be economically viable.
Contingent valuation method	A valuation methodology which uses questionnaire techniques to elicit valuations using respondents' willingness to pay for an environmental improvement.
Cost effectiveness analysis	Analysis that compares the costs of alternative ways of producing the same or similar outputs.
Direct damages	Defined in the appraisal process as immediate damages to the receptor as a result of flooding (e.g. damages to the fabric or content of buildings, clean-up costs).
Discounting	The procedure used to arrive at the sum of either costs or benefits over the lifetime of an action using a discount rate to scale down future benefits and costs. The effect of using a discount rate is to reduce the value of projected future costs or benefits to their values as seen from the present day.
Flood extent	The area that has been affected by flooding, or is at risk of flooding from one or more sources.

Term	Definition
Flood hazard	In terms of the Flood Risk Management (Scotland) Act 2009, hazard refers to the characteristics (extent, depth, velocity) of a flood.
Flood risk	A measure of the combination of the likelihood of flooding occurring and the associated impacts on people, the economy and the environment.
Incremental benefit-cost ratio	The ratio of the additional benefit to the additional cost, when two options with different standards of protection are compared.
Indirect damages	Defined in the appraisal process as damages incurred due to the knock on effects of flooding such as disruption, evacuation, costs to emergency services, loss of income or earnings/industrial production. (See also 'direct damages').
Intangible impacts	Those costs and benefits that are not traded in a market (i.e. non-material and/or emotional impacts) and are difficult to assess in monetary terms.
Market price	The price for which a good is bought and sold in a market. If restrictive conditions are satisfied, this price may be used to estimate the economic value of the good. Otherwise, the market price may need to be corrected, and a 'shadow price' derived, in order to estimate the economic value of the good.
Natural flood management	A set of flood management techniques that aim to work with natural processes (or nature) to manage flood risk.
Natura sites	Natura is the term given to Special Areas of Conservation (SACs) and Special Protection Areas (SPAs). These internationally important sites are designated under the EC Habitats and Birds Directives.
Non-residential properties	Properties that are not used for people to live in, such as shops or other commercial or industrial type buildings.
Net present value (NPV)	The stream of all benefits net of all costs for each year of the option's life discounted back to the present date.
Option	An option is a combination of one or more flood risk management actions, developed to meet an objective.
Post project evaluation	A procedure to review the performance of a project with respect to its original objectives and the manner in which the project was carried out.
Present value	The value of a stream of benefits or costs when discounted back to the present time.
Property level protection	Property level protection includes flood gates, sandbags and other temporary barriers that can be used to prevent water from entering individual properties during a flood.

Term	Definition
Receptor	Refers to the entity that may be impacted by flooding (a person, property, infrastructure or habitat). The vulnerability of a receptor can be modified by increasing its resilience to flooding.
Residential properties	Properties that are used for people to live
Residual risk	The risk that remains after risk management and mitigation. This may include risk due to very severe (above design standard) storms or risks from unforeseen hazards.
Return period	A measure of the rarity of a flood event. It is the statistical average length of time separating flood events of a similar size: a 100-year flood will occur on average once in every 100 years. The longer the return period, the rarer the event. (Also see 'Annual exceedance probability').
Risk assessment	Consideration of the risks inherent in a project, leading to the development of actions to control them.
Sensitivity analysis	Analysis of the effects on an appraisal of varying the projected values of important variables.
Standard of protection (SoP)	The flood event return period above which significant damage and possible failure of the flood defences could occur.
Sunk costs	A cost incurred in the past and which cannot be recovered whatever decision is taken now. Consequently, sunk costs are omitted in benefit-cost analyses.
Sustainable flood risk management	The sustainable flood risk management approach aims to meet human needs, whilst preserving the environment so that these needs can be met not only in the present, but also for future generations. The delivery of sustainable development is generally recognised to reconcile three pillars of sustainability – environmental, social and economic.
Transfer payment	A payment which has no impact in terms of an economic analysis (see Appendix 1). Examples are most tax payments and general subsidies.
Wave overtopping	Wave overtopping occurs when water passes over a flood wall or other structure as a result of wave action. Wave overtopping may lead to flooding particularly in exposed coastal locations.

