HANDBOOK FOR ECONOMIC APPRAISAL

2026

FLOOD AND COASTAL EROSION RISK MANAGEMENT

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1 Introduction

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AIM AND PURPOSE OF THE HANDBOOK

This Handbook is intended to be a stand-alone "How to do it" guide to assessing the benefits of flood and coastal erosion risk management (FCERM). When combined with knowledge of the costs of the plans and schemes required in that risk management, the user can assess the relationship between the benefits and the costs of investment decisions. This comparison should enable the users to identify those risk management plans and schemes which maximise the economic return to the nation (England and Wales) and therefore represent "best value for money" by being economically efficient.

The term '**scheme**' here is not meant to imply an engineering scheme but includes both structural engineering ways to reduce flood or erosion risk and non-structural alternatives (flood warning; emergency response; land use planning; etc). The term 'scheme' is used hereafter for simplicity.

Since the 2005 MCM, there has been an important shift in the governance arrangements in England and Wales for FCERM, and hence in the appraisal of investment. This has meant that:

- Department for Environment, Food and Rural Affairs (2004, 2005) has been more focused on policy development, with *Making Space for Water*, and on appraisal policy in the form of its *Policy Statement on Appraisal of Flood and Coastal Erosion Risk Management* (Defra, 2020);
- The Environment Agency (EA) provides detailed guidance on evaluating investment in FCERM schemes. The latest version of its *FCERM appraisal guidance (FCERM-AG*) can be found at https://www.gov.uk/guidance/fcerm-appraisal-guidance.

Reflecting these changes, the EA commissioned the Flood Hazard Research Centre at Middlesex University to update this Handbook and their MCM database. In Phase 1 (2009-10) the updating has been fairly straightforward, resulting in the **2010 edition** of the Handbook/CD. Phase 2 (2010 to 2013) has been more fundamental, including a complete revision of the non-residential flood damage data (Chapter 5), a new investigation of losses related to breaks in communication links and utility services (Chapter 6), and some significant modifications to the methods advocated to assess agricultural benefits (Chapter 9). Other changes have been the addition of data on park homes and damage to vehicles affected by flooding (Chapter 4). All these new data are now supplied through MCM-Online.

THIS HANDBOOK AND THE 'MANUAL'

This Handbook will allow the user to carry out economic appraisal with the minimum of effort for the majority of flood and coastal erosion risk management schemes to be assessed. However, assessments are not always straightforward and therefore this Handbook is complemented by a much more extensive Manual, colloquially termed the *Multi-Coloured Manual* or, hereinafter, as the MCM or the Manual (Penning-Rowsell et al., 2013).

The Handbook is designed to be more straightforward to use than the Manual, because that also reports the research undertaken at Middlesex University on which this Handbook and the MCM are based. The Manual also discusses the kind of complications in the appraisal of flood risk management options that can occur when the assessment is not straightforward, and provides suggestions and methods to apply in those circumstances.

Those using this Handbook should therefore appreciate the connection with the full MCM. To help this, the MCM chapters correspond with those in the Handbook and, additionally, the MCM provides further detail on the rationale behind our approaches described here. **Most values in this Handbook and its accompanying MCM-Online data sets have been updated using an appropriate and agreed annual average CPI value (from March 2025 - February 2026), unless otherwise indicated.**

HOW TO USE THE HANDBOOK

This Handbook is aimed at guiding those undertaking Flood and Coastal Erosion Risk Management (FCERM) project appraisals. It offers a step-by-step 'how-to do-it' commentary on the many types of benefits to be assessed, which are a feature of FCERM appraisal.

The Handbook seeks to develop and improve existing approaches, without compromising the principles that underpin current Department for Environment, Food and Rural Affairs (2020) and HM Treasury guidance (2026).

In the meantime, we believe that the majority (say 75%) of flood and coastal erosion risk management schemes can have their economic benefit assessments undertaken using the guidance provided here. In particular, the Handbook applies to:

- Those undertaking strategy studies who want a 'first cut' assessment of potential benefits;
- Those undertaking initial studies, who should use the methods described for this level of analysis, as covered herein;
- Those undertaking detailed scheme studies, who should generally use the more detailed methods described here and in the MCM.

Importantly, appraisers should always, in cases of doubt, seek guidance or refer to the over-riding policy framework in the Treasury 'Green Book' and the associated Defra and Environment Agency guidance (Table 1.1).

HANDBOOK STRUCTURE

The Handbook is structured to reflect three considerations:

1. The type of scheme, that is to say whether it is aimed at:
   - Flood risk management (**Chapters 2, 3, 4, 5 and 6**);
   - Delaying erosion at the coast (**Chapter 7**);
   - Providing an enhanced flooding and drainage regime for agriculture (**Chapter 9**).

2. In the case of flood alleviation, which economic sectors are under consideration, e.g.:
   - Residential and non-residential properties (**Chapters 4 and 5**);
   - Road disruption etc (**Chapter 6**);
   - Emergency services (**Chapter 6**).

3. Recreational impacts (**Chapter 8)** addresses both coastal erosion and flood risk management.

This structure is also followed in the MCM, thereby assisting cross-referencing.

HANDBOOK CONTENTS

The chapters of this Handbook each generally contain:

1. Step-by-step guidance on benefit assessments: “How to do it”
2. Data collection needs, methods and key issues
3. Methods on benefit calculation, including the relevant formulae, separated in some instances into strategic methods, initial and detailed appraisals
4. Guidance as to interpreting the results
5. Details of other relevant aspects to benefit assessment *not* discussed in this Handbook but outlined in the MCM

Because it is designed for ‘work-a-day’ situations, the Handbook includes no consideration of the complexity of the economic theory behind benefit-cost analysis which is dealt with in the MCM, Chapter 2 (Penning-Rowsell *et al.*, 2013), or of the theory of risk management. But the MCM-Online, of which this Handbook is now part, contains the MCM database on flood impacts and other relevant data.

Table 1.1: *Sources of guidance on appraising flood and coastal erosion risk management schemes and plans in England*[1]

Source reference	Document	Purpose
HM Treasury 2026	The ‘Green Book’	Identifies the preferred approach to public sector investment appraisal and statutory duties on practitioners
Environment Agency 2022	Flood and Coastal Erosion Risk Management appraisal guidance (FCERM-AG)[2]	How a project appraisal and CBA should be completed for flood and coastal erosion risk management projects
Environment Agency 2026a	New project opportunity guidance and resources for the 2025 FCERM guidance[3]	Provides guidance and resources for applying the Department for Environment, Food and Rural Affairs (2025) funding policy for new projects. This introduces a new pre-gateway 0 (GW0) approach for early prioritisation and the associated Rapid Appraisal Tool for Economics (RATE) approach and spreadsheet (Environment Agency, 2026b)

[1] Appraisers from other nations are recommended to consult any national-specific guidance where available.

[2] Department for Environment, Food and Rural Affairs (2025) announced a reform of flood and coastal erosion funding policy in England. It also states that “*The Environment Agency will update its project appraisal and funding guidance to reflect the new FCERM funding policy…This update will be completed before the start of the next investment programme in April 2026. The appraisal guidance will continually be improved*.” At the time of the preparation of this version of the MCH (late April 2026) the latest update of the appraisal guidance webpages was 17 May 2022, but these are living web documents and additions to different aspects of appraisal are often updated. Appraisers in England are advised to check for any later updates.

[3] This guidance mainly considered new projects so appraisals for existing projects should seek information on transition arrangements.

Environment Agency 2023	Partnership funding supporting documents and transition arrangements[4]	Provides guidance for setting up partnerships for FCERM
Flood Hazard Research Centre and the Environment Agency 2013	The new 'Multi-Coloured Manual' (MCM)	Gives details of relevant research and detailed guidance on benefit assessment methods and data – some of the methodologies and data have been updated since its publication. Look to the most recent version of the Handbook for details
http://www.mcm-online.co.uk http://www.fhrc.mdx.ac.uk	Middlesex University FHRC MCM-Online	Provides data and other information (including questionnaires) for the support of flood and coastal erosion risk management project appraisals

KEY ACTIVITIES IN ASSESSMENTS

This Handbook is intended to allow appraisals of flood and coastal erosion risk management schemes to be undertaken with the minimum of effort. One important dimension of this is judging the time and resources allocated to those parts of the benefit assessment process that are most important. This importance is gauged in two ways:

- Concentrating on those components of total benefits which are the largest compared with the effort expended on assessing them (e.g. non-residential property where there is a mix of non-residential and residential property at risk, because non-residential damage per unit area is generally far higher than residential damages);
- Ensuring that the data on which the benefit assessment depends is most accurate (or least inaccurate) where it has most effect on the final results (e.g. for coastal erosion, making sure projected erosion rates are as soundly based as possible; in the flooding field ensuring flood probabilities and depths are accurately assessed).

Applying these two principles will be different for different scheme types and in different economic sectors, so that each chapter of this Handbook addresses this issue in its own subject area.

In general, applying such judgement will mean ignoring sources of small amounts of benefit (e.g. road traffic disruption on minor roads) and accepting that some data will be less accurate than others. Sensitivity analysis can be used to test how the decisions that flow from these principles affect particular appraisals.

[4] The Department for Environment, Food and Rural Affairs (2025) reforms for FCERM policy withdraws Partnership Funding approaches from April 2026 as new guidance is introduced, however existing projects in England may need to continue with these arrangements. Appraisers are advised to check for transition arrangements.

THE POLICY CONTEXT

This Handbook and the MCM have been designed to support the Defra/ODPM/HM Treasury policy on "Making Space for Water" (Department for Environment, Food and Rural Affairs , 2004; 2005, 2020). This stresses holistic policies and integrated appraisal, commensurate with sustainable development.

This Handbook aligns with the latest Treasury 'Green Book' guidance[5] on investment in public sector projects including, for example, the use of weightings to assess and correct for distributional impacts, optimism bias considerations when assessing project costs, and variable discount rates for projects with long lives.

They also build on Defra's series of Project Appraisal Guidance series (e.g. PAG3) and their replacement by the Environment Agency's Flood and Coastal Erosion Risk Management Appraisal Guidance (FCERM-AG). 'Making Space for Water' (Department for Environment, Food and Rural Affairs , 2005) has led to updating Defra's guidance, separating policy guidelines/statements issued by Defra from Environment Agency best practice implementation guidance.

In summary, supplementary guidance now comprises:

- Department for Environment, Food and Rural Affairs (2020): 'Flood and coastal erosion risk management: Policy Statement';
- Environment Agency (2022): the 'Flood and Coastal Erosion Risk Management Appraisal Guidance (FCERM-AG).

In this respect appraisers of FCERM schemes should be aware of the types of risk management expenditure that Defra currently funds, not least because some benefits might not be supported in this way. Those benefits (e.g. major recreational benefits) might currently need the support of other funding streams where they are not fundamental to the relevant scheme.

Notwithstanding the above, the contents of both the Handbook and the Manual remain the responsibility of Middlesex University (FHRC) and the Environment Agency.

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[5] Although all efforts have been made to align with current English Government policy, it is important for users of these data and methodologies to check the relevant national appraisal policy guidelines for any recent updates.

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2 Using Appraisals to Make Better Choices

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OVERVIEW

This chapter presents key points on how to improve decisions through project appraisal, and is structured to consider six key questions covering the project appraisal process:

- What is project appraisal?
- Why do project appraisals?
- Why involve stakeholders?
- What is value?
- How to compare options?
- How to make the decision?

A much more detailed discussion of these points is contained in Chapter 2 of the MCM (Penning-Rowsell et al., 2013).

The framework laid out here remains the same as in all Handbooks.

However, since some early handbooks have been published, involving stakeholders in decision-making processes has been strengthened and is now routine. This inclusion may adopt various approaches including Multi-Criteria Decision Analysis (MCDA). Appraisers are recommended to consult on up-to-date best practice approaches for stakeholders' inclusion (e.g. for England see Environment Agency (2022)). Users are also recommended to consider Defra's Policy Statement (Department for Environment, Food and Rural Affairs, 2020).

LESSONS FROM EXPERIENCE

- The role of economic analysis is in supporting the stakeholders in deciding which is the best option;
- Do not look for a mechanical means of making choices; what project appraisal can provide is greater understanding of what the choice involves: decision-support, not decision-making;
- The appraiser is seeking to make 'better' choices. One of the central conflicts here may therefore be different understandings concerning what is a 'better' choice;
- The option choice process should be appraisal led;
- As a learning process, the appraiser should start by identifying the critical parameters as these that affect the choice between options and concentrate our attention upon those parameters;
- There is no universally superior project appraisal technique; the choice of technique has to be matched to the reasons why the choice is necessary;
- Do not expect all choices to be clear-cut: some will be truly marginal;
- Even though economic analysis is a central component of the appraisal process, it should always be used critically and only as an aid to decision-making; it is not an end in itself.

WHAT IS PROJECT APPRAISAL?

The Environment Agency's project appraisal guidance outlines that project appraisal is the process of identifying and then evaluating options in order to select the one that most likely satisfies the defined project objectives. The purpose of the project appraisal process is to improve decision-making towards making the 'best' choice. Good decisions and the 'best' choice are most likely to result from considering all economic, social, environmental and technical issues for a full range of options.

The methods used in project appraisal are aimed at:

1. Simplifying the complexity of choice;
2. Understanding what choice involves; and
3. Enabling this understanding to be shared by stakeholders.

To ensure that project appraisal is not a mechanical exercise, appraisal led design is essential. Appraisals should drive the design process, with the identification and specification of project options evolving through this appraisal process.

To be useful, appraisal methods should ensure best value and hence the highest rate of return for public monies. They must also provide accountability, transparency of the basis for choice, and result in a rational comparison of the available options and the consequences of these options.

WHY DO PROJECT APPRAISALS?

If the appraiser wants to make better decisions in flood and coastal erosion risk management, we need to start by understanding why we have to make the particular decision in the first place. This commences with identifying the problem and defining the objective/s.

In the simplest terms, a choice is required when there are conflict (i.e. disagreement) and uncertainty about a course of action to meet the defined objective/s. Uncertainty arises because of initial limited knowledge of an option's pros and cons (benefits and costs), and whether the 'best' choice to be made will be the most sustainable.

Economic appraisal enables the comparison of widely differing options, with careful consideration applied to how options are appraised as to their 'value' to arrive at the 'best' choice.

WHY INVOLVE STAKEHOLDERS?

A better decision is one that is both a 'just' decision and one that turns out to be 'correct' in the long run. For a decision to be 'just', it is not only the outcome that must be seen to be fair but so too must the process by which the decision is made. Critical to the achievement of a 'just' process and a better decision is therefore appropriate stakeholder involvement.

Project appraisal therefore has two roles:

1. Stakeholders need informed involvement, with information available to all: the project appraisal technique itself can contribute to creating a shared knowledge base;

2. The project appraisal method must serve as a framework through which stakeholders can explore, argue and negotiate their concerns and explore different options.

Also, relatively new techniques are being developed, including Multi-Criteria Analysis (MCA) which, when appropriately applied, could lead to improved stakeholder involvement in decision-making.

WHAT IS VALUE?

Value is central to benefit-cost analysis and, in economics, all values are subjective: the value of some 'good' is given by the individual and reflects his or her subjective preference for that 'good'. Value does not have to be measured in monetary terms only, although the Treasury Green Book (HM Treasury, 2026), suggests 'the starting point for estimating social costs and social benefits is market prices' (8.2, p59), and that 'practitioners should use time and resources proportionately when estimating social costs and social benefits. It may be disproportionate to monetise or quantify every impact. Practitioners should focus on monetising those social costs and social benefits that are likely to be most decisive in distinguishing between options*'(*6.29, p42).

In this respect, the shorthand term 'good' is used to denote any commodity, resource or item which an individual prefers or desires (for example, a coastal protection project, a flood risk management scheme, a beach, a river, or a recreational experience). The values assigned to any such good then reflect the relative contribution that this good makes to an individual's 'utility' or wellbeing.

Value is also 'sacrificial'. This means it quantifies or reflects the degree to which the individual would be willing to *give up* an amount of that 'good' in order to have *more* of another: more flood risk management means fewer hospitals. Values are, therefore, not absolute but reflect the basis upon which choices are made between enjoying these different goods (which the economist calls 'consumption').

There are three general strategies for deriving values for use in benefit-cost analysis:

1. Using market prices (e.g. the cost of repairing flood damage).
2. Using 'inferential' methods, which use statistical techniques to infer the value of something that does not have an observable market price (e.g. valuing a recreation resource by the distance people are prepared to travel to enjoy that resource).
3. Using 'expressed preference' methods which usually involve questionnaires to elicit a value (e.g. asking people what choices they would make between different recreation venues).

HOW TO COMPARE OPTIONS?

Option appraisal should provide an assessment of whether a proposal is worthwhile. However, the steps outlined in the Treasury Green Book involving *Justifying Action* (e.g. identifying need) and *Setting Objectives* should take place before *Option Appraisal*. Once options are developed, the appraisal process assesses option performance, usually by comparing the consequences of '**do something**' options against some baseline option (usually '**do nothing**'). Appraisers should only be interested in these differences. Benefit–cost analysis is normally used to make comparisons and judgments on these differences, whilst other techniques such as MCDA can improve this comparison stage.

An initial **sensitivity analysis** should ideally be undertaken at the start of the project appraisal process, and not at the end, in order to understand how sensitive the choice is to the likely accuracy of data or methods being used. An experienced appraiser should be able to anticipate those parameters to which the estimated benefits and costs are most sensitive. It is those parameters that should be progressively refined as the analysis progresses.

The consequences of the different options often differ in terms of:

- Who is affected;
- What is affected;
- How they are affected; and
- When this effect occurs.

Thus, all appraisals should focus on these points, and any comparison between options will involve judgments about how these different consequences can be brought to a common base.

HOW TO MAKE THE DECISION?

According to the Treasury Green Book, the purpose of an appraisal is to indicate that no policy, programme or project is adopted without first having the answers to these questions:

(a) Are there better ways of achieving a given objective (e.g. reduced flood risk)?

(b) Could the resources be put to better use (e.g. building a hospital)?

The appraisal also should explore how confident we can be that one option is better than a range of other options. Two criteria frequently used in comparing the different options are:

- The **benefit-cost ratio**: the ratio of the present value of all of the streams of benefits over the present value of all of the streams of costs; and
- The **net present value**: the difference between the present value of all of the streams of benefits and the present value of all of the streams of costs.

Projects are only economically viable if if they are found to deliver value for money, this is typically expressed as a BCR > 1. However, Vfm considerations should include non-monetised impacts therefore some investments may be justified even with a BCR < 1. Whereby benefits marginally exceed costs, there is often high uncertainty as to whether an option is justified, because only a small change or error in either the benefits or costs would tilt the balance the other way. So, when comparing a 'do something' option to the baseline option, confidence is needed that a 'do something' option is clearly preferable.

In this regard, the decision process explores whether the best value for money is provided while achieving the most appropriate standard of risk management. This is undertaken by assessing the incremental benefit-cost ratio of each economically viable option. The full mechanics of this decision process for England can be found in the Environment Agency's FCERM-AG appraisal guidance (Environment Agency, 2022) *Compare and select preferred option: Decision criteria and decision process* (https://www.gov.uk/guidance/flood-and-coastal-erosion-risk-management-appraisal-guidance/8-compare-and-select-the-preferred-option). Users should consult the decision rules appropriate for their context.

The Environment Agency guidance for England (and others may wish to follow the same advice) suggests that the decision should be modified as necessary to take account of factors that are not fully counted in the economic analysis. New techniques which incorporate these other factors into the decision-making process in a more consistent and transparent way have been developed (see FCERM-AG; Environment Agency, 2022).

REMAINING ISSUES

New edition of the UK Government HM Treasury Green Book

The Green Book sets the rules for UK Government economic appraisal and so is important for our work. A new version was released in 2026[1].

Key definitions: 'Private', 'public', 'collective' and 'individual' goods

- Those goods that are bought and consumed by individuals such that they are then not available to others are termed **private goods**. The assumption here is that individuals make their own purchasing decisions for their own purposes. This applies to most marketed goods, although some goods can be shared between individuals without being used-up (e.g. newspapers and books);
- **Public goods**, by contrast, occur when the provision of a good by one individual necessarily means that it is also provided for others without diminishing its value. The assumption here is that there is no way of excluding others from receiving the benefits of the goods provided (e.g. a lighthouse, or a ring flood embankment around a town);
- There are some goods that any individual, given sufficient resources, can acquire for him/herself and these are termed **individual goods** (e.g. flood proofing a house);
- **Collective goods**, by contrast, can either only, or only efficiently, be provided collectively (e.g. a public flood warning system).

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[1] Although all efforts have been made to align with current English Government policy, it is important for users of these data and methodologies to check the relevant national appraisal policy guidelines for any recent updates.

3 Flood Risk Management Benefits: Theory and Practice

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OVERVIEW

In this chapter we provide pointers as to how a flood risk management benefit assessment should be conducted. This draws on the theory that should guide this and the sources of data that will be necessary. These are not presented as step-by-step guidance, as in other chapters, but as items that need consideration before and during the work. More detail is provided in Chapter 3 of the MCM (Penning-Rowsell *et al.*, 2013).

The theoretical framework presented here remains as valid now as it was in the previous MCM (2005). However:

- Major floods in 2007 have led to research that has altered our understanding of the costs of emergency services in flood incidents, and hence questioned the universality of the 10.7% uplift factor recommended in 2005 (see also Chapter 6 herein);
- The 2007 floods also led to substantial disruption of electricity and water supplies, and these need more emphasis now, especially their off-floodplain effects;
- The land use data available for benefit assessments continues to improve, with updates to the Environment Agency's National Receptor Database (NRD). This reduces the need for expensive, time-consuming field-based survey;
- Climate change impacts on flood frequency are more fully understood and need to be factored in to assessments of the return periods of future floods. The latest UK Climate Projections can be accessed at https://www.metoffice.gov.uk/research/approach/collaboration/ukcp and potential impacts of climate change on flooding in the UK are evaluated in the latest Climate Change Risk Assessment (HM Government, 2022).

LESSONS FROM EXPERIENCE

- For schemes resourced from public funds the damages averted by flood risk management schemes should generally be assessed as national economic losses, not the financial losses to the individuals and organisations;

- Close attention should be given to accurate determination of the area potentially affected by flooding (the floodplain). Within that exercise considerable effort should be given to determining the extent and annual probabilities of the lesser floods and the flood at which damage begins;
- The different quality of different data inputs needs recognition, using a Data Quality Score (DQS) systems if appropriate to manage the process of benefit refinement targeted at those data inputs that are of poorest quality yet which contribute most to the variation in benefit totals;
- For major schemes involving considerable investment in low-lying areas (i.e. not steep catchments) close attention should be given to the topographic data that defines the thresholds of property flooding;
- Sufficient potential floods should be appraised so that an accurate picture can be developed of the shape of the loss-probability curve including, where appropriate, such events needed to define and quantify any Above Design Standard benefits.
- Particular attention needs to be given to the return period (or annual probability) at which flood damage begins at the site under investigation, as this will significantly influence the calculated Annual Average Damages (AAD) by properly defining that part of the area under the loss-probability curve.

TYPES OF FLOOD DAMAGE AND FLOOD LOSS

The benefits of flood risk management comprise the flood damage averted in the future as a result of schemes to reduce the frequency of flooding or reduce the impact of that flooding on the property and economic activity affected, or a combination of both.

Direct damages result from the physical contact of flood water with damageable property and its contents. Many items of flood damage loss are a function of the nature and extent of the flooding, including its duration, velocity and the contamination of the flood waters by sewage and other contaminants. All these affect damages and losses, and the location of the flood will affect the networks and social activities disrupted, causing indirect losses.

This situation is summarised in Table 3.1. It is important to ensure that for the purposes of benefit-cost analysis we assess only the national economic losses caused by floods and coastal erosion, and their indirect consequences, rather than the financial losses to individuals and organisations which are affected (Table 3.2). Intangible losses are those which are harder to value. However, these are becoming fewer as methodologies develop to assist in their valuation.

It is also important to ensure that benefits are not double counted, such as counting the loss of trade of a factory as well as the consequent loss of business of the factory’s retail outlets.

Table 3.1 Direct, indirect, tangible and intangible flood impacts, with examples

		Measurement	
		Tangible	Intangible
Form of Loss	Direct	Damage to building and contents	Loss of an archaeological site
	Indirect	Loss of industrial production	Inconvenience of post-flood recovery

Table 3.2 Financial and economic damages related to household flood losses
Financial
Takes the standpoint of the individual household involved
Uses the actual money transfer involved to evaluate the loss or gain (e.g. if a household has a new-for-old insurance policy and they claim for a ten year old television, the loss is counted as the market price of a new television)
VAT is included as are other indirect taxes as they affect the individual household involved
Economic
Takes the standpoint of the nation as a whole – one person's loss can be another person's gain
Corrects the actual money transfer in order to calculate the real opportunity cost (e.g. in the case of the ten year old television, the real loss to the country is a ten year old television; the depreciated value of that ten year old television is taken as the loss)
VAT is excluded, as are other indirect taxes, because they are money transfers within the economy rather than real losses or gains

NB: This is Table 4.2 in the MCM 2013

CALCULATING ANNUAL AVERAGE DAMAGES

The methodology for assessing the benefits of flood risk management combines:

- An assessment of risk, in terms of the probability or likelihood of future floods to be averted; and
- A vulnerability assessment in terms of the damage that would be caused by those floods and therefore the economic saving to be gained by their reduction.

Figure 3.1 provides the classic four-part diagram summarising the inter-relation of hydrology, hydraulics and economics as the basis of calculating the benefits of flood risk management. The annual average flood damage is the area under the graph of flood losses plotted against exceedance probability (the reciprocal of the return period in years).

Figure 3.2 gives a simplified flow chart of the stages that need to be followed in order to calculate the benefits of flood risk management (or, put another way, the stages for calculating the present value of flood damages/losses (PVd) that will occur in the future if a "do nothing" option is adopted).

ADDING EMERGENCY COSTS

Research reported in 2002 (Penning-Rowsell *et al*., 2002) showed that flood incidents in 2000 were accompanied by significant emergency costs:

- Police, fire and ambulance service costs;
- Local Authority costs;
- Environment Agency costs.

These costs were quantified at 10.7% of property damages - see Chapter 6 and the detailed research in the MCM (Penning-Rowsell *et al*., 2013). Investigations following flooding in 2007 showed proportionately lower emergency costs, resulting in a 5.6% uplift factor (see Chatterton *et al*., 2010). In any benefit assessment capped annual average property damages should therefore be multiplied by 1.107 (dispersed flood incidents) or 1.056 (concentrated settlements such as large towns and cities) to allow for these costs.

DATA INPUTS: DEFINING THE BENEFIT AREA

The benefit area is the starting point for assessing the benefits of flood risk management; it is the area affected by the flood problem, both directly and indirectly.

Usually, the benefit area will be the maximum known extent of flooding in the area or catchment involved. However, it may also be necessary to extend the benefit area beyond the floodplain as conventionally defined by, say, the 1% probability event. This is because the calculation of Above Design Standard benefits generally requires the assessment of the impacts of reducing more extreme flood events beyond any anticipated 'design flood'.

Figure 3.1 *The classic 4-part diagram summarizing the calculation of annual average flood losses*

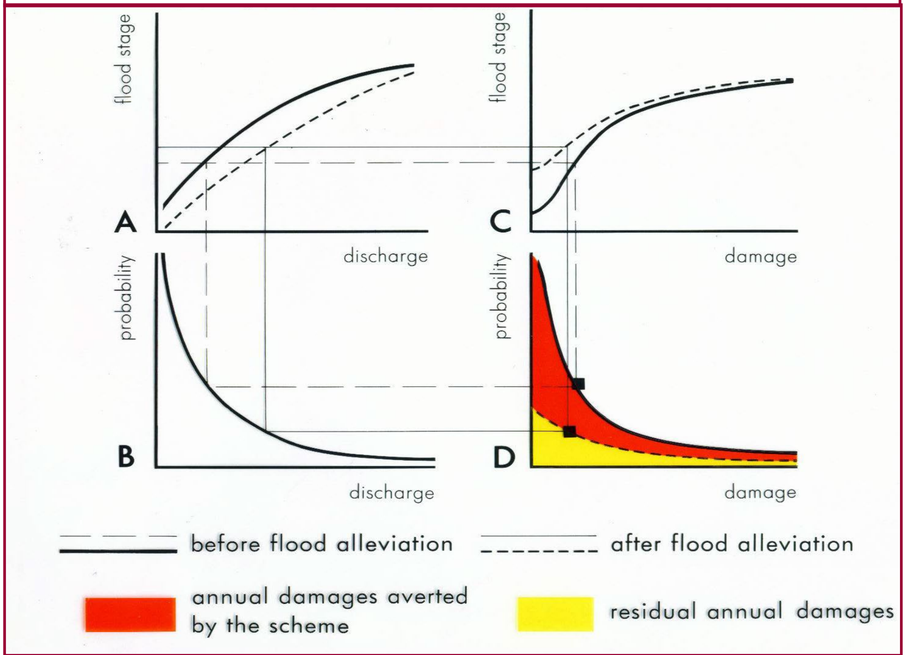
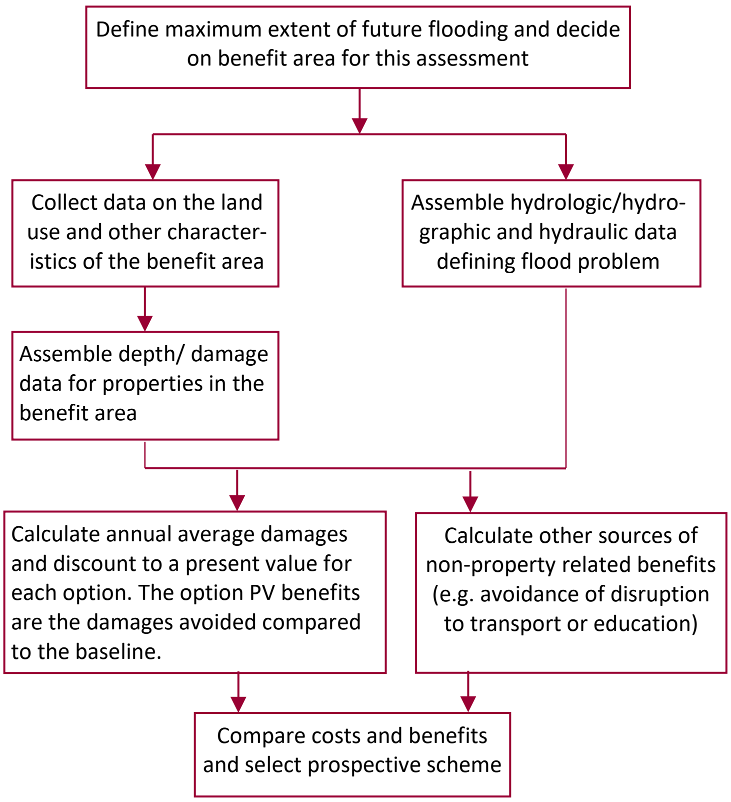


Figure 3.2 *The stages that need to be followed in order to calculate the benefits of flood risk management to compare with scheme costs*



The indirect effects of flooding can also extend well beyond the floodplain. Disruption to information and communication technology, and road and rail can occur many kilometres from the floodplain, as a flood can cause disruption to those communication and economic linkages and that disruption 'spills over' to communication links not themselves flooded. The same can apply to the disruption of water and electricity supplies (see Chapter 6).

In coastal situations it will generally be necessary to assess the floodplain as the area subject to flooding if current defences are breached or overtopped.

DATA INPUTS: ASSESSING VULNERABILITY TO FLOODING FOR THE LAND USE IN THE BENEFIT AREA

The approach to assessing the benefits of flood risk management is through investigating the potential damage to a variety of land uses in the areas to be affected.

A 'classification of land use' is available in the *Additional Resources* section of Chapter 3 on MCM-Online. It is customary within benefit-cost analysis of flood risk management investment to consider only the land use as currently existing (except where the future flood regime is likely to make current use untenable and property is assumed to be 'written off' or subject to change of use, or when agricultural land becomes suitable only for less productive uses).

For a fully comprehensive assessment of property-related benefits it will be necessary to determine:

- The geo-reference of each property (the grid reference);
- The altitude of the threshold of flooding at that property; and
- The area of the property in square metres if the property is non-residential.

Field surveys can identify land uses in the benefit area. Otherwise, the Environment Agency's National Property Database is the first source of data that should be consulted, but field surveys may also be necessary to determine the type of non-residential property in the area and its floor area.

Research evidence indicates that the social grouping of occupants of residential properties is a good indicator of damage potential and these differences are reflected in the standard flood damage tables provided with the MCM-Online. This data allows the application of equity multipliers in a structured and transparent way to better reflect the impact of investment decisions on different groups within society (see Chapter 4).

DATA INPUTS: FLOOD DAMAGE DATA, OUR GENERAL APPROACH

The general approach here to assessing the benefits of reducing the risk for properties affected by flooding encapsulates the following principles:

- Data in the accompanying MCM-Online tables assesses the potential damage in the future from a range of severities of flooding, resulting from different depths of flood waters within the property. Only in this way will the shape of the loss-probability curve be accurately determined;

- Much of the flood damage data presented here is "synthetic" (i.e. from a synthesis of many data items). It is therefore not directly derived from an analysis of properties which have been flooded in the recent past, because evidence suggests that post-flood surveys can be very inaccurate;

- The losses to individual properties must represent national economic losses. Therefore, the damage to property components (i.e. inventory items), is based on their assumed pre-flood value – their depreciated value - rather than the cost of their replacement with new items at current market prices;

- Any taxation element within potential flood losses is subtracted, because these are transfer payments within the economy rather than real resource costs. Therefore, the VAT element in repair costs is not counted;

- For indirect flood losses, it is necessary to separate financial and economic losses by not including, for example, the loss of income in one particular retail shop if the trade this represents is likely to be deferred in time or transferred to another retail outlet.

DATA INPUTS: TOPOGRAPHIC, FLOOD SURFACE AND FLOOD PROBABILITY DATA

Experience with many project appraisals has indicated that one of the most important inputs to benefit assessments is the topographic data describing the floodplain and the accuracy of the hydraulic profiles that intersect this surface.

In Britain, many floods are relatively shallow, slow-moving, and represent water accumulating towards the lower end of catchments. In these circumstances, accurate delineation of the area liable to flooding and the precise depth of flood waters on that flood plain are both essential to accurate benefit assessments. Sources of topographic data (and hence the threshold of flooding for each property in the benefit area) are:

- LiDAR or SAR data;
- Field levelling data using traditional survey methods or modern GPS methods;
- Digital terrain model data;
- Simpler methods as appropriate (e.g. topographic maps).

The estimation of the probability of flood events contributing to appraisals is also critical, particularly the probability of the threshold of flooding.

DATA INPUTS: DATA QUALITY AND "FILTERING"

Experience indicates that the different data elements have different qualities. Our recommended objective is to improve the quality of the data that makes most contribution to calculated benefits, using a system that is transparent and auditable. The description below is for calculating the benefits of flood risk management; see MCM, Chapter 3 (Penning-Rowsell *et al*., 2013) for other situations.

Step A: Data assembly and DQS scores

Assemble the following for each property in the benefit area. The National Property Dataset (NPD3) is a useful source of land use data.

1. The land use category.
2. The floor area (NRPs only: see Ch. 5).
3. The threshold height of the property.
4. The most appropriate level of detail of depth/damage data (from the MCM-Online).
5. The hydrologic/hydraulic profile data (or similar) for each return period analyses.

Assign Data Quality Scores (DQS) for each of the five elements of dataset above: "1" = good; "4" = poor (Table 3.3).

Step B: Procedure

1. Calculate the Present Value of damages (PVd) for each property and rank all properties by PVd;
2. 'Cap' PVd at each property's market value. Market value data sources include:
    a) Residential: UK House Price Index (HPI) accessed via the Land Registry website (See Chapter 4 for details);

b) Non-residential: Valuation Office Agency (www.voa.gov.uk) to gain an approximation of market or capital value (see Chapter 5 for details).

3. Consider the scores assigned to each of the five types of data. If the scores are at levels 2 or 3, or (particularly) level 4, and there is evidence to suggest that data can be improved without disproportionate cost, then clearly there is cause for concern with the existing data-set;
4. Attempt to explore the impact of the lower quality of data and whether improvement will affect the final decision. Appraisers need to question, on a case-by-case basis, whether improving data will affect decision-making, using standard sensitivity testing techniques.

Sensitivity tests may demonstrate that improved data quality will not have an effect on the outcome of the appraisal decision. Whether data improvement is achieved or not, the debate raised will be seen in the audit trail, with reviews/actions documented to support any decision on data and its use. The route to improved data quality will be different for each data item. For example, better quality property area data can come from GIS-based measurement from maps or OS Mastermap/Google 'Street View', or from field surveys.

Table 3.3 The system of Data Quality Scores (DQS)

DQS	Description	Explanation
1	'Best of Breed'	No better available; unlikely to be improved on in near future
2	Data with known deficiencies	To be replaced as soon as third parties re-issue
3	Gross assumptions	Not invented but deduced by the project team from experience or related literature/data sources
4	Heroic assumptions	No data sources available or yet found; data based on educated guesses

NB. This is Table 3.6 in the MCM 2013

LOSS PROBABILTY CURVE ISSUES

RESIDUAL FLOODING AND DIS-BENEFITS

The Environment Agency's project appraisal guidance (FCERM-AG) decision rules seek to optimise the spend considering an acceptable standard of protection and maximising the benefit cost ratio. Schemes therefore may not protect wholly or even significantly against the more major floods.

This leaves residual flooding after the scheme has been implemented, and this damage from residual flooding should not be counted towards the benefits of the scheme.

To assess these residual damages requires the assessment of the impact and damage of the major floods that are not avoided by any of the anticipated interventions/schemes. Such assessments will often be time-consuming, particularly for the very low probability floods which may cover large areas. They can be important, however, especially when the standard of protection offered by these interventions is low, such that the residual damages are quite large.

ABOVE DESIGN STANDARD BENEFITS

Above Design Standard (ADS) benefits accrue where engineered flood risk management schemes result in water levels changing for the whole range of floods experienced on a floodplain, not just the events with annual probabilities up to and including a 'design event'.

These ADS benefits will be most important where there is significant urban development at the outer edges of the floodplain, only affected by the most substantial floods, and where modest schemes can reduce flood water levels and therefore extents at these locations, even if only marginally.

However only certain types of schemes have this hydraulic effect; for example raised defences do not. The most obvious schemes where ADS benefits accrue are by-pass channels and, in most circumstances, flood storage reservoirs.

These benefits can be large. For example, in the case of the Datchet to Walton Bridge reach of the Thames, appraisal results showed that the ADS benefits could amount to some 31.5% of total benefits.

DECISION RULES AND OPTIONS

The Environment Agency (2022) provides the framework for undertaking an appraisal for flood and coastal erosion risk management in England and includes the procedures for using the benefits assessment in the decision-making process. It explains which procedure is required in different circumstances and is available on the Gov.uk website (https://www.gov.uk/government/publications/flood-and-coastal-erosion-risk-management-appraisal-guidance). Guidance relevant to Scotland is provided by Scottish Government (2016) (https://www.gov.scot/publications/guidance-support-sepa-responsible-authorities/pages/15/).

For other users we suggest you look to see if there are any appropriate guidance for your situation or follow the steps that are advocated for Agency use and tailor the processes advocated there to your local circumstances. Further information on this topic can be found in MCM 2013 (Section 3.7: "Decision Rules and Options").

WRITE-OFF AND 'CAPPING'

New FCERM appraisal guidance on *frequently flooded properties and write-off* introduces a revised approach to estimating damages and benefits for properties at very high flood risk (Frequently flooded properties and write-off in FCERM appraisal - GOV.UK).

The guidance (Environment Agency, 2026) replaces previous capping and write-off methods and no longer caps property damages at regional market values (i.e. when the AAD and the consequential capital sums for those properties would exceed their market value without this capping). The high AAD values that capping produced arose because of the assumption of repeated frequent flooding causing continual flood damage at the property.

Instead, the new method assumes continued occupation of the at-risk frequently flooded properties (which are rare), with adaptive household behaviours reducing potential damages (e.g. by installing flood resistant furniture or fitted kitchens and learning how to cope with the flooding). The result of these behavioural changes means that flood damage at the properties in the future will be less.

This is recognised by not attributing the full MCM derived potential AAD to these properties in proportion to the high flood risk that they suffer. Under the new guidance this is done by applying evidence-based damage-reduction factors to Annual Average Damages for frequently flooded properties, while restricting write-off to cases of permanent inundation or extreme internal flooding. Reduced Annual Average Damages for property damages and for evacuation and temporary accommodation AAD are achieved by applying the factors in Table 3.4.

The guidance continues by stressing that practitioners must review the finer details in Environment Agency (2026) and apply the appropriate damage-reduction factors when undertaking appraisal, and transparently reflect these assumptions in benefit estimation and option comparison, in accordance with FCERM appraisal guidance and the Green Book (2026). These policy changes and new guidance are also incorporated within the relevant MCH chapters here, and appraisals should be checked for consistency with the updated method.

An example

The Environment Agency (2026) usefully gives an example of how this works. In their example a domestic property floods above floor level in a 1 in 5-year (AEP) event but remains dry in the more frequent 1 in 2-year event. The AAD property damages are modelled to be £2,000 and evacuation cost/losses are AAD £200.

In this case, you should reduce:

- reduce the property AAD damages to £1,580, using the 0.79 coefficient (Table 3.4);
- reduce the evacuation AAD to £150 using the 0.75 coefficient (Table 3.4).

It is likely that the total AAD (£1730) is significantly less than the sum derived from the old capping method, where the capital value of the average domestic property in the region was used as the benefit figure.

Table 3.4 Annual Average Damage (AAD) reduction factors by onset of flooding (from Environment Agency 2026)

	1 in 10 AEP	1 in 5 AEP	1 in 2 AEP
Property (AAD)	0.88	0.79	0.71
Evacuation (AAD)	0.88	0.75	0.64

REMAINING ISSUES

- In locations where there is an efficient flood warning system, or local property resilience and resistance measures which results in significantly lower damage and loss values (e.g. from the kind of sandbagging operations as reported in Chapter 6), the assessment of flood damages must reflect those lower values. The flood damage data at MCM-Online represent the maximum potential damage, ignoring the damage-reducing effects of action taken after flood warnings. Data on this can be found herein in Chapters 4 and 5 and in more detail in the full MCM (Penning-Rowsell et al., 2013). Users are reminded that they should not include the benefits of flood warning unless their option also provides a flood warning service and as such includes the associated costs of implementing flood warnings;

- Sufficient potential floods should be appraised so that an accurate picture can be developed of the shape of the loss-probability curve including, where appropriate, such events needed to define and quantify any Above Design Standard benefits. Usually this means that at least 5 floods need to be appraised (e.g. the 5, 10, 25, 75 and 100+ year floods);

- Appraisers should not assume that stakeholders necessarily want to see implemented the standard of flood risk management that is identified as being optimal by the benefit-cost analyses that are undertaken. Stakeholder views and constraints should be gathered and understood as part of the wider appraisal.

- In addition to property damages, other losses should also be considered where benefits may be realised. This may include the avoidance of disruption to utilities, transportation networks and other critical services (schools, hospitals) (see Chapter 6) and recreation (see Chapter 8) and agricultural (see Chapter 9) and environment impacts (Chapter 10).

