Department for Environment Food & Rural Affairs

Llywodraeth Cymru Welsh Government

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Environment Agency

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The costs and impacts of the winter 2013 to 2014 floods

Report – SC140025/R1

Flood and Coastal Erosion Risk Management Research and Development Programme

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This report is the result of research commissioned by the Environment Agency's Evidence Directorate and funded by the joint Flood and Coastal Erosion Risk Management Research and Development Programme.

Published by:
Environment Agency, Horizon House, Deanery Road, Bristol, BS1 9AH

www.gov.uk/government/organisations/environment-agency

ISBN: 978-1-84911-372-4

Email: fcerm.evidence@environment-agency.gov.uk.

Further copies of this report are available from our publications catalogue:
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Dissemination Status:
Publicly available

Keywords:
Floods, Economics, Damages, Damages Avoided

Research Contractor:
Risk and Policy Analysts Limited (01508 528465)

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Project Number:
SC140025/R1

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Miranda Kavanagh

Director of Evidence

Executive summary

During December 2013 and March 2014, the UK experienced a sustained period of flooding caused by a continual and highly unusual pattern of winter storms. These events resulted in coastal damage and prolonged flooding. This report aims to quantify the damages caused by this flooding in England and Wales and to separate these out into categories of damages.

Information was collected at the national level and local level to provide the best estimate of damages. Both approaches involved an initial internet search to identify and collect readily available information. This was supplemented by data requests sent to the most important organisations and data holders. A total of 641 individuals and organisations were contacted and over 900 emails were sent. A total of 184 individuals and organisations responded with data on the impacts of the floods.

Over 500 data sources were also reviewed including reports, presentations and spreadsheets, both those that were publically available and those received from the engagement detailed above. These data sources covered a wide range of categories and varied in their level of detail and reliability. This was taken into account when including the information in the quantified estimate of the damages.

The winter 2013 to 2014 flood event was unusual in that it featured a combination of flood types, including coastal and fluvial/groundwater/pluvial flooding. The proportion of damages associated with the different flood types was calculated by associating damages in coastal areas with coastal flooding and damages in inland areas with fluvial/groundwater/pluvial flooding. Efforts were also made to split the damages by country (England and Wales) where possible.

The **best estimate of total economic damages is £1,300 million** in England and Wales for the winter 2013 to 2014 floods, with a range to take account of uncertainty of £1,000 million to £1,500 million).

Damages in England accounted for 91% (£1,200 million, with a range of £930 to £1,400 million) and in Wales for 2% (£28 million with a range of £23 to £33 million). Disaggregation by country was not possible for the categories making up the remaining 7%.

The greatest proportion of damages was felt by residential property holders, with 25% of total damages occurring in this sector (best estimate of £320 million incurred by up to 10,465 properties). A breakdown of the damage estimates by impact category is provided in the table below. Damages from the winter 2013 to 2014 flood event represent around a third of the £3,900 million (uprated to 2014 values) damages from the summer 2007 floods, where 38% was incurred by residential property owners and 23% by businesses. Some of the main differences between the 2013 to 2014 flood and the 2007 events relate to the location, duration, type of event (coastal, fluvial, pluvial, groundwater) and the timing.

The ranges shown in the table below take into account the uncertainty associated with the data used to estimate the damages and assumptions that had to be made to fill data gaps. The ranges are lowest where the data provided were of the highest quality, such as for flood risk management infrastructure where actual cost data were available from the Environment Agency. The ranges are greatest where there is uncertainty over the reliability of the data, especially the extent to which the damages capture just the damages from flooding and not also damages associated with winter storms, such as for transport: roads. Here, grant data were available but it was not clear whether these also included damages caused by other incidents and not just flooding.

Damage estimates by impact category

Category	Damage estimates			
	Best estimate (£ million)	**Percentage of total**	**Possible range (£ million)**	**Uncertainty (relates to the best estimate)**
Residential properties	£320	25%	£270–370	Low–moderate
Businesses	£270	21%	£230–310	Low–moderate
Temporary accommodation	£50	3.9%	£42–57	Low–moderate
Motor vehicles, boats, caravans	£37	2.9%	£31–42	Low–moderate
Local authorities and local government infrastructure	£58	4.5%	£49–66	Low–moderate
Emergency services	£3.3	0.26%	£3.3–8.7	Moderate–high
Flood risk management infrastructure and service	£147	12%	£145–148	Low–moderate
Utilities: energy	£0.82	0.06%	£0.63–1.0	Moderate–high
Utilities: water	£29	2.3%	£25–33	Low–moderate
Transport: road	£180	14%	£91–220	Moderate
Transport: rail	£110	9.0%	£93–140	Moderate
Transport: ports	£1.8	0.14%	£1.6–2.1	Moderate
Transport: air	£3.2	0.25%	£2.6–3.9	Moderate
Other communications (telecom)	No data available			
Public health and welfare	£25	1.9%	£25–67	High
Education	£1.6	0.13%	£1.2–2.0	Moderate–high
Agriculture	£19	1.5%	£12–25	Moderate
Wildlife sites	£2.4	0.19%	£1.9–3.0	Moderate
Heritage sites	£7.4	0.59%	£5.6–9.3	Moderate–high
Tourism and recreation	£3.5	0.28%	£2.6–4.4	Moderate–high
Total	**£1,300**		**£1,000–1,500**	

Notes: Values are given to 2 significant figures, except where additional significant figures are needed to illustrate differences, for example, for the range.