Term	Definition
Whole-life costs	The total costs associated with an action for its full design and potential residual life span, taking proper account of all aspects of design, construction, maintenance, and (where significant) disposal. A particularly useful approach in helping to determine economic sustainability when used to compare the relative costs of long-life actions such as flood defences, and where decisions need to be made between short-term capital costs and long-term maintenance costs.
Willingness to pay	The amount an individual is prepared to pay in order to obtain a given improvement in utility, expressed through the contingent valuation method.

## **Appendix 1: Principles for assessing costs and benefits – further information**

### **A1.1 Principles**

This appendix provided additional information on the principles for assessing costs and benefits:

- Price basis for economic valuation (A1.2)
- What is a benefit and what is a cost? (A1.3)
- Transfer payments (A1.4)
- Discounting (A1.5)

### **A1.2 Price basis for economic valuation**

Economic valuation should be undertaken using real prices; that is, inflation is ignored where 'inflation' has the everyday meaning of the price of a resource increasing without its relative value also increasing. The dates at which any economic data were derived should be established and converted into present values.

Commonly, the relative prices of the different streams of costs and benefits are assumed to be constant over time; this is generally a conservative practice. In reality, they may change over time. Growth factors may be adopted to reflect predicted changes in relative prices or demand. However, if such factors are used for one stream of benefits or costs, they should be used for all streams. Since prices are relative, it follows that, over time, some will fall relative to others. Therefore, any use of selective growth factors should be considered carefully.

Key points are:

- Inflation should be ignored in undertaking the analysis;
- Real prices should be used for all streams of benefits and costs.

### **A1.3 What is a benefit and what is a cost?**

There is no universally agreed basis for classifying a particular item as either a positive cost, or a negative benefit (disbenefit), or vice versa. The particular approach adopted can have a significant effect on the benefit-cost ratio and it is therefore important to have a common rule. The following conventions should be adopted:

- Any 'negative costs' should be regarded as benefits;
- Any 'negative benefits' should be regarded as costs.

The economic benefit for a flood risk management option is the net difference between total present value of damages with and without the option - that is, the damage avoided in comparison with baseline. Any negative benefit, or disbenefit, arising from the option represents a loss to society, and should therefore be treated as a cost. Conversely, resources which become available to society as a result of implementing the option should be regarded as a benefit.

Sales that offset the costs of construction (for example, re-use of material) are to be treated as benefits of the scheme.

Disbenefits such as noise and disruption caused by project works, and obstructions to views, should be treated as costs; but only where these disbenefits are likely to be of significant and where there are significant differences of impact between different options. Otherwise, the costing of the disbenefits is likely to be disproportionate to their magnitude. In general, disbenefits are likely to be better handled when assessing unvalued social and environmental impacts, through which mitigating actions are likely to be identified and included in scheme costs. The residual impact (the impact that remains following mitigation) will need to be described, quantified and, only where appropriate, valued as damages. If mitigation is not possible and actions are required to compensate, then these costs should also be included in the option costs.

Benefit-cost analysis aims to represent the full economic value of the option, and theoretically should include values for indirect and intangible benefits, including those without market value. Further information on the valuation of non-market benefits can be found in HM Treasury Green Book (2011) and supplementary guidance.

Pricing some of these non-market benefits can involve significant resources and it may be proportionate to describe or quantify these impacts instead. Section 11 considers how best to ensure these impacts are still taken into account in decision-making.

Benefit-costs analysis is only concerned with changes in the total value of benefits and the total cost of the resources used. People will often adjust to a flood loss, and do so in a way that minimises their losses. If flooding closes a factory, production may be increased elsewhere and the total national value remains the same. If the alteration simply varies the distribution of benefits and costs across the UK, then no economic change occurs. Changes only in the distribution of consumption and resources are termed 'transfer payments' and should be excluded from the benefit-cost analysis.