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4 Residential Properties

4 Residential Properties

OVERVIEW

Residential flood damage is significant in almost all cases of serious flooding in the UK, and remains an area of public and government concern. This damage includes both direct damages and indirect losses, measured as the tangible and intangible impacts of flooding on residential properties and householders.

This chapter addresses the appraisal of the direct damages and tangible impacts of flood waters on household inventory and building fabric items and on domestic vehicles. In addition, information is provided for the cost of evacuation, and for incorporating government guidance on the appraisal of the indirect and intangible impacts of flooding. Information and data are also provided to allow the damage-reducing effects of property-level resilience measures. Since the 2025 update, new depth-damage curves have been included in Chapter 4 Additional Resources.

The assessment of direct residential property flood damage potential should utilise the depth/damage data within the Chapter 4 section of MCM-Online. The most detailed standard data provided is for:

- Five house types;
- Six building ages; and
- Four different social grades of the dwellings' occupants.

Data are provided for various water types (see Table 4.1: *Categories of flood water* in the 'Tables & Figures' spreadsheet on MCM-Online), saltwater flooding, wave damage and also reductions following the issuing of a flood warning. We also provide a method for calculating likely vehicles damages and a comprehensive set of flood evacuation costs. Data and methods allowing the estimation of the beneficial effects of property-level resilience measures are also provided.

Since 2013 most damages have been inflated using an appropriate index (CPI, GDP deflator). In the 2021/22 version, a major revision of the damages was completed which included cost reviews by flood damage experts and updates to ownership and inventory item price values. Additionally, In the 2022/23 version, the data source for inventory item prices was revised to include values from price quotes of items in the standardised shopping basket published by the Office for National Statistics (ONS, 2026). The standardised shopping basket provides large samples of item prices collected in all regions of the UK on a monthly basis. However, not all inventory items relevant to flood damage estimation in the MCM are included in the standardised shopping basket. Item prices are therefore determined through online surveys of major retailers, as in previous MCM versions, combined with statistical analysis of price quotes from the standardised shopping basket. The changes to the methodology may have a small impact on values and will ensure more statistically robust annual price updates for future MCM versions.

For the 2026/27 version, damages have been inflated using the appropriate indices.

LESSONS FROM EXPERIENCE

- Residential flood damage data may be used in as detailed or generalised a way as required for the purpose of the benefit assessment. Dwellings and their occupants can be noted without reference to age or type or property or the social grade of resident;
- Whatever level of aggregation is chosen, there will be errors traceable to the original data sources. It is almost impossible to quantify these errors but every attempt has been made to minimise them;
- Damage susceptibility estimates: professional opinion varies on the precise effect of flood water on inventory and building fabric items. Susceptibility must be continually updated as more information becomes available;
- Inventory and building fabric data: standard checklists have been devised which are not exhaustive;
- Secondary data sources: applying nationally based data to small areas locally may lead to errors;
- Ground floor plans: individual properties will vary from these specifications to some degree.

UNDERLYING ASSUMPTIONS

The residential potential flood damage data for household inventory and building fabric items is based on economic values not financial values (see Chapter 3, Table 3.2). Financial datasets are provided separately on the MCM-Online.

Flood impacts on households are classified as direct tangible, intangible and indirect (Table 4.2). In compiling the standard flood damage data, the total inventory damage is dependent on the average remaining values (ARV - to depreciate prices), the house type, the social grade and the ownership of household items for each social group (Table 4.3: *Social grade categorisation by occupation*).

Table 4.2: The range of possible flood impacts on households (not exhaustive or necessarily mutually exclusive)

Direct Tangible Losses For Flooded Households	Intangible Losses On Flooded Households	Indirect Losses On Flooded Households	Indirect Losses For Non-Flooded Households
➢ Damage to building fabric ➢ Damage to household inventory items ➢ Clean-up costs	➢ Worry about future flooding ➢ Loss of memorabilia and irreplaceable items and pets ➢ Damage to physical and/or mental health, death or injury ➢ Loss of community ➢ Loss of confidence in authorities and services	➢ Permanent evacuation from area ➢ Disruption to household due to flood damage ➢ Temporary evacuation costs ➢ Disruption due to flood warnings or alarms ➢ Loss of utility services ➢ Loss of income/earnings ➢ Loss of leisure and recreational opportunities ➢ Additional communication costs ➢ Loss of services ➢ Increased travel costs ➢ Increased cost of shopping and recreational opportunities	➢ Increased travel costs ➢ Loss of income/earnings ➢ Loss of utility services ➢ Loss of other services ➢ Loss of leisure and recreational opportunities ➢ Increased cost of shopping and recreational opportunities

NB. This is Table 4.1 in the MCM 2013

The 'intangible' effects of flooding are recognised as significant. Defra and the Environment Agency have funded research to establish an economic valuation of the intangible health impacts of flooding. This research confirmed the significance of the health impacts of flooding and led to the publication of guidance (Defra, 2004). This has been added to by recent research and guidance considering the impacts of flooding on mental health (Environment Agency, 2021).

Tables 4.3 Social grade categorisation and weighted factor by occupation

Social Group	Description	Weighted Factor
AB	Upper middle and middle class: higher and intermediate managerial, administrative or professional	0.74
C1	Lower middle class: supervisory or clerical and junior managerial, administrative or professional	1.12
C2	Skilled working class: skilled manual workers	1.22
DE	Working class and those at the lowest level of subsistence: semi-skilled and unskilled manual workers. Unemployed and those with no other earnings (e.g. state pensioners)	1.64

NB. This is based on Tables 4.8 and 4.36 in the MCM 2013

DIFFERENT TYPES OF APPRAISALS

The framework presented below is for appraisals of different types, scale and complexity. The framework includes (1) overview appraisals which are less complex and demanding in terms of damage data requirements and which may be undertaken at the meso- or micro-scales, (2) initial appraisals which are more detailed and demanding and more suited to the micro-scale and (3) full-scale appraisals where site-specific damage data are collected. See Chapters 2 and 3 for a more detailed overview of appraisal types.

Table 4.4 Types of project appraisals (2026 values)

Overview, Initial and Full-Scale methods			
Scale of analysis	**Overview**	**Initial**	**Full-Scale**
Guidance	For rapid MDSF and similar desktop type appraisals: first approximations to identify areas where more detailed work is required	For more detailed appraisals where further assessment of household loss potential is warranted	For the detailed study of potential benefits using the most detailed of the standard data sets
Data requirements for the benefitting area	Number of properties at risk	Number, type and age of house at risk	Number, type, age and social class of houses and householders at risk
		Standard of protection (pre and post scheme for intangible values)	Standard of protection (pre and post scheme for intangible values)
			Government Weighting Factors for distributional impact analysis
Direct/ tangible method of assessment	Annual average direct damages: sector average	Generalised standard residential depth/damage data for type and age of houses	Additional data for type, age and social grade of houses and householders
	Vehicle Damages: 42% of total properties damaged x £5,600 (2021 value)	Vehicle Damages: number of properties at risk above 0.39m x £6,832 (2023 ownership values)	Vehicle Damages: number of vehicles at risk above 0.39m x £5,600 (2021 value)
Intangible method of assessment[1]	Health: £317[1] per property per year for intangibles	Health: Defra's intangibles matrix	Health: Defra's intangibles matrix
Indirect method of assessment	Evacuation per household: temporary accommodation costs (£1,580) plus alternative accommodation costs (£4,519) (2026 value)	Evacuation per household: evacuation costs per property type and flood depth	Evacuation per household: survey on percentage of households evacuated and duration of evacuation. Evacuation costs per property type and flood depth
Vulnerability Analysis	Not required	Where feasible	Where feasible
Property-level resilience damage - saving	Not required	Where such measures exist, their impact should be estimated and deducted from damage estimates where feasible	Where such measures exist, their impact should be estimated and deducted from damage estimates where feasible

[1] NB: These are the social health costs (i.e. how much a household is willing-to-pay to avoid health impacts). Users are also now directed to guidance about appraising the Mental Health Costs of flooding (Environment Agency, 2021) and the associated transitional arrangements for its use.

OVERVIEW APPRAISALS[2]

Where only the number of properties in the benefit area is known, approximate flood risk management benefits can be derived by making some assumptions about the depth of flooding expected with different return periods.

SECTOR AVERAGE DAMAGES

To provide a more refined estimate of direct damages, the depth of flooding across a range of flood events must be known. The absolute minimum number of flood events that can be considered is three:

- The threshold flood event (the most extreme flood event which does not cause any losses);
- An event larger than the possible design standard of protection;
- An intermediate flood.

With a basic understanding of the depths of flooding, appraisers should use the residential depth/data curves provided within the Chapter 4 'Tables & Figures' spreadsheet on MCM-Online. However, during overview appraisals, only the sector average figures should be used.

To employ both these methods, the appraiser needs to determine the size of the benefit area, the number of properties at risk there and, where available, the depth of potential flooding:

- The size of the benefit area is determined by the flood problem being appraised;
- The number of properties can be obtained from the National Receptor Database (NRD), from the Environment Agency;
- The depth of flooding is determined from the ground level data and the results of hydraulic modelling or more likely at this stage, from field-based assessments or historical records.

WEIGHTED ANNUAL AVERAGE DAMAGES (WAAD)

Where the appraiser has little or no understanding of the potential flood depths and return periods, use the weighted annual average damage (WAAD) approach, broken down by warning lead time and the standard of protection (Table 4.5).

The annual average damage to the average house with no flood warning and no flood protection is £6,074. Table 4.5 gives the reduced values provided by different standards of protection and different levels of flood warning (to which householders are assumed to respond effectively by moving portable property inventory i.e. contents).

However, where this value is used in outline studies, as the weighted annual average damage per residential property within a defined benefit area (say, 1 in 200-year floodplain), the number of properties affected by successively more frequent return period floods should be reduced as in Table 4.6.

[2] You may use the Rapid Appraisal Tool for Economics (RATE) spreadsheet to perform simple economic benefits calculations in England (Environmental Agency, 2026a). Please check the latest guidance for its applicability.

Table 4.5 Weighted Annual Average Damages (WAAD) (2026 values) assuming variable threshold Standards of Protection (SoP)

Existing SoP	No warning (£)	<8 hour warning (£)	>8 hour warning (£)
No protection	6,074	6,025	6,012
2 years	6,074	6,025	6,012
5 years	3,646	3,615	3,607
10 years	1,862	1,846	1,841
25 years	890	883	881
50 years	376	373	372
100 years	94	93	93
200 years	47	46	46

NB. This is Table 4.33 in the MCM 2013

Table 4.6 Estimate of the number of properties affected by different floods

Return Period	Number of properties as % of **200 year number of properties**
100	93
50	80
25	25
10	10
5	5

THE 'INTANGIBLE' EFFECTS OF FLOODING

Research into the valuation of intangible health benefits concludes that the potential value of avoiding such impacts is, on average, £317 per household per year. In addition, this research concluded that the most important factor when calculating potential intangible impacts is the flood risk (Defra/Environment Agency, 2004). At the overview appraisal level only, we recommend using this surrogate value of £317 per household to account for the willingness of households to pay to avoid health impacts. Users are also directed to recent Environment Agency (2021) supplementary guidance for values associated with the impacts of flooding on mental health. At this level of appraisal, it is suggested that an average value (rather than one associated with flood depths) is applied.

VEHICLE DAMAGES

Research for the MCM has ascertained the average value for a typical motor vehicle in the UK to be £5,600 (2021 value). Assessing exactly how many vehicles will be damaged during a flood event is very difficult, not least because vehicles are mobile. A method, which could be used for overview appraisals is based on an average property to vehicle damage ratio for the 2007 and 2012 UK floods (ABI, 2012). This method assumes that the total number of vehicles likely to be damaged during a flood occurring at any time of the day will equate to 42% of the total number of residential *and* commercial properties (see Chapter 5) at risk (from a flood of any depth). Once the number of likely vehicles has been ascertained, appraisers can multiply this by £5,600 (the value per vehicle, not the value of vehicles per household). This method does not require an assumption to be made on the presumed location of vehicles when a flood occurs.

Readers are encouraged to view Chapter 4, section 4.5 of the MCM (Penning-Rowsell et al., 2013) for a full explanation of this method. Please note that the values in this handbook are based on a later update and, therefore, are different from the ones presented in section 4.5 of the MCM.

EVACUATION COSTS

Evacuation of flood affected properties is often considered in terms of a short-term emergency response to flooding – to limit loss of life, injury and the stress caused by the flood event - and indeed it is a sensible measure to have in place. In previous versions of the MCM, the costs of emergency response and recovery have been developed to be included in appraisal calculations. In this respect, where properties are affected by flooding, evacuation from the property may also be necessary to allow flood damage to be repaired. In such cases, evacuation requires temporary or alternative accommodation for households affected and this incurs additional costs.

The duration of evacuation has a major impact on total costs, which are accrued over the time period from evacuation to the return to the property. However, to assume that, of the properties originally evacuated, all remain evacuated for the longest duration (i.e. over one year), could result in a greatly overestimated cost figure. Instead, households will return over time and only a small percentage (around 8%), are likely to remain in alternative accommodation over one year.

For overview appraisals only, we recommend using the total average cost of evacuation per household (based on an average evacuation of 23 weeks). The table *'Evacuation Costs – Overview'* on MCM-Online provides the cost for three different scenarios (high, low and average/indicative cost). The total includes average property rents, cost of temporary accommodation, food, additional transport costs and loss of earnings - see MCM, Chapter 4, Section 4.7 (Penning-Rowsell et al., 2013), for the comprehensive method.

INITIAL APPRAISALS

These appraisals require information on flood depths for each flood event being considered, and a more detailed understanding of the properties in the benefit area. In particular, the appraiser will need to know the following:

- The depth of flooding for a range of flood events;
- The type and age of houses in the benefit area, obtained from a more detailed field survey (rather than obtaining the data solely from OS Mastermap/AddressBase, Google 'Street View' and the National Receptor Database).

With this information, the appraiser can then evaluate potential direct damages using the residential depth/damage data within Chapter 4 on MCM-Online.

STANDARD RESIDENTIAL DEPTH/DAMAGE DATA

Identifying the variables used to classify dwellings should be a routine procedure in the field. Firstly, identifying the type of dwelling can be done by obtaining the property type from the NRD or, if not available, from direct observation or an online tool such as OS Mastermap/AddressBase or Google 'Street view'. Secondly, by contrast, assessing the age of any dwelling may involve a small degree of subjectivity unless planning departments can provide mapped information. In addition, the ground floor threshold level and the presence of a basement must be clarified using a site survey.

INTANGIBLE BENEFITS AND LEVEL OF RISK

Unlike a strategy study, a more detailed analysis of intangible benefits is required at an outline scale of analysis. Rather than simply applying the weighted average figure of £317 per property per year, the intangible benefits need to be determined using Defra's risk reduction matrix (Defra, 2004), see Table 4.7 *Intangible benefits associated with flood risk management improvements.* Users are also directed to recent Environment Agency (2021) supplementary guidance for values associated with the impacts of flooding on mental health. Flood depth data can be used to assign values at this level of analysis. In addition, it is also recommended that a more detailed vulnerability analysis is conducted (see below).

Government guidance now requires appraisers to consider how the level of exposure to household flood risk varies with and without the proposed scheme. This requires the appraiser to determine the level of risk, such that:

- For areas of uniform risk (such as housing on level ground behind a structural flood defence such as a flood embankment), damages are based on common standards of defence of an area;
- For areas of greatly varying risk (sloping ground away from a river), damages are based on individual levels of property flood risk.

VEHICLE DAMAGES

Research for the MCM has ascertained the average value for a typical motor vehicle in the UK to be £5,600. Based on Department for Transport figures, the average number of vehicles per household is 1.20 (Department for Transport, 2024). We therefore recommend that the average loss value for project appraisals is £6,832 (£5,600 x 1.20) per residential property in the risk area. As vehicles are most likely to be damaged and also written off at flood depths of 0.39m – on health and safety grounds – this only applies to floods greater than 0.39m above ground level (not above property threshold level) at the location of the house in question.

It should be assumed that 25% of the residential properties in the benefit area will not have a vehicle present if a warning has been issued.

EVACUATION COSTS

The cost of evacuation depends on many variables. However, a direct link between the flood depth inside a property and the evacuation rate and time was established (Table 4.8 *The probability of evacuation and duration in relation to flood depth*). In an initial appraisal where flood depth has been calculated per property type, we recommend estimating the evacuation costs as a function of the flood depth and property type. The table '*Evacuation Costs – Initial*' on MCM-Online provides the required information to perform the calculation for three different scenarios (high, low and average/indicative cost).

VULNERABILITY ANALYSIS

A vulnerability analysis for households comprises a method indicating the likely impact of floods of different severities on the households affected. Users are recommended to assess the following:

- The number of residents in the flood prone area (disaggregated by flood frequency if possible);
- The approximate proportions of households in each social group (from Small Area Census data), see: www.ons.gov.uk/census;
- The proportion of residences which are bungalows, basement flats or ground floor flats (often occupied by the elderly and infirm);
- Predicted flood depths (depths of over 0.6m can be life threatening);
- Flood warning lead-times;
- Other flood characteristics including the location of residences close to defences which may be over-topped or breached.

In undertaking a vulnerability analysis, it is sensible to concentrate on estimating the number of households who will suffer the most severe conditions and who are the most vulnerable. The variables in the SFVI, as well as those above, offer this potential.

FULL-SCALE APPRAISALS

In full-scale appraisals, it is appropriate to differentiate houses in the benefit area by their type, age and the social group of the occupants. This means that the most detailed direct damage data provided on MCM-Online can be used. In order to reflect socio-economic equity considerations this data should, where it is deemed to be 'necessary' and 'practical' (H.M. Treasury, 2026), be subjected to a distributional impact analysis. Data required for this analysis includes flood history, depth and duration, small area census data and general information on householders' views on the risk they face.

ADDITIONAL RESIDENTIAL DEPTH/DAMAGE DATA

The additional residential depth/damage data on MCM-Online takes into consideration several types and ages of residential properties, short, long and extra-long flood durations as well as different scenarios; saltwater, wave damage and various categories of water (Table 4.1).

To make full use of the additional residential depth/damage data sets, the social group of the occupants of the houses in the benefit area should be established. Because the social group variable derived from census data relates to the census output area (OA) as a whole, and not to the individual dwelling's occupants, the social group of individual occupants is calculated on the basis of averages. For example, if 60% of the dwellings in the OA fall into the C2 category and 40% fall into the DE category, the depth/damage data should be weighted accordingly.

DISTRIBUTIONAL IMPACT ANALYSIS

The Treasury Green Book (HM Treasury, 2026) recommends that, where it is ‘necessary’ or ‘practical’, potential benefits should account for distributional impacts to incorporate social equity considerations into flood and coastal defence appraisals. Determining if it is ‘necessary’ or ‘practical’ then depends on a number of circumstances, including:

- The likely robustness of any calculation of distributional impacts. Whether a community at flood risk can be identified with reliable data and categorised according to their prosperity or social class;
- The type of project being assessed. Whether the assessment will contribute to an appraisal that demonstrates equity and fairness to people;
- The scale of the impact associated with a particular project or proposal. Whether the time and effort in undertaking the assessment is proportional to the scale of the overall appraisal, either at a strategic or feasibility level.

If a distributional analysis is not required, the standard residential depth/damage curves for the property type and age should be used, without accounting for social group. If a distributional analysis is required, total weighted factors should be applied by social group (Table 4.3). However, the total weighted factors for C1 and C2 will generally have a negligible effect. Therefore, use of total weighted factors is only recommended where AB or DE social class groups are predominant. Total weighted factors may then be applied to adjust the standard depth/damage data to obtain potential damages avoided taking account of distributional impacts.

A number of points are important in this government guidance:

- Both weighted and non-weighted results should be presented;
- Where property ‘write offs’ are considered, average values should be based on average ‘no risk’ values of properties of similar type and region;
- In areas with a high proportion of rented accommodation the social group of the owner of the property should be taken into account for building fabric damages and that of the occupier applied to content damages.

INTANGIBLE BENEFITS AND LEVEL OF RISK

At the full-scale level of analysis, the intangible benefits need to be determined using Defra’s risk reduction matrix (Defra, 2004), see Table 4.7 *Intangible benefits associated with flood risk management improvements.* Users are also directed to recent Environment Agency (2021a) supplementary guidance for values associated with the impacts of flooding on mental health. Flood depth data can be used to assign values at this level of analysis. In addition, it is also recommended that a more detailed vulnerability analysis is conducted (see below).

Government guidance now requires appraisers to consider how the level of exposure to household flood risk varies with and without the proposed scheme. This requires the appraiser to determine the level of risk, such that:

- For areas of uniform risk (such as housing on level ground behind a structural flood defence such as a flood embankment), damages are based on common standards of defence of an area;
- For areas of greatly varying risk (sloping ground away from a river), damages are based on individual levels of property flood risk.

VEHICLE DAMAGES

For full-scale appraisals it is necessary to ascertain the number of vehicles in the risk area. This may be achieved by contacting local authorities or using ONS Census data (https://www.ons.gov.uk/census) which provides detail at various geographical levels. Once the likely number has been ascertained, this figure can be multiplied by £5,600 (the value per vehicle, not the value of vehicles per household, as above).

EVACUATION COSTS

In a full-scale appraisal the appraiser is expected to have a better knowledge of the duration of evacuation and the percentage of evacuation rather than relying on national averages figures. Based on local surveys and research, it is recommended that the appraiser modifies the input values for the percentage evacuated per depth band (cells B3:B9 in the 'Evacuation Cost – Full-Scale' table on MCM-Online) and for the mean duration of evacuation in weeks (cells C3:C9). The appraiser can then use the updated evacuation costs in the same table to perform the calculation for three different scenarios (high, low and average/indicative cost).

VULNERABILITY ANALYSIS

A vulnerability analysis for households comprises a method indicating the likely impact of floods of different severities on the households affected. Users are recommended to assess the following:

- The number of residents in the flood prone area (disaggregated by flood frequency if possible);
- The approximate proportions of households in each social group (from Small Area Census data), see: https://www.ons.gov.uk/census;
- The proportion of residences which are bungalows, basement flats or ground floor flats (often occupied by the elderly and infirm);
- Predicted flood depths (depths of over 0.6m can be life threatening);
- Flood warning lead-times;
- Other flood characteristics including the location of residences close to defences which may be over-topped or breached.

In undertaking a vulnerability analysis, it is sensible to concentrate on estimating the number of households who will suffer the most severe conditions and who are the most vulnerable. The variables in the SFVI, as well as those above, offer this potential.

FREQUENTLY FLOODED PROPERTIES AND WRITE-OFF

The new English FCERM appraisal guidance on *frequently flooded properties and write-off* introduces a revised approach to estimating damages and benefits for properties at very high flood risk (Frequently flooded properties and write-off in FCERM appraisal - GOV.UK).

The guidance (Environment Agency, 2026b) replaces previous capping and write-off methods and no longer caps property damages at regional market values (i.e. when the Annual Average Damages and the consequential capital sums for those properties would exceed their market value without this capping). The high AAD values that capping produced arose because of the assumption of repeated frequent flooding causing continual flood damage at the property.

Instead, the new method assumes continued occupation of the at-risk frequently flooded properties (which are rare), with adaptive household behaviours reducing potential damages (e.g. by installing flood resistant furniture or fitted kitchens and learning how to cope with the flooding). The result of these behavioural changes means that future flood damage to properties will be less.

This is recognised by not attributing the full MCM derived potential AAD to these properties in proportion to the high flood risk that they suffer. Under the new guidance this is done by applying evidence-based damage-reduction factors to Annual Average Damages for frequently flooded properties, while restricting write-off to cases of permanent inundation or extreme internal flooding. Annual Average Damages for property damages should be reduced by the factors provided in the guidance (Environment Agency, 2026b).

ESTIMATING THE DAMAGE-REDUCING EFFECTS OF PROPERTY-LEVEL RESILIENCE MEASURES

Property-Level Resilience (PLR) measures include resistance and recoverability measures. Resistance measures (e.g. flood guards) are designed to exclude floodwater from properties whereas recoverability measures (e.g. concrete floors instead of timber ones) assume that floodwater will enter a property, but internal features are designed to reduce flood damage potential. Both resistance and recoverability measures are sometimes used in conjunction with flood warnings (i.e. their implantation is dependent on action being taken once a flood warning is received) but they may also be designed to be effective independent of warnings.

The following are examples of these measures:

- Barriers for doorways and airbrick covers (automatic or manually operated);
- Non-return valves for domestic and foul drainage systems;
- De-watering pumps;
- Waterproofing and sealants;
- Internal rearrangements for electrical outlets and wiring; and
- Replacement of floors and doors with materials, which have a comparatively low damage susceptibility.

The WAAD data for warnings in Table 5.4 must not be used together with estimates of damage-reduction through the use of PLRs. Instead, the 'no warning' data should be utilised and from estimates of damages using these data, the damage-reducing effects of PLRs should be deducted.

Two approaches for estimating the benefits of PLR measures are presented.

APPROACH 1 – APPLICATION OF PROPERTY LEVEL RESILIENCE DEPTH DAMAGE DATA

Step One

Identify residential properties in the benefit area which have measures installed. Where grant schemes have led to PLR measures being installed records may be available which provide this information or alternatively a field survey may need to be undertaken. For an initial study, if the number of properties with measures is small (say 5% of properties or less), it is probably not worth taking account of the effect of these in an appraisal. Otherwise (e.g. at the project appraisal level) the estimated damage-reducing effect of measures must be taken account of. This is because PLR measures reduce damage at the more frequent flood return periods and will, therefore, have a significant effect on estimated annual average damages.

Step Two

Depth damage data for residential property with PLR measures is available in Chapter 4 Additional Resources. Resistance with a protection threshold of 60cm above the finished floor level of the property is considered both with a 5mm leak damage, and without leakage (i.e. preventing all losses up to the threshold). A recoverability scenario has also been developed which comprises common recoverability measures including resilient skirting board and flooring and raised electrical goods. Table 4.7 provides the details of these scenarios. Scenarios have been selected through analysis of commonly installed PLR packages.

Table 4.7 Details of PLR scenarios

PFR Scenario (curve name)	***Description***
60cm_resistance	60cm protection with no leakage
60cm_resistance_leak	60cm protection with 5mm leak damage up to 60cm
best_recoverability	Recoverability with 30cm skirting, resistant floor, kitchen, bathroom and raised electrical system, boiler and TV.

APPROACH 2 – DAMAGE REDUCTION FORMULAE

Step One

Calculate the number and then the total ground floor size (m²) of residential properties at risk at each return period in the benefit area up to the 1 in 75-year flood probability threshold where flooding is not expected to be greater than 1m (TGA).

Step Two

The following formulae are, to a degree, progressively more reliable if sound local parameter values are substituted for the national average values (e.g. for UP, OP) are included in them below (Clarke et al., 2015).

The formulae may be used to estimate the total £ damage reduction owing to residential property warning-independent resistance measures (WIRB).

Equation 4.1

WIRB (£) = TGA * DR * UP * EF

where:
WIRB (£) is Estimated damage reduction (i.e. benefit) by employing WIRB measures
TGA is Total ground floor area of residential properties located in benefit area within 1:75 flood risk area and where flooding is not likely to be greater than 1m
DR is Damage reduction: £94.90 per m^2 at 2026 value
UP is Uptake of WIR measures factor: 0.032
EF is Effectiveness factor: 0.75

For warning-dependent resistance measures (WDRB) the equivalent formula is:

Equation 4.2

WDRB (£) = TGA * RA * DR * UP * OP * EF

where:
WIRB (£) is Estimated damage reduction (i.e. benefit) by employing WIRB measures
TGA is Total ground floor area of residential properties located in benefit area within 1:75 flood risk area and where flooding is not likely to be greater than 1m
RA is Reliability and Availability: 0.30
DR is Damage reduction: £48.91 per m^2 at 2026 value
UP is Uptake of WDR measures factor: 0.048
OP is Operated: 0.63
EF is Effectiveness factor: 0.75

Equations 4.1 and 4.2 are only an indicative guide to the value of residential property damage reduction through use of resistance measures.

The formula below may be used to estimate a guide value for the damage reducing effects of recoverability measures on residential properties:

Equation 4.3

RISDR (£) = TGA * DR * UP * EF

Where:
RISDR (£) is Estimated damage reduction by employing recoverability measures
TGA - Total ground floor area of residential properties located in benefit area within 1:75 flood risk area and where flooding is not likely to be greater than 1m
DR is Damage reduction: £97.83 per m^2 at 2026 value
UP is Uptake factor: 0.02
EF is Effectiveness factor: 0.50

When undertaking a benefit assessment, a decision will have to be made about a) whether or not to take account of the damage reducing effects of resistance and recoverability measures (if they exist and are ignored benefits may be exaggerated) or b) to make allowance for them, possibly by using the above formulae. At the project appraisal level, PLP measures must be taken into account unless the proportion of relevant properties is a very small proportion of the total (i.e. say, less than 1%).

SOME "HEALTH WARNINGS"

- Damage estimates: Professional opinion varies on the precise effect of flood water on some inventory items. Susceptibility must be continually updated as more information becomes available;
- Inventory and building fabric data: Standard checklists have been devised which are not exhaustive;
- Average Remaining Values are not empirically assessed;
- Items are generally assumed to be approximately halfway through their lives which may distort downwards the potential damage estimates in some newly established households;
- Applying nationally based data to small areas locally may lead to errors;
- There have been recent cases were additional electricity costs for driers, blowers and dehumidifiers have been incorrectly included in appraisals. These were part of older versions of the Multi Coloured Manual but have been excluded since the 2013 update. The rationale is that the increased costs are offset by reduced electricity consumption due to properties being unoccupied. Environment Agency Economists will be monitoring this during assurance of applications for Defra Grant-in-Aid, and we advise that you make sure these values are not included.

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5 Non-Residential Properties

5 Non-Residential Properties

OVERVIEW

Flood damage to Non-Residential Properties (NRPs) can be a significant factor when considering major expenditure on flood risk management measures. Chapter 5 of the MCM (Penning-Rowsell et al., 2013) provides methods and data for assessing the direct flood loss potential of NRPs. Guidance on the estimation of indirect losses is also included as is guidance on evaluating the flood damage-reducing effects of property level resilience (PLR) measures and the movement of contents of properties prior to flooding and on receipt of a flood warning.

The NRP damage data are available as depth/damage and depth/damage/duration data in which short, long and extra-long flood durations are considered. The data have been selected and compiled to represent 95% of NRPs located in flood risk areas of England and Wales as indicated by the Environment Agency's National Receptor Dataset. The data includes damages from saltwater and wave impact and the damage-reducing effects of flood warnings.

The NRP depth/damage/duration data were compiled by employing an empirically informed, synthetic modelling approach in which our Building and Quantity Surveyor's (experienced in building refurbishment and replacement as well as in flood damage susceptibilities) were posed a series of 'What if?' questions. For example, what would the flood damages likely to be if a typical or representative supermarket or a warehouse was to be flooded to different depths? And what would be the likely range of damage susceptibilities (i.e. best case (low), worse case (high) and most likely case (indicative)? The method used in Chapter 5 is directly analogous to the now well-accepted synthetic approach used to compile the Residential Property depth/damage/ duration data (Chapter 4).

The categorisation of NRPs is simpler than in pre-2013 editions, as far fewer sub-categories are employed, reducing complexity for users. Using the sector and sub-sector weighted averages ensures the selection of damage data and its assignment to land use/property databases becomes relatively simple, although the user is always advised to have his/her wits about them when matching depth/damage/duration data to property databases as an incorrect assignment to properties may well lead to significant errors in damage estimation.

It is important to recognise that the NRP damage data represent an 'average' or 'typical' set of damage values for England and Wales. They therefore present users with a 'standardised' approach to damage estimation and one which aids comparability across the country. For this reason, and to the extent that users may find that they are presented with examples of NRPs which are not average, then the damage data will under or over-estimate actual damage potential. Deviation from the average is less likely to occur or be significant in the sub-sectors where multiples dominate and where properties have become more standardised over time. This is so in the Retail, Office and Warehouse sub-sectors but standardisation is least likely and therefore significant variance is most likely in the industrial sub-sector where unique factory or workshop premises are most likely to be found. Users should therefore consider the merits of undertaking site surveys in this case.

Where there is sound local evidence to suggest that properties are significantly different to the average or typical, then it is permissible to utilise the ‘high susceptibility’ or ‘low susceptibility’ depth/damage/duration data rather than the 'indicative' case data which should normally be used.

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However, in these cases the use of these data in appraisals should be clearly specified and supported with evidence and sensitivity testing around these susceptibility envelopes should be incorporated into the appraisal.

The 2026/27 damages have been inflated using the appropriate indices.

LESSONS FROM EXPERIENCE

- The range and diverse function of NRP types, their size, and the varying degrees of susceptibility for each component of damage, make it more difficult to construct these data than other loss data;
- The type and function of an NRP is not the most important determinant of potential NRP flood damage. Flood depth, property size and precautionary measures all come before the category of NRP in the influence they exert on flood losses;
- There will inevitably be errors in the data supplied with this Chapter. It is not possible to quantify all of these errors, although every attempt has been made to keep them to a minimum;
- Data on the Extra-Long Duration and coastal flooding, and on the potential reduction in losses following receipt of a flood warning need to be treated with some caution;
- Data relating to potential damage saving related to property-level protection are tentative and subject to many assumptions;
- Error is present in any flood damage data set and therefore it is wisest in any appraisal (at any scale) to subject these data to sensitivity testing.

DIFFERENT TYPES OF APPRAISALS

The framework presented below is for appraisals of different types, scale and complexity. The framework includes (1) overview studies which are less complex and demanding in terms of damage data requirements and which may be undertaken at the meso- or micro-scales[1], (2) initial and full-scale studies, the latter of which are more detailed and demanding and more suited to the micro-scale and (3) micro-scale site surveys where site-specific damage data are collected.

HOW DO MCM NRP FLOOD DAMAGE DATA COMPARE WITH REPORTS OF NRP FLOOD DAMAGE?

Since MCM flood damage data are primarily ‘synthetic’ data (i.e. they are constructed by building and quantity surveyors experienced in flood damage independent of actual flood damage reports) it may be considered useful to compare them with reports of actual flood damage in floods experienced in the UK in recent years. Unfortunately, insurance companies are very reluctant to release data for individual properties and post-flood property-by-property surveys of flood damage are time-consuming and costly to undertake and are often not welcomed by those who have suffered damage and have already been visited by insurance loss adjustors. In addition, property owners/managers are known to under-estimate flood damages in the period immediately following a flood because some damages only show up weeks and months later. Another problem with property-by-property surveys of flood damage is that they seldom cover the full flood depth range that is required to construct depth-damage curves: indeed, as the case in the “Non-Residential Properties: Financial or Local Economic Losses and Benefits” chapter shows, only one a very few

[1] You may use the Rapid Appraisal Tool for Economics (RATE) spreadsheet to perform simple economic benefits calculations in England (Environmental Agency, 2026a). Please check the latest guidance for its applicability.

flood depths are represented. In this 'financial losses' chapter comparisons are made, which are not repeated here, of reported flood damage values with MCM flood damage values on a £/square metre basis. Because the relationship between economic and financial flood damages values is known, the conclusions drawn about the comparison apply equally to this chapter as to the 'financial losses' chapter.

HOW TO USE THE DATA

The potential damage data need to be related to flood probability in order to calculate annual average flood damages which is the objective (see Chapter 3). A property-by-property database is required which identifies the ground floor threshold height AOD above which flooding will start to enter the property. In the case of complex NRPs which comprise a site containing a number of buildings it will normally be necessary to treat each separate building as a separate property. The latest version of the property-by-property NRD database provides the MCM codes used here, but older versions of the NRD use the old MCM codes and these codes have been translated into the latest MCM codes in Table 5.1 (see 'Tables & Figures' spreadsheet for Chapter 5 on MCM-Online). The database should also carry other property identifiers such as grid reference and postal address information. The ground floor area in m^2 of the building footprint only (excluding surrounding grounds) should also be recorded as should the ground floor threshold level. Finally, this database must be linked to a hydro-dynamic model which allows flood depths for a range of floods of different probability to be assigned to each property.

The MCM data includes cellars where it is likely that property types have cellars but not in other cases. It does not include basement data. Normally, for pre-feasibility and outline appraisals only the already included cellar data will be used. However, if there is good reason to believe that properties have basements and those that have them can be easily identified, then basement threshold level could be used as the ground floor threshold level to calculate flood damage potential. Google Street View may be used to confirm existence of basements in some cases.

OVERVIEW STUDIES

The data requirements for NRPs are as follows:

Step One: The number of properties in each of NRP sub-sector or category

This means that the number of properties in each of the following NRP sub-sectors is required: retail, offices, warehouses, leisure, public buildings and industry; together with the number of playing fields, sports centres, marina, sports stadiums, car parks and substations. These are the NRP sub-sectors and categories for which discrete weighted mean depth/damage/duration data are provided. It will also be necessary to identify the number of non-specific, miscellaneous sub-sector 9 properties i.e. where property type is unknown without further research and/or ground-truthing. The NRP sector weighted mean depth/damage/duration data are to be used in the case of miscellaneous; 'unknown' sub-sector 9 properties.

It should be noted that a very low-resolution study may just employ the total number of NRPs and the NRP weighted sector mean flood damage data. However, this is much cruder than using the sub-sector and category weighted means indicated above.

Step Two: The ground floor space and threshold level for each NRP

All depth/damage/duration data for NRPs is in £m[2] therefore the area of the ground floor space of each NRP also needs to be entered into the property-by-property database. There are now a variety of sources of information by which property floorspace (meaning the ground floor area of the building or buildings excluding grounds and car parks) may be identified. Use the National Receptor Database (NRD) to determine each property's footprint (DQS 1). If unavailable, the following sources of information may be used depending on the resources available:

- Determine area by field measurement (DQS 1) or;
- Use GIS tools to measure the area from OS Mastermap/AddressBase or equivalent (DQS 1) or;
- For specific or unconventional properties use www.royalmail.com to determine property post code, then use https://www.tax.service.gov.uk/business-rates-find/search to determine current valuation which gives the rateable valuation for the property concerned and total ground area (DQS 1). If the specific rateable value data is not available on the VOA website then a good approximation (DQS2) is available by Country and region in the *NDR Business Floorspace Tables, 2023* at: https://www.gov.uk/government/statistics/non-domestic-rating-stock-of-properties-including-business-floorspace-2023) (values also provided in Table 5.4) or;
- Use the indicative floor sizes provided in Table 5.2 within the 'Tables & Figures' for Chapter 5 on MCM-Online (DQS 3).

Step Three: The current standard of flood protection provided for the benefit area

Step Four: The Weighted Annual Average Damages (WAAD)

The WAAD (See Chapter 4, Section 4.9.1) are then taken from the table below for each NRP sub-sector or category (or in the case of miscellaneous, 'unknown' sub-sector 9 properties - the weighted NRP sector mean) and multiplied by the appropriate ground floor area. The shading in the table represents the different subsector/category levels.

Table 5.3: Weighted annual average damage by standard of protection (2026/27 values)

		Standard Of Protection						
MCM Code	**Sector Type**	**None**	**5**	**10**	**25**	**50**	**100**	**200**
2	Retail	100.61	49.72	36.24	18.63	8.31	2.08	1.03
3	Offices	98.54	45.33	34.19	17.10	7.52	1.89	0.94
4	Warehouses	113.00	59.58	43.12	21.86	9.90	2.47	1.24
5	Leisure and sport	NOT APPLICABLE - CONSTITUENT CATEGORIES TOO DIVERSE						
51	Leisure	228.04	78.51	62.50	28.38	12.17	3.04	1.52
52	Sport	NOT APPLICABLE - CONSTITUENT CATEGORIES TOO DIVERSE						
521	Playing Field	4.25	1.70	1.36	0.65	0.28	0.07	0.04
523	Sports Centre	52.45	22.70	17.37	8.45	3.69	0.93	0.46
526	Marina	18.97	8.69	6.37	3.24	1.42	0.35	0.18
525	Sports Stadium	13.29	6.48	4.77	2.43	1.08	0.27	0.13
6	Public Buildings	60.76	27.49	20.73	10.27	4.53	1.13	0.56
8	Industry	21.34	10.55	7.68	3.92	1.75	0.44	0.22
9	Miscellaneous	NOT APPLICABLE - CONSTITUENT CATEGORIES TOO DIVERSE						
910	Car park	6.55	2.92	2.17	1.10	0.47	0.12	0.06
960	SubStation	317.16	192.39	137.67	75.27	34.05	8.51	4.26
NRP sector average		104.89	54.88	40.21	21.23	9.65	2.53	1.27

INITIAL AND FULL-SCALE STUDIES

Step One: List the NRPs in the benefit area

For Project Appraisal Reports (PARs) and more detailed Strategy Reports a stepwise approach to data assembly is suggested here. Note that a Data Quality Score (DQS) 1-4 should be allocated for the land use sub sector or category of each NRP, ground floor area, the depth/damage/duration data assigned to the sub sector or category, as well as for property threshold.

- Determine the number by sub-sector or category of NRPs in the benefit area primarily by using the NRD (data quality score 2) and further enhanced by other data sources such as OS Mastermap/AddressBase) (DQS 2), Google Street View (DQS2) and preferably a site survey (DQS 1) for selected properties (see section 5.10.6). Also identify any miscellaneous (sub-sector 9) 'unknown' properties (i.e. the function of which is not known);

- Selective field checks are always recommended to authenticate data quality.

Step Two: Determine each property's ground floor area and property threshold level

Determine ground floor area by using the NRD (DQS 1). If unavailable, use one of the following sources (each with differing DQS). Selection will depend upon available budget and timescale:

- Determine area by field measurement (DQS 1) or;
- Use GIS tools to measure the area from OS Mastermap/AddressBase or equivalent (DQS 1) or;
- For specific or unconventional properties use www.royalmail.com to determine property post code, then use https://www.tax.service.gov.uk/business-rates-find/search to determine current valuation which gives the rateable valuation for the property concerned and total ground area (DQS 1). If the specific rateable value data is not available on the VOA website then a good approximation (DQS2) is available by Country and region in the *NDR Business Floorspace Tables, 2023* at: https://www.gov.uk/government/statistics/non-domestic-rating-stock-of-properties-including-business-floorspace-2023) (values also provided in Table 5.4) or;
- Use the indicative floor sizes provided on MCM-Online (DQS 3);
- Determine property ground floor threshold level through the use of a site survey. In some cases it may also be possible to do this using a tool such as Google Street View.

Step Three: Linking NRD (MCM) codes to the MCM data

- Link the NRD (MCM) codes to the weighted sub-sector or category means on MCM-Online. For some categories (most notably sport (52) and miscellaneous (9)) it will be necessary to use the corresponding 3-digit NRP category code instead. Use the NRP sector weighted mean data for any miscellaneous sub-sector 9 'unknown' properties.