For future assessments, there are a number of further studies that would improve the robustness of the damage estimates and thereby reduce the uncertainty. These studies need to focus on reducing the uncertainty in the data and also improving the basis for assumptions. It is recommended that this can be done by:

- developing data sharing agreements and identifying data champions to improve primary data collection and consistency
- ground truthing map and geographical information system (GIS) data
- carrying out studies to determine the extent to which damages are likely to be transfers, especially tourism impacts
- working with others carrying out studies on the impacts of the floods, including combining the results of research studies where the timetables allow
- carrying out further studies into how the damages avoided could be assessed in a robust and reliable manner

Acknowledgements

The research team thanks the Environment Agency as sponsors of this work and the Project Board, comprising Jonathan Day, Lydia Burgess Gamble (as project manager), Emma Harding, Adrian Philpott, Nick Haigh, Jose Pancelo-Blanco, Emma Formoy, Kevin Gibbs, Graham Verrier and Simon Mann. We would also like to thank the many individuals, businesses and organisations that provided information and assistance during the study, and the peer reviewer, Edmund Penning-Rowsell, for his assistance and suggestions.

Contents

1 Introduction

1.1 Context

From December 2013 through to March 2014, England and Wales experienced a sustained period of flooding. Key features of the floods are summarised in Figure 1.1.

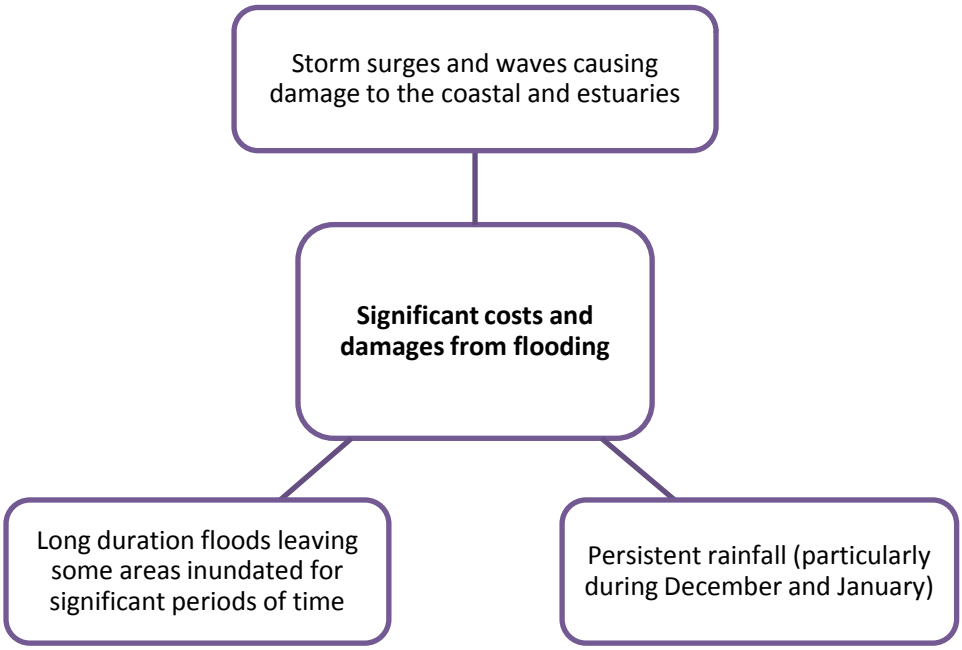

Figure 1.1 Important features of the winter 2013 to 2014 floods

The winter 2013 to 2014 floods were unusual as they were from a wide range of sources – fluvial, pluvial, coastal and groundwater (Met Office and CEH 2014, Muchan et al. 2015).

The map in Figure 1.2 shows the extent of the winter 2013 to 2014 floods. The duration of the floods is shown in Figure 1.3. A total of 148 events occurred and they lasted between 11 and 20 days. Nine events lasted between 31 and 50 days, these were all in the south-west of England.

Some of the main differences between the 2013 to 2014 floods, and the 2007 and 2012 floods, relate to location, duration, type of event and their timing. All of these factors were important when assessing the damages and the differences in damages between these events.