#### **A1.4 Transfer payments**

##### **When does a change result only in a transfer payment?**

Benefit-cost analysis is concerned with national economic efficiency where efficiency is, in effect, the ratio of the value of outputs (consumption) to inputs (resources). These inputs are yielded both from stock (e.g. engineering plant, buildings) and from flows (e.g. electricity, labour).

A transfer payment occurs when a change simply affects either who gets the consumption or who provides the resources, but there is no change in the national total of either all the consumption, or all the resources required to generate that consumption.

### **Test for a transfer payment**

Will there be any change either or both in the total value of UK consumption or in the resources required to provide that consumption? If not, then only a transfer payment is involved.

When a physical object is damaged or destroyed by a flood, a transfer payment is not involved since maintaining current levels of consumption will require the replacement of that object. There will be distributional consequences as well (e.g. builders will get more work) but the test is whether there will be a change in the total level of consumption or the resources required, including the need to repair or replace stocks which have been damaged or destroyed.

### **Examples of a transfer payment**

Examples are:

- VAT and excise duties are always transfer payments and must be netted out of the analysis. If less petrol is sold, then the Exchequer will simply find different ways of raising taxes;
- If a hotel or pub were lost, the trade would simply transfer to other outlets; the value of any such 'goodwill' element in the market price must therefore be netted out of the analysis;
- Losses of trade to commercial or retail outlets will be a transfer payment except in the circumstances given below.

### **Examples of changes which are not a transfer payment**

In some cases, a levy is made in respect of negative externalities, a 'green tax', which is intended to reflect a real economic cost, although otherwise it appears identical to other forms of taxation such as VAT. If, for example, a charge were to be levied on aggregates which reflected the real environmental damage caused by aggregate extraction, this would reflect the additional economic loss resulting from mineral workings. Therefore, an increase in aggregate extraction would result in additional economic losses to the country, in addition to the resource costs of extraction and transportation. Landfill taxes are also a 'green tax' and represent a real economic cost. Ideally, where appropriate, these additional economic losses should be quantified and included in the analysis. However, this is unlikely to be practical for most flood protection schemes and it will normally be reasonable to use the tax rates as a surrogate for the real economic loss in any analysis.

Losses of trade to commerce and retail outlets result in real losses if consumers cannot obtain equivalent goods at the same time and at the same cost. If all three conditions do not hold, an economic loss is involved. However, the normal expectation is that consumers will be able to obtain equivalent goods at no extra cost and therefore any differences will not be worth evaluating.

The test can also be applied to non-priced goods, such as visits to a riverside park. If consumers can go somewhere else and get the same amount of enjoyment at no extra cost, the change in visiting results in no real economic cost. If they cannot, the net value of the loss in enjoyment, plus any increase in cost to the visitor measures the economic loss.

## A1.5 Discounting

To test the economic efficiency of different options on a comparable basis, it is necessary to discount all of the costs and benefits of the option from the time they arise in the future, to their present value. The standard discount rates recommended in HM Treasury Green Book are 3.5% for years 0-30, 3% for years 31-75, and 2.5% for years 76-125. Where there is reason to believe failure to provide sufficient flood protection could cause irreversible damage in the future, HM Treasury (2008) recommends also using a reduced long-term discount rate of 2.57% for years 31-75 and 2.14% for years 76-125 (and applying a sensitivity test).

Beyond 50 years only large costs and benefits will have an impact and significant time should not be spent estimating these values.

The convention that should be adopted is to take all costs and benefits in any given year as accruing at the midpoint of that year, and to discount all these streams back to their present value at mid-year 0. This is the time at which capital expenditure is also to be taken to start to accrue.

In terms of good practice:

- The test discount rates specified by HM Treasury are to be used for all streams of benefits and costs;
- Each and every benefit and cost should be taken to accrue in the middle of the year when it occurs;
- Present values should be calculated as at the mid-year of year 0;
- A consistent base-year dataset should be established, using relevant uplift factors where required.





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