Step Four: Allocate depth/damage/duration data

- Within Chapter 5 of the MCM-Online, the preferred depth/damage/duration data for each NRP (MCM) code with appropriate data quality are available;
- Basement data misuse can inappropriately bolster estimates of damage potential and the present value of damage (PVd). The MCM-Online therefore does not provide data for properties with basements. However, data are provided for selected properties which are likely to include a cellar, such as a public house or restaurant. Here we assume that a cellar is a room below ground with no functional use and limited storage. For functional basements that fill completely once ground floor threshold levels have been exceeded by flooding, it is likely that all contents and equipment would be written-off or would need cleaning and repairing, and that refurbishment and redecorating would be necessary. It is therefore recommended that damage data are not assigned to basements unless field-based land use checks clearly confirm that basements are present. We recommend in such cases that the basement threshold level is used as the property threshold level in calculating damage potential;

- The *Additional Data* for Chapter 5 section of the MCM-Online provides further depth/damage/duration data for low and high susceptibilities and flood warnings where the data takes into account the potential percentage reductions in damage to moveable equipment and stock only - see MCM, Chapter 5 (Penning-Rowsell et al., 2013). These should be employed wherever there is a functioning formal flood warning system in place which affords a minimum of 4 hours flood warning lead-time to NRPs in the benefit area. The additional data section also provides salt and wave damage date. Where NRPs are likely to be subjected to wave impacts (seafront properties, for example) the wave data should be used, which also accounts for saltwater inundation. If the property is likely to be protected from the force of waves but still inundated by seawater, the 'salt data' should be used.

Step Five: Undertake present value of damages calculation

- Use proprietary software to calculate estimated property present value of damages (PVd).

Step Six: Apply evidence-based damage-reduction factors to Annual Average Damages for frequently flooded properties.

- Under the new guidance on *frequently flooded properties and write-off* (Environmental Agency, 2026b), Annual Average Damages for frequently property damages should be reduced by damage-reduction factors. Rationale, approach and damages limiting tables are available at: [Methods for calculating economic benefits - GOV.UK]

Step Seven: Filtering

- Rank each property in the benefit area by its PVd or capped value (see Chapter 3). Check the data quality of at least the top 10 contributing NRPs as these from experience contribute a significant proportion of Total PVd representing the potential for significant uncertainty.
- Work to reduce the number of sub-sector 9 'unknowns' by undertaking further Google Street View and/or field checking. A large number of these 'unknowns' can lead to significant inaccuracies (i.e. under or overestimates) in damage estimation.
- If after the filtering process and improvement of data quality any NRP contributes more than 10% of PVd or capped PVd then a site survey should be undertaken to confirm these damages.

SITE SURVEYS

The variety of NRPs is considerable, and average/standard depth/damage data given may be considered inappropriate for one of the following reasons:

1. A property may contribute more than 10% of the PVd; and/or;

2. A property may be so unusual or unique that it warrants the replacement of mean standard damage data by damage data that would be considered to be more reliable.

In such cases a site survey of the property is probably required depending upon the type or scale of appraisal (a standard NRP site survey proforma may be downloaded from the *Additional Resources* section of Chapter 5 on MCM-Online). However, site surveys are time-consuming and require the willing cooperation of the company concerned which might itself take time to acquire. This means that site surveys, where required, are usually reserved for the largest NRPs with high flood frequencies and therefore potentially average annual damage.

For a site survey, the following is a guide as to whom to approach within the business organisation to help complete the site survey questionnaire:

- Small firms - the owner;
- Medium size firms - the plant or company manager;
- Large complex firms - the Managing Director or Financial Director, senior accountant, insurance claims Officer, estates manager or emergency planning officer.

A simplified approach will focus on the following questions making sure that damage or cost estimates exclude VAT:

1. What is the cost of re-build (I.e. the building structure and fabric)?
   Note that this is for the footprint of the building(s) and not the Footprint of the property.
2. What is the value of services installed?
3. What is the value of moveable equipment?
4. What is the value of fixtures and fittings including static machinery and equipment?
5. What is the value of stock, raw materials and work-in-progress?
6. Are losses of trade to overseas competitors likely to be significant (see below)? If so, what are they likely to be?
7. What are the likely costs of clean up after the flood?

Realistic rounded estimates of damage and loss potential are required (e.g. to the nearest £1,000 for smaller firms, or the nearest £10,000 for larger organisations), where indicative values of equipment (moveable and static) and stock etc. may run into £millions.

The values for each damage component are converted to values per square metre of the buildings in question and can these be entered into a spreadsheet (provided in the *Additional Resources* section for Chapter 5 on MCM-Online) for the nearest MCM code of the property in question to obtain correct susceptibility levels. The susceptibility to damage for each component is assumed unchanged from the previous research and depth/damage/duration data are automatically generated based on the revised component values derived from the site survey. In short, valuation of component damages is revised with respect to a specific property and applied to existing susceptibility curves.

INDIRECT FLOOD LOSSES

Obtaining accurate data on indirect flood losses is difficult. Users must decide whether or not to include an estimate of indirect losses. Indirect losses are of two kinds:

- Losses of business to overseas competitors, and;
- The additional costs of seeking to respond to the threat of disruption or to disruption itself which fall upon firms when flooded.

The first of these losses is unusual and is limited to highly specialised companies which are unable to transfer their productive activities to a branch site in this country, and which therefore lose to overseas competitors. The second type of loss is likely to be incurred by most NRPs which are flooded. They exclude post-flood clean-up costs but include the cost of additional work and other costs associated with inevitable efforts to minimise or avoid disruption. These costs include costs of moving inventories, hiring vehicles and costs of overtime working. These costs also include the costs of moving operations to an alternative site or branch and may include additional transport costs.

Chapter 5, Section 5.7 of the MCM (Penning-Rowsell *et al*., 2013) provides a relatively crude method for estimating and including potential indirect costs where these are the additional costs associated with trying to minimise indirect losses. This is by calculating total indirect losses as an uplift factor of 3% of estimated total direct NRP losses at each return period included within the damage estimation process. This uplift factor of 3% remains as the best estimate of economic indirect flood losses to NRPs even though the uplift factor for financial indirect flood losses has now been revised significantly upwards as a result of new evidence (see Non-Residential Properties: Financial or Local Economic Benefits and Losses).

If an NRP is likely to contribute over 10% of the overall PVd, then it may well be worth seeking to ascertain indirect costs through asking the questions on disruption and indirect losses included in the site survey questionnaire which is recommended in this case. Also, if a business appears to be highly specialised and may not have competitors in this country, it may also be worth pursuing an estimate of indirect cost of flooding in the same way.

The site survey questionnaire can be found in the *Additional Resources* section for Chapter 5 on MCM-Online.

ESTIMATING THE DAMAGE-REDUCING EFFECTS OF PROPERTY LEVEL RESILIENCE MEASURES

Currently there is significantly less use of property-level resilience (PLR) measures in the NRP sector than in the residential sector where much of the emphasis in national policy has focused (Haskoning UK Ltd, 2012; Merritt, 2012). PLR survey and installation is being increasingly professionalised to ensure effectiveness (May et al. 2015) and small and medium sized enterprises (SMEs) are now being targeted for PLR measures. However, in general, take-up is currently significantly lower than in the residential sector. In Britain, businesses are likely to use various generic coping strategies that support business continuity, rather than property-level protection measures against flooding. Confirming this, Ingirige and Wedawatta (2011) found that SMEs tend to mostly rely on general business continuity and/or risk management strategies, although the uptake of those strategies was also found to be minimal. Generally, the level of up-take was higher among the SMEs with previous flood-related hazard experience, and such businesses were more likely to implement PLR measures than the SMEs without such experience. Obtaining property insurance, having a business continuity plan, using a business data backup system, and obtaining business interruption insurance were the commonly implemented business continuity measures by SMEs (Wedawatta and Ingirige, 2012). Further confirmation of the current low uptake of PLR measures by businesses in Britain, as well as in other parts of Europe is provided by Parker *et al*. (2012).

In the NRP sector, PLR are only likely to be relevant for small and some medium sized business properties (i.e. generally those of SMEs). Larger business premises are likely to be more complex, possibly with a number of buildings, and generally other approaches rather than PLR will be more relevant here.

An assessment of flood damage potential may or may not therefore warrant inclusion of the damage-reducing effects of property-level resilience measures: it depends on the purpose of the assessment, the user's objectives in undertaking the assessment and the size of business premises. If the decision is made to assess and include the estimated impact of these measures, then they are to be entered into any working spreadsheet as deductions of damage potential once damage potential has been estimated using one of the procedures above.

Where it is known that if PLR measures have been installed, their potential impact should be reflected in damage calculations otherwise damage potential will be over-estimated. However, if the number of NRPs protected in this way is small (say 5% of properties or less) it may well not be worth taking account of the impact of these measures in an appraisal. If the objective is to assess the potential for installing PLR measures then a with-and-without appraisal needs to be undertaken, and the method below will only provide a very crude estimation of damage-savings which will need to be taken further. Identifying those properties which have already installed PLR measures can be difficult and time-consuming if there is no adequate record already in existence. A field survey designed to identify these properties will be necessary and to identify resilience measures in particular, contact may well need to be made with property occupants. These measures are most likely to be found in the 1:75-year flood extent envelope where the 100-year flood is no deeper than 1 metre.

RESISTANCE MEASURES

If flood resistance measures are identified as installed in NRPs or are being considered, then the damage-reducing effects of these measures may be estimated. A **first method** by which an estimation may be achieved is by raising the ground floor threshold level assigned to the properties in question by 0.6 metres within the land use/property database constructed for the appraisal. The 0.6 metres above property threshold level is considered by May and Chatterton (2012) to be the maximum level at which resistance measures can work effectively. This is, however, likely to lead to some overestimation of damage reduction because other factors such as the effectiveness of resistance measures needs to be taken into account.

A **second method** is to use formulae 5.1 and 5.2 below, although this method also has limitations. When using these formulae locally derived and appropriate parameter values should be used. Only where these do not exist should the default values below (which approximate average values for the nation) be used.

Surveys of the performance of predominantly residential PLR measures in four locations following the 2012 floods revealed that where PLR measures were deployed and actually required, these measures have helped to reduce the impact of flooding in 84% of properties (although performance varied considerably between locations) (May *et al.*, 2014). There was also evidence that water will still seep into properties through brickwork generating flooding of up to one inch. For this reason, the damage-reducing effects of resistance measures must be factored by 0.84 if a more appropriate locally relevant value is unavailable. This only applies to properties which have a ground floor size of 320m^2 or less. NRPs of more than 320m^2 are much less likely to be protected by PLR measures because of the complexity and cost. Instead, they may be protected by demountable defences close to properties or more remotely from them. The damage-reducing effects of demountable – if there are firm plans to deploy them – should also be taken into account by raising the ground floor property threshold of the protected property (as in the first method explained above). However, for PLR measures, damage savings at each return period should be factored by 0.84 to take account of reliability issues.

Uptake values (UP) are the proportion of NRPs within the 1:75-year flood envelope which are expected to have PLR measures installed (e.g. 10% = 0.1). Because take-up of PLR is currently significantly less for NRPs than for residential properties, the national uptake factors are reduced here to 0.016 for warning-dependent resistance measures (WDRM) and 0.024 for warning-independent resistance measures (WIRM) (i.e. the values given in Penning-Rowsell *et al*. (2013) have been adjusted downwards to reflect lower take-up in the NRP sector). Damage reduction (DR) values are derived using economic costing rather than financial costing principles and are intended for use as broad average values. Not all property owners can be expected to operate their warning dependent measures and so an OP variable is included in Equation 5.2 to reflect this.

Step One: Calculate the number and then the total ground floor size (m^2) of NRPs at risk at each return period in the benefit area up to the 1 in 75-year flood probability threshold where flooding is not expected to be greater than 1m. Include only those NRPs with a ground floor size of $320m^2$ or less.

Step Two: The following formulae may then be used to estimate the total £ damage reduction owing to NRP warning-independent measures (WIR):

Equation 5.1

WIRB (£) = TGA * DR * UP * EF

where:
WIRB (£) is Estimated damage reduction (i.e. Benefit) by employing WIR measures;
TGA is Total ground floor area of NRPs located in benefit area within 1:75 flood risk area and where flooding is not likely to be greater than 1m (for each return period in the appraisal);
DR is Damage reduction: (national default value = £97.55 per m^2 at 2026/27 values);
UP is Uptake of WIR measures factor: (national default value = 0.016);
EF is Effectiveness factor: (national default value = 0.84).

The resultant £ value result must then be converted to annual average damages saved.

Step Three: For NRP warning-dependent resistance measures (WDR) the equivalent formula is:

Equation 5.2

WDRB (£) = TGA * RA * DR * UP * OP * EF

where:
WDRB (£) is Estimated damage reduction (i.e. Benefit) by employing WDR measures
TGA is Total ground floor area of NRPs located in benefit area within 1:75 flood risk area and where flooding is not likely to be greater than 1m (for each return period in the appraisal.) Include only those NRPs with a ground floor size of $320m^2$ or less;
RA is Reliability and Availability: (national default value = 0.30);
DR is Damage reduction: (national default value = £97.55 per m^2 at 2026/27 values);
UP is Uptake of WDR measures factor: (national default value = 0.024);
OP is Operated: (national default value = 0.63);
EF is Effectiveness factor: (national default value = 0.84).

The resultant £ value result must then be converted to annual average damages saved.

To summarise, the above formulae are only a rough guide to the value of NRP damage reduction through use of resistance measures for the following principal reasons:

- The uptake factor (UP) applies to the number of properties although here we apply it to TGA which is a surrogate measure for property numbers;
- The effectiveness of PLR measures varies between locations;
- DR in £m^2 is derived from research into detached houses; and
- Only reduction in direct damage is included whereas in practice reduction of stress and anxiety may also be relevant.

A **third method** may only be relevant where local data on the existence of PLR measures are unavailable or the scale and objective of the appraisal does not warrant a more penetrating appraisal, but where the effect of these measures is still considered to be important to include. Here, the average annual damage potential can be factored in some suitable way to take account of the damage-reducing effect of these measures - see Chapter 5 of the MCM (Penning-Rowsell *et al.*, 2013) for further guidance.

RECOVERABILITY MEASURES

For England and Wales, the estimated uptake (UP) of recoverability measures for properties in benefit areas up to the 1:75 flood probability England and Wales is 2% (Clarke *et al.*, 2015) although this value applies more to residential than to NRP properties. For this reason, this value has now been adjusted downwards below to reflect significantly lower uptake (0.01). The effectiveness (EF) of these measures is known to be lower than for resistance measures and this is reflected in a value of 0.50 for EF. Again, damage reduction (DR) values are derived using economic costing rather than financial costing principles and are intended for use as broad average values.

Step One: A rough estimate of the value of the damage reducing effects of recoverability measures on NRPs may be made by applying the following formula and deducting the resultant £ average annual damage value from the potential average annual damage value at each return period used in the appraisal:

Equation 5.3

RISDR (£) = TGA * DR * UP * EF

where:
RISDR (£) is Estimated damage reduction by employing recoverability measures;
TGA is Total ground floor area of NRPs located in benefit area within 1:75 flood risk area and where flooding is not likely to be greater than 1m (at each return period);
DR is Damage reduction: (national default value = £79.43 per m^2 at 2026/27 values);
UP is Uptake factor: (national default value = 0.01);
EF is Effectiveness factor: (national default value = 0.50).

The resultant £ value result must then be converted to annual average damages saved.

Very similar simplifying assumptions to those applicable to the procedure for estimating the damage reducing effects of resistance measures are also applicable to recoverability measures. A further simplifying assumption which can affect the reliability of these estimates is that in some cases resistance and recoverability measures may be used in combination. The uptake factor may improve in the future and/or local evidence of uptake of resistance and recoverability measures in which case the uptake value can be altered to more closely match with evidence.

SUBSTITUTING LOCAL VALUES INTO EQUATIONS

The national default values which appear in the above formulae (i.e. for calculating WIRB and WDRB) are derived from the best available data within England and Wales and represent mean national level values. Each value should be substituted by local values where there is evidence to support a more customised local appraisal. For example, if it is known that in a particular benefit area that, say 10% of properties have WIR measures, then the UP parameter value may be altered from 0.032 to 0.10 and so on with other parameter values.

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6 Other Flood Losses

6 Other Flood Losses

Infrastructure, Transport, Education & Health and Emergency Costs

OVERVIEW

This Chapter presents information and appraisal guidance for indirect flood losses. This includes when floods disrupt utility services and communications, affects transportation networks and public buildings and imposes extra costs on those involved in managing floods and in the recovery phases. The impacts and losses experienced due to the disruption of services and transportation networks will have impacts outside of the flooded area as well as within it, and in some cases the impacts may be geographically far reaching. Understanding and being able to quantify such potential losses can provide a more comprehensive account of flood damages for inclusion in project appraisals.

Proportionality is a key feature of this chapter. The effort in the assessment of any type of loss should be proportional to its impact and although it may be technically feasible to assess the potential of loss to many assets, it may not be effective or necessary to do so. Methodologies for appraisal vary depending on the specifics of the losses but often include an element of the willingness of a consumer to avoid a disruption to a service or a traveller avoiding a delay. There is often little data from which to make an assessment of the potential losses due to flooding and therefore these methodologies draw on experiences from previous flood events (in particular 2007 and 2012) to underpin the approaches identified. The complexity and interdependency of many of these assets mean that when the likelihood of damages due to the disruption of services or damage to infrastructure is likely to be significant a site survey is recommended.

This Chapter is divided into five subsections. The first of which (Introduction) presents a process for filtering and prioritising those assets which should be included within appraisal and it is therefore recommended that appraisers review this introduction prior to other sub-sections:

- Introduction to appraising the losses from utilities, schools, hospitals, transportation networks and emergency services: Prioritisation of losses for inclusion in project appraisal;

- Infrastructure: Estimating the losses to electricity, gas, telecommunications, water and water treatment assets caused by the disruption to supply;

- Transport: Losses due to the flooding of roads and losses from rail disruption;

- Education and Health: Estimating the potential losses due to the disruption of school education and the flooding of hospital services;

- Local Authority, Emergency Services and Recovery costs: Appraising the additional costs of flooding to the emergency services, the Environment Agency and Local authorities.

6 Introduction

To appraising the losses from utilities, schools, hospitals, transportation networks and emergency services: Prioritisation of losses for inclusion in project appraisal

TYPES OF LOSSES

In general losses to infrastructure can accrue in the following ways:

1. The physical susceptibility of a plant and/or its supporting networks. This relates directly to the physical damage potentially caused by flood waters and therefore on the performance of the asset. Henceforth, this will be referred to as the 'direct damages' component of losses.
2. The wider economic impact. This will include the disruption caused to locations both inside and outside of the flood risk zone.
3. Wider less tangible impacts. How these impacts affect those living both inside and outside of the flood risk zone.

Each of these losses may impact services and infrastructure to different degrees, the severity of which may depend upon:

- The **dependency** of properties/businesses/other infrastructure served by utility plants and networks;
- The ease and cost of **transferability** of production to sites not affected by flooding (e.g. the degree of redundancy in the system): if a service can easily be replaced by another service it is said to have high redundancy/transferability;
- The **duration** of any disruption.

(Penning-Rowsell *et al*., 2005 and Cabinet Office, 2010)

The effort and resources used in the assessment of any type of loss should be proportional to its impact and significance. Therefore, although it may be technically feasible to assess the potential of loss to many assets, it may not be effective or necessary to do so. Consequently, the initial step therefore, within any project appraisal is a prioritisation of the potential losses which should be included for quantification within an economic assessment.

PRIORITISATION OF LOSSES FOR INCLUSION IN PROJECT APPRAISAL

The prioritisation process is illustrated in Figure 6.1 (within the *Tables and Figures* for Chapter 6 on MCM-Online) and consists of five steps:

Step One: Identify those assets at risk of flooding

Step Two: Determine the likelihood of flooding of assets

Step Three: Determine the criticality of the assets to flooding

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Step Four: Utilise a risk matrix for prioritisation

Step Five: Assess the impact of resistance and resilience

Through this filtering process, a shortlist of assets is prepared as candidates for detailed economic appraisal. This should be viewed in conjunction with the Appraisal Summary Tables (AST) within the Environment Agency FCERM guidance (2022a; 2022b).

Those assets that do not make the short-list should be merely enumerated and described (as illustrated in Table 6.1) to give qualitative weighting to the appraisal and provide details for any prospective Multi-Criteria Analysis.

THE TOTAL RISK MATRIX

One of the key elements of the prioritisation process is the use of a 'total risk' matrix. This provides a classification of the likelihood of damage or disruption and the scale of this impact. This process acts as a risk filter with generally only those assets considered to be at **High** or **Very High** risk being fully quantified within an appraisal: although there may be situations where it is appropriate to appraise other categories.

Table 6.2 *Risk Matrix*

IMPACT**	Significant	Medium Risk	**High Risk**	**Very High Risk**
	Moderate	Low Risk	Medium Risk	**High Risk**
	Low	Negligible Risk	Low Risk	Medium Risk
		Very Low	*Low*	*Medium/High*
			LIKELIHOOD*	

* These follow the Environment Agency's Risk of Flooding from Rivers and Sea likelihood bands.
** The significant, moderate and low impact categories are defined for each receptor type.

Since flooding in 2007 there has been an increased focus on the securing of the continuity of service of utilities and communication networks during flooding. This has meant that many utility and transportation organisations have begun a process of assessing the susceptibility of their assets to flooding and have developed appropriate risk registers. These registers if accessible to appraisers will replace steps 1 to 3 in the prioritisation process and any filtering using the risk matrix.

LESSONS FROM PREVIOUS FLOODS: PERCENTAGE UPLIFTS FOR ASSESSING POTENTIAL LOSSES

A less resource intensive approach to assessing the potential losses due to the flooding of infrastructure which has been adopted by project appraisers has been to 'uplift' the potential direct damages by a percentage factor. These percentage values have been calculated based upon the actual losses estimated from previous national-scale floods in 2000 and 2007 (Penning-Rowsell *et al*., 2002; Chatterton *et al*., 2010).

The appropriateness of use and transferability of the values to different flood situations will primarily depend on the context of the situation being examined. These values have been generated from some of the most severe flooding experienced in England and Wales in the last 50 years and therefore should not be considered typical of all flood situations. Therefore, these percentage values should ***not*** be used blindly as a 'fix' for assessing damages in these benefit categories. Where the likelihood of damages due to the disruption of services or damage to infrastructure is likely to be significant (based on assessment using the prioritisation process) a full appraisal is recommended.

SUMMARY OF THE RELATIVE IMPORTANCE OF UTILITY AND INFRASTRUCTURE LOSSES

A summary of the relative importance of all utility and infrastructure measures adopting the risk matrix approach (with the addition of scale) can be found in Table 6.3. This table provides a qualitative indicator of the proportionality of including the investigation of an infrastructure asset within an appraisal.

There may however be particular circumstances whereby an asset assumes greater significance; for instance when it is likely to be frequently flooded or whereby a disproportionate number of people may be impacted. Appraisers are therefore always recommended to undertake their own filtering approach and if in doubt speak to the infrastructure owners/providers to determine the criticality of assets.

Although not an exhaustive list we suggest a full monetary quantification of utility damages/losses is required (i.e. proportional) and will contribute significantly to the present value of benefits in the following situations. Where there is:

- Tidal inundation of electricity transmission lines greater than 132 kV unless flooding thresholds are less frequent than 1 in 75 years (1.3%);
- Tidal inundation of electricity transmission lines of less than 132 kV but only if flooding is more frequent than 1 in 25 years (4%);
- Flooding of sewage treatment works when the risk of flooding is more frequent than 1 in 75 years (1.3%) and the effluent dry weather flow is greater than 5,000 cumecs;
- Flooding of sewage treatment works when the risk of flooding is moderate (i.e. more frequent than 1 in 200 years; 0.5%) and the effluent dry weather flow is greater than 30,000 cumecs;
- Flooding of water treatment works when the risk of flooding is more frequent than 1 in 75 years (1.3%) and the population affected is greater than 5,000;
- Flooding of water treatment works when the risk of flooding is moderate (i.e. more frequent than 1 in 200 years; 0.5%) and where the dependent population is significantly large (i.e. >20,000);
- Flooding of electricity grid substations (including super grid and bulk supply point installations) when the risk of flooding is moderate (i.e. more frequent than 1 in 200 years; 0.5%) as these serve greater than 125,000 and up to 500,000 customers;

- Flooding of primary and grid substations where when the risk of flooding is more frequent than 1 in 75 years (1.3%); thereby serving a dependent population of greater than 5,000 people.

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6 Infrastructure: Utilities

To appraise the losses from electricity, gas, water, waste water and telecommunications

Electricity and Gas

Estimating the losses to electricity and gas assets caused by the disruption to supply

OVERVIEW

This sub-section introduces methodologies for the estimation of losses to both electricity and gas assets. This focuses mainly on the losses caused by the disruption to the supply of services as well as some comment on direct damages to these infrastructure types. The impacts of the loss of electricity are particularly significant as the consequences can radiate beyond the immediate vicinity of a flood area and the high number of associated interconnections. Appraisal is primarily based on estimating the amounts that customers are willing to pay to avoid the disruption to service.

There are many assets potentially at flood risk with HR Wallingford (2012) reporting that there are 10,600 electricity and 250 gas assets at significant risk of flooding in England which account for 6.6% or 8.3% of all assets. More recent estimates identify that 22% of electricity and 35% gas infrastructure assets are located in areas at risk from rivers, sea and surface water (Environment Agency, 2024). Furthermore, research by the University of Oxford and Rebalance Earth (Edghill et al, 2026) estimates that 4,000 substations supplying electricity homes and businesses are at risk of flooding. This creates additional vulnerability of disruption to 27,000 businesses which themselves are not themselves at risk of flooding which an estimated £90 million per day financial running costs (Raynor, 2026).

The 2007 floods highlighted the severe consequences and disruption that can occur if electricity infrastructure assets are flooded or threatened and have provided some key lessons for the appraisal of both gas and electricity infrastructure. In total, there were an estimated electricity supply losses of £138-9m which accounted for 20% of all infrastructure losses or over 4% of all economic losses.

LESSONS FROM EXPERIENCE

- Of all the utility assets electricity is the most important to appraise due to the inherent interconnectivity within the system.
- Due to the serious repercussions of severe power outages and high interconnectivity with other essential services, both electricity and gas companies are under a legal duty to ensure security of supply (HM Government 1996; 2002; 2023).
- Since 2007, the need for increasing resilience in utility supply has been highlighted and efforts have begun and more are planned (Pitt, 2008; National Grid Gas, 2010). These measures need to be considered within a project appraisal.

- The 2007 floods illustrate that the loss of perceived value to users accounted for more than 90% of the total economic costs of flooding in the electricity sector and highlights the importance of assessing the likely value of this disruption of power supplies to large numbers of customers.
- Prioritisation in appraisal is essential with assets on the Protected Site List (PSL) or large populations having higher priority; however, the higher up the distribution chain for electricity the greater the degree of redundancy. Therefore, the risk matrix should be applied.
- Flooding risk to gas infrastructure and/or the continuity of supply is considered to be low with high transferability of service within the gas network. The highest risk is posed by a failure of communications or equipment reliant on electricity supplies.

ESTIMATING DIRECT DAMAGES TO ELECTRICITY AND GAS INFRASTRUCTURE

Depth/damage data are not available for the distribution and grid substations because in these instances damage is potentially highly variable and depends on the configuration and siting of transformers, switch gear and other equipment. Site surveys and further discussions with infrastructure owners would be required to assess the direct damages to grid and distribution substations.

Readers are referred to Chapter 5 for guidance on assessing direct damages to primary substations. In addition to this, we recommend that appraisers discuss the costs of direct damage owing to the flooding of gas assets with National Grid Gas or other distributers.

METHODOLOGY FOR ESTIMATING THE LOSSES DUE TO THE DISRUPTION OF A SERVICE

Step One: Identify the locations and types of substations

Identify with the typology all electricity substations in the floodplain under consideration and for which the National Grid or Distribution Network Operator (DNO) is responsible.

The table below illustrates the different types of electricity substation and permits the prioritisation of assets to consider.

Table 6.4 *Types of electricity substations (ENA, 2009; 2018b)*

Substation type	Typical Voltage transformation levels	Approximate number in UK	Typical size	Typical numbers of customers supplied
Grid (Super grid)	400kV to 132kV	377	250m x 250m	200,000 to 500,000
Grid (Bulk Supply Point)	132kV to 33kV	1,000	75m x 75m	50,000 to 125,000
Primary	33kV to 11kV	4,800	25m x 25m	5,000 to 30,000
Distribution	11/kV to 400/230V	230,000	4m x 5m	1 to 500

NB. This is Table 6.6 in the MCM 2013

Using Table 6.4 above, identify the risk for each substation based on the likelihood and impact of flooding using the following risk matrix (Table 6.5) to prioritise those assets which should be quantified – only those which are categorised as **high** or **very high** risk should be examined further.

Table 6.5 *Risk matrix for electricity substations*

IMPACT	Sig: Grid substations with serving a population of > 125 000	Medium Risk	**High Risk**	**Very High Risk**
	High: Primary substations those with > 10000 *population supplied*	Medium Risk	**High Risk**	**High Risk**
	Mod: Primary substations with 5,000 to 10,000 population supplied	Low Risk	Medium Risk	**High Risk**
	Low: Distribution substations with fewer than 500 people supplied.	Negligible Risk	Low Risk	Medium Risk
		Very Low	*Low*	*Medium/High*
		LIKELIHOOD		

NB. This is Table 6.7 in the MCM 2013

Step Two: Estimation of population served

Estimate the population served based on length of perimeter using the table below and the presence of any "Protected Sites" designated as part of the Protected Sites List (PSL) process (from DNO, see DESNZ, 2026) examples of which are provided in Figure 6.2.

This is a broad estimate. The results from discussions with National Grid or the appropriate DNO will, of course, be more accurate.

Table 6.6 *Estimations of population served based on the perimeter fence length (after ENA, 2018b)*

Substation type	Average Perimeter Fence	Ratio customers to metres of perimeter
Grid (Super grid)	1000m	225:1
Grid (Bulk Supply Point)	300m	183:1
Primary	100m	150:1

NB. This is Table 6.8 in the MCM 2013

Step Three: Assess whether an asset is defended against flooding

Much investment and activity has focussed on improving the resiliency of substations and associated infrastructure (National Grid, 2022) so it is likely that some at-risk assets will have protection. The third and fourth round of Climate Change Adaptation Reporting in accordance with the Climate Change Act 2008, provides the updated information on climate resilience for each supplier (Defra, 2023; 2025). Concern following the North Hyde substation fire in March 2025 ,which caused significant disruption to electricity supplies particularly to Heathrow Airport, led to recommendations for the strengthening of resilience of energy supplies (NESO, 2025). The UK Government response to the NESO report (UK Government, 2025a) and its action plan and the associated launch of a new Energy Resilience Strategy (UK Government, 2025b) to be implemented in 2026 may lead to increased attention to substation and other electricity asset's resilience to flooding.

Establish whether the site is within an existing flood-defended area and determine the condition of the defences and their actual standard of protection.

Where defences are below the Environment Agency's set target condition grade and/or the standard of protection is below the resilience levels set by ETR 138 (Issue 3; ENA, 2018a) and Engineering Design Standard (UK Power Networks, 2024) (Table 6.7) establish the flooding threshold for key parts of the substation that will trigger disruption of supply to customers and critical infrastructure.

If an asset is not in an existing flood-defended area move to Step Four.

Table 6.7 *Resilience levels for electricity substations**

Flood type	Protection level			Allowance for climate change rises	Freeboard
	Grid Substation	Primary Substations† > 10,000 unrecoverable connections	Primary Substation† < 10,000 unrecoverable connections		
Fluvial	1:1000 Flood level	1:1000 Flood level	1:100 Flood level	Flood Depth x 20% or use of EA CC factored levels	300mm
Tidal	1:1000 Flood level	1:1000 Flood level	1:200 Flood level	105mm or use of EA CC factored levels	300mm
Surface	1:1000 Flood level	1:1000 Flood level	1:100 Flood level	Flood Depth x 20%	300mm

Source: UK Power Networks (2024, 10); ENA (2018a, 20).

* Please note that critical infrastructure resilience is a priority area following recent floods and storms and the *National Flood Resilience Review* (HM Government, 2016) and so the resilience levels may be subject to change. Furthermore, some DNOs have issued guidance recommending additional safety factors are applied (e.g. Electricity North West, 2017). In particular, the updated ENA (2018a) suggests that Network Operators should ensure that they utilise the most recent guidance available. It is recommended that appraisers also check for updated information from DNOs who own assets in the benefit appraisal area. The third and fourth round of Climate Change Adaptation Reporting in accordance with the Climate Change Act 2008, for each supplier can provide additional information on climate resilience for each supplier (Defra, 2023; 2025).

† ENA (2018a) suggests that network operators should focus on the resilience of service provision to sites supplying significant local communities (SLCs) (which are defined as those comprising at least 10,000 customers/connections) and to the level of the EA's Extreme Flood Outline (i.e. 1/1,000 flood risk). Therefore, those primary substations which are likely to serve a customer population of over 10,000 should have the same protection level (1:1000) as grid substations.

Step Four: Assess presence and importance of resilience measures

If not in an existing flood defended area establish whether the site has been made resilient against flooding with either permanent or temporary locally-installed measures. If the measures are temporary establish whether the site is in receipt of a flood warning (provided by organisations such as the Environment Agency, Natural Resources Wales or SEPA) and that the erection of temporary measures is practical within the lead-time of warnings provided.

If the site is either not in receipt of flood warnings or these are inadequate to secure the site consider the flooding thresholds for key parts of the substation and the potential for transferring other supply to customers and critical infrastructure. If no flood intervention measures are in place or planned imminently by the DNO establish the flooding threshold for key parts of substation likely to disrupt supply to customers and critical infrastructure.

Step Five: Assess the importance of network interconnectivity

Establish the degree of network interconnection to minimise loss of supply to customers and critical infrastructure. Where transferability of supply is 'seamless' losses associated with flooding are only direct damages to the substation.

Step Six: Identify appropriate flood intervention measures

If the project appraisal is specific to the substation, establish the most appropriate flood risk management system, in conjunction with the DNO, to protect the substation. Table 6.8 provides the potential intervention measures for electricity infrastructure with their advantages and disadvantages.

Step Seven: Cost-benefit analysis

Conduct a cost-benefit analysis methodology of preferred solution(s) including an assessment of societal risks. This includes the evaluation of damages by flood depth for critical plant and equipment and the cost of customer supply losses.

'Customer/minutes' loss as a result of flooding during the accounting period including the 2007 floods were only 4.2% of total (with lightning and wind and gales contributing to over 20%). However, the widespread losses of electrical power extend well beyond the obvious consequences and the following should be included where possible as part of the assessment of societal losses.

- Loss of traffic lights can lead to traffic gridlock with knock-on effects on the ability of emergency services to respond.
- Mobile telephony will overload and fail within 6 hours.
- Domestic central heating (even gas fired) will fail and hypothermia is a real threat during winter flooding.
- Disruption of water supplies and sewage treatment and disposal could pose a serious health hazard.
- Petrol pumps, cash tills and cash machines will fail.
- Radio and TV broadcasts will fail to reach the affected population.

- Use of candles and alternative cooking practices could pose potentially serious fire hazard and dangers of asphyxiation.

The appraiser should create a template about when each of the above benefits is worthy of further analysis. The ratio of property within the floodplain to those outside the floodplain serviced by a distribution substation subject to flooding (within Flood Zone 3) may determine whether induced losses should be assessed. Appraisal is probably only worthwhile if more than 50% of the properties served by a flooded distribution substation are largely flood free (i.e. in Flood Zones 1 and 2).

Step Eight: Quantify the potential costs due to the disruption of services (using the equation below).

Equation 6I.1

CD = P * EC * WTP * D

where:
CD is Estimated total cost of disruption as a consequence of the flooding (£)
P is Number of properties affected by power outage[1]
EC is Hourly electricity consumption (kWh)
WTP is Willingness-to-pay value to avoid power outage (£/kwh)
D is Estimated duration of disruption to supply (hours)

Some indicative values of average energy consumption and willingness to pay to avoid a disruption in service are provided in Figure 6.3.

DURATION OF ELECTRICITY DISRUPTION

In general, most repairs to distribution substations would be achieved within a 24-hour period and therefore power restored to properties relatively quickly. However, those properties and businesses which are themselves flooded will suffer electricity outages for longer, because the property-level electrical fittings will also need repair. The specific impacts of these outages will depend upon whether residents are in temporary accommodation (and therefore may be less impacted by the lack of supply) or whether they are remaining in the affected property. Therefore, in some situations it may be appropriate to estimate the number of households that might be flooded within the area served by a distribution substation and remove these from the total number of properties affected by the power outage.

DISRUPTION TO GAS SUPPLIES

Overall, the pressurised gas network is far more resilient than electricity distribution. National Grid Gas have been working to increase the resilience of its assets to flooding including activities such as reinforcing river banks and further research about what the impacts of flooding are on pipelines and other equipment (National Grid Gas, 2010). As part of this process risks have been categorised (on a four point scale) according to the degree of material risk they pose to different assets and how robust business process and/or action plans are to deal with these risks. For flooding, the majority of risks are considered either to be low in terms of the damage likely to be sustained or that the continuity of supply would not be threatened. National Grid Gas (2016; 2021) and National Gas (2024) reports on the progress of resilience efforts and the Climate Change Adaptation Reporting (under the Climate

[1] i.e. total number of properties served by the substation or infrastructure affected

Change Act, 2008), third and fourth round reports highlight the progress on climate resilience by each supplier (Defra, 2023; 2025). However, the following should be considered for appraisal:

- A gas compressor station was considered to be at risk of flooding, but supply was not thought to be threatened if it was inundated.
- National Transmission Pipe work (~70 barg). These were considered to be at risk as there is the potential for these pipes to float if the ground around and above them is flooded. However, the main concern is that there is insufficient information about these risks and therefore further research is required to be able to quantify fully their susceptibility to flood water
- The main concern remains the pipework and their pressure gauges where the ingress of flood water may necessitate a mass purge of the affected pipeline.

Should a gas installation be located in a floodplain under investigation then discussions with the National Grid Gas or other distributers may be appropriate on the lines of the step-by-step guide above for electricity. In those situations where further analysis of a loss of gas supply is required the calculation provided for electricity may also be adopted. An estimation of the annual gas energy consumption for the average UK home is provided in Figure 6.3.

KEY ELECTRICITY ASSETS FOR APPRAISAL FROM EXPERIENCE

A summary of the relative importance of all utility and infrastructure measures adopting the risk matrix approach (with the addition of scale) can be found in Table 6.1. Although not an exhaustive list (and appraisers should undertake their own filtering approach) we suggest a full monetary quantification of utility damages/losses is required (i.e. proportional) and will contribute significantly to the present value of benefits in the following situations:

- Tidal inundation of electricity transmission lines greater than 132 kV unless flooding thresholds are less frequent than 1 in 75 years (1.3%).
- Tidal inundation of electricity transmission lines of less than 132 kV but only if flooding is more frequent than 1 in 25 years (4%).
- Flooding of electricity grid substations (including super grid and bulk supply point installations) when the risk of flooding is moderate (i.e. more frequent than 1 in 200 years; 0.5%) as these serve greater than 125,000 and up to 500,000 customers.
- Flooding of primary and grid substations where when the risk of flooding is more frequent than 1 in 75 years (1.3%); thereby serving a dependent population of greater than 5,000.

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Water and Waste Water

Estimation of potential losses due to the flooding of water infrastructure

OVERVIEW

This sub-section provides a methodology for estimating the potential losses due to the flooding of water infrastructure. Appraisal in this sub-section is based on the Ofwat (2008) guidance on the costs imposed on households when water is cut-off and on willingness-to-pay valuation of customers to avoid a disruption to either water supply or waste water services. In addition to this, the Security and Emergency Measures Direction (SEMD) 1998 provision about the minimum requirement of water which should be provided (per person) when water supply is cut-off is also utilised.

HR Wallingford (2012) has reported that there are 970 sewerage and 290 assets located in areas at moderate or significant risk of flooding in England; with the Environment Agency (2024) estimating that 34% of water pumping stations and treatment plants are located at risk of flooding from multiple sources. The floods in 2007 served to highlight the susceptibility of the water supply network and the potential large-scale disruption that can occur when only one major single source of water supply serving a large number of users is flooded. The overall costs to Severn Trent Water alone were in the order of £30 million with supply being interrupted for approximately 350, 000 customers (Chatterton et al., 2010).

LESSONS FROM EXPERIENCE

- Generally, sewage treatment and pumping facilities are not as susceptible to flooding as water supply facilities.
- In 2004, the Water UK Council established a mutual aid protocol for all members to ensure delivery of water by companies during an emergency. The protocol (amended after 2007) includes agreements to share emergency equipment and to support affected member companies during incidents and enhances the resilience and contingency options of the sector.
- Regulators have a key role in supporting the UK's resilience agenda, and the Pitt Review recommended that this was recognised by "placing a duty on economic regulator to build resilience". These resilience activities (and future planned activities) need to be included within project appraisal. Of particular use to appraisers are the indicators some companies have used for defining and measuring resilience.
- Similar to electricity the interconnectivity of water infrastructure means that losses can extend widely beyond the flooded area.

ESTIMATING DIRECT DAMAGE TO WATER INFRASTRUCTURE

Readers are referred to Chapter 5 for guidance on assessing direct damages to sewage treatment works. The data contained on MCM-Online provide sector average indicative values only and therefore site surveys or discussions with the infrastructure owner are recommended to verify these estimations and to appraise the potential damages to water supply infrastructure which are not included as depth/damage curves in Chapter 5.

APPRAISAL FOR WATER RELATED ASSETS AT FLOOD RISK

The Cabinet Office (2011, 28) suggests a benchmark that "as a minimum essential services provided by Critical National Infrastructure (CNI) in the UK should not be disrupted by a flood event with an annual likelihood of 1 in 200 (0.5%)". The guide goes on to indicate that the costs and benefits of individual projects should be considered when deciding which projects to fund and whether the benchmark can be achieved. The benchmark does not apply to other infrastructure that is not designated as Critical National Infrastructure. The Climate Change Adaptation Reporting (under the Climate Change Act, 2008), third and fourth round reports highlight the progress on climate resilience by each supplier (Defra, 2023; 2025).

There is a fundamental difficulty in creating a definitive listing of water supply and sewerage infrastructure at risk from flooding (or any critical infrastructure, e.g. electricity substations, for that matter). Any reference to sites/assets being critical infrastructure indicates that the asset is important and could provide useful targeting information for those with a 'terrorist' intent. Such information may require a protective marking (e.g. "RESTRICTED"). Consequently, an appraiser must rely on the often incomplete data provided by the Environment Agency's National Receptor Dataset as a starting point and follow up the results with direct contact with the water supply and sewage treatment providers.

The process of evaluating the contribution of a water supply or water treatment works to the total flood losses of a community is similar to the step-by-step procedure outlined for electricity installations (Section 6b) but with different impact filters to account for.

Step One: Apply the relevant risk matrix

Identify the risk based on likelihood and impact of flooding using the appropriate risk matrices for sewage treatment and water supply works below. Using this as a decision filter – only consider steps 2 onwards for **High** and **Very High Risk** assets.

Table 6.9 *Risk matrix for sewage treatment works*

IMPACT	*Sig: > 30,000 cumecs effluent dry weather flow*	Medium Risk	**High Risk**	**Very High Risk**
	Mod: 5,000 to 30,000 cumecs effluent dry weather flow	Low Risk	Medium Risk	**High Risk**
	Low: < 5,000 cumecs effluent dry weather flow	Negligible Risk	Low Risk	Medium Risk
		Very Low	*Low*	*Medium/High*
		LIKELIHOOD		

NB. This is Table 6.12 in the MCM 2013

Table 6.10 *Risk matrix for water supply*

IMPACT	*Sig: > 20,000 population supplied or PSL customers*	Medium Risk	**High Risk**	**Very High Risk**
	Mod: 5,000 to 20,000 population supplied	Low Risk	Medium Risk	**High Risk**
	Low: < 5,000 population supplied	Negligible Risk	Low Risk	Medium Risk
		Very Low	*Low*	*Medium/High*
		LIKELIHOOD		

NB. This is Table 6.13 in the MCM 2013

Step Two: Assess whether an asset is defended against flooding

Establish whether the site is within an existing flood defended area and determine the condition of the defences and their actual standard of protection. Where defences are below the Environment Agency's set target condition grade and/or the standard of protection is below the optimum design standard proposed by the Environment Agency establish the flooding threshold for key parts of the works likely to disrupt supply to customers and critical infrastructure (see Protected Site List established for electricity in Figure 6.2).