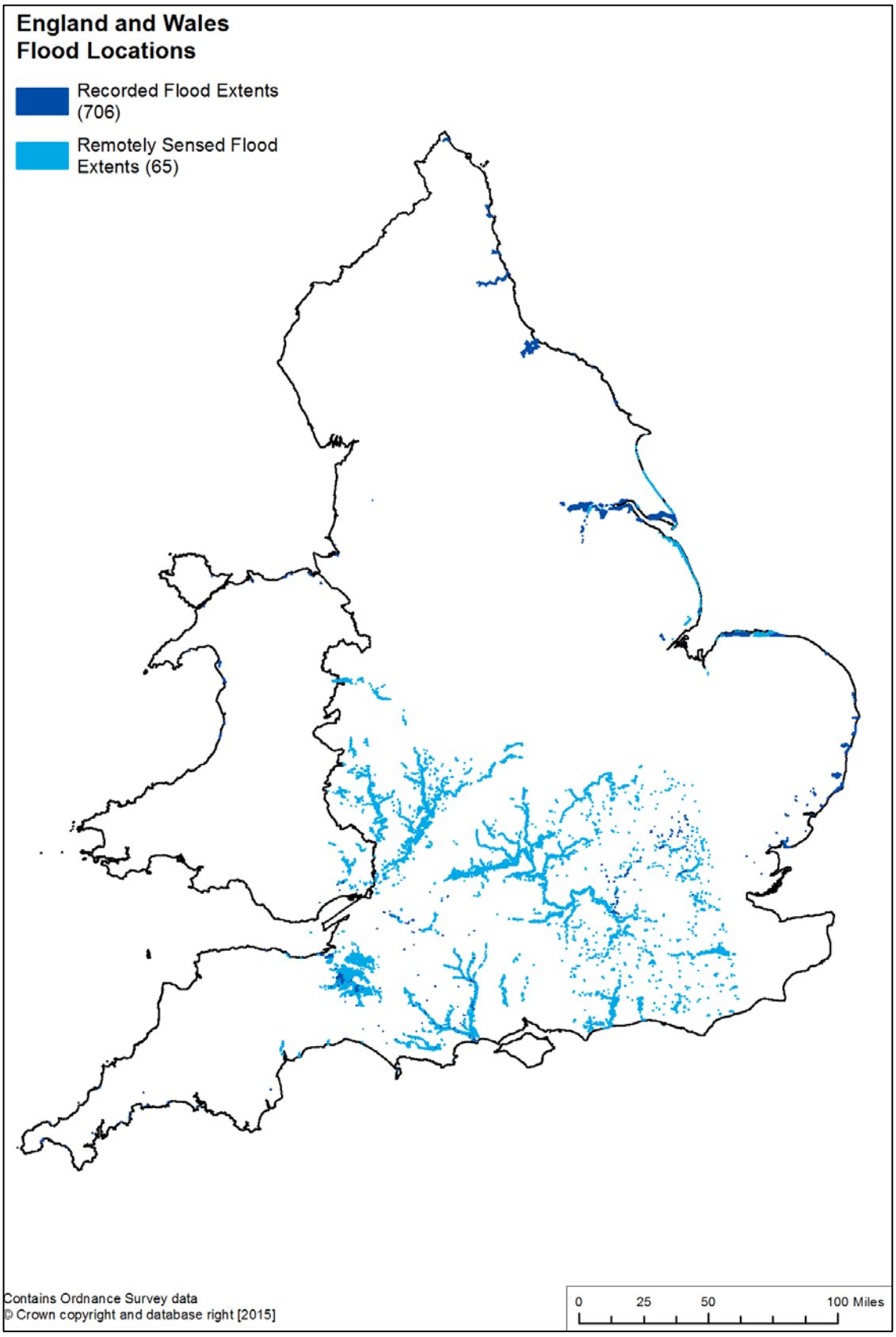

Figure 1.2 Extent of flooding in 2013 to 2014

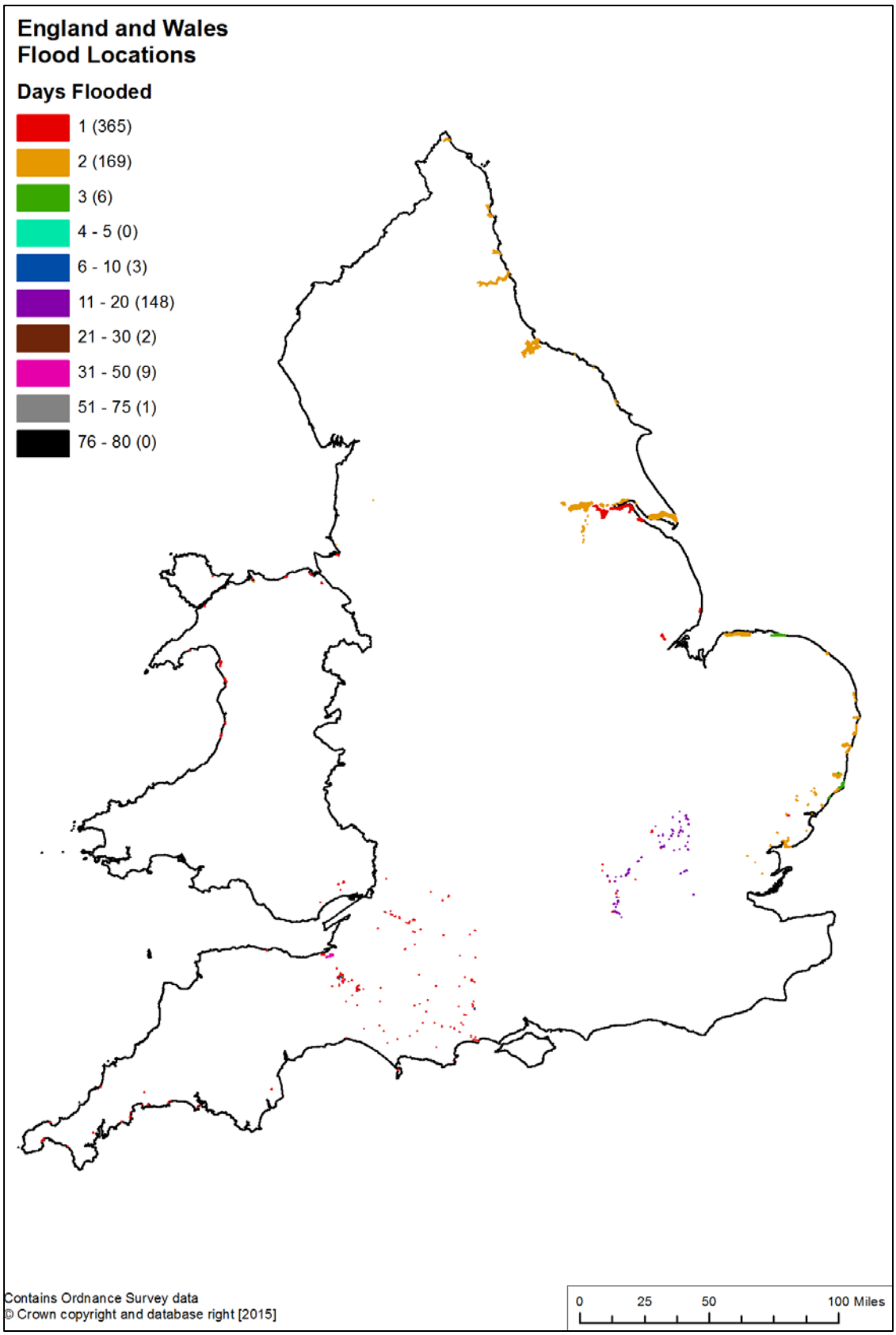

Figure 1.3 Duration of flooding (by number of days flooded)

1.2 Aims and objectives

The overall objective of this project was to establish the range of impacts and to calculate the financial and economic damages resulting from the flooding in England and Wales during winter 2013 to 2014.

The summer 2007 flood study is used in this project as a reference to estimate subsequent flood damages to residential and non-residential properties, services and infrastructure.

1.3 What is a flood?

For this study we had to define what a flood is, in order to identify what data to collect to develop our damage estimate.

Many organisations collecting data, especially Lead Local Flood Authorities (LLFAs), have their own definitions of what a flood comprises. Table 1.1 gives the definitions used by some Lead Local Flood Authorities (LLFAs) compiling their detailed flood investigation report under Section 19 of the Flood and Water Management Act. For this study we have used the definitions developed by each LLFA.

Table 1.1 Examples of definitions of flooding which trigger a flood investigation report by LLFAs

Source	Flood definition for a flood investigation report (Section 19)	Reference
Blackpool Council	Any internal flooding Flooding to highways which causes disruption or danger to traffic Flooding affecting local infrastructure in accordance with assets identified within Multi Agency Flood Plans Flooding to gardens and open space deeper than 0.25m	Blackpool Council (2014)
Cumbria County Council	Internal flooding of one property experienced on more than one occasion Internal flooding of 5 properties experienced during one single flood incident Risk to life as a result of flooding	Cumbria County Council (no date)
Dudley Metropolitan Borough Council	All incidents: risk to loss of life Residential property: flooding of more than 15 people or 5 or more residential properties flooded internally above ground floor level in one location Critical services/installation (healthcare, education, emergency service, utility services): • More than one property marooned or flooded above ground flood level and/or one or more healthcare facilities rendered inoperable due to impassable access • More than one flooded critical installation resulting in loss or potential loss of service or causing or potentially causing flooding to other property	Dudley Metropolitan Borough Council (no date)

Source	Flood definition for a flood investigation report (Section 19)	Reference
	Commercial properties: more than 2 properties flooded above ground floor level in one location Transport: any motorway or strategic route impassable due to flooding for 2 or more hours	
Northamptonshire County Council	Flooding affecting critical infrastructure for a period in excess of 3 hours from the onset of flooding Internal flooding[1] of one property experienced on more than one occasion in the last 5 years Internal flooding of 5 properties in close proximity experienced during a single flood incident	Northamptonshire County Council (undated)
Surrey County Council	Six or more properties in a catchment experience internal flooding[2] A single property experiences repeat internal flooding within 5 years of the initial flooding Six or more commercial properties experience internal flooding or a single commercial property greater than 500m^2 experiences internal flooding One or more items of critical national infrastructure experience flooding A transport link is impassable for a number of hours (2 hours for major rail links, motorway, trunk road or Surrey Priority Networks 1 and 2, 6 hours for minor rail links and Surrey Priority Network 3, 10 hours for Surrey Priority Networks 4a and 4b and all other locations)	Surrey County Council (undated)

Notes: [1] Water passing over the threshold of a commercial or residential property

[2] Flooding of the habitable part of the dwelling and excludes garages, outhouses and gardens.

1.4 Structure of the report

This report describes the approach to the study as well as details of the findings. It is structured as follows.

Section 2 sets out the approach to the study. It is supported by spreadsheets that have been used to record all data collected and the results of any analysis, adjustments and extrapolation.

Section 3 presents the damage estimates, the number of assets affected and the damages per asset.

Section 4 describes the damages avoided due to the presence of flood risk management assets and actions taken before and during flood incidents.

Sections 5 to 24 present the damages associated with each impact category, the method used to estimate these damages and the associated uncertainties.

Section 25 gives a summary of the conclusions and presents recommendations to help make similar studies easier in the future.