Step Three: Assess the presence and importance of resilience measures

If not in an area already benefiting from flood risk management measures, establish whether the site has been made resilient against flooding by the Water Company with either permanent or temporary locally installed measures. If the measures are temporary establish whether the site is in receipt of flood warnings and that erection of temporary measures is practical within the lead-time of warnings offered.

If the site is either not in receipt of flood warnings or these are inadequate to secure the site consider the flooding thresholds for key parts of the works and the potential for transferring other supply/treatment capacity to customers and critical infrastructure. If no flood intervention measures are in place or planned imminently by the water company establish the flooding threshold for key parts of works likely to disrupt supply to customers and critical infrastructure.

Step Four: Assess the importance of network interconnectivity

Establish the degree of network interconnection to minimise loss of supply/treatment to customers and critical infrastructure. Where transferability of supply is 'seamless', losses associated with flooding are only direct damages to the works.

Step Five: Identify appropriate flood intervention measures

Establish the most appropriate flood risk management system in conjunction with the water company (see Table 6.8 for examples established for electricity which provides a starting point for these)

Step Six: Cost-benefit analysis

Apply a conventional cost-benefit analysis of preferred solution(s) including societal and environmental risks. This includes the evaluation of damages by flood depth for critical plant and equipment and the cost of customer supply losses using cost of water under Security and Emergency Measures Direction (SEMD) (as amended) (Defra, 2022; 2024a) provision as a minimum cost, supplemented with willingness to pay data/surveys as appropriate. MCM (2005) (Penning-Rowsell et al., 2005) provides an example of appraisal for the Newport Waste Water Improvement Scheme which highlights the process that could be applied.

Under the Guaranteed Standards Scheme (GSS) customers are entitled to financial recompense when water is disconnected without prior warning (Ofwat, 2008; 2025; HM Government, 2028; 2025). In October 2025 new standards came into force which for English water customers increased the payments homeowners and businesses are entitled to for emergency disruptions to service (HM Government, 2025). Please note that the new standards have been adopted in England and the standards for Wales remain unchanged as of April 2026[2]. Appraisers therefore should consider where an affected property is located and the water and sewerage service supplier.

For customers with a disrupted supply in England the GSS (Ofwat, 2026; p25) provides a minimum amount that companies must provide; £50 for domestic customers plus an additional £50 for each subsequent 12 hours (up to cap of twice customer's annual water supply charge) the supply remains cut-off. For non-domestic customers suppliers should provide minimum payments of £100 plus an additional and £100 for each subsequent 12 hours (up to cap of twice customer's annual water supply charge) the supply remains unrestored.

For customers with a disrupted supply in Wales the GSS (Ofwat, 2026; p10-11) provides a minimum amount that companies must provide; £20 for domestic customers plus an additional £10 for each subsequent 24 hours the supply remains cut off. For non-domestic customers suppliers should provide minimum payments of £50 plus an additional £25 for each subsequent 24 hours the supply remains cut off.

This compensation agreement is often waived in extreme weather conditions or exceptional circumstances; however, it may be used to estimate the potential costs of disruption of supply. Water UK (2017) provides a Technical Guidance Note detailing operational principles to be considered by water undertakers when fulfilling their responsibilities under licensing requirements (Defra, 2022 as per Section 208 of the Water Industry Act 1991) which requires all water companies to provide 10 litres of water per person per day or 20 litres per person per day in incidents lasting more than 5 days.

[2] Welsh Government has indicated that similar changes will be pursued separately in Wales. Appraisers should consider whether there are any similar regulations in the country where they are undertaking analysis.

KEY WATER ASSETS FOR APPRAISAL FROM EXPERIENCE

A summary of the relative importance of all utility and infrastructure measures adopting the risk matrix approach (with the addition of scale) can be found in Table 6.3. Although not an exhaustive list (and appraisers should undertake their own filtering approach) we suggest a full monetary quantification of utility damages/losses is required (i.e. proportional) and will contribute significantly to the present value of benefits in the following situations:

- Flooding of sewage treatment works when the risk of flooding is more frequent than 1 in 75 years (1.3%) and the effluent dry weather flow is greater than 5,000 cumecs.
- Flooding of sewage treatment works when the risk of flooding is moderate (i.e. more frequent than 1 in 200 years; 0.5%) and the effluent dry weather flow is greater than 30,000 cumecs.
- Flooding of water treatment works when the risk of flooding is more frequent than 1 in 75 years (1.3%) and the population affected is greater than 5,000.
- Flooding of water treatment works when the risk of flooding is moderate (i.e. more frequent than 1 in 200 years; 0.5%) and where the dependent population is significantly large (i.e. >20,000).

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Information and communication technology

Appraising potential losses owing to the flooding of information and communication technology infrastructure

OVERVIEW

This sub-section explores the potential losses caused by the flooding of information and communication assets. Modern communication network infrastructure plays a pivotal role in contemporary society, enabling seamless information exchange, economic activity, and emergency response. CIRIA (2010) report that British Telecom has approximately 8,000 sites including telephone exchanges, with 500 major assets located within floodplain areas. The 2007 floods highlighted that "the interconnected nature of the network provided a degree of resilience and helped prevent significant failures" (Pitt Review interim report, 2007; 97). Chatterton et al. (2010) reported that during the 2007 floods there were few reports of failures or damages to the telephone network or exchanges and that damages were estimated to be lower than £1 million; although data to provide estimates was limited.

It is necessary to consider a wide view of ICT which incorporates fibre optics, cloud storage, data centres, and the widespread adoption of 4G/5G mobile networks. Indeed, this sector is also highly dynamic and through increasing the accessibility of broadband coverage is undertaking one of the largest infrastructure projects in the UK (ISPA/INCA, 2024). It is essential to evaluate the resilience, recoverability, and redundancy of these networks in times of flooding, consistent with the MCM methodology for appraising networks and other flood losses. Despite the importance of the ICT sector to societal and economic resilience, the fourth-round adaptation reporting associated with the Climate Change Act (2008) indicates high consideration of flooding and the prevention of associated losses. Both ISPA/INCA (2024) and Ofcom (2024) highlight the requirement to avoid locating assets at risk of flooding and the integration of mitigation measures for high-risk sites, as well as the integration of planning for network recovery. Importantly, Ofcom (2024) also highlight that fibre networks remain broadly unaffected by flooding and services remain unaffected as long as electricity is retained; thereby illustrating the interconnectivity between utilities and potential losses.

Consistent with MCM principles, the appraisal of flood impacts on communication networks requires a structured approach:

1. *Infrastructure vulnerability assessment:* Identifying key assets at risk during flood events.
2. *Risk quantification*: Determining probabilities of network failure based on flood models.
3. *Economic impact evaluation:* Estimating economic losses related to customer communication downtime.
4. *Resilience measures*: Assessing mitigation strategies, such as flood barriers for data centres or backup mobile towers.
5. *Redundancy analysis*: Evaluating multi-site networks and failover mechanisms.

This sub-section describes those situations where an appraisal might be appropriate and proportional and local and up-to-date knowledge is generally recommended to react to the changing nature of areas.

LESSONS FROM EXPERIENCE

- There is considered to be a great deal of redundancy in the system, in particular, in relation to telephone systems and the transfer of services to mobile communications. Furthermore, providers are undertaking adaptation and resilience measures to avoid flood losses and disruption.

- Flooding of communication assets in flood plains cannot be fully avoided by resistance strategies but with the advent of cloud storage data resilience is significantly enhanced during floods by offering off-site, decentralized storage, ensuring critical information remains accessible and protected even if local infrastructure is flooded.

- The roll out of fibre broadband services nationally and the implementation of glass fibre cables (rather than copper cabling) which is more resilient to water damage is likely to lead to increased resilience in the future.

- Despite the advanced technology, improved resilience to assets located in the floodplain and increased redundancy, if assets are affected by flooding there is still the need to engage with network providers, especially Openreach, to evaluate the costs, properties affected and lengths of downtime for vulnerable cabinets and chambers.

- The largest potential danger from flooding is often the knock-on impact of a loss of electricity supply on telecommunications, rather than flooding directly impacting the telecommunication assets.

ROLES AND RESPONSIBILITIES OF TELECOMMUNICATION PROVIDERS

Communication Network Providers have responsibilities as part of the Civil Contingencies Act 2004[3] and as Category 2 responders to include any person who provides a public electronic communications network which makes telephone services available (whether for spoken communication or for the transmission of data) (HM Government, 2004; 25). Additionally, the Communications Act 2003 permits the regulator Ofcom the scope to impose specific requirements regarding the availability and use of the communications network and services during an emergency situation (HM Government, 2003). There are also standard requirements as part of licensing conditions to maintain services and restore services as quickly as possible, where practicable.

COMMUNICATION NETWORKS: ASSETS AT RISK IN THE UK

Ofgem provided a case study in 2014 based on UK Flooding and Implications for Openreach (an organisation which maintains telephone cables, ducts, cabinets and exchanges and runs digital networks in the UK) (Ofgem, 2014). This was in response to expectation of more severe weather in future control periods. The extremes of weather cause extreme fault intakes raising overall levels of faults experienced by Openreach.

Openreach infrastructure[4] is extensive, and all major asset classes (ducting, poles, copper, fibre and street cabinets and chambers) are predominantly externally located (approximately two-thirds of the access infrastructure is underground). Moreover, Openreach has substantial infrastructure in the 1% probability floodplain in the UK:

- 7,178 (7.8% of total)[5]
- 9,198 T-codes (8.1%)
- 1,569,247 lines (6.0%)
- 502,272 jointing chambers (8.4%)[6]

Flooding not only affects Openreach equipment but also their ability to respond by reaching fault locations or in diagnosing faults and accessing plant.

The pattern of exposure to flooding can be substantial. At the height of the 2013/2014 flooding, 2,383 faults were recorded in Openreach's Wessex area alone. During flooding, Openreach's ability to service end-users and access its infrastructure is severely disrupted, and extensive damage is caused to infrastructure both over and underground, causing very high fault intake rates, increases contractual agreements, increased costs, longer travel times and significant health and safety concerns for engineering teams; all directly raising costs for the business.

During the period 2013 September to August 2014 the frequency of outages reported to Ofcom, by location indicated that faults are more correlated with centres of population (especially London) than locations experiencing severe winter weather. Overall, the average duration of an incident for a given

[3] Although the UK Government has been consulting on its effectiveness (https://www.gov.uk/government/consultations/strengthening-partnerships-consultation/outcome/outcome-report-html). It is expected that any regulatory changes will be taken as part of the post-implementation review of the Civil Contingencies Act in 2027.

[4] Openreach serves the vast majority of the UK's residential and business customers and delivers the infrastructure element of the UK telephony Universal Service Obligation (USO).

[5] An Openreach T code refers to a specific identifier used in their systems to track orders, faults, or equipment.

[6] An Openreach jointing chamber is an underground structure used to house and protect telecommunications cables and joints. These chambers are essential for maintaining and managing Openreach's network infrastructure. They provide access points for engineers to perform tasks such as splicing, repairing, or upgrading cables.

month increased during the winter months. This is consistent with providers' incident response operations and the challenges their engineers face during severe weather (Chatterton et al., 2015).

INCREASING RESILIENCE THROUGH THE IMPLEMENTATION OF CLOUD STORAGE

Flooding of communication assets in flood plains cannot be fully avoided by resistance strategies but with the advent of Cloud storage data resilience is significantly enhanced during floods by offering off-site, decentralized storage, ensuring critical information remains accessible and protected even if local infrastructure is flooded:

1. Off-Site and Distributed Data Storage
Cloud storage providers maintain multiple data centres across various geographical locations, reducing the risk of total data loss due to localized flooding. If one facility is affected, data remains accessible from backup servers elsewhere.

2. Backups and Redundant Systems
Most cloud services employ redundancy strategies, meaning data is copied across multiple locations. This ensures that if one data Centre experiences flooding, mirrored data remains intact, minimizing downtime and preventing permanent loss.

3. Accessibility from Anywhere
Cloud storage allows users to access their files remotely via the internet, meaning businesses, government agencies, and individuals can retrieve critical data even if local servers are damaged by floodwaters.

4 Hardware failures.
Cloud storage eliminates the need for localized servers, significantly improving resilience.

5 Disaster Recovery and Failover Mechanisms
Many cloud providers have disaster recovery (DR) solutions that quickly restore data and services following a natural disaster. Failover mechanisms automatically redirect operations to unaffected servers, ensuring continuity.

6. Reduced Dependence on Physical Infrastructure
Traditional on-premise data storage is vulnerable to flood damage, power outages, and physical hardware failures. Cloud storage eliminates the need for localized servers, significantly improving resilience.

7. Scalable and Real-Time Protection
Cloud providers frequently update security protocols, monitor threats in real time, and offer scalable solutions tailored to different risk levels, ensuring ongoing protection against environmental disruptions.

In conclusion, by leveraging cloud storage, organizations and individuals can mitigate the risks posed by flooding to their data hardware, ensuring uninterrupted access to vital data and its swift recovery.

MITIGATING POTENTIAL DAMAGE AND SERVICE LOSS

Flooding can pose significant challenges for underground telecom infrastructure, including Openreach access chambers, though in recent times traditional modular systems such as Stakkaboxes[7] made from lightweight yet durable materials, for example, Glass Reinforced Polyester (GRP)[8] are providing increased resilience. Even though these chambers to protect cables and joints are engineered to be water-resistant and incorporate drainage features, extreme flood events can sometimes overwhelm these defences. While Stakkabox-style chambers systems (known for their strength, scalability, and cost-effectiveness compared to traditional concrete chambers) are designed with tight seals and sometimes even self-draining properties, heavy or prolonged flooding can force water and extraneous debris into the chamber. This may lead to damage of the internal wiring, fibre optic cables, and any electronic components housed within. Once water enters the chamber, even after the flood subsides, residual moisture can cause corrosion and functional degradation over time, reducing performance.

Flooding may also hinder routine inspection and maintenance. When water covers large areas, detecting early signs of damage becomes more challenging, potentially delaying repairs. This delay increases the risk of further degradation or additional water ingress if issues aren't promptly addressed.

Openreach and other network providers generally mitigate flood risks to chambers and cabinets by:

- Installing chambers in less flood-prone areas and using enhanced waterproof seals to minimize ingress.
- Designing the chambers with built-in drainage pathways to quickly expel any water that might seep in during heavy rains.
- After significant flooding events undertaking dedicated inspections and rapid repairs to restore full functionality and prevent long-term deterioration.

COSTS OF REPAIRS TO CHAMBERS AND CABINETS AFTER FLOODING

Repairing flood-damaged chambers involves water extraction, drying, and replacing damaged components like cables or seals. Costs can range from hundreds to thousands of pounds per chamber, depending on the extent of the damage.

Prolonged outages due to flooding can lead to financial losses for telecom providers and inconvenience for customers. Emergency repairs often require additional resources, increasing costs. Repeated flood damage can lead to higher insurance premiums for telecom providers, adding to long-term expenses.

Innovative resilience methods are being introduced such as Portadam's modular barrier Flood protection systems[9] and remote sensing technologies with historical data analytics to produce real-time flood alerts in high-risk areas (Bukhari et al., 2025). The cost trade-off between investments in preventative technology and event repair costs is justified through improved resilience and reliability of telecom networks, ensuring service continuity in the face of increasingly frequent flood events.

[7] e.g. https://elliotts.uk/product/cubis-stakkabox-jmf-104-915x445x150mm; https://www.castingsdrainage.co.uk/product/bt-quadbox-stakkabox/
[8] Modular units can cost as little as £100 each
[9] https://portadam.com/whats-new/blog/telecom-infrastructure-flood-protection/

The cost of repairing Openreach chambers or cabinets after flooding can vary significantly depending on the extent of the damage and the specific components affected.

1. Chamber Repairs

- Minor repairs, such as resealing joints or replacing small components, might cost a few hundred pounds per chamber.
- Major repairs, including structural damage or complete replacement of a chamber, could escalate to thousands of pounds.

2. Cabinet Repairs

Flood-damaged cabinets often require water extraction, drying, and replacement of electronic components like DSLAMs (Digital Subscriber Line Access Multiplexers). These repairs can range from £1,000 to £5,000 or more, depending on the cabinet's size, complexity and duration of flooding.

3. Network Downtime Costs

Beyond physical repairs, service disruptions can lead to additional costs, including customer compensation and emergency response measures. Ofgem compensation for disruption of landline or loss of broadband services is £9.98 (2025) for each calendar day that the service is not repaired *after an elapsed 2 day*s. Most communication providers (Virgin, EE, Talk Talk etc) have signed up to this scheme and provide a customer charter concerning continuity of service[10]. Openreach are limited to the extent that they can site assets within the network such that floodplain exposure is reduced. The ability to move such network assets (cabinets) etc. further away might either not be possible, result in poorer service or be a significant additional investment.

A substantial portion of the millions of broadband customers in the UK rely on these street cabinets for their internet and telephone services. Indicative customer numbers are as follows:

- **Urban Areas**: In high-density urban settings, a single cabinet can often serve anywhere from 300 to 500 or more customers due to the tighter clustering of premises.
- **Rural/Suburban Areas**: In less dense regions, the same cabinet might be responsible for connecting closer to 200–300 customers.

IMPLICATIONS FOR MODERN COMMUNICATION NETWORKS

By integrating fibre optics, cloud storage, data centres, and advanced mobile networks into the appraisal framework, resilience and redundancy strategies can be optimized, mitigating losses and improving post-flood recoverability.

1. ***Fibre Optic Networks***: Fibre optic technology revolutionised data transmission by replacing traditional copper-based networks with high-speed optical fibres, offering:

- *High bandwidth* - Enabling rapid data transfer
- *Low latency* - Enhancing real-time communication applications, including financial transactions and emergency response
- *Flood resilience*- Compared to copper networks, fibre optics are less prone to electromagnetic interference and degradation from water exposure, though underground fibre routes may still be affected by floodwaters.

2. Cloud Storage and Data Centres have shifted digital infrastructure away from local servers, enabling decentralized data management:

[10] Ofgem does however indicate that specific exceptions may apply to the receipt (and level) of compensation. One of these exceptions is for disruption caused by extreme weather (https://www.ofcom.org.uk/phones-and-broadband/service-quality/automatic-compensation-need-know). Therefore, some customers may not receive compensation following disruptions from flooding.

- Organisations store critical data in cloud environments managed by providers such as Amazon Web Services (AWS), Microsoft Azure, and Google Cloud.
- Data centres house vast digital infrastructure which can be vulnerable to physical threats including flooding
- However, multi-site cloud solutions allow for seamless failover systems (a measure of redundancy) in case one data centre is compromised by flooding.

3. Mobile Networks and 4G/5G Technology: The widespread adoption of 4G and 5G networks has dramatically enhanced wireless connectivity providing reliable mobile broadband, supporting digital commerce and communication, though Cellular infrastructure (e.g., base stations and towers) can be affected by flood-related power outages and equipment damage. Mobile networks often have backup generators remote recovery and capabilities, though physical damage to infrastructure may necessitate post-flood restoration efforts.

EXAMPLES OF FLOOD DAMAGE ON COMMUNICATIONS ASSETS

The Climate Risks Study for Telecommunications and Data Center Services prepared for the US General Services Administration (GSA) reviews selected case studies where extreme weather—including floods—led to operational disruptions (Adams et al., 2014). These studies highlight how water ingress, whether affecting above-ground sites (like cell towers and microwave links) or underground assets (such as fibre cables), compromises both the integrity of physical devices and the continuous delivery of digital services.

In the UK, assessments reveal that similar risks are emerging domestically (UK Climate Risk, 2021). Heavy rainfall, which can result in localised flooding, has been linked to issues such as power failures at mobile base stations and degraded performance of radio systems. While these incidents might not always receive the same headline attention as severe storms, they nonetheless illustrate an ongoing vulnerability—especially when existing infrastructure was not originally engineered to handle the increased intensity and frequency of such weather events.

Storm Eowyn in early 2025 tested the resilience of communications Infrastructure in the UK and Ireland with performance heavily compromised especially in Northern Ireland and Scotland. In early 2022 three storms in succession resulted in nationwide power cuts severing broadband connectivity. In Shrewsbury alone dozens of roadside cabinets were sealed by emergency Openreach teams to prevent failure (Openreach, 2025). More recently in January 2026, Storm Goretti severely damaged communication infrastructure, particularly poles in South West England (Openreach, 2026) with reports of 28,000 households in Cornwall remaining without broadband for extended periods some for up to a month (BBC, 2026).

These examples demonstrate the importance of resilience measures, such as backup power systems, network redundancy, and improved infrastructure protection (water proofing sensitive equipment) and elevating installations away from flood-prone areas to mitigate the impact of flooding on communication networks.

APPRAISING THE POTENTIAL FOR DISRUPTION TO TELECOMMUNICATIONS

Chatterton et al. (2010) describe the origin of the additional costs due to flooding in this sector as including:

- Repair costs due to direct damage of the infrastructure asset.
- Additional maintenance costs.
- Extra operating costs during an emergency.

As discussed previously, communication assets are generally considered to be quite resilient to the effects of flooding. Proportionally, damages to this sector will be lower than to other utility and transport networks and indeed the communication providers argue that a power failure will be more problematic than direct flooding of their network. Therefore, it is suggested that appraisers need to identify if there are major information and communication technology assets located within the benefit area (e.g. major exchanges) or assets are in areas at high probabilities of flooding. In these situations, for improved accuracy, we strongly propose speaking with infrastructure owners to understand the vulnerability of the asset from flooding and potential damage and losses accruing.

The following process provides an approach for analysing damages and losses to network assets.

Step One: Risk Evaluation

Assess the flooding probability of assets exposed to flooding. If the probability is very high (bands 1 and 2)[11] trigger flooding consequences. If the probability is in bands 3 and 4 ignore the potential consequences.

Step Two: Enumerate the assets

Estimate the number of telecommunication assets in probability bands 1 and 2 for the floodplain in question.

Step Three: Area Type Determination

If the assets are in an urban area assume 400 properties linked to each asset. If assets are in a suburban area assume 300 properties, and if in a rural area assume 200 properties.

Step Four: Identify the likely duration of disruption

If the duration of the flood is determined to be long (a prolonged or severe event), and/or the depth of flooding in the vicinity of the assets greater than 0.5m, compensation to customers is triggered[12] at a rate of £9.98 per property per calendar day after outages of more than 2 days.

Step Five: Consider any redundancies in the system

Compensation is removed from the consequences of flooding if the asset is resistant to flooding or customer networks can be transferred seamlessly.

Step Six: Costs of operational repairs

If the asset is not resilient to flooding then costs involved in resuming service are £1,000 where duration is short and flood depths low and £3,000 if duration to repair is extensive and or depth of flooding is significant.

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[11] Band 1 - greater than 3.3% chance of flooding in any year; Band 2 - between 3.3% and 1% chance of flooding in any year (see https://www.gov.uk/check-long-term-flood-risk)

[12] Unless the service provider indicates that the extreme weather experienced is a specific exception for providing compensation for disrupted service.

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6 Transport:

To appraise the losses associated with disruption to road and rail networks

Road disruption

OVERVIEW

This sub-section provides methodologies to estimate the potential losses due to the flooding of road networks. The Environment Agency (2024) estimates that one third (38%) of all roads are at risk from one or more sources of flooding; with about 18% of roads being at high or medium risk. Therefore, flooding has the potential to cause significant damage to roads and disruption to both travellers and businesses with the resulting losses being some of the highest non-property losses from flooding experienced.

Assessing the losses occurring from the disruption to routes is difficult and complex as it requires assessing the numbers of vehicles potentially affected and an appreciation of how their journeys may change under flooding conditions. Therefore, four approaches to the estimation of the impacts of road traffic disruption are presented. These vary in their level of complexity and therefore the appraisal resources that they require. The selection of the most appropriate method to use will depend upon the scale of the likely disruption; where losses are likely to be significant the more in-depth and detailed approaches are recommended.

LESSONS FROM EXPERIENCE

- The key factors for estimating traffic disruption costs include flood duration, the number of roads likely to be impacted and the importance of those roads affected (i.e. whether a flood causes a significant knock-on effect to other parts of the network).

- As the responsibility for roads falls between the Highways Agency, for major roads and motorways, and Local Authorities for local roads, and therefore it may be necessary to consult with these organisations when considering quantifying the potential losses from roads, depending on the types of roads affected.

- Although in general the greatest losses will occur on the roads with most traffic (i.e. motorways, or A roads). The 2012 floods highlighted the importance of connectivity and the presence of alternative routes as some roads (in particular the A361) were closed for weeks rather than hours or days.

- Adopting a proportional approach to appraisal is critical for appraising the losses emanating from the flooding of roads. It must be stressed that the first three methods highlighted below should be used to obtain an informed disruption cost which can be used to ascertain whether a more detailed analysis is required using sophisticated traffic modelling and specific, local data.

DIRECT DAMAGES TO ROAD INFRASTRUCTURE

Road reconstruction costs following flooding will vary depending upon the type and scale of damage, the type of road impacted, the location of the required repair and where in the country is affected (there is both local and regional variations in the potential costs of repair). Costs for repair are particularly sensitive to the action of flooding. Some faster flooding events may have a scouring impact on road surface, whereas others where water is sitting on road surfaces may be less damaging. The type of road surfacing will also impact the estimated costs of repair. Unit reconstruction costs for resurfacing a local road range between approximately £15/m^2 for a quiet road to up to approximately £50 m^2 for a busier road (which require a thicker surface layer and road works may need to occur at night or off-peak and thus incurring overtime costs) (Hertfordshire County Council, undated; Conway County Borough Council, 2013). For locations where significant damage to roads is expected it is recommended that appraisers contact the Local Authorities Highways team for guidance concerning likely unit costs.

If severe damage occurs or other road structures, such as bridges, are affected, costs may be considerably higher and will need to be evaluated on a case-by-case basis. Unit costs for the potential repair of bridge structures can be found in ADEPT (2017), although their use will require consideration of which elements of the bridge will be affected. The Highways Agency should be contacted separately for roads under their management as they will have different unit costs for repair and reconstruction.

LOSSES DUE TO ROAD TRAFFIC DISRUPTION

Estimating traffic disruption based on previous flood events is inadvisable as the severity of disruption can vary dramatically. Traffic disruption cost estimates for the summer 2007 floods, for example, highlighted a large range of between £22 and £174 million (Chatterton et al., 2010). As a percentage of direct damages, traffic disruption for the 2007 floods was approximately 10% of property damages (using the highest estimates for both), whereas for the autumn 2000 floods, this figure was nearer 2% (Penning-Rowsell et al., 2002).

The chief determining factors for traffic disruption costs include flood duration, the scale of the area affected (and therefore the number of roads) and specifically which roads are impacted (whether a flood causes significant knock-on effects to other parts of the network). Therefore, estimates based on previous events could lead to drastically over- or under-estimated figures as losses are highly location specific.

The three situations when the calculation of traffic disruption costs are most likely to be justified are when any of the following (or a combination of the following) are present:

1. When the annual probability of the flood event that causes traffic disruption is greater than 20%;
2. When a significant part of the local network is affected;
3. When the duration of the flooding is several days or even weeks/months; as happened on the A361 in Somerset in 2012.

Four approaches for appraising road traffic disruption costs will be described and the suitability of each will depend on available resources and the likely severity of the road disruption:

Method 1: The delayed-Hour Method: An average cost per hour for a delay on an average Highway's Agency road.
Method 2: The diversion-Value Method**:** The value of time based solely on the length of diversion (assuming that there is no reduction in traffic speed).
Method 3: The speed-Time Method**:** Reduced speeds are considered and a value of time applied for each diverted vehicle.
Method 4: Origin–destination matrix Method**:** Using sophisticated transport appraisal and modelling tools (e.g. SATURN/PARAMICS).

METHOD 1: THE DELAYED-HOUR METHOD

A very crude disruption cost could be ascertained using averages of Highways Agency (HA) data and Department for Transport estimate of the values associated with travellers' time.

Assuming an average speed of 100kmph (approximately 60mph), a single car delay of one hour on a motorway or A road will cost the UK £16.80. According to Department for Transport (2025) in 2024, the average annual vehicle flow per hour on the strategic road network in England is 2,421 vehicles). Based on this, we can estimate that the average delay of one hour on a road will cost the UK approximately £39,414.

This figure can be refined if specific data about the hourly flow rate of the particular road being appraised is available and weighted accordingly if other vehicles (e.g. LGVs and HGVs) are included. The averaged figure should only be used on Highways Agency roads (i.e. motorways and major trunk roads in England) as it will vary considerably at lower average speeds and on other road types.

A table of resource costs is available in Table 6.11 and can be used to refine the hourly cost per vehicle based on the average speed for the road(s) in question and these can then be multiplied by the calculated traffic flow for each particular road. This hourly figure will then need to be multiplied by the estimated duration of disruption. Indicative delay durations at different return periods are provided in Table 6.12. These are relatively basic estimations and local knowledge should be used to refine these where available.

The *Delayed-Hour* method is considered to be superior to the use of a percentage uplift estimate of property damages, however it will still provide a very crude estimate. More refined modelling should be undertaken where possible and if an appraiser thinks it is proportional to do so.

The following three approaches each adopt the same following basic principle: that if a road is closed; traffic will be diverted around this disruption point in the network. Essentially, Methods 2 and 3 are extensions of the same approach, but it is the level of detail which increases including how costs are attributed.

In both Methods 2 and 3 additional costs incurred due to a flood can be estimated using Equation 6T.1:

Equation 6T.1

CD = VD * AC * D

where:
CD is Estimated costs incurred during disruption (£)
VD is Number of vehicles delayed per hour
AC is Additional cost per vehicle (£)
D is Flood duration (hours)

When considering the traffic disruption caused by flooding, the first question is whether it is worth calculating these benefits at all. The above equation should be used to derive an initial crude estimate of the likely benefits of alleviating traffic disruption, since otherwise the costs of calculating these benefits can exceed the present value of the traffic disruption benefits is disproportionate.

METHOD 2: THE DIVERSION-VALUE METHOD

The simplest way of applying the above equation is to assume that cars will be diverted on to neighbouring roads and therefore the distance that they travel will increase; however, their speed will be unaffected. For example, suppose that 15,000 vehicles travel through the local network each hour and will have to travel on average 2 kilometres further but their average speed (40 kph) will not be reduced. In this scenario, the cost of that flood event will be equal to 15,000 * 0.54[1] * 2 for each hour of the disruption due to flooding. If the flood lasts six hours, the costs of traffic disruption amounts to £97,200. In this instance, the figure is small and therefore it is disproportionate to refine this value further using more sophisticated modelling.

METHOD 3: THE SPEED-TIME METHOD

The MCM (2005) provides a more in-depth method for calculating traffic disruption, and where possible this should still be used in conjunction with the updated figures provided here. In line with experience since 2005, we have attempted to produce a simpler and less time-consuming method which will give an adequate estimate of traffic disruption costs. More detailed modelling of local traffic conditions and driver behaviour may be the preferred option where the likelihood of road traffic disruption due to flooding is significant; for example, the Somerset floods of 2012.

Step One: Determine which roads will be disrupted by floods of different annual probabilities and the durations of closure in each case.

As an approximation, a road should be assumed to be closed when the middle of the lane is inundated and certainly when the crown of that road is flooded. Although this may be considered quite cautious it is consistent with Environment Agency advice which attempts to prevent the public driving through flood waters.

[1] (see Table 6.11 *Total Resource Costs*)

Step Two: Estimate the volume of traffic using each road in the local network (e.g. including those roads on to which traffic is likely to be diverted in a flood).

Annual average daily traffic flows for all major and minor roads in Great Britain are available from the DfT website: https://data.gov.uk/dataset/208c0e7b-353f-4e2d-8b7a-1a7118467acc/gb-road-traffic-counts. The data are disaggregated by category of vehicle (car, LGV, HGV etc), which is relevant for calculating the different costs of travel for each vehicle type (covered in Step 5 below). An appraiser might also consult the Highways Agency and/or Local Authority who retain a large amount of data about traffic flows. It is also possible to utilise sources which provide data on 'live' traffic conditions to estimate "normal" traffic flow (e.g. Google Maps, Bing and Open Routing Service). Users should think carefully about the representativeness of any dates or times that are utilised and document the decisions which are made.

Step Three: Calculate the costs to traffic of using the local network under normal conditions.

The Department for Transport provides free flow speeds for all built-up and rural road types: https://www.gov.uk/government/collections/speeds-statistics. Free flow vehicle speeds provide information on the speeds at which drivers choose to travel and their compliance with speed limits, but should not be taken as estimates of actual average speed across the road network. Alternatively, column 1 "Free Flow speed" in the *Speed-Flow Relations* in Table 6.13, can be used for this purpose.

Step Four: For each flood event, determine the routes that diverted traffic will take.

For diversion distances, and where local expertise is absent, an online tool can be used. For example, the 'Get directions' feature on Google Maps provides distance information on the length of a selected stretch of road. As different traffic flow values are applicable to different types of road (single carriageway built-up roads; dual carriageway rural roads; motorways; etc) it is necessary to ensure that the diversion route is calculated using a separate distance value for each particular road type used (see Step 5). There are many assumptions that need to be made when establishing the likely routes for diversion and there is the need to concentrate primarily on diversions using major routes rather than minor roads.

Step Five: Calculate the costs to traffic of using the network under these flood conditions

The most difficult aspect here is to calculate how the non-flooded network will cope when the diverted traffic is added to it. Each road type has a free flow limit (see column 2 in Table 6.13 *Speed-Flow Relations Table*) and a capacity limit (see column 3 in Table 6.13) and when this is reached speed flows will be reduced linearly. The following equation can be used to calculate the reduced speed of vehicles on the diversion routes above the limiting capacity (QM; Table 6.13).

Equation 6T.2

$$\text{Speed} = \frac{\text{VM}}{1 + \frac{\text{VM}}{8\ \text{DIS}} \times \left(\frac{\text{F}}{\text{QM}} - 1\right)}$$

Where:
DIS is the length of the road between junctions (in km);
F is the traffic volume in the pcu (per car unit) equivalents; and
VM and QM are as defined in the *Speed-Flow Relations Table* (Table 6.13)

When the reduced speed has been calculated for each diversion route, a cost per vehicle type must then be assigned using the Resource Costs Table (Table 6.11). This includes the value of time and the cost of running a vehicle (excluding indirect taxes and fuel duty etc) and is based on TAG Unit 3.5.6 (Department for Transport, 2012). It is now possible to calculate the total traffic disruption for the flood event using the equation below:

Equation 6T.3

EP = VA * L * C * D

where:
EP is Estimated potential costs of road traffic disruption (£)
VA is Number of vehicles affected (for each vehicle type)
L is Length of diversion (km)
C is Total cost of travel per km (for each vehicle type) (£)
D is Flood duration (hours)

An estimate of flood duration (in hours) for each return period is provided in the table of Indicative delay durations (Table 6.12). This should not be used as a substitute for detailed flood modelling but should be applied cautiously where no site-specific probabilities and durations are available.

METHOD 4: THE ORIGIN–DESTINATION MATRIX METHOD

The most sophisticated method of assessing road traffic disruption costs employs an origin-destination matrix and complex traffic modelling results. This would provide the most accurate of approaches. If an origin-destination traffic matrix is available for the area, then the flows on the different roads can be calculated using transport models such as SATURN (which is a general traffic assignment model) or PARAMICS (which is a more commonly-used micro-simulation model, like the old DRACULA model). Given the complexity of transport modelling, we recommend the support of a specialised transport modeller. More details can be obtained from https://www.gov.uk/transport-appraisal-and-modelling-tools.

Unless the network being modelled is small (e.g. less than 20 roads between junctions) then it is tedious to carry out an analysis without an available origin-destination matrix.

HIGH FREQUENCY EVENTS AND FLOODS WHICH AFFECT A SIGNIFICANT PART OF THE NETWORK

Roads are often the first points to flood in a floodplain, either because they run along the riverbank or because they cross the floodplain. Consequently, they may be flooded in very frequent events and perhaps be flooded several times a year. This needs to be accounted for within any calculations. However, in many cases the costs of raising the road and therefore solving flooding problems via a road engineering solution may be lower than a flood risk management option. In these circumstances it may be appropriate to cap the Present Value Damage (Pvd) due to road traffic disruption at the least cost solution of raising the road above the flooded level.

When considering floods which affect a significant part of the network, there are two sub-categories:

1. Disruption to sparse rural networks where diversion routes are long (e.g. 10 kms); and
2. Dense, heavily trafficked urban networks.

The former can be handled through the methods just described. However, the latter often involve dozens of links and, to be feasible, analysis of such networks requires the existence of an origin-destination matrix and a traffic model.

LONG DURATION FLOODS

Since traffic disruption losses are calculated on an hourly basis, the total losses from floods lasting several weeks can obviously be very significant, as experienced in Somerset during winter 2012/13.

During longer flooding events, awareness of road closures will increase and drivers will themselves begin to find alternative routes, may vary their journeys to less busy times of day, may select alternative transport options or choose not to travel and therefore traffic on the diverted routes may begin to ease. Additionally, not all diverted routes will be full to capacity at all times of day and therefore traffic speeds may vary and there is the need to ensure that the costs of traffic disruption is not severely overestimated in these circumstances.

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Rail disruption

OVERVIEW

This sub-section details a methodology for estimating the potential damages and losses caused by the flooding of railways. The Environment Agency (2024) over one third or 37% of railways are at risk from one or more sources of flooding; with, around 18% of railway lines at high or medium risk of flooding. The 2007 floods caused estimated losses of £36 million in the rail sector of which £10.5 million were direct damages to the track or other infrastructure, with the remaining £25.6 million being attributed to disruption costs. This equated to 5% of the economic losses to infrastructure.

Appraisal of the potential losses owing to the disruption of rail services are quantified in two ways: estimates of the compensation paid to Train Operating Companies (TOCs) by Network Rail following a delay in service or performance as a result of severe weather and the Value of Time (VOT) approach which quantifies the value of a delay. Each of these depends upon an estimate of the likely number of services affected and the likely duration of the flooding.

LESSONS FROM EXPERIENCE

- Site surveys are recommended in many cases as the specific circumstances of the flooding and the siting of equipment and other assets may significantly impact the losses experienced.

- Since the 2007 floods Network Rail has increased their focus on the current and future flood resilience of the rail network. This has included drainage improvements and other work to improve the resilience of assets to flooding as well as the mapping and assessment of assets at risk. Therefore, discussions with Network Rail are critical to clearly understand the potential impacts and losses of flooding on rail infrastructure.

- When appraising the benefits of schemes to reduce rail disruption owing to flooding, care is needed to calculate costs which can actually be prevented by any flood management interventions: rail service disruption may be caused simply by heavy rainfall which cannot be prevented by flood risk management investment.

- Experiences in 2012 in South-West England highlighted the importance of the specific line impacted to the losses generated and the density of the rail network and therefore alternative routes. In 2012, both of the main lines into the South- West were disrupted, thereby effectively cutting all rail travel to the region.

- The inter-dependency of the railway assets (e.g. signalling, track, buildings) means that appraisal should be considered as soon as any there is the potential of flooding on any of Network Rail's land.

TYPES OF LOSSES EXPERIENCED

Flooding of the rail track and associated infrastructure will cause some services to be cancelled and others to be delayed. The more severe the flooding the more severe will be the disruption and the larger the number of services cancelled.

Losses due to flooding can arise in the following areas:

1. Damage to assets. Network Rail incurs direct damages to infrastructure assets including track and circuits, embankments, structures and stations. There is also the potential for TOC rolling stock to be damaged although generally these losses are likely to be relatively minor.

2. Performance delay/cancellation costs. These occur as a result of delays and or cancellations in the train service and will involve costs to Network Rail for compensation to Train Operating Companies (TOCs) and to TOCs for loss of revenue and compensation to reimburse inconvenienced passengers.

3. Costs of alternative travel arrangements. When trains are cancelled owing to flooding the TOCs are under an obligation to enable passengers to continue their journey and provide alternative transport (such as replacement bus services). Although these are noted here as a separate category of loss, Network Rail's compensation to TOCs will include an element to reimburse for these losses.

ESTIMATING DIRECT DAMAGES TO RAIL ASSETS

Direct damage to rail assets is difficult to quantify as it varies considerably depending upon the circumstances of the flooding and the particular element of infrastructure affected; e.g. embankment, track, signalling etc. Therefore, to estimate potential direct damages a site survey is highly recommended along with discussions with local Network Rail engineers. However, to inform estimates the following indicative unit reconstruction values for Network Rail assets might be used: £4,000 per metre for embankments, £3,000 per metre for soil cuttings and £4,000 per metre for rock cuttings.

A METHOD OF BENEFIT ASSESSMENT FOR DISRUPTION TO THE RAIL NETWORK

The mapping of assets at risk has been improved by Network Rail's Asset Management with the development of a GIS system which is used to identify and categorise risks to assets. Network Rail has a much-improved understanding and categorisation of both the location and potential impacts of flooding on their systems and it is strongly advised that FRM project appraisers make use of this knowledge and that any significant assessment of rail damage and disruption should include a site visit and discussions with the appropriate Network Rail route engineer.

The appraisal method described below is based on, and adapted from, that described in MCM (2005) and that undertaken for the Meteorological Office (Posford Duvivier et al., 2002) and is based upon analysing the number of services or passenger journeys impacted by flooding. Two methods are presented; firstly, estimating the compensation payments made to TOCs/FOCs by Network Rail to recompense for delayed or cancelled service, whereas the second method uses a Value of Time approach accounting for how much time travellers would pay to avoid a delay. The first approach uses the total number of likely services impacted by flooding; whereas the latter utilises the number of passenger journeys impacted by flooding. If no information on the number of passenger journeys per 24 hours is available then the average number of passenger journeys per train, 182, (Burr, 2008) might be used to provide an estimated value based on the likely number of services affected.

The following steps should be used to calculate the costs of disruption:

Step One: Identify assets at risk of flooding

Obtain or create a map of the rail network running through the area at risk of flooding or the potential flood risk management benefit area. This should include the specific Train Operating Companies (TOCs) which run services on the affected part of the network. Information on the routes that each of the TOCs operate can be found on the National Rail website (http://www.nationalrail.co.uk/stations_destinations/maps.aspx).

Step Two: Determine the number of services impacted and/or the passenger journeys for the rail line at risk from flooding per 24-hour period

This information can be difficult to identify as the Office of Rail Regulation (ORR) only presents global annual passenger numbers for each of the rail companies for detailed assessment in their National Rail Trends Portal (ORR, 2013) (these averaged data are provided in Table 6.14). Therefore, it is necessary to approach each TOC operating on the rail lines within the appraisal area to refine these global passenger numbers and to identify the relative significance of the line.

Step Three: Estimate how many services will be cancelled and how many will be delayed

The Met Office research (Posford Duvivier et al., 2002) provides some benchmark data for delay and cancellation. This suggests using a 40/60 split for passenger train between delay and cancellation in this simplified algorithm.