2 Approach to the study

2.1 Collecting data

For this study, data collection involved 2 main approaches (Figure 2.1):

- national level assessment
- local level assessment

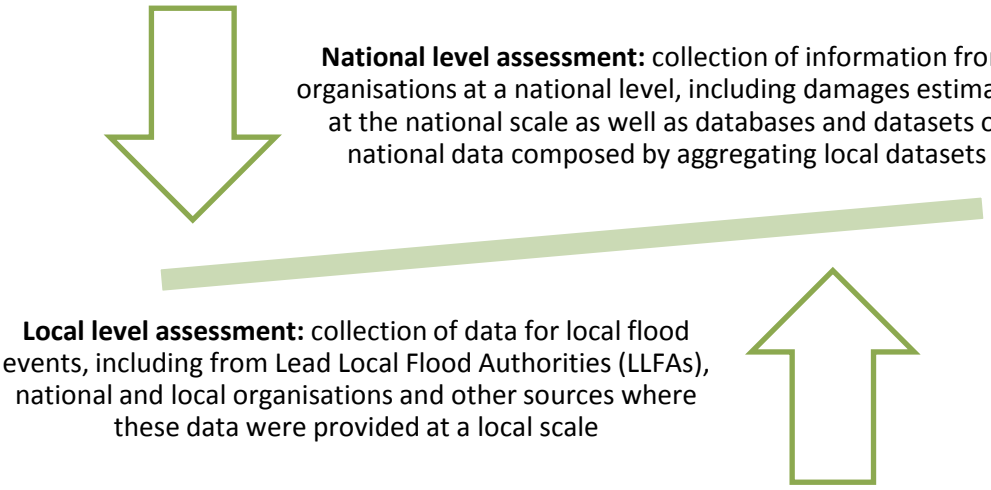

Figure 2.1 Approaches to data collection

Both the national and local level assessments involved an initial internet search to identify and collect readily available information on the winter 2013 to 2014 floods. The findings were supplemented by:

- data and data sources provided by the Environment Agency
- data requests sent to crucial organisations and data holders

A total of 641 individuals and organisations were contacted. In many cases, it was necessary to approach several people within each organisation before the one best placed to provide a response was found. Over 900 emails were sent and 392 responses were received. These responses were made up of the following categories:

- those providing cost information
- those who were not affected
- those who did not collect the information
- those who did not have information at the time requested and would not within the study timeframe

In total, 184 individuals and organisations responded with data on the impacts of the floods. For a full summary of the engagement with others see Appendix A.

Over 500 data sources were reviewed including reports, presentations and spreadsheets, both those publically available and those received from the engagement. These data sources cover a wide range of categories and vary in their level of detail and reliability, both of which were taken into account when determining whether to include the information.

2.2 Recording data

2.2.1 Grouping data into impact categories

Damages caused by the winter floods need to be grouped to reflect who or what was affected. The aim is to have sufficient categories to enable the damages to be described in detail, but without having so many categories that the evidence is scarce or the results too uncertain.

The categories used in the study are based on those from the 2007 report (Environment Agency 2007). This allows similar data holders to be identified (where these still exist) and provides a good basis for comparing damages from 2013 to 2014 with those from 2007. Some categories were amalgamated to reduce the risk of double counting. The study continually built on data already collected and focussed on crucial data gaps.

2.2.2 What are the impact categories?

The categories used in the study are listed in Table 2.1. The same categories were used to assess the damages caused by flooding and the damages avoided due to flood risk management assets and actions.

Table 2.1 Impact categories

Category	Sub-categories (if any)
Residential properties	
Businesses	
Temporary accommodation	
Motor vehicles, boats, caravans	
Local authorities and local government infrastructure	
Emergency services	Fire and Rescue, Ambulance, Police, Military, RNLI, Coastguard
Flood risk management infrastructure and service	Environment Agency, Natural Resources Wales, Internal Drainage Boards, LLFAs
Utilities	Energy, water
Transport	Road, rail, ports, air
Other communications	Telecommunications
Public health and welfare, including caring services (non-emergency)	
Education	
Agriculture	
Wildlife sites	
Heritage sites	
Tourism and recreation	

2.2.3 Using different sources and types of data

The data types identified as needed and collected are summarised in Table 2.2. Some of the data come from national reports or datasets; others are built up from local data,

including data from Lead Local Flood Authorities. A number of different types of data were used to enable damage figures to be estimated.

Using different data sources means that there should be fewer data gaps. These data sources include:

- estimates of damages across each of the impact categories
- numbers of assets affected, or length, area and so on to provide context for the damages (for many categories, data on numbers, length or area were available but data on damages were not)
- grants as a surrogate of the actual damages (where no specific damage information was available)

Table 2.2 Types of data identified and collected for each category

Data source	Data identified and collected more or less fully	Data identified and collected partly	Limited or no data identified
Residential properties	Number of properties flooded Repair and renewal grant funds	Damages (overall) Damages (per property)	Breakdown of ABI data Insurance company data
Businesses	Number of properties flooded Business support grant funds	Damages (overall) Damages (per property)	Breakdown of ABI data Insurance company data
Temporary accommodation		Number of households affected	Cost of rehousing provided by councils Breakdown of ABI data Insurance company data Cost of private rehousing
Motor vehicles, boats, caravans		Number of vehicles, boats, caravans affected	Breakdown of ABI data Number of vehicles affected or having to be moved Damage (overall)
Local authorities and Local government infrastructure	Number of people /staff hours involved in response Number of assets affected Severe Weather Recovery Scheme funding Bellwin Scheme funding Reduction in council tax/business rates as a cost	Damages to assets	Loss of revenue through car parks
Emergency services		Number of calls received, advice given Number of incidents attended Number of assets affected Cost of response	