Table 6.15 *Percentage delay/cancellation due to flooding (Posford Duvivier et al., 2002)*

Rail Service	Delay %	Cancellation %
Passenger service	40	60
Freight service	45	55

NB. This is Table 6.19 in the MCM 2013

Apply the relevant split from the table above to the number of services/passenger journeys per 24 hours which would be affected by flooding. An estimate of the likely length of a delay to a service is also required. This can be quite complex and we recommend discussions with Network Rail engineers to identify the average number of delay minutes that a service might suffer if a route is affected.

Step Four: Quantify the losses

Two methods are described below for quantifying these losses. The first relies on estimating how much compensation will be paid by Network Rail to TOCs and FOCs and therefore represents the additional costs due to flooding. The second method uses the Value of Time (VOT) approach adopted by the National Audit Office (Burr, 2008) in their investigation of rail delays.

Step Five: Convert the costs calculated per hour to annual average disruption

This requires an assessment of the depth and extent of flooding likely at different probabilities. Owing to the complexity and context-specific nature of the rail network it is preferable to undertake a site survey to understand fully the likely impacts of flooding and the likely length of a delay. Where this is undertaken, site-specific annual flooding probabilities should be applied. The inundation of areas around the track may also critically affect other assets such as signal infrastructure and affect the stability of embankments. Therefore, potential losses should be considered as soon as any Network Rail property is affected by flooding (including property assets; embankments; drainage; culverts; bridges; other crossings). These estimates can then be refined through discussion with local Network Rail route engineers.

In the absence of site-specific annual flooding probabilities (which are to be preferred) use road traffic return period disruption durations (Table 6.12). Disruption will escalate significantly as flooding becomes regional or if a key junction or station in the network is affected. Situations where widespread disruption occurs – and therefore where both rail response and repair teams and rail replacement infrastructure are stretched – are likely to have losses disproportionate to the sum of the aggregated flooding incidents. Therefore, disruption figures calculated using the approach presented here represent a minimum economic cost of disruption, relating to the separate flooding of individual floodplain areas and rail links, rather than all-region impacts.

QUANTIFYING DISRUPTION COSTS DUE TO SERVICE DELAY AND CANCELLATION

UTILISING NETWORK RAIL COMPENSATION PAYMENTS

This first method uses the compensation payments made to TOCs/FOCs by Network Rail to recompense for delayed or cancelled services. This utilises the average compensation costs that Network Rail pays to the TOCs under Schedules 4 and 8 of the Track Access Agreements. Standard costs set out in these agreements are assigned to the delay/cancellation depending on the type of route affected, the operator affected and the location of the incident; with the busiest routes allocated the highest weighting. Thus, a delay close to London in peak rush hour will be assigned a higher delay cost than, say, a delay in rural Wales. Indicative compensation values per delay minute and per cancelled service are provided in Table 6.16.

A low, medium and high value is provided for passenger services performance delays (per minute) and cancellations (per service) to account for the wide variation between TOCs and the lines impacted. These values could be used to provide a range of the potential losses due to rail disruption. Alternatively, it may be appropriate to select one of the values depending on the significance of the rail line within the assessment area. For instance, if a busy rail line (such as a main commuter route or east/west coast mainline) will be impacted the higher value should be applied. Conversely, if a less busy, rural route is within the assessment area the low value may be more appropriate.

A single indicative value for delay and cancellation for freight is provided, as these compensation values appear to be more constant. These values should be multiplied by the likely minutes of delay and estimated number of services impacted, to provide an approximation of the potential losses due to flooding.

A VALUE OF TIME APPROACH (VOT) TO QUANTIFYING THE LOSSES

Similar to the compensation approach, this method also calculates loss based on the number of delay minutes experienced. However, this approach utilises willingness-to-pay approaches presented by the New Approach to Transport Appraisal (NATA) (Department for Transport, 2011b). A monetary value is provided in Table 6.17 (based on willingness-to-pay surveys) for different types of transport user (e.g. commuter; business user and other) based on how much they would pay to avoid a travel delay.

These values can be used to approximate the costs of a delay to different passenger types and therefore to calculate the costs of travel disruption when multiplied by the length of any delay. If a local analysis is to be undertaken, data needs to be gathered on the proportions of the different types of passengers travelling per train which will vary by train line as well as the average number of passenger journeys per train (see Step 2 above).

Averaged data is available on these proportions for each TOC (Table 6.18) and a national and regional breakdown Table (6.19) by journey purpose is available here. Although these data can be used for a general assessment, specific lines and services may vary considerably in their composition and so a per railway line analysis should be undertaken where possible.

It is also possible to use average data for an approximation of the value of time costs of rail disruption. Burr (2008) utilised data from Department for Transport, Network Rail and the ORR to calculate the average number of passengers per train and an average estimation of the type of passenger split for all journeys throughout a week. This identified that an average train contained 14 business travellers, 95 commuters and 73 'other' passengers. They then applied these to the VOT figures for 2007 and calculated an average value of £73.47 for every minute a train is delayed. Applying the updated VOT figures in Table 6.17 provides an updated figure of £104.14 per delayed minute of a train.

Each of the methods above provides a slightly different estimate of the potential costs of disruption. The compensation payment method provides an estimate of disruption due to the delay of a service and is broadly related to the value of the fare being paid by a passenger. The second approach provides an estimate based on the value of time and attempts to quantify the inconvenience or lost work time caused by a delay or cancellation. Combining these estimates provides an upper estimate on the value of a disruption. This arguably includes some degree of double counting as the compensation value - which if reclaimed by affected passengers – does provide some recompense for their inconvenience, however, may provide a closer estimate to the true costs of the disruption of rail services.

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6 Education and Health

Estimating the potential losses due to the flooding of Schools and Hospital Services

Schools

Estimating the potential losses due to the disruption of education in schools

OVERVIEW

This sub-section provides a methodology for assessing the potential losses owing to the flooding of schools. There is a high potential for schools to be impacted by flooding. HR Wallingford (2012) estimated that there are over 1,600 schools in areas of flood risk; 740 of which are at moderate or significant risk with over 200,000 enrolled pupils. The floods in 2007 had widespread impacts with schools in Kingston-upon-Hull and East Riding of Yorkshire being particularly badly affected with the total costs of the repair and replacement of school buildings being estimated at £12.2 million (Chatterton et al., 2010). Environment Agency (2024) estimates that 21% education facilities are located in areas risk of flooding from multiple sources.

Direct damages occur due to the flooding of school buildings, the cost of temporary classroom accommodation and additional costs such as student counselling. The methodologies presented here to assess the potential losses caused by the disruption to education are based on estimating the likely number of pupil days lost due to the closure or part closure of a school. Estimates of losses are then based upon accounting for assessing the 'value' of those education days lost as well as any losses that may occur due to parents' absenteeism from work while they care for children who are unable to attend school.

LESSONS FROM EXPERIENCE

- A school does not have to be directly flooded to be impacted by flooding. Due to access issues (both by teachers and pupils) schools close to, as well as within, a benefit area should be considered within an appraisal.

- Schools are likely also to be closed due to the disruption to essential services such as electricity, water or waste water.

- It may be proportional in most cases to enumerate the losses for those schools which are likely to be closed for more than two days. However, if there are several schools which suffer only minor flooding or disruption the cumulative losses at these multiple sites may be significant.

- The duration of disruption should be minimised by school or Local Authority contingency planning to source temporary or alternative classroom accommodation and therefore the maximum time a school is closed is estimated to be 5 days. After this period it is likely that alternative or temporary accommodation would be secured.

ESTIMATING DIRECT DAMAGE TO SCHOOLS

Readers are referred to Chapter 5 for guidance on accessing direct damages to schools.

Other direct costs which appraisers may need to include are the:

- Costs of additional temporary classrooms and/or other accommodation costs.
- Costs to the school/Council of added support services to pupils affected by flooding (e.g. the cost of additional counselling services).

These costs are difficult to estimate and will vary depending on the severity of the flooding experienced and the length of time pupils need to be taught elsewhere. Where available it is recommended that appraisers should use local estimates for the costs of mobile classrooms or alternative buildings.

There are some lessons however, that can be learnt from the experiences in Hull in 2007 where the average cost for classroom accommodation was £15,000 per school. This is calculated by taking the total alternative accommodation estimate of £700,000 (Chatterton et al., 2010) and dividing it by the 46 most severely impacted schools. However, in all likelihood the most severely affected three schools should be assigned a much higher proportion of these temporary accommodation costs. Despite this, this estimate does provide a starting point for appraisal and might be considered to be a minimum estimate.

An average cost of approximately £150 per pupil for additional counselling might also be adopted as a crude estimate. This is based upon the Chatterton et al. (2010) estimate of total additional costs of £514,000 spent in the Hull case in 2007 divided by the estimate of 3,000 pupils most directly impacted by flooding (Coulthard et al., 2007).

ESTIMATING LOSSES DUE TO THE CLOSURE OF A SCHOOL

Losses from a school closure may include:

- The loss of parents' earnings (or number of staff days lost) due to the need to take time off to care for dependent children.
- The value of the loss of a pupil's education.
- Additional travel costs to alternative schools or temporary school locations (this is very difficult to establish as it would require knowing the additional journeys of all pupils/staff).

An estimation of each of these losses is a function of the duration of closure and subsequent disruption to the school and assessment of the number of pupils affected (and in particular younger pupils).

The following steps should be followed to assess the disruption losses due to the flooding of schools:

> Step One: Identify the location of schools within and close to the flood risk area

Schools directly adjacent to the flood risk area should also be considered within this process. These schools may be impacted by flood warnings, any emergency actions and transport problems. Assess whether there are alterative flood-free routes to access the schools. Use this information to create a shortlist of schools for consideration for appraisal.

Step Two: Identify the type of each of the schools on the shortlist and the number of pupils enrolled

Information about every school (including mapped schools, school type and numbers of pupils) is available within the Department of Education's Performance Tables (https://www.compare-school-performance.service.gov.uk/)[1] (Department of Education (DoE), 2025a). Alternatively, the average figure for the number of pupils in a primary school in England is 272 and a secondary school is 1062 (DoE, 2025a) and these may be used as indicative estimates, however actual values should be collected and used where possible.

Step Three: Assess the likely impact of flooding on each school under different flooding likelihoods

This assessment needs to focus on the severity of the impact and the duration. This should address the following questions:

- Will the school be directly flooded or is it only likely to be impacted by access issues?
- Is the entire school site impacted by flooding? Or would it be possible to continue to educate children in other school buildings once flood waters have receded and while buildings are being repaired?
- How long is the school likely to be closed or partially closed? Note that half of all schools affected in Hull were able to open after one week.

As described in the lessons from experience it may be appropriate and proportional only to enumerate the losses for those schools which are likely to be closed for more than two days. However, if there are several schools which suffer only minor flooding or disruption the cumulative losses at these multiple sites may be significant. The maximum disruption time for a school to be closed should be assessed at five days. After this period, it would be expected that a school would be re-opened or alternative accommodation secured (whether in another location or temporary classrooms).

Step Four: Calculate the number of pupil days lost due to flooding for each school

This can be achieved by multiplying the number of pupils in each school likely to be impacted (i.e. this will be all pupils if the whole school is closed or only a proportion if a school is partially closed) by the number of days the school is likely to be impacted.

Step Five: Quantifying the value of the loss of education

The first loss to calculate is a value attributed to the loss of a day of education (Equation 6E&H.1). This step provides a minimum estimate of the value of the school days lost. It is based on estimating the equivalent daily costs to the Local Authority to educate a pupil as adopted by both the National Audit Office (2005) and Chatterton et al. (2010). Values of annual pupil expenditure for every school in England and Wales can be found at the Department of Education's Performance Tables (https://www.compare-school-performance.service.gov.uk/) (DoE, 2025a) and/or via the Schools Financial Benchmarking data (https://financial-benchmarking-and-insights-tool.education.gov.uk/).

[1] NB: The 2024-2025 data are the latest released by the Department of Education as of April 2026.

Alternatively, national averages can be used, which for 2024/2025[2] are calculated at £36.55 for primary schools and £40.976 for secondary schools per pupil per day, based on median values for all national (England) schools and 190 school days a year[3].

The following equation should be applied to all pupils irrespective of age.

Equation 6E&H.1

LD = PD * E

where:
LD is Estimate of the value of school days lost (£)
PD is Number of pupil days lost due to flooding
E is Average daily expenditure per pupil (£)

Step Six: Quantifying the paid productivity loss from parental absenteeism from work during the period of school closure

This second loss utilises estimates of the costs of parents missing work days due to the closure of school (based on Coulthard et al. (2007) and Sadique et al. (2008)). This method also utilises the estimate of the total pupils days lost due to closure; however we must adjust this value to account for various mitigating factors which reduce the overall number of pupil days lost due to flooding.

Firstly, not all school-age children will require supervision if a school is closed. Therefore, secondary schools should be excluded from an analysis of the parent work days lost as it would be expected that the majority of children at these schools would be able to remain at home without parental supervision. Schools which educate a mixed range of children should be included but only an appropriate percentage of the pupil affected days should be taken to represent primary-aged children.

Secondly, there is also the need to account for the following:

- The presence of siblings within a school population (i.e. to avoid double counting a parent's work days missed);
- That one parent may already be at home looking after younger siblings;
- That one parent may be unemployed;
- That some parents may choose to take annual leave (and therefore will not cause an economic loss);
- The fact that some parents may have alternative childcare arrangements (i.e. grandparents or childminders).

Indeed, the longer a school remains closed the increased likelihood that many parents will be able to find alternative arrangements and a reduction in the wider impact on the economy through work days lost.
Sadique et al. (2008) provide a more in-depth and complex way of analysing the percentage of the workforce that would be impacted by a school closure. This approach may be adopted if a more

[2] NB: As stated above the 2024/2025 data are the most recently released data as of April 2026. Averages have been calculated using combined financial benchmarking data for both Academies and Local Authority Maintained Schools (https://financial-benchmarking-and-insights-tool.education.gov.uk/). It is suggested that users check at time of appraisal for their school(s) of interest most up to date and specific data (https://www.find-school-performance-data.service.gov.uk/).
[3] NB: Data are also available for more specialist types of school such as Pupil Referral Units.

comprehensive analysis is required. However, Coulthard et al. (2007) divides the number of pupil days by two to account for the presence of siblings at the same school. However, we suggest that this is insufficient to account for all of the conditions described above and therefore dividing by a factor of three is recommended here.

The following equation can be adopted to calculate the potential loss of work days due to the closure of a school.

Equation 6E&H.2

VL = (PPD / 3) * W

where:
VL is Value of loss (£)
PPD is Total number of primary age pupil days lost
W is Value of a day's wage (£)

There are various values which could be attributed to the loss of a working day and appraisers may wish to provide estimates based on local information about average wages. A minimum estimate might use the value of a day's wage lost at minimum wage or an average wage in the UK and current estimates are provided in Table 6.20. Economic values have been provided to give daily wage estimates net of income tax and National Insurance contributions.

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Hospitals

Estimating the potential losses due to the flooding of hospital services

OVERVIEW

The flooding of hospitals can have social widespread impacts. This section describes approaches to the assessment of potential losses including the direct impact of flooding on hospital buildings, as well as due to the disruption and/or cancellation of hospital services. In 2007 there were only two instances of direct flooding to hospitals reported. The 2007 floods highlighted the high interdependency of hospitals on other services (including power and water supply) and transport networks; all of which can be impacted by flooding. Environment Agency (2024) estimates that 25.5% of medical facilities are located in areas risk of flooding from multiple sources.

Despite very minor direct damage being experienced, the flooding led to the cancellation of some hospital services with over 1,200 surgery operations and approximately 8,000 outpatient appointments being cancelled in Gloucestershire alone, primarily due to the disruption in water supply (Gloucestershire Hospitals, 2008).

It is therefore dependency and the interconnectivity of services which makes hospitals particularly susceptible to the impacts of flooding as disruption may not occur directly to the hospital site; but to one of the essential services. This dependency on external services and service providers which may be located off-site, coupled with the complexity of NHS funding arrangements, means that it can be extremely difficult to appraise any potential losses due to flooding. Therefore, the methodologies presented here include a qualitative description of potential losses as well as quantification. Quantification is proposed to estimate the potential losses due to the redundancy of a particular service or piece of equipment and utilises the cost of running that service as a proxy to loss. Additionally, in the cases where evacuation of patients will be necessary, appraisers should quantify the additional costs of transporting patients.

- A site survey and discussion with hospital managers is strongly recommended when appraising any hospital sites. This is due to the complexity and range of hospital services as well as the wide variation in hospital layout. It is likely that a hospital's administration will have investigated particular risks and identified potential contingencies which may assist in loss appraisal.

- Understanding the dependency (and redundancy in the system) of the hospital services is critical to a decision about whether a hospital needs to be investigated further and whether the potential flood related losses are significant. Hospitals close to, as well as within a benefit area, should therefore be considered for appraisal. Hospitals are likely also to be closed due to the disruption to essential services such as electricity, water or waste water and the knock-on impacts of traffic disruption.

- Assessing losses due to the closure/disruption of services is difficult as in some instances a closure of a facility will mean just a transfer within the NHS system (and therefore no net increase in cost) or even a reduction in overall running costs.

- In the absence of complex economic modelling, in many situations a qualitative description of the potential losses is recommended at least initially, to recognise and capture the complexity.

- One of the key elements is whether flooding will critically affect services, such as those for medical emergencies (e.g. Accident and Emergency and other critical care) as alternative provision will be necessary in these cases.

DIRECT DAMAGES TO HOSPITALS

The complexity of the layout of hospital buildings and assets means that a site survey is highly recommended to attribute both direct damages and disruption from losses. However, readers are referred to Chapter 5 for guidance on assessing direct damages to hospitals.

LOSSES DUE TO THE FLOODING OF HOSPITAL SERVICES

Hospitals are complex facilities to investigate. As discussed above they often comprise a number of buildings and/or sites and can have unique footprints. As well as being dependent upon the usual range of services and networks (i.e. electricity, water, sewerage, communications and transport) hospitals are also dependent on a range of other services which are critical to the running of a hospital and the continuity of care. These include amongst others: catering; waste disposal services; clinical waste disposal; laundry and various different stores services (including pharmaceutical, general stores, equipment, sterile goods). The situation is further complicated by the fact that in some instances these services are performed on site and directly by the NHS Trust and in other circumstances they rely upon external private-sector organisations and are located off-site.

In theory, there are a number of different ways in which the services of a hospital may be impacted, each of which may have economic cost implications. Some of these losses are direct in nature (such as the direct flooding of hospital infrastructure), whilst others are indirect (such as flooded roads leading to staff shortages and patients unable to reach their appointments). The total losses will also depend upon the scale of a closure (i.e. where a part, or all, of a hospital site is affected) and the duration of any impacts.

Potential losses/costs:

- Direct damage to the building and fabric of the hospital.
- Damage to equipment and the closure or wards and other facilities (operating theatres, scanners, etc.) due to the direct flooding of hospital buildings.
- Costs of evacuation/transfer of patients, to other hospitals or, in the case of some long-term care elderly patients to temporary alternative accommodation.
- Losses attributed to the redundancy of hospital infrastructure (e.g. scanners and other equipment which is not able to be used).
- Increased costs due to the transfer of services elsewhere (some of these may be transferred within the NHS and therefore only the increased cost should be included, whereas others may be provided by private hospitals).
- Increased staff and out-patient travel costs to alternative sites.
- Increased staff costs – if flooding prevents some staff from getting to work it is likely that agency staff may be required to cover positions, with an increased cost.
- Closure of wards/equipment and the cancellation of appointments due to staff shortages.

Assessing the losses to a hospital is in itself very complex. Although there will be social costs to individuals through the cancellation of services or operations and a general reduction in the total available hospital resources, quantifying these impacts is complicated. In some situations, for instance where acute care is closed (such as Accident and Emergency departments or emergency operations), other health care facilities will need to cover these activities and so the direct costs will be transferred to these providers. In the most part these costs remain within the NHS and so there may be little increase to the UK as a whole. Also, strictly speaking in the short-term the closure of a ward may lead to an overall reduction in the direct costs to a hospital trust as running costs will be avoided. The difficulty of assessing losses due to flooding is compounded by the complexities of the NHS funding. For instance, the cancellation of services may have longer-term implications for an NHS Trust as it may fail to reach performance targets; thereby affecting their next period's government funding. As a result however, a Strategic Health Authority or Primary Care Trust may choose to cover this shortfall, resulting in no net decrease in funding due to the flooding disruption. In addition, although hospitals may save money through a reduction in running costs, there may be many capital assets (such as scanners, theatres, etc.) lying idle and so there will be an overall loss to the country due to the non-operation of this equipment. It is this redundancy in equipment that we aim to quantify for closed or disrupted services.

Understanding the dependency (and redundancy in the system) of the hospital services is critical to a decision about whether a hospital needs to be investigated further and whether the potential flood-related losses are significant. This includes the size of the hospital and the likely numbers of patients impacted as well as the presence and location of alternative service providers.

One of the key elements is whether flooding will impact the NHS providing a service for emergencies (e.g. Accident and Emergency and other critical care), as these are the services which need to be maintained and transferred to alternative providers. Impacts are therefore proportional to those key services which are being provided as well as the transferability of those services.

The following illustrates the basic steps that might be followed in order to appraise losses to hospitals:

Step One: Identify the location of hospitals

Hospitals (and hospital services) located within the floodplain and close to the periphery of the floodplain need to be identified (as these may also be impacted if major transport routes are cut). It is strongly advised that this is undertaken in consultation with the Hospital Trust to fully understand the interdependencies of services as they are likely to have already identified critical infrastructure at risk.

Step Two: Assess the assets likely to be affected by flooding

For quantifying direct damages**,** identify the footprint of the hospital and those services at ground and basement level that may be impacted directly by flooding (i.e. number of wards and potentially numbers of beds impacted that may be closed at different flood return periods). Readers are then referred to Chapter 5 for guidance on assessing direct damages to hospitals. These data should be refined where possible through discussion with hospital authorities; especially if the hospital Present Value Damages (PVd) constitutes a significant proportion (e.g. greater than 10%) of the total potential losses.

Step Three: Assess the likelihood that wards will need to be closed

This should identify how many patients these wards care for and therefore the numbers that might need to be transferred to alternative hospital/nursing home/hospice providers (e.g. if there is some redundancy on site, some patients may be moved to unaffected areas).

Step Four: Estimation of losses due to care service closure

Where possible, enumerate the loss in value through the closure of a ward (i.e. the loss of bed space) or other service/facility. This method of enumeration utilises the average cost of that asset per day to the NHS. Although not strictly an economic loss; it can provide a proxy value for the loss of use of a particular asset.

Based on the level of care and staffing required, different NHS beds have different associated costs, examples of which can be found in Table 6.21. So for ward closures, identify the number of beds of a particular type that might be affected and utilise the following equation to estimate the costs due to the redundancy of beds. Where possible it is also preferable to divide the number of beds not able to be used between general and surgery and critical care as the costs are quite difficult.

Equation 6E&H.3

CR = N * CB

where:
CR is Costs due to the redundancy of beds (£)
N is Number of beds not available to be used
CB is Average cost per bed (divided if possible by the type of bed)

The same procedure can be applied if whole procedures or other out-patient procedures are cancelled. NHS Reference Cost information is provided annually and provides an average cost of a procedure in England and Wales. These can be accessed via the government's website (https://www.england.nhs.uk/national-cost-collection/) and if appropriate used to enumerate the cost of cancelled services. For instance, the average unit cost of Treatment in Accident and Emergency (A and E) in 2024-2025[4] is approximately £281, taking account of the numbers attending A and E and the total cost of treatment in A and E Departments. A figure such as this might be used to give a very approximate loss estimate to the closure of this emergency service if multiplied by the number of people usually treated over the period a service is likely to be closed.

Step Five: Patient Transportation Costs

If evacuation of patients would be necessary, quantify the transport costs of transferring the patients to alternative healthcare providers.

Equation 6E&H.4

CT = (P – BR) * CPT

where:
CT is Cost of transporting patients (£)
P is Number of patients to be evacuated
BR is Number of beds available elsewhere in the hospital (bed redundancy)
CPT is The average cost of a patient transfer (£)

[4] NB: From 2024/25 National Cost Collection. 2024/24 data is the most up to date as of April 2026.

Some indicative values for the cost of patient transfers are provided in Table 6.22.

Step Six: Qualitatively investigate other impacts

Discuss with the Hospital Trust the likely effects of flooding on the continuity of services. The continuity of the following essential services needs to be included within the narrative:

- Electricity supply
- Water supply
- Sewerage services
- Laundry services
- Catering services
- Waste disposal services
- Clinical waste services
- Sterile services

In addition, investigate other aspects such as whether sufficient staff are able to access hospital buildings.

Step Seven: Identify what the hospital will do under different scenarios and how long disruption is likely to last

Learning from 2007 the likely impacts include:

- The closure of wards which are threatened with flooding
- The closure of Accident and Emergency services
- The cancellation of operations
- The pre-emptive cancellation of outpatients and cancellation of other non-urgent treatment

Broad annual statistics for hospitals in England and Wales can be found at NHS Digital (https://digital.nhs.uk/). This includes information such as the annual number of inpatients/outpatients, the numbers of hospital admissions and the total number of annual patient contacts. These can be used to calculate average daily contacts and be used to contextualise the level of likely disruption. Target and performance statistics (such as at how close to capacity a hospital runs) can also be used to understand broadly the level of redundancy in the system and the ability of the services to be transferred.

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6 Local Authority, emergency services and recovery costs

OVERVIEW

Emergency and recovery costs during flood events such as autumn 2000 and summer 2007 are substantial, but not all these costs are allowable as contributing to the benefits of flood risk management schemes. This is for two reasons: a) some of these costs are covered elsewhere in the benefit assessment; b) some items, such as sandbagging, prevent damage in themselves, and project appraisals can assume that this damage does not therefore occur. For this reason, identifying and highlighting the costs related to emergency activity and recovery can be very difficult.

Flood-related expenditure varies between Local Authorities; depending on those assets which were affected by flooding. Overall, the most significant category of flood-related expenditure in 2007 was the cost of repair and reconstruction of infrastructure assets which accounted for close to three-quarters of Local Authority costs. Indeed, the total recovery cost for the sixteen most affected Local Authorities was £194.3 million.

These expenses included the considerable costs necessary to repair assets such as highways, schools and other council owned property.

LESSONS FROM EXPERIENCE

- There will be circumstances in project appraisals where the use of the standard data is not appropriate, or not considered accurate enough for project appraisal purposes;
- There are clear relations between flood emergency costs and the numbers of properties flooded. However, while this is interesting (and logical), it is not always sensible to use this approach for scaling purposes, not least because much of the emergency costs are spent in preventing property being flooded, such that it is perfectly possible for there to be substantial emergency services costs without any property being flooded at all;
- There is a difficulty in estimating marginal costs for many organisations as these can vary significantly. For instance, during the 2007 floods the expenditure for the sixteen most affected Local Authorities ranged from £2.2 million to £29 million.

TYPES OF COST

The benefits of flood risk management include reducing the costs incurred by a number of organisations in tackling flood incidents and in the recovery process. Depending upon the severity of the flood event, several emergency services may be involved in both emergency works and clean-up operations, during and after the flood event. Extra staff time and materials may be required, and additional administrative costs may be involved. Authorities and bodies providing emergency services include the following:

- local authorities;
- police authorities;
- fire services;
- ambulance operations;
- the Environment Agency/Natural Resources Wales;
- voluntary services; and
- the armed forces.

Care should be taken in this exercise to separate fixed costs from marginal costs. Local authorities and the Environment Agency have staff who are employed specifically to deal with emergencies, and a reduction in flooding will not necessarily lead to a reduction in these costs. Similarly, both the police and the fire authorities are themselves emergency services, and the reduction in flooding or coastal erosion would not necessarily reduce the costs to the nation of these services. Therefore, their fixed costs cannot legitimately be included within the benefits of flood risk management. Nevertheless, all these emergency services may incur extra costs as a result of particular flood events (marginal costs), which may be counted in the benefits of flood risk management.

STANDARD DATA

Organisations active in the flood management and recovery phases are allowed to recoup a proportion of their costs from central government under what is termed the Bellwin Scheme. This process insists that eligible expenditure be made 'on or in connection with the immediate action to protect life or property,' (HM Government 1989, Section 155). The system of thresholds is based on the judgement that prudent authorities should budget to cover a proportion of the costs of emergencies from their own reserves and resources. Annual guidance provided by the Ministry of Housing, Communities & Local Government describes the procedures and rules that Local Authorities must adhere to when claiming Bellwin assistance (MHCLG and DLUHC, 2023[1]).

Local authorities in England and Wales were also eligible to apply for financial aid from the European Union Solidarity Fund (EUSF) in the event of major natural disasters, including floods (Council of the European Union, 2002). The summer 2007 floods qualified as one of the forty-nine EUSF interventions since 2002, whereby €162.3 million was granted in aid to the United Kingdom (European Commission, 2013). Both the Bellwin claims data and the applications to the EUSF provide data from which to estimate the costs of emergency and recovery activities.

The approach adopted by the MCM has been derived from research taking the total emergency costs incurred by local authorities, the severe weather payments such as to Highway Authorities, and the Environment Agency's emergency costs and recovery, and allowing only those costs appropriate to project appraisals (i.e. deducting for betterment).

[1] NB: Guidance is provided when specific Bellwin Schemes are initiated and therefore guidance may be updated. Different guidance documents on the Bellwin Scheme are available for Scotland and Wales.

Expressing this amount as a percentage of the total economic property losses in Autumn 2000 gave a percentage of 10.7%. This, therefore, represents a multiplier on top of property damages that accounts adequately and appropriately for emergency costs and recovery.

The same approach was adopted for assessing the total emergency costs and recovery during the summer 2007 floods in England. The total emergency costs (Table 6.23) are £110 million, that is 5.6% of the total economic property losses.

The difference in terms of percentage between 2000 and 2007 floods may be explained by an effect of economy of scale. Indeed the 2007 summer floods affected a higher number of properties (up to 73,000 versus about 10,000 properties) but a lower number of Local Authorities claiming under the Bellwin scheme (38 versus 87 Local Authorities). In other words, the figure obtained from autumn 2000 reflects dispersed flood affected communities whereas the figure obtained from the Summer 2007 floods reflects more densely populated communities.

The AAD (residential and non-residential) property values calculated in project appraisals of flood alleviation schemes should therefore be multiplied by a factor ranging between 1.107 and 1.056 to allow for the emergency and recovery costs that can be justified as real economic costs, not counted elsewhere in the benefit assessments. This figure should be applied for floods at all annual probabilities and for all scales of flood alleviation scheme, in the absence of better information. We recommend that the lower factor should be applied in urban areas to reflect economy of scale in emergency services.

SITE SPECIFIC ASSESSMENTS

There will be circumstances in project appraisals where the use of the standard data as given above is not appropriate, or not considered accurate enough for project appraisal purposes.

In this case, it will be necessary to collect data from the authorities relevant to the area in question. This is not easy, particularly in the absence of a recent flood, and care needs to be taken to ensure that fixed and marginal costs are separated, in order to identify just the latter for counting within project appraisals.

Notwithstanding the above comments, a standard checklist is provided in the Additional Resources for Chapter 6 on MCM-Online as a guide to obtaining these data.

Table 6.23 *Overall emergency costs as applicable to project appraisals (Summer 2007 Floods)*

Emergency costs applicable to project appraisals (based on Summer 2007 Floods - England)			
Cost item	**Amount**	**Allowed* amount (%)**	**Allowed amount**
Total Bellwin and roads:			
Bellwin	£30.20	42.5	£12.84
Roads infrastructure	£175.00	50	£87.50
Environment Agency costs+:			
Emergency repairs**	£14.80	50	£7.40
Emergency response	£2.20	100	£2.20
TOTAL	**£222.20**		**£109.94**
As % of economic property losses of £1,942m =			5.57%

* Judged to be proper economic costs, not counted elsewhere in Benefit-Cost Analyses. The figure for roads recognizes some betterment after repair (hence the 50% taken).
** As for roads, some element of betterment here, hence 50% taken.
+ England and Wales

Source: Chatterton *et al*. (2010).

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7 Coastal Erosion: Potential Losses and Benefits

7 Coastal Erosion: Potential Losses and Benefits

OVERVIEW

This chapter gives the procedures and techniques for assessing the potential benefits of investment in coastal erosion risk management. These benefits principally arise from delaying the processes of erosion and thereby delaying the loss of land and property for the duration of the life of any proposed protection works.

Key points to understand are:

- Erosion is effectively permanent and irreversible;
- This means that future uses of that land or property are lost;
- Decisions about investment versus no investment must start from a realistic evaluation of the "do nothing" option.

Coast protection works, which are designed to arrest this process of erosion, normally have a finite life.

- Hence the benefit from a particular coast protection project should be seen as a temporary - but usually lengthy – extension to the useful life of the land and property protected;
- The most reasonable assumption thereafter is that the original long-term erosion rates as before will start again;
- Coast protection projects are compared with a 'do nothing' option. This 'do-nothing' option may involve 'walk-away' and hence the prospect of substantial erosion of coastal property (see the Environment Agency guidance on 'do nothing');

The approach to assessing these losses and benefits has not altered significantly since the MCM 2005. The changes here only comprise providing up-to-date data on average property annual rental values in the UK (Tables 7.3 and 7.4), where there have been some net reductions in these values since 2005 (then expressed as property prices). Given that, generally, there have been increases in the costs of coast protection works over this time, this means that it is now less likely than in 2005 that protecting property from loss to the sea will be economically viable.

Recent research and guidance "acknowledge that there is a likelihood of increased rates of depression and anxiety for people whose homes are at risk of erosion". Please refer to Environment Agency (2021) for carrying out the mental health impact of erosion assessment.

LESSONS FROM EXPERIENCE

- Flooding and erosion are often inextricably inter-linked; probabilities can become very complex to calculate;
- Unless they are very near the edge of cliffs, houses alone generally provide a poor base for the justification of major coastal risk management works;
- Accurate and realistic erosion rates and probabilities are the key to accurate benefit estimation;
- The prices of houses situated on the tops of cliffs do not accurately reflect their risk of falling into the sea and the loss of one person's view is another person's gain: the view itself is not lost;
- The environmental benefits of coastal risk management are mixed: some assets gain (e.g. eroding cliffs revealing important archaeological or geological sites), others involve losses (e.g. the loss of habitats for bird species);
- The recreation benefits of coastal risk management have been widely ignored and yet they are often a key reason for scheme implementation;
- Delay is a real option that should be considered seriously;
- A systematic comparison of investment versus no investment must start from a realistic evaluation of the "do nothing" option.

THE RECOMMENDED APPROACH

The recommended approach for assessing the benefits of coast protection is summarised in Figure 7.1. The key points about this approach are as follows:

1. Estimates are needed of erosion rates and cliff top edges projected for 50 or even 100 years into the future.

Alternatively, a probabilistic approach to erosion can be taken, resulting in a range of probabilities that a particular parcel of land or property will be eroded and therefore lose its use value.

2. A procedure is provided for evaluating the losses due to erosion, or the extension to the expected life and use of the property and land due to a delay in the erosion process resulting from investment in coastal risk management. Techniques are provided for finding the appropriate values for properties (residential and NRPs) whose market prices are likely to be affected by perceived erosion risk.

Figure 7.1 *Flow Chart of the assessment process*

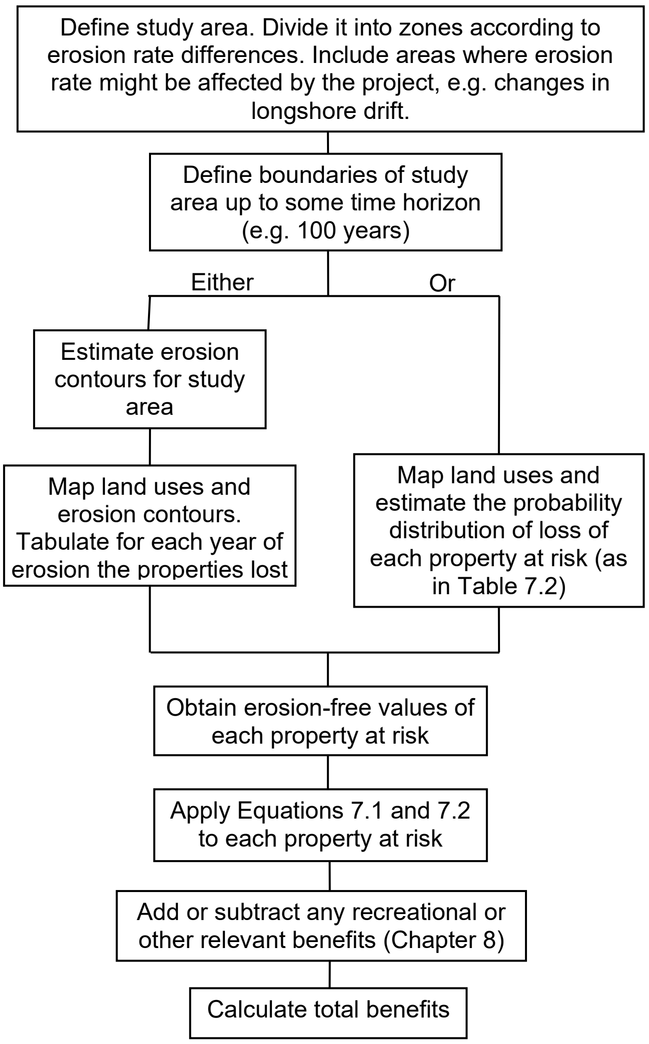

Table 7.1	Basic data for a hypothetical project to delay coastal erosion	
Property	**Value (£)**	**Mean year lost**
House A	80,000	4
House B	60,000	7
3 mobile homes	3,000	10
Public house	240,000	13
House C	120,000	16
House D	90,000	17

Table 7.2	A best estimate of the probability that house 'A' will be lost in any given year					
Year	0	1	2	3	4	5	6
Probability	0.05	0.1	0.15	0.2	0.35	0.1	0.05

Step One: Collect data on the study area's characteristics

EROSION RATES AND EROSION 'CONTOURS'

- Produce a set of predicted erosion 'contours' for the coastline in question, initially using, say, 5-year intervals, for at least the projected life of the proposed coastal protection works. Use smaller time intervals if erosion rates are particularly rapid;
- These erosion predictions will not be certain, and will need to be based on averages of the likely effects of storms of different magnitudes, and sensitivity analysis used to gauge the significance for benefit totals of the assumptions made here;
- For properties at risk from erosion there will be some minimum acceptable safety margin between the cliff top edge and the building: this is the point of erosion where the use of the property is assumed to be lost. Defra has recommended a 2-year margin.

CALCULATING BENEFITS BY ASSESSING THE PROBABILITIES OF EROSION

Since erosion is often episodic, with sudden losses of land and slides of cliffs, the use of erosion contour lines can be misleading whereby it is assumed that erosion will reach a certain point inland in a given year. Therefore, the use of a probabilistic approach should be considered, depending on the distribution of probabilities of cliff falls and hence losses over time.

Table 7.1 gives some data for a hypothetical project and Table 7.2 gives a best estimate of the probability that house "A" will be lost in any given year where the same probability function also applies to all the other properties. If it is assumed that the scheme has an engineering life of 20 years at which point it fails, then the present value of erosion benefits is £215,758.

If, instead, we assume that each property is lost in the year at which the probability of loss is the maximum (i.e. year 4 for house "A"), then the present value of erosion benefits is £205,000. So, in this case the probabilistic approach makes very little difference. However, where the distribution of probabilities (as in Table 7.2) is very asymmetric there can be much larger differences in calculated benefits.

The FCERM-AG economic appraisal spreadsheets use the probabilistic approach (see FCERM-AG supplementary guidance). If the probability of loss for a given property is set to 1.00 in a given year, then the method can be used deterministically.

Step Two: Collect valuation data for properties at risk

THE IDEA OF BENEFIT AS A DELAYED LOSS

The benefit of coast protection works is an extension to the life of, or the delay in the loss of, erosion-prone property and land for a period of time equal to the life of the protection works (scheme life). This assumes that erosion after the end of the project's life would proceed at the same rate as it would have done without the project.

Thus, a property that is predicted to be lost by erosion in 20 years' time without protection would, with effective coast protection works having a life of 50 years, be expected then to be lost in 70 years' time. Thus, the benefits of coast protection are critically affected by the timing of the extension of the life of the property.

THE PROCEDURE FOR VALUING PROPERTY LIFE EXTENSION

The procedure recommended here for valuing erosion-prone properties, involves the following stages:

- Determine the erosion-free market value of similar properties in the local area: market-based property prices;
- Use the Equation 7.1 [see Step 3] to determine the present value of the use of that property up until the time when it is lost through erosion at current erosion rates;
- Use the Equation 7.2 [see Step 3] to determine the present value of the use of the property with the extended life provided by the coast protection scheme (i.e. the life as above plus the anticipated lifetime of the scheme).

EROSION-FREE PROPERTY PRICES

- The property and land prices required are market freehold values, not adjusted for erosion risk. Tables 7.3 and 7.4 provide data sets for values of the main types of dwelling found in this country. These values can be used in the equations below, but greater reliability may be achieved by obtaining values locally for the specific types of property to be affected by the project. Values used for residential property should reflect its location type – such as being near the sea – but it should be safe (i.e. based on properties which do not have an erosion risk);
- Department for Environment, Food and Rural Affairs (2004) provides guidance on distributional impacts in their interim guidance note.

LOCALLY APPROPRIATE PROPERTY PRICES CAN BE OBTAINED THROUGH:

- The Coast Protection Authority's own valuation department, if it has one;
- Local estate agents: use typical or average values for the type of property which ignore the risk of the properties being lost through erosion without a coast protection scheme also and ignore factors such as a sea view.

Table 7.3 *UK dwelling prices and average annual rental values by Region*

Region	New dwellings (Jan 25 - Dec 25) £	All dwellings (Jan 25-Dec 25) £	Annual Average rent (Feb 26) £
North East	286,000	160,169	8,448
North West	277,279	212,433	12,876
Yorkshire & Humberside	299,879	204,104	10,920
East Midlands	352,021	239,383	10,884
West Midlands	331,061	245,760	12,480
East	434,363	336,102	15,396
London	508,694	560,269	24,804
South East	488,524	381,461	17,016
South West	387,492	302,655	14,040
England	377,629	290,182	14,096
Northern Ireland	245,008	189,723	11,316
Scotland	307,241	189,324	11,544
Wales	323,396	208,992	10,752

Source: H.M. Land Registry (2026), https://www.gov.uk/government/statistical-data-sets/uk-house-price-index-data-downloads-february-2026 (dwelling prices are calculated as an average over the 12-month period indicated);

Homelet (Average rent: February 2026: https://homelet.co.uk/homelet-rental-index)

Table 7.4 *Residential property prices and annual rent by dwelling type*

Average 2026 values by residential property type						
	Region	**Detached**	**Semi-detached**	**Terraced**	**Flat/ Maisonette**	**All**
Property price (£)	England	477,208	292,548	247,576	245,362	302,976
	Wales	325,697	207,453	165,393	133,545	212,577
	Scotland	336,666	200,503	158,187	128,187	187,327
Annual rent (£)	England	21,326	13,074	11,064	10,965	13,540
	Wales	15,591	9,931	7,917	6,393	10,176
	Scotland	19,690	11,727	9,252	7,497	10,956

Property prices from: H.M. Land Registry (2026), https://www.gov.uk/government/statistical-data-sets/uk-house-price-index-data-downloads-january-2026
*Annual rent for each property type has been calculated as a proportion of the average annual rent (see Table 7.3)
Source: Homelet 2026 (Average rent: February 26: https://homelet.co.uk/homelet-rental-index)

Step Three: Perform the calculations

The two formulae identified in Step 2 are as follows:

Equation 7.1

PV (without scheme) = MV $(1 – 1 / (1 + r)^{p})$

Equation 7.2

PV (with scheme) = MV * $(1 – 1 / (1 + r)^{p+s})$

where:
PV is Present value
PV asset value = MV * $(1 - [1 / (1 + r)^{\text{year of loss}}])$,
where r = discount rate
PV is Asset loss = MV – PV asset value =
MV * $[1 / (1 + r)^{\text{year of loss}}]$
p = expected life of property with no coast protection project
s = expected life of the coast protection project

This amounts to:

PV benefit = PV asset value (with scheme) – PV asset value (without scheme) or PV benefit = PV asset losses (without scheme) – PV asset loses (with scheme)

Both calculations of PV benefit produce the same answer.