Data source	Data identified and collected more or less fully	Data identified and collected partly	Limited or no data identified
Flood risk management infrastructure and service	Number of people/staff hours involved in response Repair costs Flood Defence Grant-in-Aid (FDGiA) recovery fund	Damages to assets	
Utilities: energy	Number of energy assets affected Number of customers losing supply	Number of network incidents Breakdown into flooding versus other weather impacts Hours over which service was affected	
Utilities: water	Number of assets affected Damages to assets, including additional operational costs Response costs		Hours over which service was affected Number of properties affected
Transport: road	Number of roads/ bridges affected/closed Length of closure Highway repair funds Severe weather road repair fund Effects of flooding on traffic disruption		Cost of road/car park repairs Breakdown into flooding versus other weather (for example, storm/wind) impacts
Transport: rail	Damages to assets Remedial/repair costs Cost of flood related disruption to rail operators and passengers		
Transport: ports	Damages to assets Small ports funds	Cancellation of ferry services	Loss, disruption costs
Transport: air	Assets lost Damages (overall) Delays/cancellation of air services (Gatwick Airport) Number of cancellations/delays (Gatwick Airport)		Other airport (non-Gatwick) information Breakdown between floods and other severe weather impacts
Other communications (telecom)			Impacts on telecoms infrastructure Effects on service users, including loss, disruption, alternative cover

Data source	Data identified and collected more or less fully	Data identified and collected partly	Limited or no data identified
Public health and welfare, including caring services (non-emergency)	Number of injuries and fatalities	Health assets affected	Effects on service users, including loss and disruption, alternative cover Cost of work absences, medical treatment Morbidity/mortality costs Health impacts of stress, anxiety and so on Bellwin costs for adults and health Data from NHS area teams Public Health England data
Education		Impacts on education assets	Cost of repair/remedial works Number of school days lost Data from Department for Education Repair costs (other than for Hampshire) Bellwin costs for education
Agriculture	Flood Recovery Fund	Hectares of farmland affected Damages to crops, livestock	Confirmation of flood areas and duration Data from Centre for Ecology and Hydrology Forest Enterprises Crown Estates burdens on farming families due to long duration disruption
Wildlife sites	Flood Recovery Fund Additional operational costs	Number/area of wildlife sites affected Number of dead birds, animals found Impact on ecosystem services that relate to societal benefit Repair/remedial costs, extra operations	
Heritage sites		Number of heritage assets affected Repair/remedial/ operational costs Damage to/loss of designated/listed features and associated services Revenue losses	Impact on visitors, trade and associated value added
Tourism and recreation		Number (and type) of tourism/recreation assets affected	Repair/remedial costs Damage to local economy Loss of opportunity for recreational activities (for example, restricted access)

In the case of the national approach, 46 reports or data sources providing national level information on the economic cost of flooding were analysed.

For the local approach, information on the cost of flood damages under each category was collected at LLFA level. In many cases, multiple numbers were obtained for the same category and LLFA. To ensure the most appropriate and reliable figure was selected, each individual figure (and associated data source) was assessed. The most reliable LLFA level figures were then summed together in each category to provide a national level estimate of the cost impacts of the floods.

Table 2.3 lists the data holders contacted and the data sources used for this study. Government reports, publically available evidence (internet searches) and shapefiles (for geographical information systems) provided by the Environment Agency were used to inform all of the categories.

Table 2.3 Data sources providing data used in the study

Data source	Organisations providing data	Organisations contacted but no data provided	Other sources used
Residential properties	ABI (national level) DCLG		LLFA/Council
Businesses	ABI (national level) DCLG CLA	Chambers of Commerce LEPs	LLFA/Council
Temporary accommodation	ABI (national level) DCLG		LLFA/Council
Motor vehicles, boats, caravans	ABI (national level)		LLFA/Council
Local authorities and local government infrastructure	DCLG		LLFA/Council
Emergency services	Ministry of Defence Local Resilience Forums Maritime and Coastguard Authority Emergency Services Associations Fire and Rescue Services		
Flood risk management infrastructure and service	DCLG Coastal Partnerships ADA/IDBs Environment Agency		LLFA/Council
Utilities: energy	Ofgem National Grid Electricity Distribution Network Operators		
Utilities: water	ADA/IDBs Ofwat Water companies		
Transport: road	Highways Agency Department for Transport		LLFA/Council
Transport: rail	Network Rail		LLFA/Council
Transport: ports	Maritime and Coastguard Authority ABP Humber		
Transport: air	Gatwick Airport		

Data source	Organisations providing data	Organisations contacted but no data provided	Other sources used
Other communications (telecom)	Ofcom	Openreach	
Public health and welfare		Public Health England (studies not complete) NHS Area Teams	
Education	Department for Education		
Agriculture	National Farmers' Union Central Association of Agricultural Valuers FWAG ADAS Forestry Commission Natural Resources Wales Interviews with farmers		
Wildlife sites	Natural England Biodiversity/ Wildlife Partnerships Wildlife Trusts RSPB Natural Resources Wales		
Heritage sites	English Heritage National Trust		LLFA/Council
Tourism and recreation	Visit England		LLFA/Council

Notes: ABI = Association of British Insurers
ABP = Associated British Ports
ADA = Association of Drainage Authorities
CLA = Country Land and Business Association
DCLG = Department of Communities and local government
IDB = Internal Drainage Board
NHS = National Health Service

The categories for which limited data were identified result in high levels of uncertainty in any damage figures, where such damages could be estimated. This is particularly true for categories where data were available for the report on the 2007 floods (Environment Agency 2010), but were no longer available here. These include disaggregated claims data that are no longer held by the Association of British Insurers (ABI). The lack of these data means that damages to properties (residential and non-residential), to motor vehicles/boats/caravans and as a result of use of temporary accommodation can only be estimated at the national level. Grants have been used as surrogates for the damages in the local assessment. It is recognised that these do not provide an accurate estimate of the damages (as it is not always clear whether the grants provided cover the full cost of repairs/impacts) and are hence used to provide an indication of the potential costs where no specific cost information is available. As a result, the figures provided by the national and local assessments are measuring very different things and cannot be considered to provide a range of the estimated damages. Combining data from the national and local assessments introduces uncertainties and may potentially lead to some double counting. Despite the risks of uncertainties associated with inconsistencies within the different data sources and double counting, data availability issues mean that, unless some data are combined, neither the national nor local estimates would cover all categories. Therefore data were combined with careful assumptions where considered necessary to fill data gaps. Data gaps were also filled by using extrapolation (see Section 2.3.3).

2.2.4 Disaggregating the damages

Breaking down the damages by flood type and location

The damage figures were obtained for England and Wales and across all flooding sources. It is useful to consider whether those damages can be presented by flood type – fluvial, groundwater, pluvial and coastal flooding.

The main limitation on the breakdown of damages is the data. Those data provided at the national level cannot be attributed to one single flood type (as they cover all flood types) and often cannot also easily be separated into figures for England and Wales.

The discussions below provide an overview of the approaches used to differentiate between damages by flood type and by location.

Separating the damages for England and Wales

Where local data are used as the basis for the best estimate of damages, the division between England and Wales is simply a case of summing the local data for each nation individually. The approach is more complex where national data are used as the best estimate.

The sections of this report discussing the damages for each category explain the assumptions used to separate costs for England and Wales.

Identifying damages by flood type

To assess whether damages vary by source of flooding, an attempt was made to separate out the damages attributed to coastal impacts associated with the winter 2013 to 2014 floods. This enables an estimate to be made of the damages from coastal flooding; the remaining damages can then be attributed to fluvial, groundwater and other sources such as pluvial.

It was not possible to separate fluvial from groundwater and other sources. However, it is clear from the dataset that fluvial data are likely to be the main source of damages – recognising that groundwater and other sources may be the main source of damages in some areas at the local level.

The separation of coastal impacts is based on the assumption that the majority of the flood impacts experienced by coastal LLFA areas during the winter 2013 to 2014 floods were caused by tidal surges or increased wave action. This is clearly a simplification, but there is insufficient detail within the data to allow more sophisticated analysis.

Table 2.4 lists those LLFAs located along the coastline of England and Wales. It is recognised that this is a simplified approach and may overestimate the coastal impacts as, in some cases, fluvial, pluvial and groundwater sources of flooding will also have occurred in coastal regions. However, this is considered to be appropriate for the purposes of comparing the coastal economic costs of flooding with the total costs (for England and Wales). Also, where it is obvious that the cost/damage figures obtained do not relate to coastal impacts, these values have not been included.

Table 2.4 Coastal LLFAs in England and Wales

Region	LLFA
Wales	Cardiff Carmarthenshire Ceredigion Conwy Flintshire Gwynedd Isle of Anglesey Neath Port Talbot Pembrokeshire Swansea The Vale of Glamorgan
East Midlands	Lincolnshire
East of England	Essex Norfolk Southend-on-Sea Suffolk Thurrock
North East	Hartlepool North Tyneside Northumberland Redcar and Cleveland South Tyneside Sunderland
North West	Blackpool Cumbria Lancashire Liverpool Wirral
South East	Brighton and Hove East Sussex Hampshire Isle of Wight Kent Medway Portsmouth Southampton West Sussex
South West	Bournemouth Cornwall Devon Dorset Isles of Scilly North Somerset Plymouth Poole Torbay
West Midlands	None
Yorkshire and Humber	East Riding of Yorkshire North East Lincolnshire North Yorkshire

2.2.5 Quality assurance of data

A quality assurance procedure was used to ensure the quality of the data used was sufficient for purposes of the study. The way in which data are used is discussed in Section 2.3.

Collation of a large amount of information from a variety of different sources is prone to problems such as double counting. This can be due to some sources quoting figures for large areas which include many smaller areas for which costs are also available. Alternatively, it may be due to reporting by different sources of the costs in different formats.

To minimise the impacts of any inconsistencies in the data, a strict quality assurance protocol was followed.