Step Four: Interpret the results

The benefit of carrying out the scheme is the difference between the two values of present value which represent the gain from 's' years of equivalent annual benefit ('s' being the scheme's effective life).

The procedure, very simply, involves the calculation of the discounted value of the property loss with coast protection less the discounted value of the same property loss without any proposed protection works.

The greater the life of the scheme the larger the benefit, but not proportionately, because losses further into the future are discounted more heavily than those incurred in the medium or short term.

The benefits calculated as above need to be compared with the costs of the scheme, both capital and maintenance. Costs in the future need to be discounted to present values.

- A ratio of benefit-cost greater than 1.0 indicates that the scheme is economically worthwhile;
- Delay in scheme implementation will increase the benefit-cost ratio, as the cliff edge gets nearer to the property, with erosion.

KEY POINTS WITHIN THE BENEFIT ASSESSMENT PROCESS

- Realistic erosion rates and probabilities are the key to accurate benefit estimation;
- Assessment of the effective life of any scheme is important to determine, with as much accuracy as possible, as this determines the delay of erosion and 'drives' the benefit calculations;
- The recreation benefits of coast protection (see Chapter 8) are often very large and can be a key reason for scheme implementation. They can be costly to assess (with site surveys), so caution is necessary here;
- All appraisals should be based on the existing properties at risk. No allowance should be made for new developments or possible regeneration of sea frontages.

REMAINING ISSUES

1. House value trends not covered here

Coastal risk management works are generally appraised for a long-expected project life of perhaps 50 or even 100 years. Whilst general inflation over this time is ignored in benefit-cost analysis, potential changes in relative real prices are relevant (HM Treasury, 2026).

However, no conclusive reason and no reliable method for making future predictions of long-term house price or rental trends have been found. The standard approach of assuming constant relative prices is therefore recommended, for benefits and costs.

2. Other matters not covered here

The following are not covered here but are tackled in the full MCM:

- Infrastructure loss (promenades and associated structures);
- Infrastructure loss integral to properties at risk from erosion (gas; water; electricity; etc);
- Infrastructure lost that is serving areas not at risk from erosion at the same time (gas; water; electricity; etc);
- Valuing non built-up land: agricultural land and other open space.

SOME COMMON MISCONCEPTIONS

- Property and land must be protected at all cost;
- Decisions in the future about coast protection should reinforce planning decisions made in the past;
- A valuable promenade is a benefit if it is to be protected (even if it is falling down);
- There is no merit in delay;
- The sea will not win in the end.

SOME KEY LESSONS FROM EXPERIENCE

- Flooding and erosion are often inextricably interlinked; probabilities can become very complex to calculate;
- Market prices of houses situated on the tops of cliffs do not accurately reflect their risk of falling into the sea;
- Many people claim that the loss of a view from a property, if that property is lost due to erosion, is important. But the loss of one person's view is another person's gain: the view itself is not lost (so there is no economic loss);
- The environmental benefits of coast protection are mixed: some assets gain (e.g. eroding cliffs revealing important geological sites); others involve losses (e.g. the loss of habitats for birds);
- Delay is a real option that should be seriously considered.

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8 Recreational Gains and Losses

8 Recreational Gains and Losses

OVERVIEW

This chapter outlines the procedures and techniques for assessing the potential recreation and amenity benefits of – or losses from - coastal erosion or fluvial flood risk management. The term ‘recreation benefits’ covers benefits arising from the enjoyment of landscape, wildlife and natural amenities as well as from the enjoyment of recreational activities.

The approach to assessing these gains and losses has not altered in any way since 2010. The changes here only comprise providing up-dated data in Table 8.3: *£ gains and losses per adult visit with coastal protection scheme options at coastal sites* and Table 8.4: *£ value of losses and gains per visit for various changes at river sites* in Tables and Figures for Chapter 8 on MCM-Online. This up-dating has been done using the Office for National Statistics (ONS) Consumer Price Index (CPI).

LESSONS FROM EXPERIENCE

- Estimating the visit numbers or the number of beneficiaries deserves to be given as much attention as estimating valuations, and this has not always been the case in the past;
- The kind of visitors who visit ‘natural’ undeveloped coasts are different in some respects from those who go to developed sites. If coastal sites were to be changed radically to a more ‘natural’ condition, they might draw on a different constituency of visitors (making the new visit numbers difficult to determine);
- The public are generally supportive of measures to protect and defend the coast through major interventions such as seawalls and off-shore reefs;
- People who visit or live at the coast are reluctant to see natural erosive processes take their course at the coast and want the coast to continue to be maintained and defended as it had been in the past. This makes such options as ‘managed realignment’ or ‘retreat’ difficult to implement;
- The few river restoration studies, in contrast, show that residents are supportive of, and attach value to, works to restore rivers to a more natural condition, where the level of flood risk is not increased;
- Public responses to, and thus valuations of, options and structures at the coast, such as rock groynes vary from site to site in ways that are difficult to predict. This makes benefit transfer approaches problematic;
- The recreation benefit assessment methodology recommended here does not take into account new visits (as opposed to transferred visits) that may be generated among local residents or more widely. Nor is additional visiting by current users easily allowed for (again not transferred visits);
- Questionnaire surveys can make a valuable additional contribution to public consultation and participation on coastal and fluvial projects, but early engagement is an ideal that may be difficult to achieve, not least because new options emerge within the appraisal period;

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- Recreation and amenity changes are of vital public interest. There are few – if any - legal obligations in this respect on those promoting coastal and fluvial risk management, as opposed to the Water Framework Directive's strictures, but the issues still need very close attention.

ESTIMATING RECREATION BENEFITS

Recreation benefits are calculated by multiplying the £ value of a visit for recreational use (often a small number), derived using the Contingent Valuation (CV) method, by the number of visits or beneficiaries (often a large number). The crucial stage in estimating recreational benefits is usually the estimation of the number of visits or beneficiaries.

The CV method (see 'expressed preference' methods in Chapter 2) is essentially a questionnaire survey method in which respondents are asked directly in carefully designed survey questions to say what value they place on, or how much they would be willing to pay (WTP) for, a change in the availability of a resource such as beach or riverside recreation.

We have developed and tested a particular variant of the CV method, the value of enjoyment per adult visit (VOE) method. In this approach, respondents are asked to say what value they put on their enjoyment of a day's visit under varying options in £ and pence.

In the WTP approach, respondents are asked how much they would be willing to pay in entrance fees or in rates and taxes for a change in recreation opportunities/values such as provided by a coastal protection scheme. The advantages and disadvantages of the two approaches have been debated but in this Handbook and the associated MCM (Penning-Rowsell et al., 2013) the VOE approach remains the recommended method and the basis for the standard data presented here.

THE RECOMMENDED APPROACH AND TECHNIQUES

A two-stage framework for recreation benefit assessment is recommended. This involves:

- **An initial study stage** for initial examination of projects and for strategy studies. This will normally rely upon secondary source data and desktop methods. Table 8.1 presents a range of methods for estimating visit numbers. It is acceptable here to use standard values or data from existing CV studies and visit data. Data that can be used on visit numbers are presented in Table 8.2: *Examples of visit numbers used for benefit assessment purposes*. Table 8.3: *£ gains and losses per adult visit with coastal protection scheme options at coastal sites* gives data on losses and gains with various options at coastal sites, and for rivers in Table 8.4: *£ value of losses and gains per visit for various changes at river sites*. Using secondary source data on values and visit numbers in this way is, however, a very approximate approach;

- **The full detailed study** stage involving detailed site-specific information and data collection methods: site-specific counts of visit/visitor or resident numbers and a site-specific CV survey to provide site-specific estimates of the value of recreation with the different scheme options. These surveys and count procedures are expensive and time-consuming activities to mount and manage.

In making the key decision as to whether or not to proceed to a feasibility study, it is recommended that a form of sensitivity analysis is undertaken using combinations of the highest and lowest appropriate estimates of visit numbers and £ value per visit (based on data in Tables 8.2-8.4) to obtain four annual recreation estimated benefit assessments.

Then, the difference the four estimates make to the overall benefit-cost ratio for the scheme can be considered, to aid a decision as to whether it would be worth refining visit number estimates or valuations through site-specific data collection.

At both outline and detailed study stages it will be necessary to go through the same steps (see below) but at different levels of detail.

Step One: Define the problem and objectives

This is the definition of the nature and rate of coastal erosion or degradation or of coastal or fluvial flooding, and with it the geographical area affected: its length and breadth and its characteristics and the type of changes to the physical characteristics that are likely to take place in the future with the 'do nothing' situation.

Problems such as coastal erosion may be site-specific or may affect a more extensive area. Similarly, the problems affecting a river may be present in much of the catchment or may be site specific. It is essential in this way to consider problems and the options for dealing with them in their wider context.

Step Two: Identify adult recreation and amenity users or beneficiaries

Find out whether there is current or potential recreational use of the site and identify the range of recreational activities that are, or could be, undertaken there. Although children may be important users of the coasts and riversides, the benefit assessment methods apply to adult users or beneficiaries only.

Visitors can also be classified according to their origins:

- **Local visitors.** Those living within a three-mile radius of a site;
- **Day visitors.** Anyone starting and finishing their trip from their permanent home;
- **Staying visitors**. Anyone staying away from home for one or more nights.

Recreation benefit assessments can be refined by obtaining and using separate visit number and £ value per visit estimates for these different categories of user as presented in the *Checklist of recreational uses* and *Summary of possible effects of options on coastal and riverine recreation and amenity* available in the Additional Resources section for Chapter 8.

A crucial issue in both outline and detailed studies is to establish the level of use of the site in terms of the number of visits it receives or the number of those who benefit from recreation at the site. It is recommended that two or more of the methods presented in Table 8.1 should be used and that indirect methods (items 4-8) should only be used in initial study stages.

Table 8.1		Sources and methods of information on recreation users/beneficiaries
Source/ method		**Comments**
1	Long period counts using people counters	Infra-red or other counters installed over a period (at least March to September). Counters are manually calibrated to relate passages to adult visits. Mainly applied in detailed studies: in conjunction with a CV survey – see MCM, Section 8.5.3 (Penning-Rowsell et al., 2013).
2	Short period manual count /surveys	Manual counts/surveys over a period of days normally including the August Bank holiday. At initial stage, this method might be combined with site visits and at detailed study stage, with the CV survey.
3	CV survey data	CV survey data on the frequency of visiting by local residents in conjunction with census data on the number of adult residents and staying visitors (in conjunction with managers' estimates of occupancy rates) can be used to generate visit number estimates. However, the tendency of survey respondents to overstate their visiting frequency has to be noted - see the Corton Case Study in the MCM, Section 8.7 (Penning-Rowsell et al., 2013).
4	Old survey/ count data for the project	Planning, tourism or recreation departments of local authorities or local colleges or schools may have undertaken surveys or counts at the project site in the past, which can be updated to indicate current levels of use.
5	Inferred estimate	The number of visits to a coastal or river site is inferred from counts of visits to a related site nearby such as: Car and coach parks multiplied by the average adult car or coach occupancy rate (Hengistbury Head), funfair, cafe, visitor centre, historic site or museum (Hurst Spit and Hurst Spit castle). This requires estimating the proportion of all visitors to the project site who also use the counted site and vice versa. At detailed level, this can be done in conjunction with the CV survey.
6	Visitor equations	A number of equations have been developed which predicts-distance-frequency functions so that from census data on the population in different zones a prediction can be made as to the number of visitors generated by the site.
7	Estimates from an informed persons or source	Written, telephone or personal contacts with: Car park attendants, park rangers/wardens, visitor centre staff, staff at associated visitor attractions, local authority tourism, sport and recreation or planning staff, regional or local offices of organisations such as the English Tourist Board, National Trust or English Heritage and their Welsh equivalents, the Environment Agency's recreation and fisheries staff, managers of general recreation or staying visitor facilities or tourism business organisations that may have information on bedspaces and occupancy rates - see the Corton Case Study in the MCM, Section 8.7 (Penning-Rowsell et al., 2013); both commercial and club managers of specialist facilities (e.g. sailing, boating/sailboarding, fishing, birdwatching) and specialist organisations at national regional and local level for information on the availability of alternative sites e.g. for caravans or sailing.
8	Average number of visits to equivalent sites	This benefit transfer approach is only suitable for initial and strategic studies. The number of adult visits to the project site is estimated as being of the same order as the number of visits made to an equivalent site. However, there are few sites for which good data are available and little research to enable reliable identification of an equivalent site.

Step Three: Identify options

Identify the options for dealing with the problem and their likely impacts on the physical characteristics of the site as well as the 'Do nothing' option. Thus, recreation benefits may have the following two components:

1. The prevention of further deterioration - losses with the 'Do nothing' option.
2. A reinstatement of the condition of the site from the current state to a better one – gains. For example, the replacement of hard river flood defence structures reaching the end of their life with soft engineered defences may enhance the recreational value of a river site. Beach nourishment for coastal protection purposes may result in a 'better' beach in recreational terms.

Step Four: Identify the recreation and amenity benefits

Identify the impacts on recreation and amenity of the changes to the physical environment resulting from the 'Do nothing' and the 'Do something' options.

This process will benefit from the participation of the recreational stakeholders, particularly at the initial stage. They may have particular insights into how changes will impact on their recreational enjoyment.

Step Five: Determine the annual recreation and amenity benefits

Annual recreation benefits. Step 5 involves first deriving estimates of the annual recreation benefits arising from the options and comparing the benefits for the options.

There are two components that have to be estimated:

1. The value that individual adult users or beneficiaries place on the changes that would occur with the options in place. These values will be derived from an application of the CV method using either the VOE per visit or the WTP approach.
2. The annual number of adult visits to the site (for the VOE approach) or beneficiaries who have an interest in the site (for the WTP approach).

The annual recreation benefits can then be determined as:

Equation 8.1

Annual benefits =
£ value of the options (VOE gains and/or losses) or (WTP valuations) * the number of visits per annum (VOE) or number of beneficiaries/ visitors (WTP)

Where the options involve both VOE losses and gains, the annual benefits should be calculated separately for the losses and the gains because these may need to be treated differently for discounting (see Total recreation benefits below).

National economic benefits and substitute sites. If changes to a particular coastal or river site simply transfer recreation from one site to another without any overall gains or losses in the value of recreational enjoyment, once travel costs have been taken into account, then no national gain or loss will be involved. The availability of substitute sites must therefore be considered when recreation benefits are being assessed.

Total recreation benefits. The total recreation benefits of a scheme are estimated by discounting the annual benefits over the life of the project using the recommended 'Green Book' discount rates. A different approach and separate calculations are required where there are annual benefits from both VOE losses and gains with the options, since gains become available on scheme completion whereas losses are likely to be incurred only after some years of site deterioration.

Losses under the 'Do nothing' option: VOE approach[1]

The following two equations should be used for estimating possible losses (or gains) under the 'Do nothing' option: some respondents may enjoy the site under the 'Do nothing' option more than the current site and therefore might gain.

Benefit for those who continue to visit:

Equation 8.2

$$L1 = Eo - E^1$$

Benefit for those who would visit an alternative site under the 'Do nothing' option:

Equation 8.3

$$L2 = (Eo - Ea) + (Ca - Co)$$

where:
L is The benefit per person (in cases 1 and 2)
Eo is The value of enjoyment of today's visit/ a visit in current conditions
E^1 is The value of a visit under the 'Do nothing' option
Ea is The value of a visit at the alternative site under the 'Do nothing' option
Co is The cost incurred visiting the present site
Ca is The cost incurred in visiting the alternative site under the 'Do nothing' option. The difference between Co and Ca is derived from a question in the questionnaire.

[1]These equations are explained more fully in the MCM (Penning-Rowsell et al., 2013)

Gains under the 'Do something' option formulae:
VOE approach

Two similar equations should be used for estimating possible gains (or losses) under the 'Do something' options: some respondents may enjoy the site less than the current site under the 'Do something' option, for example where there is a radical change in the appearance or recreational facilities with the option. Also, they might wish to visit elsewhere instead.

Benefit for those who continue to visit:

Equation 8.4

G1 = Exn - Eo

Benefit - for those who would visit an alternative site under the 'Do something' option n:

Equation 8.5

G2 = (Eo - Ean) + (Can - Co)

where:
G is The benefit per person (in cases 1 and 2)
Eo is The value of enjoyment of today's visit/ a visit in current conditions
Exn is The value of a visit under the 'Do something' option n
Ean is The value of a visit at the alternative site visited under the 'Do something' option n
Co is The cost incurred visiting the current site
Can is The cost incurred in visiting the alternative site under the 'Do something' option n. The difference between Co and Ca is given by a question in the questionnaire.

Using these equations, the losses and gains should be calculated for each person in the survey and then the mean value should be calculated.

REMAINING ISSUES

- Estimating the visit numbers or the number of beneficiaries deserves to be given as much attention as estimating the VOE or WTP valuations. Shoreline Management Plans (SMPs) should be investigated for this data, and Catchment Flood Management Plans (CFMPs) may be sources for fluvial cases;
- Coastal studies indicate that the public are often reluctant to see natural processes take their course at the coast and may want the coast to continue to be maintained and defended as it had been in the past;
- Visitors who visit 'natural' undeveloped coasts are different in some respects from those who go to developed sites;
- Public responses to, and thus valuations of, options and structures at the coast such as rock groynes, vary from site to site in ways that are difficult to predict. Therefore, there is still a need for most schemes for site-specific CV surveys at detailed studies stage for both coastal and riverine sites;
- The few river restoration studies, in contrast, show that residents are supportive of, and attach value to, works to restore rivers to a more natural condition where the level of flood risk is not increased;
- The recommended methodology does not take into account new visits (as opposed to transferred visits) that may be generated among local residents or more widely. Nor is additional visiting by current users easily allowed for (again not transferred visits). Both are impossible to gauge without substantial databases or surveys. There may, therefore, be significant underestimating of the benefits of schemes which offer substantial improvements or attractive new facilities.

REFERENCES

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

9 Appraisal of Flood Risk Management for Agriculture

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9 Appraisal of Flood Risk Management for Agriculture

OVERVIEW

Flood and Coastal Erosion Risk Management (FCERM) for agricultural land and businesses is an important element of government support to the agricultural sector in Britain. Many floodplain and coastal areas benefit from publicly funded flood defence[1] and land drainage schemes that reduce flood loss and damage on agricultural land and provide opportunities for productive farming (Morris, 1992).

FCERM for agricultural land can facilitate agricultural production where otherwise it would be impeded, for the whole or part of the year, by surface inundation and saturated soils. Agricultural land may be lower than high tide or fluvial flood levels and investment in FCERM infrastructure and services can protect these areas from frequent flooding, in some cases assisted by pumping schemes. Sea defences can prevent inundation by sea water that would result in complete crop loss and also reduced yields in subsequent years. Coastal protection may prevent agricultural land from being lost to the sea.

Increased flooding associated with changes in climate, land use and urban development, and concerns about the efficacy of traditional engineering responses, have encouraged greater use of Natural Flood Management (NFM) that seeks to 'protect, restore and emulate the natural functions of the catchment, floodplains, rivers and the coast' (Burgess-Gamble et al., 2018; Morris et al., 2014; SEPA, 2015). Simultaneously, there has been a drive to integrate FCERM in rural areas with other objectives such as nature conservation, soil protection, water quality improvement and recreation (CaBa, 2017), often supported by an 'ecosystems' approach to the management of land and water resources (Posthumus et al., 2010; Rouquette et al., 2011).

[1]The terms flood 'defence' and 'protection' are often used in the agricultural case, reflecting the past focus on reducing flooding on agricultural land to enhance its productivity. The term 'flood risk management', however, is now more appropriate for the appraisal of the range of flood management options on agricultural land and businesses, including the intentional use of farmland for the retention and/or temporary storage of flood waters. In the assessment of natural hazards, the terms 'loss' and 'damage' are commonly used. Loss denotes negative impacts on output and incomes (and value-added). Damage denotes negative impacts on asset values. In the agriculture case, typically over 80% of flood costs are losses associated with reduced crops and livestock production and 20% are damages to assets.

In this context, agricultural land and businesses are a ***recipient*** of FCERM benefits where FCERM measures reduce the risk of flooding on farmland. They are a ***provider*** of FCERM benefits where 'on-site' mitigation actions are taken to control runoff and retain and/or facilitate the controlled movement of potential flood waters in the farmed landscape to reduce flooding elsewhere, especially in the urban space (Morris et al., 2023).

Considering agriculture as a beneficiary of FCERM, the role of appraisal is to determine whether it is worthwhile to provide a given standard of FCERM service for agriculture (Figure 9.1). This may involve comparing some existing or proposed standard with the 'Do-Nothing' option, recognising that tolerance of flooding and associated flood costs vary considerably amongst land uses (Table 9.1). Appraisal may require a comparison of the financial (to farmers) and economic (to the national economy) performance of agricultural land use under a range of different FCERM regimes, and how these compare with the costs of delivering those options. Conversely, where agriculture is a provider of FCERM services, appraisal seeks to assess the impact on agricultural land and businesses of NFM measures on farmland as this affects exposure to flooding with consequences for land use, agricultural productivity, and agricultural businesses (Morris et al., 2023).

Where farming is not possible in the absence of protection from flooding, Defra (2008) advise estimating economic loss (and therefore the potential benefits of flood protection) in terms of the loss of the market value of agricultural land, adjusted to remove the possible effect of agricultural subsidies on land prices. A detailed assessment of agricultural losses may be justified where large areas of prime agricultural land are concerned that have strategic importance for national food security and for local and regional economies.

The approaches needed for appraisal may vary according to context and purpose.

- At a broad catchment and coastal area scale, appraisals will at least require information on the types and areas of land use and the extent to which these might be affected by a change in flood frequency and coastal erosion risk;
- At a detailed scheme appraisal level, there will be a need to collect primary data and undertake detailed analysis of farming systems and businesses, in proportion to the significance of agriculture within the investment programme as a whole. Such detailed scheme-level analysis can be complex. Further guidance is available in MCM online (Penning-Rowsell et al., 2013).

Concerns about global food security and the possible impacts of climate change have renewed interest in improving the productivity of British agriculture. 1.4 million ha of agricultural land in England and Wales (12% of the total) is at risk of flooding from rivers (61% of the flood risk area), the sea (23%), or both (16%) (Roca, 2011). Almost 60% of Grade 1 Agricultural Land in England is dependent on flood risk management and land drainage, including coastal defences and pumping infrastructure. However, for major flood events in the UK, agricultural losses tend to be a relatively small proportion of total loss and damage costs. Flooding occurred on between 40,000 ha and 45,000 ha of farmland in the 2007 summer floods in England and also in the winter 2013/14 floods England and Wales. In both cases 'on-farm' agricultural flood costs only accounted for about 3% of the estimated total economic costs of the event (Chatterton et al., 2010; Chatterton et al., 2016, Hess et al., 2023). Agricultural flood costs may however be regionally or locally concentrated: agricultural costs accounted for about 8% of total estimated economic costs attributed to flooding in Somerset during the long duration winter 2013/14 event (Parsons Brinkerhoff, 2015).

The assessment of agricultural flood costs, whereby the attributes of flooding are combined with the characteristics of agriculture land use as a receptor, is based on the methods explained in Chapter 9 of the MCM (Penning-Rowsell et al., 2013). The methods draw on evidence from the studies of flood events in England and Wales, notably during summer 2007 (Posthumus et al., 2009), spring and early summer 2012 (Morris and Brewin, 2014), winter 2013/14 (Chatterton et al., 2016), and from a rapid evidence review of the impacts of flooding on agriculture in England and Wales (Hess et al., 2023).

The 2024 update of the MCH included the extended use of historic data on agricultural land use and farming systems published by Defra to derive estimates of the economic value of agricultural production. It has also developed the estimates of flood costs by broad categories of land use and farming system, Agricultural land Classification Grade, flood duration, water quality (salinity) and seasonality, all consistent with the methods outlined in Chapter 9 of the MCM. Notably, flood loss and damage costs to agriculture for FCERM investment appraisal are estimated using regional Farm Business Surveys data (Defra, 2024a) on land use, productivity and financial performance by type of farm for the 5-year period 2018/19 - 2022/23 inclusive, updated to 2026 prices using GDP deflators (ONS, 2024).

Medium to long run agricultural prices and 'profitability', critical for FCERM appraisal, are difficult to predict. Agricultural commodity prices in the UK are strongly influenced by world market prices, moderated by UK£ exchange rates. Disruption to international markets associated with the COVID pandemic and more recently the Ukrainian conflict has increased the volatility of agricultural markets and prices, especially for bulk commodities such as cereals and oil seeds, and for inputs such as fertiliser and energy (Defra, 2024b). Variable global and regional climatic conditions have further added to commodity price variation, especially in seasonal fresh produce. There is concern that future global and national food insecurity could refocus the role of agriculture within the UK national economy. The medium-term outlook for agriculture at the global scale is characterised by a high level of uncertainty in agricultural markets with a range of plausible outcomes (FAO-OECD, 2023; EC, 2023). A cautious approach is required when estimating the value of agricultural output that is supported by long term FCERM investments, especially where large areas of prime agricultural land are involved.

For this annual update applying the GDP deflator is more appropriate than using the agricultural price series for outputs and inputs that would require detailed disaggregation and would not justify the appraisal effort in most cases. A GDP deflator of 6% is applied to the 2024 values in MCH Chapter 9 for Agriculture to update them to 2026 values.

The recent changes to the Environment Agency FCERM guidance for RMAs (1 April 2026) have not yet been fully incorporated in this version of the handbook; however, the three scenarios in the guidance are comparable to those presented herein. Appraisers in England are recommended to consult on up to date FCERM guidance for RMAs: valuation of agricultural land and output for appraisal purposes - GOV.UK

LESSONS FROM EXPERIENCE

- There is a close connection between the management of flood risk for agriculture and the management of agricultural land drainage as this affects the productivity of farmland. Managing flooding on farmland cannot be seen in isolation of managing waterlogging and groundwater flooding.

- The main factors affecting the costs of a flood event on agricultural land are the type of land use, and the seasonality and duration of flooding. Flood costs are much higher on arable land than on grassland, especially where the production of high value potatoes, vegetable and salad crops is affected. Flooding in summer results in much higher losses (£/ha) than flooding in winter, especially on arable crops and grassland conserved for winter feed. Generally, the longer the period of flooding, the greater are the losses. Most arable crops and grassland can sustain short duration winter flooding of less than one-week, but yields may be affected. Longer duration floods have much greater impact, as do coastal floods involving saline water.

- Over 80% of agricultural flood costs are commonly associated with loss of production or additional production costs. The remainder is associated with damage to property and equipment. Generally, production losses are not insured.

- At the individual farm scale, the bigger the proportion of the total farm area affected by flooding, the bigger is the likely magnitude of the costs (£/farm) and impact on the farm business as a whole.

- Data and methods for the appraisal of FCERM capital investments for agriculture might be adapted to evaluate the benefits of the ongoing maintenance and operation of FCERM services and standards (Morris et al, 2023).

- Methods to assess the economic impacts of flooding on agricultural land might also be used to help appraise Natural Flood Management (NFM) options that involve Working with Natural Processes (WwNP) such as the retention of flood water in the general landscape, floodplain conveyance and storage, and the creation of wetlands.

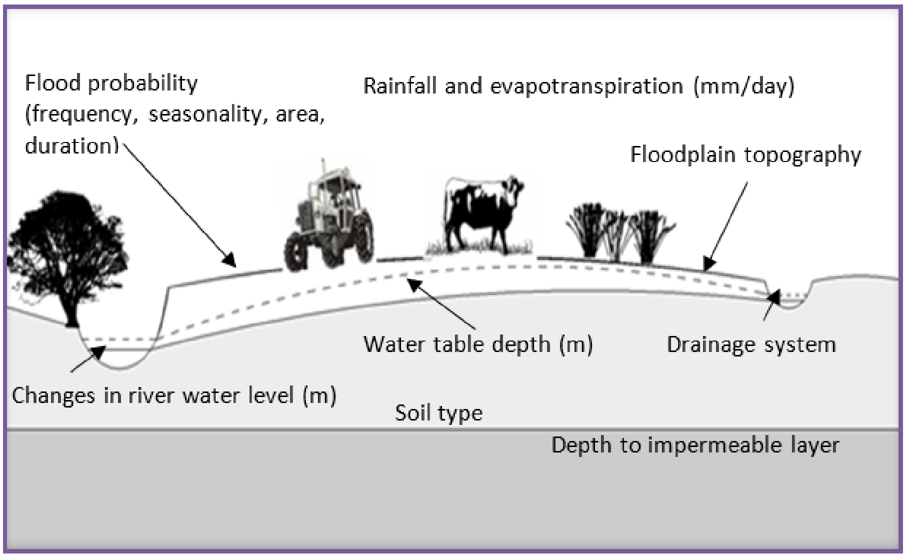

Figure 9.1 Flooding and drainage factors influencing agricultural productivity on floodplains

Table 9.1 General tolerance of flooding by agricultural land use in England and Wales

Agricultural land use Type	**Common minimum acceptable flood frequency: annual probability**	
	Whole Year	April to October
Horticulture and field scale vegetables	5%	1%
Intensive arable including sugar beet and potatoes	7%-10%	4%
Extensive arable: cereals, beans, oil seeds	10%-15%	7%-10%
Intensive grass: improved grass, usually dairying	50%	20%
Extensive grass, usually cattle and sheep	≥100%	33%

METHOD FOR ASSESSING AGRICULTURAL BENEFITS

The principle behind the appraisal is to identify and quantify the impact of flooding regimes on agricultural land and businesses. Three main steps are required to derive a monetary value of agricultural benefits under different FCERM/NFM conditions. These are considered below. The greatest detail will be required to assess possible changes in exposure to flooding on relatively intensively cropped high grade agricultural land, including intensive grassland for dairying. Less detail may be justified for initial broad scale or 'overview' assessments at the catchment scale, although this may prompt further enquiry.

Step One: Defining agricultural productivity

This step involves three actions. The *first* action identifies the total area that is liable to flooding, and hence the 'benefit area' of FCERM interventions. The *second* action determines land use classified into major crop and grassland types (Table 9.1) in order to estimate the likely impact of flooding on the physical and financial performance of arable crops, grassland and associated livestock production.

The *third* action assesses the likely soil 'drainage' and associated waterlogging conditions as determined by field water table levels during critical periods of the farming calendar. Land drainage conditions are a key determinant of agricultural land use and productivity, and hence the cost of flooding on farmland when flooding occurs (Table 9.2). Under 'Good' agricultural drainage conditions, land uses and yields typical of a well-drained site for the soils concerned can be expected. 'Bad' agricultural drainage conditions, associated with 'sub-surface' flooding and waterlogging of soils, reduces yields and limits land use options relative to the 'Good' condition. 'Very bad' drainage conditions impose severe constraints on land use. It is important that the agricultural drainage conditions associated with different FCERM options are identified and factored into the assessment[2]. Flood event costs (£/ha) are likely to be greater on well-drained soils compared to poorly drained soils because land use is likely to be more intense and 'normal' yields higher.

Table 9.2 Drainage conditions for agriculture and water levels in fields and ditches

Agricultural drainage condition	Agricultural productivity class	Depth to water table from surface	Springtime freeboard* in water-courses (natural drainage)	Springtime freeboard* in water-course (field drains)
Good: 'rarely wet'	Normal, no impediment imposed by drainage	0.5 m or more	1 m sands 1.3 m peats 2.1 m clays	1.2 m clays to 1.6 m sands (0.2 m below pipe outfall)
Bad: 'occasion-ally wet'	Low, reduced yields, reduced field access and grazing season	0.3 m to 0.49 m	0.7 m sands 1 m peats 1.9 m clays	Temporarily submerged pipe outfalls
Very bad: 'commonly or permanently wet'	Very low, severe constraints on land use, much reduced yields, field access and grazing season: mainly wet grassland	Less than 0.3 m	0.4 m sands 0.6 m peats 1 m clays	Permanently submerged pipe outfalls

Notes to table: Freeboard refers to the mean difference between water level and adjacent field level

With respect to estimating the productivity and financial performance of agricultural land use:

- For **arable land**, estimates of crop yields can be obtained from bespoke farm surveys or from published data on regional yields adjusted for local drainage conditions (Table 9.3). Farmers are usually able to report the degree to which yields on poorly drained parts of their farm are lower than elsewhere;
- Assessing the productivity of **grassland** is more complicated, requiring information on the type and age or weight of grazing livestock, livestock feeding regime, length of grazing season, liveweight gain or milk yield, and type and tonnage of conserved grass (Table 9.3);
- Using data from secondary sources and from farm surveys in the benefit area, the productivity of grassland can be estimated from the type and number of livestock that can be carried per hectare (ha) under different drainage conditions – see Chapter 9, MCM (Penning-Rowsell et al., 2013).

[2] There is increased recent interest in the causes and effects of groundwater flooding in the urban sector whereas the groundwater levels and management of groundwater flooding have long been of concern for agricultural land use and productivity. FCERM investments for agriculture in the 20th Century generally combined measures to simultaneously reduce flooding and improve land drainage.

Step Two: Defining the attributes and impacts of flooding

The attributes of flooding that affect the type and magnitude of agricultural flood impacts can be distinguished as follows:

- Frequency of occurrence (including the chance of multiple floods per year);
- Seasonality (especially the distinction between winter and summer floods);
- Duration (from a few days to one or more weeks);
- Depth (relative to the height of standing crops and livestock, and property);
- Water quality (including contamination, sedimentation and salinity);
- Velocity (as this affects erosion risk, flow related impacts, and debris).

The costs of flooding depend on the characteristics of the agricultural land use and businesses in flood receptor areas and their sensitivity to flood attributes (Hess et al., 2023). The key question is 'what changes in agricultural benefits and costs result from a change in exposure to flooding?'. The key components of agricultural flood costs are as follows:

- Flood costs for arable crops include the loss of the value of output, the costs of additional inputs less any savings in uncommitted costs if crops are not harvested, and remedial work such as land restoration and re-sowing of crops;
- For grassland, costs include the loss of grass-feed valued at substitute feed prices, the cost of additional inputs such as fertiliser less any 'savings' in hay/silage making costs if output is reduced, plus restoration costs if reseeding is required;
- Livestock costs include the loss of grazing days and the cost of relocating and/or housing animals, increased veterinary expenses, increased morbidity/mortality and loss of sales;
- 'Other' costs include damage to buildings and contents, field infrastructure (fencing, drain, tracks), machinery, the cost of clean-up and restoration, and disruption to utilities and services.

Flooding can also result in changes in soil properties with consequences for agricultural productivity, associated for example with compaction, erosion, and loss of soil biota. Remedial action may be required to reduce the impacts on soil degradation on yields in subsequent years.

The seasonal timing of flooding critically affects flood costs (£/ha) on farmland depending on the type of land use. Summer floods usually result in much higher losses (£/ha) than winter floods (see Table 9.4).

In the case of coastal saline flooding, yield losses on most crops are approximately 20% higher than freshwater losses if flooding occurs only for a few days, except for potatoes and horticultural crops that would be completely lost. Longer duration saline flooding can result in significantly higher losses, with effects in subsequent years (Gould et al., 2020). Planting a salt tolerant crop such as barley in the year following flooding may be required, with resultant loss in profitability compared with normal cropping. Remedial application of gypsum to neutralise saline soils may be required. Coastal flooding tends to result in much higher livestock fatalities than fluvial flooding.

Where flooding is of sufficient magnitude and severity, indirect effects may extend beyond the farm gate into the agricultural supply and value chains (Hess et al., 2023). Businesses supplying goods and services to farms may be affected, as well as downstream industries dependent on farm outputs for processing and marketing. For example, the tidal surge in the winter of 2013/14 in eastern England affected poultry farms supplying a major food company, imposing indirect costs of over £650,000 in

2024 prices (Chatterton et al., 2016). These indirect, off-site impacts can be substantial for major events, especially at the local and regional scale.

Step Three: Expressing any difference in monetary values

GROSS AND NET MARGINS

The monetary value of changes in the exposure of farmland to flooding can be determined using the accounting conventions of Gross Margins, and Net Margins, expressed either as per hectare (ha) or for a farm as a whole.

The level of detail required depends on the purpose and context of the appraisal. Where the 'Do-Nothing' option involves the potential loss of agricultural land, guidance (Defra, 2008) recommends that agricultural land market prices can be used (as explained below). In many other cases, however, it will be necessary to estimate the financial (to farmers) and economic (to the national economy) performance of agriculture under different FCERM options.

Gross Margins (£/ha/year) of crop or grassland-based livestock activity are used to measure the value of output less variable costs such as seeds, fertiliser and supplementary animal feed if appropriate (Table 9.5). Variable costs are directly related to each unit of activity and can be avoided if that activity is not pursued. Gross Margins show the monetary gain (or loss) associated with one more (or one less) unit of an activity, assuming other so-called 'fixed' resources available to the business, such as regular labour, machinery, buildings and land (and their associated costs) remain unchanged. Net Margins provide an estimate of average annual profit after average Fixed Costs (£/ha/year) are subtracted from Gross Margins.

ECONOMIC VALUATION

Defra (2008) guidance for economic appraisal requires two main types of adjustment to financial estimates: namely, the removal of subsidies (and taxes) and allowance for 'displacement' effects.

Adjustment to remove direct subsidies from crop and livestock Gross Margins is no longer required because previous direct production subsidies have been replaced by direct income support under the 'Basic Payments Scheme' (BPS). Eligible farmers are paid annual amounts (£/ha/year) based on historical entitlement to subsidies. Since the departure of the UK from the European Union and the Common Agricultural Policy, government support for agriculture has shifted from direct income subsidies (BPS) towards the Environmental Land Management scheme (ELMs) and, within this, to Sustainable Farming Incentives and programmes for Nature and Landscape Recovery (Defra, 2023a). Approaches vary between the UK's devolved Governments. In England, for example, the initial post-Brexit policy for Agricultural Transition (Defra, 2024c) proposed complete withdrawal of BPS by 2027/28, to be replaced by payments under ELMs. There is some uncertainty whether this will happen. BPS payments (£/ha) in England in 2024 have declined to about 50% of their 2021 levels, while take up of ELMs options has reportedly been slower than intended (UK Parliament, 2024). Other UK National Government have retained larger elements of BPS and have their own arrangements for agri-environment and nature recovery (Welsh Government, 2024a).

While the income subsidies to farmers are excluded for the purpose of the economic assessment of FCERM agricultural benefits, the types and scale of income subsidies and agri-environment payments have a critical effect on the incentives to farmers and the viability of farm businesses. It is noted for example, that in the absence of BPS and agri-environment payments, many farms would be rendered financially non-viable, especially in the Grazing Livestock sector.

Agri-environment payments to farmers under ELMs options (and associated Countryside Stewardship (Natural England, 2024a)) that integrate with FCERM benefits such as floodplain storage, wetland creation and coastal realignment, should be factored into the assessment of FCERM options. In such cases, agricultural benefit assessment should be extended to include wider environmental aspects, possibly using natural capital and ecosystems frameworks (Morris et al., 2023).

Regarding displacement, Defra (2008) advises that persistent flooding of high value horticultural crops, field vegetables and potatoes, and commodities subject to quota such as sugar beet and dairy milk (subsequently withdrawn in 2015), would lead to the relocation of their production elsewhere, displacing winter sown wheat as the dominant arable crop in the UK by area. For this reason, areas of high value crops and dairying are valued as an equivalent area of winter wheat in the economic analysis of permanent changes in FCERM. This assumption may not apply where the potential changes are large scale, of strategic importance, or where an area has a special comparative advantage that is not easily transferable. Over the past decade, however, the financial comparative advantage of high value but high-cost vegetable production has declined relative to that of wheat, but this trend may not continue in the longer term.

Further adjustments are often required to derive economic values for agricultural benefits. The cost of unpaid family labour should be included, valued at an equivalent wage rate. The costs associated with land purchase and rents should be excluded. Payments for land are an ‘economic rent’ and not an extra resource cost: land is there whether it is used or not. Here, the purpose is to assess the economic value of a particular land use (£/ha) in terms of the benefits generated, excluding the financial cost of acquiring the land itself. Furthermore, taxes and charges such as Sales or Value Added Tax and National Insurance are also excluded from economic analysis.

DERIVING FINANCIAL AND ECONOMIC VALUES FOR AGRICULTURAL LAND USE

To illustrate the approach, estimates of key financial and economic indicators for winter wheat, the dominant arable crop, and for the main lowland arable and grassland farm types for England are given in Table 9.5. These have been derived from historic data for the 5-year period 2018/19 to 2022/23 from the annual regional Farm Business Survey (FBS) (Defra 2024a). Annual mean estimates have been weighted by GDP deflators (ONS, 2024) to derive estimates of mean values in 2024 prices, then uplifted using ONS GDP deflator for the 2026 values. Similar statistics are available for farm incomes in Wales (Welsh Government, 2024b).

Estimates of Farm Business Income attributable to agricultural activities (excluding subsidies and other sources of income to the farm as a business) (Table 9.5) provide a measure of business profitability similar to an annual return on management effort and shareholder capital. As explained above, for the purpose of economic assessment, financial estimates are adjusted to exclude land rent and to include the imputed cost of unpaid family labour. This adjustment mainly reduces Net Margin (£/ha/year), for example, from £508ha/year to £455/ha/year in the case of Wheat. Notably, charging an ‘economic price’ for unpaid family labour results in a large negative average Net Margin for Grazing Livestock farms (excluding subsidies and other income). Table 9.5 also shows the effect of treating high value cropping and dairy areas as equivalent areas of wheat to derive economic values. For example, the estimated Economic Net Margin for the ‘average’ Dairy Farm is £287/ha/year, considerably lower than the adjusted Financial Net Margin of £461/ha/year.

It is noted that the 'mean' estimates for the 5-year period 2018/19 to 2022/23 hide considerable variation amongst years and amongst low, mean and high performing farms. For detailed analysis, it is important that there is further disaggregation of data and estimates to allow for regional and local differences, and especially to allow for variation in farm performance. The top third of farms by performance, for example, generate mean Gross Margins and/or Net Margins that can exceed the mean estimate by 20% to 40%, especially in the Grazing Livestock sector where the variation between farms is very high.

Estimates of Financial Gross Margins based on historic time-series data can be different from those more readily available from Farm Business Management Handbooks (e.g. Redman, 2023; SAC, 2023). The latter typically provide single-year forward budgets and may not include the aforementioned adjustments. These Handbooks are, however, invaluable and comprehensive sources of supporting information to which reference can be made. Detailed appraisals of FCERM investments where agriculture is a key beneficiary should take a long-term view, extrapolating from locally relevant historic data and allowing for possible future market and policy conditions.

Detailed analysis should consider plausible variations in key factors affecting agricultural revenues and costs over time. Low and high estimates used in sensitivity analysis are likely to be at least plus and minus 50% of the central estimates given in Table 9.5.

SCENARIOS AND THEIR TREATMENT

Defra (2008) appraisal guidance identifies three scenarios which reflect the nature of changes in flood and coastal erosion risk, namely:

- Scenario I: Permanent loss of agricultural land;
- Scenario II: One-off damages arising from infrequent flood events;
- Scenario III: Permanent change in FCERM standards.

These scenarios use different methods for the assessment of flood risk management benefits (Table 9.6).

Regarding Scenario I, Defra (2008) advise that land permanently lost to agriculture should in most cases be valued at market 'vacant possession' prices, excluding buildings. Current and historic agricultural land prices are available from leading land agents and advisors (Strutt and Parker, 2024; Savills, 2024; RICS/RAU, 2023).

In 2023, agricultural land prices averaged £27,900/ha for arable land (range £18,500/ha to £30,900/ha), and £21,500/ha for pastureland (£13,600 to £22,850/ha) (Strutt and Parker, 2024) with prices varying according to land quality and region. According to Savills (2024), land agent assessment of sales by Agricultural Land Classification (ALC) Grades in 2023 showed mean values for prime arable land (Grade 1 and 2) at £26,200/ha, good arable land (Grade 3) at £21,500/ha, good pasture (Grade 3) at £17,800/ha and poor pasture (Grade 4 and 5) at £14,300/ha. Agricultural land prices in 2023 returned to the peak prices last recorded in 2014/15. They are expected to either level off due to policy uncertainty (Strutt and Parker, 2024) or rise by between 1.5% and 3.5% per year (in current prices) over the next 5 years, mainly reflecting interest from non-farming and institutional buyers (Savills, 2024).

Defra (2008) guidance stipulates a deduction of £927/ha (2026 prices) (£600/ha: 2008) from agricultural land market prices to reflect the subsidy effect of farm income support[3]. Many non-agricultural factors affect agricultural land prices such that care is required when using market prices to reflect the value of land retained in agriculture, especially for prime agricultural areas of strategic national importance.

Regarding Scenario II, estimates of flood costs will reflect the likely impacts on output loss, Gross Margins and other costs for a given land use. Table 9.7 contains indicative estimates in 2026 values of the seasonally weighted economic [4] loss and damage costs (£/ha) of a single flood occurring in a year with a duration of one to two weeks and two to four weeks according to land use, associated farm types and agricultural drainage condition[5]. The costs of a single flood event are, for example, £636/ha and £1,340/ha for the two flood durations respectively on Extensive Arable land (assuming normal yields for ALC Grade 3 where this type of land use is common) and good drainage conditions. Table 9.7 also shows the economic costs of flooding by saline water that are typically 50% to 100% higher than freshwater flooding according to land use and duration.

There are broad associations between ALC Land Grade, land use and agricultural yield performance, and between ALC Grade and exposure to flooding, but these can vary considerably at the local scale. Table 9.8 shows indicative estimates of flood event costs (£/ha) according to ALC Grade and associated land use, allowing for variations in 'normal' crop yields amongst ALC Grades (see notes to Table 9.8). For example, estimated seasonally weighted freshwater flood costs on ALC Grade 1 are £1,207/ha and £1,854/ha for the one to two week and two to 4 four-week events respectively. Table 9.8 should be amended to suit local variation in land use and farm types.

Regarding Scenario III, the analysis is more complicated because a change in flood frequency can induce a change in land use and the costs of flooding when it occurs. Table 9.9 provides a simple example, drawing on the contents of earlier tables. A switch from an existing FCERM provision with flooding occurring once in 20 years to a future Do-Nothing option with flooding at least once per year and poor drainage results in a change of land use from General Cropping to Extensive Grazing. The estimated economic loss is £697/ha/year at full scenario development. Possible agri-environmental options under Extensive Grassland could, however, generate additional net benefits in excess of £264/ha/year that would be included in the FCERM appraisal.

The central estimates of flood costs in the preceding tables assume a within-year monthly distribution of flood probability based on Roca et al. (2011) for the all England case, although distributions can vary across the regions. Broadly, the relative seasonal probability of a single flood occurring in a year (p=100%) are Winter (December to February inclusive) 45%, Spring (March to May) 20%, Summer (June to August) 10%, and Autumn (September to November) 25%. Climate change effects could

[3] This guidance may be revised by Defra given the significant changes in agricultural support since the withdraw from the European Union Common Agriculture Policy.

[4] At the farm scale, the financial costs (excluding subsidies, taxes and land costs, and including unpaid labour) and the economic costs of an infrequent flood event are the same because costs cannot be avoided once a flood occurs.

[5] The estimates in Table 9.8 and subsequent tables combine both loss and damage costs. Damage cost estimates (£/ha/event) are based on farm survey data of 'other' costs (as referred to earlier in the text). Where damage to agricultural business property is known to be high and is not included elsewhere as damage to commercial property, e.g. as warehousing or processing plant, it should be separately identified and valued. This may require some adjustment to the 'other' costs included here in the average costs of flooding (typically 15% of total costs (£/ha)).

significantly change these seasonal distributions. Table 9.10 shows the weights that can be applied to derive seasonal estimates of flood costs by major land uses relative to the reference all England annual distribution. For example, the costs of a single flood of one to two weeks occurring in Summer only can be derived by weighting the central estimates of flooding in Table 9.7 by a factor of 2.71 for all Intensive and Extensive Arable land uses, by 1.75 for Intensive and Extensive Grazing and by 1.28 for Rough Grazing. For example, the estimated cost of a single freshwater flood of one to two weeks duration occurring in the summer period on Extensive Arable land use under good drainage conditions is £636/ha (Table 9.7) raised by a factor of 2.71 (Table 9.10) to give £1,726/ha. Under similar circumstances, estimated flood costs are £2,264/ha for a summer flood of two to four weeks duration (£1,340/ha x 1.69). Further sensitivity analysis of the seasonal distribution of flooding can be carried out if appropriate.

Table 9.10 Weights applied to central estimates of the cost of a single flood occurring in a year to derive estimates of the seasonal costs of flooding on agricultural land in England and Wales

Flood season[1] and duration	Intensive and Extensive Arable		Intensive and Extensive Grass		Rough Grazing	
	Freshwater	**Saline**	**Freshwater**	**Saline**	**Freshwater**	**Saline**
1 to 2 weeks						
Winter	0.47	0.71	0.44	1.20	0.49	0.74
Spring	1.21	1.15	2.50	1.76	1.18	2.00
Summer	2.71	1.91	1.75	1.21	1.28	1.12
Autumn	1.38	1.19	1.07	1.37	0.42	0.80
2 to 4 weeks						
Winter	0.69	0.81	0.52	1.18	0.42	0.63
Spring	1.31	1.20	2.32	1.86	1.20	1.79
Summer	1.69	1.45	2.13	1.41	1.00	1.00
Autumn	1.21	1.12	0.80	1.29	0.42	0.63

Notes to table:
1. Winter: December to February inclusive. Spring: March to May. Summer: June to August. Autumn: September to November.

Throughout the appraisal process, it is important to identify major sources of risk and uncertainty and the possible effect on benefit and cost estimates. It is advisable to derive a range of low, central and high estimates, with some assessment of relative likelihood, rather than any one single value estimate.

While this guidance generally applies, specific advice should, however, be sought from Defra for:

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

DATA NEEDS, SOURCES AND COLLECTION METHODS

It is advisable to start with an exploratory survey of the study area to define the geographical boundary of influence, that is the benefit area, and to determine current flood risk management standards and issues arising. Agricultural statistics can be obtained from Government sources (Defra, 2025, 2023b, 2024a; AHDB, 2024), including geographically referenced data sets (RPA, 2023; Natural England, 2024b)

This ‘overview’ survey will also identify broad categories of land use, dominant farm types and systems, possible flood risk management options, the likely impact of these and the views of key stakeholders, especially farmers.

Key informants will include:

- Staff with flood risk management interests in regional offices of the Environment Agency and Defra;
- Local Internal Drainage Boards;
- Representatives of farmer organisations (such as the National Farmers Union);
- Local advisors and land agents;
- Environmental and conservation groups such as the local Wildlife Trusts, Farming and Wildlife Advisory Groups (FWAGs), River Trusts and National Parks;
- College and University Agricultural Economics and Agriculture Departments.

In most cases some form of farm survey will be needed, usually involving a sample of representative farmers that covers the major variations in farm circumstance (e.g. size, tenure, land type, flood risk), farm practices (e.g. enterprise mix, drainage improvements), and farmer characteristics (e.g. age, skills, preferences and motivation). Those embarking on such a survey should refer to Chapter 9 of the MCM (Penning-Rowsell et al., 2013).

For agricultural enhancement schemes, the extent to which flooding and drainage currently constrain farming will be a focus of enquiry, together with the factors that are likely to encourage farmer take-up of potential benefits (Morris et al., 2023). Conversely, the adoption NFM measures to provide FCERM benefits elsewhere may require changes in agricultural land use or result in increased flood costs to farmers that need to be assessed as part of a wider financial and economic appraisal of NFM interventions (Morris et al., 2023).

REMAINING ISSUES

- There is currently considerable uncertainty facing the agriculture sector in England and Wales associated with Post-EU Exit policy reform, disruption in international commodity markets, and climate change.
- Further changes in subsidies for farmers in England were announced in the Government’s Autumn Budget 2024. These are scheduled for complete removal by April 2028 and are assumed to be zero from 2028 onwards. Defra is currently reviewing the appraisal guidance for the valuation of agricultural land and output, and interim advice can be sought from Defra where relevant.
- While FCERM tends to focus on surface inundation and erosion processes, groundwater flooding and waterlogging are critically important for the agricultural case.
- In line with government policy, appraisals in future will seek to integrate FCERM with other rural land use objectives such as agriculture, biodiversity and nature recovery, enjoyment of the countryside and adaptation to climate change;
- Farm surveys should be carried out by competent and experienced interviewers with knowledge of farming systems;

- Flooding from estuarine and coastal sources results in greater impact and higher losses than freshwater flooding, and agricultural land is likely to take longer for full production to be restored.

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TABLES AND FIGURES

4 Residential Properties

Tables and figures

Table 4.1 Categories of flood water

Category of Water	Description
Major clean/grey (IICRC Category 2)	Water contains significant contamination and can contain potentially unsafe levels of microorganisms or nutrients for microorganisms, as well as other organic or inorganic matter: commonly discharge from washing machines, dishwashers or toilet overflows (not including faeces).
Minor black (IICRC category 3)	Water is grossly contaminated: As 'Major clean/grey', but includes sewage backflow scenarios from an internal source where water may contain faeces, urine and other waste through toilet discharge system.
Major flood/storm (IICRC category 3)	Water is grossly contaminated: This is the most common category for a typical fluvial, surface water or coastal flood scenario. Water may contain: organic matter, pesticides, heavy metals or toxic organic substances.
Major Flood including sewage (IICRC category 3)	Water is grossly contaminated: As 'Major flood/storm', but with the inclusion of animal and human waste materials.
Major Flood 'Contaminated' (IICRC Special situations)	Water may contain regulated hazardous waste (as per Technical Guidance WM2, see: https://www.gov.uk/how-to-classify-different-types-of-waste), including (but not limited to): asbestos, heavy metals, pesticides, solvents, caustic chemicals etc.

Adapted from: Institute of Inspection, Cleaning and Restoration Certification (IICRC) (2006) S500: Standard and Reference Guide for Professional Water Damage Restoration. 3rd edn, IICRC: Washington DC.

Table 4.2 The range of possible flood impacts on households (not exhaustive or necessarily mutually exclusive)

Direct Tangible Losses For Flooded Households	Intangible Losses On Flooded Households	Indirect Losses On Flooded Households	Indirect Losses For Non-Flooded Households
➢ Damage to building fabric	➢ Worry about future flooding	➢ Permanent evacuation from area	➢ Increased travel costs
➢ Damage to household inventory items	➢ Loss of memorabilia and irreplaceable items and pets	➢ Disruption to household due to flood damage	➢ Loss of income/earnings
➢ Clean-up costs	➢ Damage to physical and/or mental health, death or injury	➢ Temporary evacuation costs	➢ Loss of utility services
	➢ Loss of community	➢ Disruption due to flood warnings or alarms	➢ Loss of other services
	➢ Loss of confidence in authorities and services	➢ Loss of utility services	➢ Loss of leisure and recreational opportunities
		➢ Loss of income/earnings	➢ Increased cost of shopping and recreational opportunities
		➢ Loss of leisure and recreational opportunities	
		➢ Additional communication costs	
		➢ Loss of services	
		➢ Increased travel costs	
		➢ Increased cost of shopping and recreational opportunities	

Tables 4.3 Social grade categorisation and weighted factor by occupation

Social Group	Description	Weighted Factor
AB	Upper middle and middle class: higher and intermediate managerial, administrative or professional	0.74
C1	Lower middle class: supervisory or clerical and junior managerial, administrative or professional	1.12
C2	Skilled working class: skilled manual workers	1.22
DE	Working class and those at the lowest level of subsistence: semi-skilled and unskilled manual workers. Unemployed and those with no other earnings (e.g. state pensioners)	1.64

Table 4.4 Types of project appraisals (2026 values)

Overview, Initial and Full-Scale methods			
Scale of analysis	**Overview**	**Initial**	**Full-Scale**
Guidance	For rapid MDSF and similar desktop type appraisals: first approximations to identify areas where more detailed work is required	For more detailed appraisals where further assessment of household loss potential is warranted	For the detailed study of potential benefits using the most detailed of the standard data sets
Data requirements for the benefitting area	Number of properties at risk	Number, type and age of house at risk	Number, type, age and social class of houses and householders at risk
		Standard of protection (pre and post scheme for intangible values)	Standard of protection (pre and post scheme for intangible values)
			Government Weighting Factors for distributional impact analysis
Direct/tangible method of assessment	Annual average direct damages: sector average	Generalised standard residential depth/damage data for type and age of houses	Additional data for type, age and social grade of houses and householders
	Vehicle Damages: 42% of total properties damaged x £5,600 (2021 value)	Vehicle Damages: number of properties at risk above 0.39m x £6,832 (2023 ownership values)	Vehicle Damages: number of vehicles at risk above 0.39m x £5,600 (2021 value)
Intangible method of assessment	Health: £317 per property per year for intangibles	Health: Defra's intangibles matrix	Health: Defra's intangibles matrix
Indirect method of assessment	Evacuation per household: temporary accommodation costs (£1,580) plus alternative accommodation costs (£4,519) (2026 value)	Evacuation per household: evacuation costs per property type and flood depth	Evacuation per household: survey on percentage of households evacuated and duration of evacuation. Evacuation costs per property type and flood depth
Vulnerability Analysis	Not required	Where feasible	Where feasible

Table 4.5 Weighted Annual Average Damages (WAAD) (2026 values) assuming variable threshold Standards of Protection (SoP)

Existing SoP	No warning (£)	<8 hour warning (£)	>8 hour warning (£)
No protection	6,074	6,025	6,012
2 years	6,074	6,025	6,012
5 years	3,646	3,615	3,607
10 years	1,862	1,846	1,841
25 years	890	883	881
50 years	376	373	372
100 years	94	93	93
200 years	47	46	46

Table 4.6 Estimate of the number of properties affected by different floods

Return Period	Number of properties as % of 200 year number
100	93
50	80
25	25
10	10
5	5

Table 4.7 Intangible benefits associated with flood risk management improvements (2026 values)

			Standard of Protection After – AFP (RP in years)							
Standard of protection before – AFP (RP in years)			**0.007**	**0.008**	**0.01**	**0.013**	**0.02**	**0.033**	**0.05**	**0.1**
			-150	**-125**	**-100**	**-75**	**-50**	**-30**	**-20**	**-10**
	1	**-1**	£396	£390	£363	£277	£133	£46	£21	£9
	0.1	**-10**	£388	£381	£354	£268	£123	£39	£14	£0
	0.05	**-20**	£373	£366	£341	£256	£109	£24	£0	-
	0.033	**-30**	£350	£343	£317	£231	£86	£0	-	-
	0.02	**-50**	£263	£257	£230	£146	£0	-	-	-
	0.013	**-75**	£119	£113	£86	£0	-	-	-	-
	0.01	**-100**	£33	£27	£0	-	-	-	-	-
	0.008	**-125**	£7	£0	-	-	-	-	-	-

AFP = Annual Flood Probability
RP = Return Period
Annual Benefits = Damages (before) - Damages (after)

Source: Department for Environment, Food and Rural Affairs (Defra) (2004) Flood and Coastal Defence Project Appraisal Guidance. FCDPAG3 Revisions to Economic Appraisal on Reflecting Socio-economic Equity in Appraisal and Appraisal of Human Related Intangible Impacts of Flooding. Supplementary Note to Operating Authorities. July 2004. Defra: London.

Table 4.8 The probability of evacuation and duration in relation to flood depth

Maximum depth in house (cm)	% who evacuated	Mean duration of evacuation in weeks
0	23	11
1-10	41	12
10-20	55	18
20-30	59	18
30-60	69	21
60-100	76	23
100+	87	33

5 Non-Residential properties

Tables and figures

Table 5.1 Matching NRD (MCM) codes to the latest MCM code

NRD MCM code	Description	MCM Code	Property type
2	**Retail**	**2**	**Retail**
21	Shop/Store (Weighted mean)		
211	(High Street) Shop		
213	Superstore/Hypermarket		
214	Retail Warehouse		
215	Showroom		
216	Kiosk		
217	Outdoor market		
218	Indoor Market		
22	Vehicle Services (Weighted mean)		
221	Vehicle Repair Garage		
222	Petrol Filling Station		
223	Car Showroom		
224	Plant Hire		
23	Retail Services (Weighted mean)		
231	Hairdressing Salon		
232	Betting Shop		
233	Laundrette		
234	Pub/Social club/wine bar		
235	Restaurant		
236	Café/Food Court		
237	Post Office		
238	Garden Centre		
3	**Offices**	**3**	**Offices**
310	Offices (non specific)		
311	Computer Centres (Hi-Tech)		
320	Bank		
4	**Distribution/logistics**	**4**	**Warehouses**
410	Warehouse		
411	Electrical w/h		
412	Ambient goods w/h		
413	Frozen goods w/h		
420	Land Used for Storage		
430	Road Haulage		
5	**Leisure and Sport**	**NOT APPLICABLE - CONSTITUENT CATEGORIES TOO DIVERSE**	
51	**Leisure (Weighted mean)**	51	Leisure
511	Hotel		
512	Boarding House		

513	Caravan Mobile	Due to a change in Environment Agency guidance, readers should no longer apply the MCM damage value for caravan sites. Please see the following document for further information: **Environment Agency (2008) Economic evaluation of damages for Flood Risk Management projects, Environment Agency, Bristol**	
514	Caravan Static		
515	Self-catering Unit	51	Leisure
516	Hostel (including prisons)		
517	Bingo hall		
518	Theatre/Cinema		
519	Beach Hut		
52	**Sport (Weighted mean)**	**NOT APPLICABLE - CONSTITUENT CATEGORIES TOO DIVERSE**	
521	Sports Grounds and Playing Fields	521	Playing Field
522	Golf Courses	521	Playing Field
523	Sports and Leisure centres	523	Sports Centre
524	Amusement Arcade/Park	523	Sports Centre
525	Football Ground and Stadia	525	Sports Stadium
526	Mooring/Wharf/Marina	526	Marina
527	Swimming Pool	523	Sports Centre
6	**Public Buildings**	**6**	**Public Buildings**
610	School/College/University/Nursery		
620	Surgery/Health Centre		
625	Residential Home		
630	Community Centres/Halls		
640	Library		
650	Fire/Ambulance station		
651	Police Station		
660	Hospital		
670	Museum		
680	Law court		
690	Church		
8	**Industry**	**8**	**Industry**
810	Workshop		
820	Factory/Works/Mill		
830	Extractive/heavy Industry		
840	Sewage treatment works		
850	Laboratory		
9	**Miscellaneous**	**NOT APPLICABLE - CONSTITUENT CATEGORIES TOO DIVERSE**	
910	Car Park	910	Car park
920	Public Convenience	NOT CURRENTLY AVAILABLE	
930	Cemetery/Crematorium	NOT CURRENTLY AVAILABLE	
940	Bus Station	NOT CURRENTLY AVAILABLE	
950	Dock Hereditament	526	Marina
960	Electricity Hereditament	960	Electricity sub-station

Table 5.2 Indicative floor sizes for NRPs

New MCM Code	Property Type	Floor Area (m^2)
2	Retail	340
3	Offices	360
4	Warehouses	3,270
5	Leisure and sports	NA
51	Leisure	1,020
52	Sports	NA
521	Playing Field	21,850
523	Sports Centre	5,400
526	Marina	1,860
525	Sports Stadium	25,600
6	Public Buildings	1,300
8	Industry	2,480
9	Miscellaneous	NA
910	Car park	3,500
910	MS Car park	2,700
960	Sub Station	48

Table 5.3 NRP Weighted Annual Average Damages (WAAD) (2026 values)

		Standard Of Protection						
MCM Code	**Sector Type**	**None**	**5**	**10**	**25**	**50**	**100**	**200**
2	Retail	100.61	49.72	36.24	18.63	8.31	2.08	1.03
3	Offices	98.54	45.33	34.19	17.10	7.52	1.89	0.94
4	Warehouses	113.00	59.58	43.12	21.86	9.90	2.47	1.24
5	Leisure and sport	NOT APPLICABLE - CONSTITUENT CATEGORIES TOO DIVERSE						
51	Leisure	228.04	78.51	62.50	28.38	12.17	3.04	1.52
52	Sport	NOT APPLICABLE - CONSTITUENT CATEGORIES TOO DIVERSE						
521	Playing Field	4.25	1.70	1.36	0.65	0.28	0.07	0.04
523	Sports Centre	52.45	22.70	17.37	8.45	3.69	0.93	0.46
526	Marina	18.97	8.69	6.37	3.24	1.42	0.35	0.18
525	Sports Stadium	13.29	6.48	4.77	2.43	1.08	0.27	0.13
6	Public Buildings	60.76	27.49	20.73	10.27	4.53	1.13	0.56
8	Industry	21.34	10.55	7.68	3.92	1.75	0.44	0.22
9	Miscellaneous	NOT APPLICABLE - CONSTITUENT CATEGORIES TOO DIVERSE						
910	Car park	6.55	2.92	2.17	1.10	0.47	0.12	0.06
960	Substation	317.16	192.39	137.67	75.27	34.05	8.51	4.26
NRP sector average		104.89	54.88	40.21	21.23	9.65	2.53	1.27

Table 5.4 Business floor space: rateable value per m² of floor space (most recent available data, 31st March 2023)

Area	Main Category	Rateable value per m² of floor space
ENGLAND	Total	88.00
ENGLAND	Retail	161.00
ENGLAND	Offices	181.00
ENGLAND	Industrial	41.00
ENGLAND	Other	91.00
NORTH EAST	Total	54.00
NORTH EAST	Retail	124.00
NORTH EAST	Offices	75.00
NORTH EAST	Industrial	28.00
NORTH EAST	Other	58.00
NORTH WEST	Total	59.00
NORTH WEST	Retail	126.00
NORTH WEST	Offices	94.00
NORTH WEST	Industrial	31.00
NORTH WEST	Other	71.00
YORKSHIRE AND THE HUMBER	Total	55.0
YORKSHIRE AND THE HUMBER	Retail	130.00
YORKSHIRE AND THE HUMBER	Offices	88.00
YORKSHIRE AND THE HUMBER	Industrial	31.00
YORKSHIRE AND THE HUMBER	Other	64.00
EAST MIDLANDS	Total	52.0
EAST MIDLANDS	Retail	122.00
EAST MIDLANDS	Offices	80.00
EAST MIDLANDS	Industrial	35.00
EAST MIDLANDS	Other	64.00
WEST MIDLANDS	Total	59.0
WEST MIDLANDS	Retail	128.00
WEST MIDLANDS	Offices	99.00
WEST MIDLANDS	Industrial	36.00
WEST MIDLANDS	Other	75.00
EAST	Total	76.0
EAST	Retail	145.00
EAST	Offices	120.00
EAST	Industrial	46.00
EAST	Other	85.00
LONDON	Total	257.0
LONDON	Retail	170.00
LONDON	Offices	359.00
LONDON	Industrial	83.00
LONDON	Other	212.00
SOUTH EAST	Total	96.0
SOUTH EAST	Retail	136.00

SOUTH EAST	Offices	133.00
SOUTH EAST	Industrial	57.00
SOUTH EAST	Other	88.00
SOUTH WEST	Total	70.0
SOUTH WEST	Retail	109.00
SOUTH WEST	Offices	100.00
SOUTH WEST	Industrial	41.00
SOUTH WEST	Other	73.00

6 *Other flood losses:* Utility, schools, hospitals, transportation networks and emergency costs

Tables and figures

Introduction: Prioritisation of losses for inclusion in project appraisal

Figure 6.1 Prioritisation process for selecting those assets to quantify potential losses

STEP 1

Identify those assets at risk of flooding

This first step is simply to identify those assets at risk of flooding and thereby the scale of the issue.

There are a number of ways in which to enumerate assets depending on the type of asset (e.g. km of network, or numbers of assets) but mapping of these is preferable.

Use GIS tools

STEP 2

Determine the likelihood of flooding of assets

Utilise flood threshold information to identify on a simple scale (e.g. low, moderate, significant) the likelihood of flooding and include the probability of a particular asset being affected.

STEP 3

Determine the criticality of the assets to flooding

Categorise the affected asset using a criticality scale (e.g. such as a Risk Matrix or a variant)

This should take into account the scale of the loss or disruption and the joint and the joint effect of *susceptibility*, *dependency* and *transferability* within the system.

Utility and transport organisations have been developing risk registers since 2007.

These should be accessed where possible as for many assets Steps 1 to 3 may have already been undertaken

STEP 4

Utilise total risk matrix for prioritisation

A risk matrix approach should be adopted obtain an estimation of the total risk of assets to induced losses. This combines the scales in Steps 2 and 3 to identify the significant assets.

FIRST DEGREE OF PRIORITISATION

At this stage those assets which will have a significant impact upon induced losses to flooding will be identified.

STEP 5

Assess the impact of resistance and resilience

Identify those assets where resistance and resilience measures are implemented and/or planned and where the impact of flooding is mitigated.

These should be excluded from the assessment and quantification of induced losses.

SECOND DEGREE OF PRIORITISATION

Update the likelihood and/or impact categories to account for resistance and resilience measures.

STEP 6

Quantify losses for 'high' and 'very high risk' assets

Judgement is required about which risk categories should be quantified. However, it is suggested that only those high or very high risk assets should be considered.

Assets which are in lower risk categories should be included but described qualitatively in the project appraisal.

Table 6.1 Enumeration, descriptors and valuation measures to gauge the scale of the infrastructural risk

Infrastructure type	Enumerator/ Descriptor	Valuation Measures
Roads	Length (in km) of motorways, A, B, minor within the floodplain; flood thresholds	User numbers (cars, HGV, LGV, PSV) Flood free alternatives
Railways	Length (in km) of intercity, regional, local, commuters tracks; flood thresholds	No. of passengers of different types (commuter, business, other), trains per day,
Electricity transmission	KV, lengths, thresholds of flooding of plinth	Supply catchment, population served
Electricity distribution	Size of substations; threshold of flooding	Supply catchment, population served
Gas pressure, pumping stations [1]	Type and number	Supply catchment, population served
Water treatment works	Type and number (pumping station, booster station etc); thresholds of flooding	Supply catchment, population served
Sewage treatment works	Type and number (biological filter, activated sludge, pumping station etc); thresholds of flooding	Drainage catchment, population served
Telecommunications [2]	Exchanges, cabinets, pillars, threshold of flooding	Population served
[1] Water distribution and supply mains, trunk sewers and gas lines can all but be ignored unless likelihood of fracture is high (e.g. on exposed river crossing or where it might be threatened by the ground around it becoming saturated so that it floats and threatened the pipe work joints).		
[2] Redundancy is now high with universal application of mobile telephony. Telecommunication losses and disruption can all but be ignored unless physical damage is likely with high probability within an exchange.		

Table 6.2 Risk Matrix

IMPACT**	*Significant*	Medium Risk	**High Risk**	**Very High Risk**
	Moderate	Low Risk	Medium Risk	**High Risk**
	Low	Negligible Risk	Low Risk	Medium Risk
		Very Low	*Low*	*Medium/High*
			LIKELIHOOD*	

* These follow the Environment Agency's Risk of Flooding from Rivers and Sea likelihood bands.
** The significant, moderate and low impact categories are defined for each receptor type.

***Table 6.3 Summary of impacts for utility and infrastructure assets assuming that there are no flood resilience measures or actions taken to increase* redundancy**

Utility/ infrastructure	Susceptibility	Dependency	Redundancy/ Transferability	Scale 1 = few 2 = many 3 = very many	Total likely impact
Electricity transmission and distribution					
> 132 kV (fluvial)	Low	High	Low	3	Low
>132 kV (tidal) [1]	High	High	Low	3	High
<132 kV (fluvial)	Low	High	Low	2	Low
<132 kV (tidal)	High	High	Low	2	Medium
Grid (Super grid) substation	High	High	High	3	Medium [2]
Grid (Bulk Supply Point) substation	High	High	Medium	3	Medium [2]
Primary substation	High	High	Medium	2	Medium[2]
Distribution substation	High	High	Low	1	Medium/ Low [3]
Gas transmission					
Gas pressure stations	Medium	Medium	Low	1	Low
Gas pressure stations	Medium	Medium	Low	2	Medium
Water and waste water treatment					
Sewage treatment	Medium	High [4]	Low [5]	1	Medium
Sewage treatment	Medium	High [4]	Low	2	Medium
Water treatment	High	High	Medium [6]	1	Medium
Water treatment	High	High	Medium [6]	2	High
Water pump stations	High	High	Low	1 and 2	Medium
Telecommunication systems					
Connection points – cabinet	Low	Medium	High	2	Low
Telecoms connection points – pillars	Low	Medium	High	1	Low [7]
[1] Transmission lines across a coastal floodplain are likely to collapse during a severe tidal inundation. Also if a transmission line is within an area flooded for any considerable period of time, then maintenance of that structure will be difficult and the integrity of the asset threatened.					
[2] The absolute impact will depend upon the specific site plan and the location of equipment within it; in particular the positioning and height of the switching gear and transformers.					
[3] This is 'low' in the situations whereby the properties the substation is servicing are also flooded as the substation will be repaired before the houses. It is 'medium' in situations where the substation is servicing properties which remain dry (i.e. 'unflooded' properties).					
[4] Environmental damage through treatment bypass might be as important as physical damage.					
[5] A reminder that in this circumstance the redundancy remains low – unless measures have been taken as a consequence of the Pitt Review to increase the transferability of the service.					
[6] Depends upon locality.					
[7] Redundancy of landline facilities is extremely high with saturation coverage of mobile telephones.					

NB. This is Table 6.14 in the MCM 2013

Infrastructure

Table 6.4 Types of electricity substations (ENA, 2009)

Substation type	Typical Voltage transformation levels	Approximate number in UK	Typical size	Typical numbers of customers supplied
Grid (Super grid)	400kV to 132kV	377	250m x 250m	200,000 to 500,000
Grid (Bulk Supply Point)	132kV to 33kV	1,000	75m x 75m	50,000 to 125,000
Primary	33kV to 11kV	4,800	25m x 25m	5,000 to 30,000
Distribution	11/kV to 400/230V	230,000	4m x 5m	1 to 500

NB. This is Table 6.6 in the MCM 2013

Energy Networks Association (ENA) (2009) ‘Resilience to flooding of grid and primary substations’, Engineering Technical Report (ETR 138), issue 1, Energy Networks Association, London.

Table 6.5 Risk matrix for electricity substations

IMPACT	Sig: Grid substations with serving a population of > 125 000	Medium Risk	**High Risk**	**Very High Risk**
	High: Primary substations those with > 10000 *population supplied*	Medium Risk	**High Risk**	**High Risk**
	Mod: Primary substations with 5,000 to 10,000 population supplied	Low Risk	Medium Risk	**High Risk**
	Low: Distribution substations with fewer than 500 people supplied.	Negligible Risk	Low Risk	Medium Risk
		Very Low	*Low*	*Medium/High*
		LIKELIHOOD		

NB. This is a revised version of Table 6.7 in the MCM 2013

Figure 6.2 List of Approved Designated Services eligible to apply for the Protected Sites List

Tier	Designated Service	Lead Government Department/Devolved Administration
0 (Z)	Licensed electricity generators, and licensed network operators' key operational facilities	DESNZ
	Gas reception terminals; storage installations including boosting and compression equipment; gas compressor stations and principal development and control sites for the control of gas supply systems and emergency procedures	DESNZ
1	Hospitals as agreed with Department for Health/Scottish & Welsh Government. This includes major trauma centres, burns centres, acute hospitals with A&E and intensive care units	Department for Health and Social Care/Devolved Administration
2	Emergency services of regional significance, including: • Ambulance Control Centres • Fire Control Rooms • Critical Police sites • Coastguard rescue coordination centres	Home Office, Ministry of Housing, Communities and Local Government, Department for Transport, Department for Health & Social Care/Devolved Administration
	Vital Health Organisations as agreed with Department for Health and Scottish Government, which could include: • UKHSA - core laboratories • NHS blood and transplant manufacturing sites • Large residential care homes	Department for Health and Social Care/Devolved Administration
	Sites, as agreed with the Ministry of Defence, where the security of the United Kingdom that cannot be reasonably mitigated (i.e., Atomic Weapons Establishment)	Ministry of Defence
	Digital and telecommunication services where there is a national need for continued operation, such as critical broadcast infrastructure	Department for Culture Media and Sport and Department of Science, Innovation and Technology
	Data centres which are vital to the operation of Essential Services	Department for Science Innovation and Technology
	Prisons as agreed with MoJ/Devolved Administration	Ministry of Justice/Devolved Administration
	Nuclear decommissioning, waste process sites and nuclear fuel manufacturers.	DESNZ
	Oil refineries and vital oil pumping stations import/storage/distribution terminals	DESNZ
	Essential drinking water (i.e., abstraction, treatment and distribution sites) and sewerage installations	Department for the Environment, Food & Rural Affairs/Devolved Administration
	A major location for essential food manufacture as agreed with the Department of Environment, Food and Rural Affairs	Department for the Environment, Food & Rural Affairs/Devolved Administration
	Critical transport sites as agreed with the Department of Transport, such as: • Major airports and associated control facilities • Significant railway operations • Ports which have a national infrastructure significance	Department for Transport/Devolved Administration
3	Financial services where there is a national need for continued operation	His Majesty's Treasury
	Chemical suppliers as agreed with the Department of Business and Trade	Department for Business & Trade
	Energy intensive industries (i.e., ceramics, glass, paper, steel and metals)	Department for Business & Trade

Source: Department for Energy Security and Net (2026; Table 2).

Department for Energy Security and Net Zero (DESNZ) (2026) Electricity Supply Emergency Code (ESEC), Updated 13 April 2026, https://www.gov.uk/government/publications/electricity-supply-emergency-code?1777966822, accessed 5 May 2026.

Table 6.6 Estimations of population served based on the perimeter fence length (after Energy Networks Association, 2018b)

Sub station type	Average Perimeter Fence	Ratio customers to metres of perimeter
Grid (Super grid)	1000m	225:1
Grid (Bulk Supply Point)	300m	183:1
Primary	100m	150:1

NB. This is Table 6.8 in the MCM 2013

Energy Networks Association (ENA) (2018b) ‘Resilience to flooding of grid and primary substations: Annex’, Engineering Technical Report (ETR 138 Annex), Issue 1, 2018, Energy Networks Association (ENA): London, , https://www.ena-eng.org/ena-docs/D0C3XTRACT/ENA_ET_138_-_Annex_Extract_180902050351.pdf, accessed 15 April 2026.

*Table 6.7 Resilience levels for electricity substations**

Flood type	Protection level			Allowance for climate change rises	Freeboard
	Grid Substation	Primary Substations† > 10,000 unrecoverable connections	Primary Substation† < 10,000 unrecoverable connections		
Fluvial	1:1000 Flood level	1:1000 Flood level	1:100 Flood level	Flood Depth x 20% or use of EA CC factored levels	300mm
Tidal	1:1000 Flood level	1:1000 Flood level	1:200 Flood level	105 mm or use of EA CC factored levels	300mm
Surface	1:1000 Flood level	1:1000 Flood level	1:100 Flood level	Flood Depth x20%	300mm

Source: UK Power Networks (2024, 10); ENA (2018a, 20).

* Please note that critical infrastructure resilience is a priority area following recent floods and storms and the *National Flood Resilience Review* (HM Government, 2016) and so the resilience levels may be subject to change. Furthermore, some DNOs have issued guidance recommending additional safety factors are applied (e.g. Electricity North West, 2017). In particular, the updated ENA (2018a) suggests that Network Operators should ensure that they utilise the most recent guidance available. It is recommended that appraisers also check for updated information. The third and fourth round of Climate Change Adaptation Reporting accordance with the Climate Change Act 2008, provides the updated information on climate resilience for each supplier (Defra, 2023; 2025).

† ENA (2018a) suggests that network operators should focus on the resilience of service provision to sites supplying significant local communities (SLCs) (which are defined as those comprising at least 10,000 customers/connections) and to the level of the EA's Extreme Flood Outline (i.e. 1/1,000 flood risk). Therefore, those primary substations which are likely to serve a customer population of over 10,000 should have the same protection level (1:1000) as grid substations.

Department for Environment, Food and Rural Affairs (2023) Climate change adaptation reporting: third round reports, Reports from organisations invited to report under the third round of the climate change Adaptation Reporting Power, Latest update 9 August 2023, https://www.gov.uk/government/collections/climate-change-adaptation-reporting-third-round-reports#energy-companies, accessed 15 April 2026.

Department for Environment, Food and Rural Affairs (2025) Climate change adaptation reporting: fourth round reports, Reports from organisations invited to report under the fourth round of the climate change adaptation reporting power, Energy, https://www.gov.uk/government/publications/climate-adaption-reporting-fourth-round-energy, accessed 15 April 2026.

Electricity North West (2017) Substation Flood Protection, Electricity Policy Document 355, Issue 3, April 2017, https://www.enwl.co.uk/globalassets/get-connected/cic/icpsidnos/g81-policy/policy-library-documents/substation/epd355---substation-flood-protection.pdf, accessed 15 April 2026.

Energy Networks Association (ENA) (2018) 'Resilience to flooding of grid and primary substations', Engineering Technical Report (ETR 138), Issue 3, June 2018, Energy Networks Association, London.

HM Government (2016) National Flood Resilience Review, September 2016, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/551137/national-flood-resilience-review.pdf, accessed 15 April 2026.

UK Power Networks (2024) Substation Flood Protection, Engineering Design Standard EDS, EDS 07-0106, version 4.1, https://g81.ukpowernetworks.co.uk/library/design-and-planning/substations-major/general/eds-07-0106-substation-flood-protection, accessed 15 April 2026.

Table 6.8 ***Potential intervention measures for electricity infrastructure with their advantages and disadvantages***

Intervention Measure		Advantages	Disadvantages
Permanent	EA intervention measure (wall or embankment)	Removes flood risk to design flood level	High cost solution and long 'solution' lead time
Permanent	Buildings and Critical assets protected 365 days per year	Access maintained and all apertures sealed with site not requiring to be manned during flood	Protection generally only effective to a height of 1 metre above ground level. Medium cost solution
Permanent	Barriers and gates at critical openings in perimeter	Access to critical pant maintained	Site needs to be manned during flood incident. Medium cost solution
Permanent	Substation critical assets raised	Removes risk of flooding to new design threshold	High cost solution with long construction lead time
Permanent	Substation relocation outside floodplain	Wholly removes flood risk	Very high cost solution and disruptive to customers during construction
Demountable	Buildings and critical assets where supports are permanent and panels etc stored on site	Removes flood risk to design flood level	Medium to high cost solution and resource intensive during flooding with potential for operational failure.
Demountable	Site protection where supports are permanent and panels etc stored on site	Removes flood risk to design flood level	Medium to high cost solution and resource intensive during flooding with potential for operational failure.
Temporary	Site protection measures installed following flood warning	Low cost solution	High deployment and training costs for erection etc.

Source: Adapted from Energy Networks Association (2009)

NB. This is Table 6.10 in the MCM 2013

Energy Networks Association (ENA) (2009) 'Resilience to flooding of grid and primary substations', Engineering Technical Report (ETR 138), Issue 1, October 2009. Energy Networks Association, London.

Figure 6.3 Indicative figures for average energy and gas consumption and willingness to pay to avoid a power outage

Average electricity consumption† – 2023 estimates

Annual Energy Consumption per household (Ofgem, 2023)	Daily Energy Consumption per household
2,700 kWh	7.4 kWh

Average gas consumption – 2023 estimates

Annual Gas Consumption per household (Ofgem, 2023)	Daily Gas Consumption per household
11,500 kWh	31.5 kWh

Willingness-to-pay* to avoid disconnection of supply for electricity (2026 values)

Willingness to pay to avoid disconnection – Domestic users (BERR, 2007)***	Willingness to pay to avoid disconnection – Business users** (BERR, 2007)
£16.57 per kWh	£58.01 per kWh

The annual consumption per household figure is the medium Typical Domestic Consumption Value calculated by Ofgem (2023) – the higher or lower values might be used to provide a more conservative or maximum estimate and where more information is known about the type of property. TDCVs are industry standard values and are those recommended by the industry. The latest update was published on 23rd May 2023 and so the presented values are correct as of April 2026.

†TDCV Electricity Profile Class 1 has been used (i.e. those not on an Economy 7 tariff) the assumption being that households are not only reliant on electricity for power and this will provide a more conservative estimate. For a maximum estimate, TDCV Profile Class 2 can be used and accessed from Ofgem (2020).
*****These values have been generated in relation to electricity supply. However, this might also be used in the case of the disruption to a gas supply in the absence of other appropriate estimates.
******This is an average value and there is likely to be significant variation amongst business owners depending upon the type of business and its dependency upon water.
*** New data commissioned by the Energy Networks Association (ENA) concerning the willingness of energy customers to pay to avoid electricity disruption was published in 2025 (NERA, 2025). These new values may be integrated into an updated version of Chapter 6, however need review by Environment Agency economist prior to adoption.

Department of Business, Enterprise and Regulatory Reform (BERR) (2007) Electricity Priority Users Arrangements, Department for Business, Enterprise and Regulatory Reform, https://webarchive.nationalarchives.gov.uk/ukgwa/20090609003228/http://www.berr.gov.uk/files/file40466.pdf, accessed 05 April 2026.

NERA (2025) Value of lost load study in Great Britain: Work Package 2 report, Prepared for the Energy Networks Association, 17 October 2025, https://www.energynetworks.org/publications/value-of-lost-load-study-in-great-britain, 05 April 2026.

Ofgem (2023) 'Typical Domestic Energy Consumption Values', https://www.ofgem.gov.uk/information-consumers/energy-advice-households/average-gas-and-electricity-use-explained, revised 25th May 2023, accessed 05 April 2026.

Table 6.9 Risk matrix for sewage treatment works

IMPACT	*Sig: > 30,000 cumecs effluent dry weather flow*	Medium Risk	**High Risk**	**Very High Risk**
	Mod: 5,000 to 30,000 cumecs effluent dry weather flow	Low Risk	Medium Risk	**High Risk**
	Low: < 5,000 cumecs effluent dry weather flow	Negligible Risk	Low Risk	Medium Risk
		Very Low	*Low*	*Medium/High*
		LIKELIHOOD		

NB. This is Table 6.12 in the MCM 2013

Table 6.10 Risk matrix for water supply

IMPACT	*Sig: > 20,000 population supplied or PSL customers*	Medium Risk	**High Risk**	**Very High Risk**
	Mod: 5,000 to 20,000 population supplied	Low Risk	Medium Risk	**High Risk**
	Low: < 5,000 population supplied	Negligible Risk	Low Risk	Medium Risk
		Very Low	*Low*	*Medium/High*
		LIKELIHOOD		

NB. This is Table 6.13 in the MCM 2013

Transport

Table 6.11 Total resource costs of travel as a function of speed (pence/km) (updated to 2025 values)

Total resource costs (pence per km)								
Speed (km/hr)	**5**	**10**	**20**	**40**	**50**	**80**	**100**	**120**
Car average p/km	366	185	98	54	46	31	28	25
LGV average p/km	429	223	118	67	57	43	40	38
OGV1 p/km	472	251	137	78	67	52	-	-
OGV2 p/km	603	327	184	111	96	77	-	-
PSV p/km	2715	1391	729	394	327	-	-	-

Data supplied by the Department for Transport (2012)

This is Table 6.15 in the MCM 2013

Department for Transport (2012) 'UNIT 3.5.6: Values of Time and Vehicle Operating Costs', Transport Analysis Guidance (TAG), October 2012, Department for Transport, London. This is now restructured into the following TAG guidance, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1102785/tag-unit-a1.3-user-and-provider-impacts.pdf, accessed 1 April 2026.

Table 6.12 Indicative delay durations at different return periods

Likelihood of flooding	Delay duration (Hours)
Up to and including the 5-year return period (0.2%)	6
Up to and including the 10-year return period (0.1%)	6
Up to and including the 25-year return period (0.04%)	12
Up to and including the 50-year return period (0.02%)	24
Up to and including the 100-year return period (0.01%)	48
Up to and including the 200-year return period (0.005%)	96

This is Table 6.17 in the MCM 2013

Table 6.13 Speed-flow relations

Road type	**Free Flow speed (kph)**	**Free Flow limit (pcu/h/lane)**	**Limiting capacity (pcu/h/lane)**	**Speed at Limiting Capacity (kph)**
	VC	QC	QM	VM
	Free flow speed	Speed falls linearly over this range		
Rural motorway	90	1800	2600	76
Rural dual carriageway	79	1600	2400	70
Rural all purpose road	70	400	1800	57
Rural all purpose road – poorly aligned	50		600	50
Urban motorway	80	1700	1400	66
Urban dual carriageway				
With limited access and 80 kph limit	65	1400	2200	56
65 kph speed limit	50	600	1100	30
Urban single carriageway road				
outer area	45	500	1000	25
intermediate area	35	350	600	25
central business area	25	250	500	15
Suburban – major radial or outer ring roads				
No major intersections	Speed limit		2000	47
< 1 major intersection per km			1700	27
1-2 major intersection per km			1200	20

Source: Department for Transport (1981)
Department for Transport has confirmed that these 1981 values are still applicable.

NB. This is revised Table 6.16 in the MCM 2013

Department for Transport (DfT) (1981) Traffic Appraisal Manual, Department for Transport, London

NB: This has been corrected for the 2019 MCH. A formatting error was present for the final three rows and additionally the limiting capacity of an 80 kph limited urban dual carriageway was corrected to read 2200pcu/h/lane.

Table 6.14 Passenger numbers and statistics by Train Operating Company (Franchised companies only)

Train Operating Company	Passenger Journeys per year 2024-2025 (millions)	Passenger Journeys per 24 hours 2024-25 (averaged by dividing by 365)	Passenger kilometres 2024-2025 (millions)	Passenger train kilometres 2024-2025 (millions)	Route Kilometres operated 2024-2025
Avanti West Coast	34.9	95,620	6,608.6	30.5	1,310.0
c2c	37.3	102,154	872.1	6.7	125.5
Caledonian Sleeper	0.3	813	196.6	1.4	1,470.9
Chiltern Railways	22.9	62,771	1,218.2	9.4	349.2
CrossCountry	37.8	103,476	3,272.7	24.9	2,710.1
East Midlands Railway	31.5	86,336	2,515.4	24.8	1,490.3
Elizabeth line	242.9	665,388	2,379.8	12.0	118.0
Govia Thameslink Railway	298.0	816,322	8,085.6	59.2	1,149.0
Grand Central	1.7	4,701	455.6	2.8	518.0
Great Western Railway	89.0	243,912	6,209.1	46.8	1,997.0
Greater Anglia	81.8	224,133	3,612.9	28.0	511.0
Heathrow Express	4.3	11,736	110.3	1.4	29.0
Hull Trains	1.6	4,305	354.9	1.6	344.4
London North Eastern Railway	26.6	72,975	6,154.4	23.6	1,404.4
London Overground	180.4	494,150	1,247.6	11.4	173.7
Lumo	1.4	3,790	606.1	2.1	629.6
Merseyrail	29.9	81,886	542.4	6.3	122.0
Northern Trains	91.8	251,446	2,701.6	51.0	3,180.0
ScotRail	84.7	232,069	2,630.0	42.4	3,129.9
South Western Railway	165.6	453,759	4,889.8	35.3	997.8
Southeastern	137.9	377,837	3,779.2	32.4	748.3
TfW Rail	31.3	85,781	1,207.5	25.6	1,826.6
TransPennine Express	27.5	75,407	2,106.1	19.6	1,358.7
West Midlands Trains	67.7	185,409	2,811.1	24.3	899.6

Source: Data downloaded from the ORR National Rail Trends Portal (2026)

NB: Train operating companies change as franchises generally operate over a fixed period. * These data have also changed since the MCM (2013) as the ORR National Rail Trends Portal no longer provide data on 'timetabled train kms', but rather on 'passenger train kms.'

These data have been updated to the most recently available figures (2024/2025). The rail usage data reporting no longer discusses the impact of the pandemic and it is assumed that rail data is now reflective of altered working and travel patterns.

As these data were collected for the 2024/2025 period and operators may since have changed, it is suggested that users access the Rail Trends Portal at time of use.

Office of Rail Regulation (ORR) (2026) 'The National Rail Trends (NRT) Portal', http://dataportal.orr.gov.uk/, accessed 01 April 2026.

Table 6.15 Percentage delay/cancellation due to flooding (Posford Duvivier et al., 2002)

Rail Service	Delay %	Cancellation %
Passenger service	40	60
Freight service	45	55

NB. This is Table 6.19 in the MCM 2013

Table 6.16 ***Indicative compensation values for performance delays and cancelled services (data from Network Rail)***

Actual compensation values for each of the Train Operating Companies (TOCs) and Freight Operating Companies (FOCs), as agreed in the Track Access Agreements, are restricted information. Therefore, these indicative values are based on data of the actual delay costs and cancelled services between 2011 and 2013.

	Delay compensation value £s per minute per service *			**Cancellation compensation value £s per service cancelled****		
	Low value (£)	Medium value (£)	High value (£)	Low value (£)	Medium value (£)	High value (£)
Passenger services	40	71	97	673	2034	2591
Freight services	-	18	-	-	1900	0

NB. This is Table 6.20 in the MCM 2013

* Including a delay multiplier of 3
** Including a cancellation multiplier of 3

These delay multipliers have been applied according to the Department for Transport (2009) which Burr (2008, 46) argues is "used by the rail industry to recognise that unexpected delays are more costly to passengers".

Burr, T. (2008) *Reducing passenger rail delays by better management of incidents*, report by the comptroller and auditor general, HC 308, Session 2007-2008, 14 March 2008, National Audit Office, The Stationary Office, London, https://webarchive.nationalarchives.gov.uk/ukgwa/20170207052351/https://www.nao.org.uk/wp-content/uploads/2008/03/0708308es.pdf, accessed 15 April 2026.

Department for Transport (2009) 'Unit 3.5.7: The Reliability Sub-Objective', *Transport Analysis Guidance (TAG),* April 2009, Department for Transport, London. This is now restructured into the following TAG guidance https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1102785/tag-unit-a1.3-user-and-provider-impacts.pdf, accessed 15 April 2026.

Table 6.17 Values of Time - based on the willingness to pay of each type of passenger per hour (2026 values)

	Value of time* (VoT) £ per hour		
	Business passenger	Commuter	Other passenger
Original values per hour	£57.97	£7.98	£7.02
Uplifted to account for an unexpected delay**	£173.92	£23.95	£21.07

NB. This is Table 6.21 in the MCM 2013

*The resource cost estimate has been utilised in this instance as these values net of indirect taxation. Department for Transport (2012) have been updated utilising HM Treasury (2026) GDP Deflator (March 2026).

** The values have been uplifted by applying the 'delay multiplier' factor of 3.0 (Department for Transport, 2009) which Burr (2008, 46) argues is "used by the rail industry to recognise that unexpected delays are more costly to passengers".

Burr, T. (2008) Reducing passenger rail delays by better management of incidents, report by the comptroller and auditor general, HC 308, Session 2007-2008, 14 March 2008, National Audit Office, The Stationary Office, London, https://webarchive.nationalarchives.gov.uk/ukgwa/20170207052351/https://www.nao.org.uk/wp-content/uploads/2008/03/0708308.pdf, accessed 1 April 2026.

Department for Transport (2009) 'Unit 3.5.7: The Reliability Sub-Objective', Transport Analysis Guidance (TAG), April 2009, Department for Transport, London, This is now restructured into the following TAG guidance https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1102785/tag-unit-a1.3-user-and-provider-impacts.pdf, accessed 1 April 2026.

Department for Transport (2012) 'UNIT 3.5.6: Values of Time and Vehicle Operating Costs', Transport Analysis Guidance (TAG), October 2012, Department for Transport, London. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1102785/tag-unit-a1.3-user-and-provider-impacts.pdf, accessed 1 April 2026.

HM Treasury (2026) 'Latest figures, GDP deflators at market prices, and money GDP', https://www.gov.uk/government/statistics/gdp-deflators-at-market-prices-and-money-gdp-march-2026-quarterly-national-accounts, accessed 1 April 2026.

Table 6.18 ***Percentage breakdown of the journey purpose of rail travellers by Train Operating Company* and grouped train operators in 2025*****

Train Company	Commute	Business	Personal/Leisure
Avanti West Coast	28	16	56
c2c	44	6	50
Chiltern Railways	30	14	55
CrossCountry	22	14	64
East Midlands Railway	24	13	63
Elizabeth Line	41	12	46
Eurostar	36	12	52
Gatwick Express	28	11	61
Grand Central	47	10	43
Great Northern	29	8	62
Great Western Railway	24	10	66
Greater Anglia	29	10	61
Heathrow Express	29	26	44
Hull Trains	26	12	62
London North Eastern Railway	26	15	59
London Northwestern Railway	40	13	47
London Overground	42	8	50
Lumo	11	2	87
Merseyrail	28	4	69
Northern	30	5	65
ScotRail	32	8	59
South Western Railway	32	8	60
Southeastern	39	7	54
Southern	38	6	55
Thameslink	36	7	56
TransPennine Express	21	12	67
Transport for Wales	34	5	60
West Midlands Railway	38	6	56
Grouped train operators	**Commute**	**Business**	**Personal/Leisure**
Long distance operators	25	14	61
London and South East operators	35	8	57
Regional operators	31	6	63

Source: Passenger Focus (2025) **NB. This is Table 6.22 in the MCM 2013**

* Please note that where operating franchise companies have changed between the surveys conducted, the data from the old and new operators have been merged to create this annual percentage. Data on journey purpose is also available for some specific routes and can be accessed in the datasets presented in the links below.

** These data have been updated to values provided by the Transport Focus *Rail User Survey* data. The latest available data are surveys undertaken in the period August 2024 to July 2025 (inclusive). In July 2025 the *National Passenger Survey* ceased and was replaced by the *Rail Customer Experience Survey*. However, as of April 2026 a full year's worth of data has not been collected and so as yet is unable to be used to provide average annual values of journey purpose.

Transport Focus (2025) 'National Passenger Survey data' https://transportfocusdatahub.org.uk/, accessed 06 April 2026.

Table 6.19 Percentage breakdown of the journey purpose of rail travellers by region (2010 data)

Region	Commuting	Business	Leisure
Scotland	59	11	30
Wales	50	12	38
North East	40	21	39
North West	53	12	35
Yorkshire and Humberside	54	14	32
East Midlands	49	17	33
West Midlands	55	14	31
East of England	67	12	21
London	69	12	19
South East	63	13	24
South West	46	19	34
Great Britain	63	13	24

NB: the percentages do not equal 100 due to rounding
Source: Department of Transport (2010)

Department for Transport (2010) 'National Rail Travel Survey Overview Report, Updated December 2010 Results from a survey of rail travel across Great Britain' https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/73094/national-rail-travel-survey-overview-report.pdf, accessed 30 April 2026.

Education and Health

Table 6.20 Estimates of the value of a lost day's work – 2026 estimates

Minimum estimate*	Average estimate
£83.09	£111.493

*The minimum estimate is calculated using the £12.71 per hour National Living Wage (April 2026) for an adult and a 7.6 hour working day.

The average estimate is calculated using a median hourly wage for a full-time adult (excluding overtime) in April 2025 of £17.90 and a 7.6 hour working day (ONS, 2025).

The minimum estimate has been adjusted from gross pay values using HMRC (2026) to provide economic values net of Income Tax and National Insurance Contributions.

HMRC (2026) 'HMRC Tax Calculator', https://www.gov.uk/estimate-income-tax, accessed 06 April 2026.

Office for National Statistics (ONS) (2025) 'Annual Survey of Hours and Earnings, 2025 Provisional Results' ASHE: Table 6.6a, 23 October 2025, https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/earningsandworkinghours/datasets/agegroupashetable6, accessed 05 April 2026.

Table 6.21 Average cost(s) of a hospital bed

	Average bed cost in the NHS [1]	Average bed day cost for elective and admissions [2]	Average bed day cost for non-elective admissions [2, 3]	Average bed day cost for critical care [2]
Average cost of a bed per day	£345	£2,349	£901	£1,881

These values have been presented by the Minister of State (Department of Health and Social Care) in a written response to a question raised in Parliament (Quince, 2023). They have been calculated using the 2020/21 NHS cost data.

[1] The standard bed costs the average cost of a bed day excluding any treatment costs.

[2] The figures for critical care and elective and non-elective beds include the cost of treatment.

[3] Patients who are admitted as non-elective admissions often spend longer in hospital (inc. recovery and waiting for discharge), so whilst the total costs for non-elective treatment is higher than elective treatment, the average day cost is reduced as it is spread over many more days.

NB: These data provide the most updated values for average bed cost provided by the NHS reference cost data. The latest updated publicly available National Schedule of NHS Costs data (2024/26) does not provide values for average bed costs. However, users are advised to check recent information to see if these have been updated NHS England https://www.england.nhs.uk/costing-in-the-nhs/national-cost-collection/.

Furthermore, users should refer to these data and the specific services provided by hospitals at risk to identify the potential disruption and associated costs caused by flooding.

2020/2021 NHS National Cost Collection Data https://www.england.nhs.uk/publication/2020-21-national-cost-collection-data-publication/, accessed 05 May 2026.

Quince, W. (2023) Hospital Beds: Costs. Department of Health and Social Care written question – Question for Department of Health and Social Care UIN 165361, tabled on 14 March 2023 and answered on 30 March 2023. UK Parliament 2024 https://questions-statements.parliament.uk/written-questions/detail/2023-03-14/165361#, accessed 05 May 2026.

Table 6.22 Indicative costs per patient transfer – 2012/13 estimates for mileage and 2024/2025 estimates for fixed and time costs.

Ambulance costs vary depending upon whether a journey is made as part of a contract or as a private journey, a cost per hour, the distance travelled and includes a minimum cost. Additionally, there are additional charges for long journeys (over 300 miles return) and on public holidays.

Appraisers will need to identify alternative sites for healthcare provision and the distance (in miles) to that location. It appears that this should also include the return journey as the ambulance will be required to return to its base. This distance should be multiplied by the costs per mile (which is approximately £0.30) to calculate the total mileage costs.

These can then be added to either of the fixed and time costs in the table below. There is a minimum charge for any ambulance transfer which might be used as a minimum indicative cost. However, this would only be applicable for journeys which are undertaken in less than one hour.

Above this minimum, the costs rise according to the circumstances of the transfer, how long it takes and the day on which it occurs. Therefore, a second higher indicative value is presented in the table below which is based on the following assumptions:

- Only NHS patients transferred
- The distance to the alternative supplier is less than 150 miles (and therefore does not incur the additional charge)
- That the transfer does not occur on Statutory Bank holidays
- That the transfer takes a total of 1.5 hours (including waiting time)

Cost type	Minimum value	Higher indicative value
Fixed costs and time costs	£364	£489
Mileage costs	Number of miles x 0.30 per mile	Number of miles x 0.30 per mile

Data provided by the London Ambulance Service NHS Trust in 2012/2013 values for the mileage costs. The Fixed costs and time costs have been updated using the 2024/25 NHS Reference costs (https://www.england.nhs.uk/costing-in-the-nhs/national-cost-collection/) based on the principles provided by the London Ambulance Service NHS Trust.

Local Authority and Emergency Services

Table 6.23 ***Overall emergency costs as applicable to project appraisals (Summer 2007 Floods)***

Emergency costs applicable to project appraisals (based on Summer 2007 Floods - England)			
Cost item	**Amount**	**Allowed* amount (%)**	**Allowed amount**
Total Bellwin and roads:			
Bellwin	£30.20	42.5	£12.84
Roads infrastructure	£175.00	50	£87.50
Environment Agency costs+:			
Emergency repairs**	£14.80	50	£7.40
Emergency response	£2.20	100	£2.20
TOTAL	**£222.20**		**£109.94**
As % of economic property losses of £1,942m = 5.57%			

* Judged to be proper economic costs, not counted elsewhere in Benefit-Cost Analyses. The figure for roads recognizes some betterment after repair (hence the 50% taken).
** As for roads, some element of betterment here, hence 50% taken.
+ England and Wales

Chatterton, J. Viavattene, C., Morris, J., Penning-Rowsell, E., Tapsell, S. (2010) The costs of the summer 2007 floods in England. SC070039/R1. Environment Agency: Bristol.

8 Recreational gains and losses

Tables and figures

Table 8.1: Sources and methods of information on recreation users/beneficiaries

Table 8.2: Examples of visit numbers used for benefit assessment purposes

Table 8.3: £ gains and losses per adult visit with coastal protection scheme options at coastal sites

Table 8.4: £ value of losses and gains per visit for various changes at river sites

Table 8.1 Sources and methods of information on recreation users/beneficiaries

Source/ method		Comments
1	Long period counts using people counters	Infra-red or other counters installed over a period (at least March to September). Counters are manually calibrated to relate passages to adult visits. Mainly applied in detailed studies: in conjunction with a CV survey – see MCM, Section 8.5.3 (Penning-Rowsell et al., 2013).
2	Short period manual counts/ surveys	Manual counts/surveys over a period of days normally including the August Bank holiday. At initial stage, this method might be combined with site visits and at detailed study stage, with the CV survey.
3	CV survey data	CV survey data on the frequency of visiting by local residents in conjunction with census data on the number of adult residents and staying visitors (in conjunction with managers' estimates of occupancy rates) can be used to generate visit number estimates. However, the tendency of survey respondents to overstate their visiting frequency has to be noted - see the Corton Case Study in the MCM, Section 8.7 (Penning-Rowsell et al., 2013).
4	Old survey/ count data for the project	Planning, tourism or recreation departments of local authorities or local colleges or schools may have undertaken surveys or counts at the project site in the past, which can be updated to indicate current levels of use.
5	Inferred estimate	The number of visits to a coastal or river site is inferred from counts of visits to a related site nearby such as: Car and coach parks multiplied by the average adult car or coach occupancy rate (Hengistbury Head), funfair, cafe, visitor centre, historic site or museum (Hurst Spit and Hurst Spit castle). This requires estimating the proportion of all visitors to the project site who also use the counted site and vice versa. At detailed level, this can be done in conjunction with the CV survey.
6	Visitor equations	A number of equations have been developed which predicts-distance-frequency functions so that from census data on the population in different zones a prediction can be made as to the number of visitors generated by the site.
7	Estimates from an informed persons or source	Written, telephone or personal contacts with: Car park attendants, park rangers/wardens, visitor centre staff, staff at associated visitor attractions, local authority tourism, sport and recreation or planning staff, regional or local offices of organisations such as the English Tourist Board, National Trust or English Heritage and their Welsh equivalents, the Environment Agency's recreation and fisheries staff, managers of general recreation or staying visitor facilities or tourism business organisations that may have information on bedspaces and occupancy rates - see the Corton Case Study in the MCM, Section 8.7 (Penning-Rowsell et al., 2013); both commercial and club managers of specialist facilities (e.g. sailing, boating/sailboarding, fishing, birdwatching) and specialist organisations at national regional and local level for information on the availability of alternative sites e.g. for caravans or sailing.
8	Average number of visits to equivalent sites	This benefit transfer approach is only suitable for initial and strategic studies. The number of adult visits to the project site is estimated as being of the same order as the number of visits made to an equivalent site. However, there are few sites for which good data are available and little research to enable reliable identification of an equivalent site.

Table 8.2 Examples of visit numbers used for benefit assessment purposes

Site*		**Annual visit numbers**	
Name	**Characteristics**	**High estimate**	**Low estimate**
Undeveloped coastal sites			
Hengistbury Head, Christchurch, Dorset	Natural headland, a SSSI, with nature, geology and archaeology sites	609,000	584,000
Hurst Spit, Hampshire	Undeveloped shingle spit with heritage site, Hurst Castle	107,000	880,000
Developed coastal sites			
St Mildred's Bay, Westgate, Kent	Small resort with promenade and sandy beach	212,000	-
Cliftonville, near Margate Kent	Small resort with clifftops and a mainly sandy beach	146,000	136,000
Corton, near Lowestoft, Suffolk	Small village resort with cliffs and partly sandy beach	97,000	75,000
River sites			
Local park	Park drawing visitors from 800m radius with no special attractions	30,000	60,000
'Honey pot' site, country park	Site drawing visitors from a 3 km radius	60,000	250,000

* At all these sites, both coastal and riverine, almost all the visits involved informal use of the site for activities such as sitting, sunbathing and picnicking, strolling, dog walking, and, at coasts, playing informal games, playing in the sand and swimming or paddling. Very few visits involved specialist uses such as angling or boating or sailboarding.

Table 8.3 £ gains and losses per adult visit with coastal protection scheme options at coastal sites

		£ per adult visit updated to 2026	
		Mean gain with options	Mean loss with 'Do nothing'
Beach and promenade erosion			
Yellow Manual Standard data: 4 sites	Nourished beach and promenade	4.35	10.47
Lee-on-Solent	(a) Shingle beach renourishment	2.49	5.39
	(b) Rock groynes with shingle beach renourishment	2.44	
Herne Bay Visitors Centre	(a) Reef or jetty with no boat facilities	7.33	10.08
	(b) Reef or jetty with boat facilities	3.80	
	(c) Higher seawall, and promenade, rock groynes	-4.70	
Cliftonville	(a) Concrete lower promenade	6.54	10.08
	(b) Rock lower promenade	3.86	
Corton	(a) Hold the line for a limited period. Short term protection to cliff, limited access to beach and along seawall	3.75	3.78
	(b) Hold the line for a longer period >50 years. Full access along renewed seawall and onto all the beach from village	16.78	
	(c) Managed retreat. Sea defences and seawall removed to leave a 'natural' seafront', direct access from village to beach	2.62	
St Mildred's Bay	Improved beach and promenade	4.10	15.09
Hastings	Beach improvement	0.00	10.67
Breach Scenarios			
Hengistbury Head	(a) 5 rock groynes full cliff protection	0.06	6.28
	(b) 3 rock groynes partial protection	-3.53	
	(c) Beach nourishment Annual disruption	-5.30	
Hurst Spit	Slightly enlarged shingle spit	0.98	9.48

NB. This is Table 8.7 in the MCM 2013

Table 8.4 £ value of losses and gains per visit for various changes at river sites

Site	£ mean value of loss: updated to 2026	£ mean value of gain: updated to 2026
River Misbourne: Low flows		
Visitors	6.66	3.89
Residents	6.65	3.30
River Wey: Low flows		
Residents		3.78
River Ravensbourne: Full River restoration		
Visitors and residents		3.48
River Skerne: River restoration		
Residents		4.42

NB. This is Table 8.8 in the MCM 2013

9 Appraisal of flood risk management for agriculture

Tables and Figures

Figure 9.1 Flooding and drainage factors influencing agricultural productivity on floodplains in England and Wales

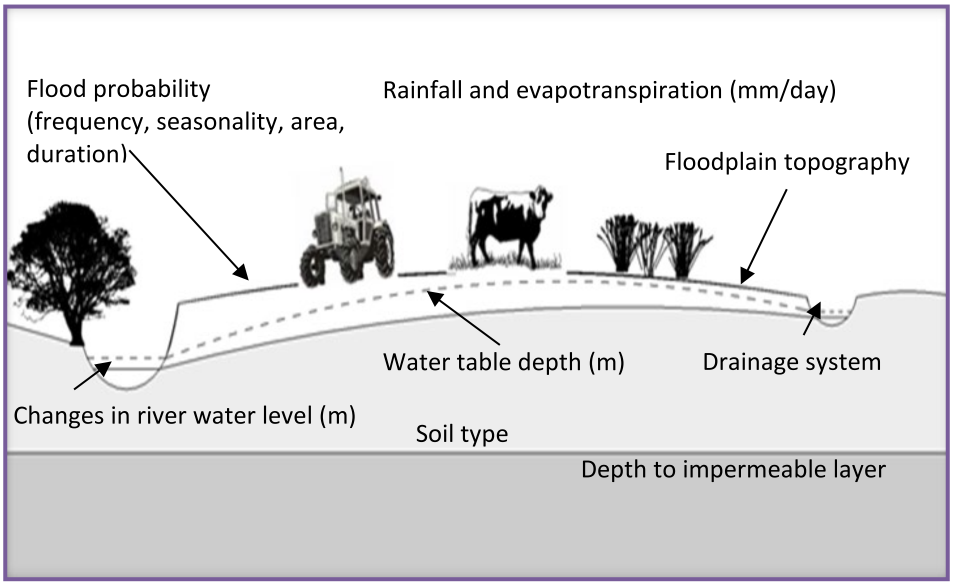

Table 9.1 General tolerance of flooding by agricultural land use in England and Wales

Agricultural land use Type	Common minimum acceptable flood frequency: annual probability	
	Whole Year	April-October
Horticulture and field scale vegetables	5%	1%
Intensive arable including sugar beet and potatoes	7%-10%	4%
Extensive arable: cereals, beans, oil seeds	10%-15%	7%-10%
Intensive grass: improved grass, usually dairying	50%	20%
Extensive grass, usually cattle and sheep	≥100%	33%

Table 9.2 Drainage conditions for agriculture and water levels in fields and ditches In England and Wales

Agricultural drainage condition	Agricultural productivity class	Depth to water table from surface	Springtime freeboard [1] in water-courses (natural drainage)	Springtime freeboard [1] in water-course (field drains)
Good: 'rarely wet'	Normal, no impediment imposed by drainage	0.5 m or more	1 m sands 1.3 m peats 2.1 m clays	1.2m clays to 1.6m sands (0.2m below pipe outfall)
Bad: 'occasionally wet'	Low, reduced yields, reduced field access and grazing season	0.3 m to 0.49 m	0.7 m sands 1 m peats 1.9 m clays	Temporarily submerged pipe outfalls
Very bad: 'commonly or permanently wet'	Very low, severe constraints on land use, much reduced yields, field access and grazing season: mainly wet grassland	Less than 0.3 m	0.4 m sands 0.6 m peats 1 m clays	Permanently submerged pipe outfalls

Notes to table:
1. Freeboard refers to the mean difference between water level and adjacent field level

Table 9.3 Common farming performance and field drainage conditions in England and Wales (these 2026 values are based on £2024 derived estimates uplifted using ONS GDP deflator)

£ 2026 Values	Field Drainage Conditions		
	Good	Bad	Very Bad
Arable			
Yield as % of 'good' category			
Winter wheat and barley	100	80	50
Spring wheat and barley	100	90	80
Oil seed rape	100	90	80
Potatoes, Peas, Sugar Beet	100	60	40[1]
Wheat financial gross margin [2] £/ha/year	£1271-£1589	£847-£1059	£349-£455
Grassland			
Typical nitrogen use kg N/ha/year	150 - 200	50 – 75	0 - 25
Grass conservation	2 cut silage	1 cut silage or graze	1 cut hay or graze
Typical stocking rates [3]; Livestock units/ha/year	1.7 - 2.0	1.2 - 1.4	0.7 - 1.0
Typical livestock type	Dairy, intensive beef and sheep	Beef cows, 24-month beef, sheep	Fattening of 'store' cattle, and sheep
Financial gross margins[2] £/ha/year (after forage costs)	£2,331-£3,178 (dairy) £635-£1006 (intensive beef/sheep)	£455-£667	£264-£455
Days reduction in grazing season compared to 'good' category[4]	none	Spring: 14 to 21 Autumn: 14 to 21	Spring: 28 to 42 Autumn: 28, no stock out in winter

Notes to table:
1. Not grown if persistently 'very bad'.
2. Gross Margins estimates based on Defra Farm Business Survey data 2018/19 to 2022/23, weighted by GDP deflators to 2024 and 2026 prices, see Table 9.5
3. Livestock units (Lu): dairy cow, 1 Lu; beef cow, 0.8 Lu; 24-month beef, 0.7 Lu; sheep plus lambs, 0.14- 0.17 Lu.
4. A grazing day is worth about £3.2/Lu in spring/summer, £1.6/Lu in autumn, and £0.8/Lu in winter in terms of savings in housing costs and feed conservation costs.

Table 9.4 The Impacts of flooding on farmland by type of agricultural land use and the seasonality of flooding in England and Wales

	Spring	Summer	Autumn	Winter
	March – May	June- August	September – November	December – February
Horticulture (soft fruits, salad crops)	Complete loss of soft fruits and winter/spring salads	Complete loss of annual production, possible loss of perennial stock	Loss of late season harvest, possible loss of perennial stock: replanting/reseeding	Damage to standing crops, annuals /perennials
Intensive Agriculture (including field vegetables & roots)	Delay in planting or loss of established crops	Likely complete loss of standing root crops e.g. potatoes/onions/carr ots	Loss of unharvested autumn crops, notably potatoes. Delayed planting or loss of winter crops, substituted by spring sown crops	Possible loss of winter harvest crops (sprouts, and sugar beet). Yield loss on autumn sown crops
Extensive arable (cereals and oil seeds)	Loss or delay of spring sown cereals, yield loss on winter sown cereals, delayed spring treatments	Complete or partial loss of unharvested crops	Loss of unharvested autumn crops. Delayed planting or loss of winter crops, substituted by spring sown crops	Yield loss on autumn sown crops, reseeding with spring sown crops if severe damage
Grassland: intensive (mainly dairy)	Loss of grass yields, delayed stock turnout, delay fertiliser applications. Grass reseeding if long duration flooding	Loss of grass yields, partial or complete loss of hay/silage crop, loss of grazing, stock morbidity/mortality. Grass reseeding if long duration flooding	Loss of autumn grazing, stock relocation /housing. Possible reseeding if long duration.	Loss of winter 'accommodation' pasture.
Extensive (mainly beef and sheep)	Loss of grass yields, delayed stock turnout, delayed fertiliser applications.	Loss of grass yields, partial or complete loss of hay/silage crop, loss of grazing, stock morbidity/mortality.	Loss of autumn grazing, stock relocation /housing.	Limited impact on flood tolerant grass swards

Table 9.5 Estimated Financial and Economic Gross Margins and Net Margins (£/ha/year, 2026 prices) for wheat and selected farm types in England (these 2026 values are based on £2024 derived estimates uplifted using ONS GDP deflator)

	£ 2026 values		**Winter Wheat[3]**	**Cereals (Extensive Arable)**	**General Cropping (Intensive Arable)**	**Dairy (Intensive Grass)**	**Lowland Grazing (Extensive Grass)**
	Financial assessment [1,2]						
a	*Gross Output*	*£/ha/year*	2,070	1,538	2,021	5,078	1,046
b	*Variable Costs*	*£/ha/year*	664	625	874	2,658	545
c	*Gross Margin (a-b)*	*£/ha/year*	1,406	913	1,147	2,420	501
	Fixed Costs (including rent, excluding unpaid labour)						
d	*Semi-fixed Costs*	*£/ha/year*	324	264	353	634	217
e	*Total Fixed Costs*	*£/ha/year*	897	750	989	1805	623
	Financial Net Margin[4]						
f	*After semi fixed costs (c-d)*	*£/ha/year*	1,081	648	793	1,785	283
g	After full fixed costs (c-e)	*£/ha/year*	508	163	157	614	-122
	Adjustment to Financial Net Margin [5]						
h	Plus Farm rents	*£/ha/year*	134	112	163	264	89
i	Less unpaid family labour	*£/ha/year*	178	148	112	417	386
j	Subtotal (h-i)	*£/ha/year*	-45	-38	50	-153	-298
	Adjusted Financial Net Margin (excluding income subsidies)						
k	after semi fixed costs (f+j)	*£/ha/year*	1037	611	844	1632	-14
l	After full fixed costs (g+j)	*£/ha/year*	464	126	208	461	-419
	Economic Assessment [6]						
	Adjustment for high value crops and dairy		None	None	High value crop area treated as wheat	Dairy area treated as wheat	None
	Gross Margin (c weighted by wheat area)	*£/ha/year*	1,406	913	1,199	1,224	501
	Net Margin						
	After semi fixed costs (k weighted by wheat area)	*£/ha/year*	1037	611	882	826	-14
	After total fixed costs (l weighted by wheat area)	*£/ha/year*	464	126	259	287	-419
	Range high [7]	*£/ha/year*	696	189	389	431	-210
	Range low	*£/ha/year*	232	63	130	144	-629

Notes to table:

1. Estimated mean annual values in 2024 prices derived from Regional Farm Business Survey (FBS) mean annual values, for England (all farms by type) 2018/19 to 2022/23. weighted by GDP deflators (ONS, 2026)
2. Farm type classifications are based on the proportion of Total Output by value attributable to given enterprises, where more than 67% of total output by value is attributable to particular crop or livestock enterprises, namely Cereals (cereals and

combinable crops such as field peas and beans, and oils seeds), General Cropping (arable crops including field scale vegetables), Dairy (milk production) and Grazing Livestock (beef and sheep).
3. Wheat: average yields 8.6 t/ha (2018/19 - 2022/23), average price 2024 (weighted) £217/t. The 10-year (2014/15-2023/24) GDP weighted price for wheat is £212/t in 2024 prices. Average total fixed costs (£/ha/year) for Winter Wheat are about 20% higher than the overall average for Cereals farms based on FBS crop production data.
4. Net margins here are the same as the Farm Business Income estimates derived by the Farm Business Survey and used in reporting Farm Incomes (Defra, 2024a). Net margins here show the financial returns generated by 'agricultural' activities, excluding income from subsidies and other sources, including land rents paid and paid wages and salaries but excluding charges for family labour. Basic Payment Scheme direct income subsidies averaged £117/ha/year in 2024 for eligible land. Agri-environment payments currently average about £40/ha/year on Lowland Grazing Livestock Farms.
5. For economic analysis, land purchase and/or rental costs are excluded, and unpaid familiar labour is included at equivalent cost. No deduction has been made here for National Insurance costs on labour, averaging about 10% of labour costs.
6 For economic analysis, the areas given to high value cropping and dairy production are treated as equivalent areas of a wheat crop. About 20% of cropping on General Cropping farms comprises high value root and field vegetable crops. About 80% of the area on Dairy farms directly supports milk production with the balance is for livestock rearing and fattening. These proportions can be treated as wheat equivalents. Detailed assessment of enterprise types and performance is recommended to allow for local variation.
7. The high to low range in estimated Net Margin is approximately +/-50% of the central estimate reflecting top and bottom quartile means and variations of between a 12% and 15% change in either Gross Output or Total Costs (£/ha/year).

Table 9.6 Defra guidance for the appraisal of alternative agricultural FCERM scenarios [1]

	Scenario I	**Scenario II**	**Scenario III**
	Land lost to agriculture	**Temporary, one-off loss of agricultural output**	**Permanent change in the value of agricultural output**
All agricultural land use	Loss equivalent to market value of land less £600/ha (2008 prices) [2] to reflect 'single payment' subsidies where received (no adjustment on land for fruit and vegetables)		
Crops: Cereals; oilseeds; beans/ peas. **Grassland:** Beef and sheep		Loss of Gross Margins £/ha/year (adjusted for possible savings in costs), plus clean-up costs	Change in Net Margins £/ha/year associated with change in flood and land drainage conditions
Other: Dairy; sugar beet; potatoes; high value fruit/ vegetables		As above, treated as though area occupied by wheat	As above, treated as though area occupied by wheat

Notes to table:
1. Following Defra (2008) Guidance (See also Tables 9.4 and 9.5 above)
2. £927/ha in 2026 prices

Table 9.7 Estimated economic cost of freshwater and saline flooding (£/ha in 2026 prices) for a single event of a given duration in weeks by land use and associated farm types in England (these 2026 values are based on £2024 derived estimates uplifted using ONS GDP deflator)

	Drainage condition	Freshwater flooding and duration [3]		Saline flooding and duration [2]	
Land Use Type [1, 2]		1 to 2 weeks	2 to 4 weeks	1 to 2 weeks	2 to 4 weeks
1. Extensive Grass. Lowland Grazing livestock	Good	79	288	382	935
	Bad	67	245	353	870
	Very Bad	41	171	104	242
2. Intensive Grass. Mainly Dairy	Good	120	430	464	1,156
	Bad	82	374	405	1,068
3. Grass/ Cereal Rotation. Dairy/Cereal mixed	Good	376	873	727	1,462
	Bad	242	584	532	1,132
4. All Cereal	Good	631	1314	992	1,768
	Bad	401	795	660	1,197
5. Extensive Arable, crops harvested by combine harvester	Good	636	1340	992	1,750
	Bad	411	827	704	1,238
6. Intensive Arable with root crops (sugar beet and potatoes)	Good	985	1,666	1,306	2,721
7. Intensive Arable with specialist root crop and field scale vegetable production	Good	2,448	3,409	3,784	6,741

Notes to table:
1. Indicative associated Agricultural Land Classification Grade (ALC) by land use are as follows. Land use 1: ALC 4. Land use 2 and 3: ALC 3a and b. Land use 4 and 5: ALC 3a. Land use 6: ALC 2. Land use 7: ALC 1.
2. Average arable crop yields for land use and ALC associations are assumed relative to ALC 3, at + 15% for ALC 1, +10% for ALC 2 and -15% for ALC 4, but local conditions vary substantially and should be checked.
3. Assumes monthly distribution of flood probability for all England, with weighted monthly flood costs that vary according to land use and estimated monthly loss and damage to crops and livestock according to production cycles

Table 9.8 Estimated economic cost of flooding (£/ha in 2026 prices) in England for a single event of a given duration in weeks by Agricultural Land Classification (ALC) Grade and associated agricultural land use (these 2026 values are based on £2024 derived estimates uplifted using ONS GDP deflator)

ALC grade [1]		Intensive Arable with root and vegetable crops	Intensive Arable with root crops (sugar beet and potatoes)	Extensive Arable: mainly cereals and oils seeds	Intensive Grass: mainly Dairy	Extensive Grass: mainly beef and sheep	Average Flood costs £/ha/event [2]
1	% of area	15	75	10			
	1 to 2 weeks	£2,447	£1,027	£704			£1,207
	2 to 4 weeks	£3,411	£1,732	£1,504			£1,854
2	% of area	5	60	35			
	1 to 2 weeks	£2,341	£985	£683			£948
	2 to 4 weeks	£3,263	1,663	£1,441			£1,690
3a	% of area		30	70			
	1 to 2 weeks		£911	£635			£720
	2 to 4 weeks		£1,536	£1,340			£1,398
3b	% of area			50	50		
	1 to 2 weeks			£603	£137		£370
	2 to 4 weeks			£1,260	£487		£874
4	% of area			20	40	40	
	1 to 2 weeks			£572	£121	£79	£190
	2 to 4 weeks			£1,186	£434	£286	£524
52	% of area					100	
	1 to 2 weeks					£42	£42
	2 to 4 weeks					£169	£169

Notes to table: (estimates are rounded)

1. Broad indicative associations of land use and farm type by ALC Grade for England are assumed that should be verified locally. Flood costs (£/ha) reflect difference in normal yields by ALC Grade relative to ALC Grade 3, namely: ALC Grade 1, 115%; Grade 2, 110%; Grade 3, 100%; Grade 4, 85%.
2. Monthly distributions of flood probability for all England are assumed, with weighted monthly flood costs that vary according to land use and crop, grassland and livestock production cycles.

Table 9.9 A simple example of the economic assessment of flood induced agricultural land use change (these 2026 values are based on £2024 derived estimates uplifted using ONS GDP deflator)

		Existing FCERM service	**Future FCERM options**	
			Option 1: Do Minimum	Option 2: Do Nothing
Flood return period (years) [1]		20	8	1
Land Use		General Cropping	Extensive Arable	Extensive Grass
Drainage condition		Good	Good	Bad
Net Margin [2]	£/ha/year	259	126	-419
Flood cost [3]	£/event	985	631	67
Annual flood cost [4]	£/ha/year	48	79	67
Net Margin less flood costs	£/ha/year	210	47	-487
Change in net benefits relative to Existing FCERM service [5, 6]	£/ha/year		-164	-698

Notes to table:
1. Based on Table 9.1
2. Based on economic Net Margins by land use in Table 9.5
3. Based on Table 9.7, single annual event, duration 1 to 2 weeks
4. A simple average cost for a single flood event is assumed for illustrative purposes rather than a complete estimate of Average Annual Damage (AAD) costs
5. Indicative changes in net annual economic benefits to agriculture at full implementation of FCERM scenario
6. Extensive Grassland Net Margin excludes potential annual agri-environment benefits that should be factored in.

Table 9.10 Weights applied to central estimates of the cost of a single flood occurring in a year (£/ha) to derive estimates of the seasonal cost of flooding on agricultural land in England and Wales

Flood season[1] and duration	Intensive and Extensive Arable		Intensive and Extensive Grass		Rough Grazing	
	Freshwater	Saline	Freshwater	Saline	Freshwater	Saline
1 to 2 weeks						
Winter	0.47	0.71	0.44	1.20	0.49	0.74
Spring	1.21	1.15	2.50	1.76	1.18	2.00
Summer	2.71	1.91	1.75	1.21	1.28	1.12
Autumn	1.38	1.19	1.07	1.37	0.42	0.80
2 to 4 weeks						
Winter	0.69	0.81	0.52	1.18	0.42	0.63
Spring	1.31	1.20	2.32	1.86	1.20	1.79
Summer	1.69	1.45	2.13	1.41	1.00	1.00
Autumn	1.21	1.12	0.80	1.29	0.42	0.63

Notes to table:
1. Winter: December to February inclusive. Spring: March to May. Summer: June to August. Autumn: September to November.