- All data sources were recorded in a spreadsheet to provide a comprehensive record of data sources searched, organisations contacted and data received (from whom).
- Each dataset was critically assessed to determine if and how it could and should be used in this study. Any uncertainties associated with the data were identified, along with the reasons for the uncertainty and the implications for the data and study objectives.
- Some sources appeared to quote costs for wider areas (such as county level), while others reported damages to specific locations and assets. The approach taken was to choose the most robust figure while also taking into account the type of costs quoted. For instance, total grants received at the regional level may be a better estimate of the total costs than damages at a small number of specific locations.
- For areas where figures were reported for both repair costs and grants given, it was not always certain how much of the former were covered by the grants. This creates a risk of double counting the economic costs. The approach taken was to use the figure that appeared to be the most robust.
- Where there were sufficient data points and where the reported damages were similar in type, an effort was made to compare data to enable verification of damages, for example, comparing national and local estimates. However, in most cases there were insufficient data points or not enough detail on what the damages covered specifically to allow such verification to be made.

2.3 Analysing data

2.3.1 Approach to assessing damages

Three estimates of damages are provided for each category.

- **Best estimate**: this is the estimate that, taking into account uncertainties and assumptions, gives the most reliable estimate of the damages.
- **Low estimate**: this estimate provides an indication of the uncertainty surrounding the best estimate by determining a reasonable low end of the range. This is estimated using the uncertainty rating attributed to each impact category, which is based on data availability and quality as well as expert judgement.

- **High estimate**: this estimate provides an indication of the uncertainty surrounding the best estimate by determining a reasonable high end of the range. As with the low estimate, the high estimate is determined using the uncertainty rating attributed to each impact category, which is based on data availability and quality as well as expert judgement.

Further details, including the matrix used to determine the uncertainty ratings for each category along with the approach used to provide a range around the best estimate, are given in Section 2.3.4.

A method statement was developed for each category (see Annex 1) to show the approach used to estimate the economic costs of the floods. These method statements are based on a flow diagram showing how the data and assumptions are combined to provide the best estimate of the economic damages for each category. Each category has its own method statement to reflect the specific data and assumptions used in developing a damage estimate.

The sections in this report for each category, combined with the method statement, provide full details of the approach and data sources used to quantify the impacts and monetise the damages of that category.

2.3.2 Adjusting damage estimates to economic costs

Many of the data collected on damages were provided as financial estimates. These have been converted to economic estimates.

Each piece of data used was assessed to determine the extent to which it might need adjusting and the specific adjustments required.

Gross domestic product (GDP) impacts are not considered as a separate category due to complications with linkages between impacts and categories, and the difficulty of separating out those impacts that could affect GDP. For example, while the costs of work absences and health impacts do affect levels of economic activity, overall GDP impacts are dependent on a range of factors including costs of repairing damaged defences and infrastructure.

The approaches used for each impact category are described in the method statements. Some of the main adjustments are as follows.

- Insurance claims are considered as financial costs unless specified otherwise and adjusted to provide an economic cost estimate by:
  - removing VAT (at 20%)
  - allowing for a degree of under-insurance
  - using an inventory to non-inventory split of 75/25% and 45/55% for residential properties and businesses respectively, and for inventory items making adjustments for betterment
- Adjustments to account for betterment (that is, replacing a used or old asset with a new one) are used across all categories (residential properties, businesses as well as local authorities, flood risk management infrastructure, utilities, heritage assets such as visitor centres, and tourism and recreation assets). It is recognised that in certain cases the asset that was damaged and required repair or replacement was of equal quality or condition to a new asset (potentially the case for well-maintained flood defences), effectively resulting in a like-for-like replacement. However, due to the lack of information on the condition of each asset damaged during

the 2013 to 2014 winter storms, the use of a default betterment figure of 50% is considered a reasonable approach.

- Repair and damage costs not thought to be covered by insurance are considered to be financial costs and adjusted for VAT and betterment as above to provide an economic estimate.
- Grant money is used as a proxy (surrogate) of the economic costs, unadjusted, to the different stakeholders in the absence of any better estimates. These include different grants to different stakeholders such as the Severe Weather Recovery Schemes and Bellwin Scheme (Sandford 2015) to help local authorities, but also flood support schemes to businesses such as the Repair and Renewal Grant Scheme and tax reliefs. However, this approach probably underestimates the total costs particularly as, in certain cases, the amount of grant funding received is capped such that the total private costs may not be covered by grants.[1] As monies received by private individuals from grants have been used as a surrogate for estimates of economic costs, they should not be interpreted as private financial costs to individuals.
- Tax reliefs, both business and council tax, are considered to be an economic cost to local authorities as they represent an opportunity cost from the flooding events.
- Some information received refers to the costs of staff overtime. In this study these are considered to be an economic cost and have not been adjusted.
- Any data on welfare impacts that occurred as a result of the flooding events are considered to be economic cost and have not been adjusted.

2.3.3 Extrapolating to fill data gaps

Extrapolation is used to estimate damages where there are data on the number (length and area) of assets affected but no damage data. First, average (mean) damages per asset are estimated by dividing the damages by the numbers affected to calculate an average 'unit' cost under each category where both data are available for any one LLFA. This average 'unit' cost is then used to estimate the costs or damages for other areas where only data on the number of assets affected by flooding has been identified.

In addition, the extrapolation does not always result in damages for all LLFAs affected under each category as there are not always data available on numbers of assets. Hence, extrapolation only goes part of the way to addressing data gaps.

Extrapolation also introduces further uncertainty. The magnitude of the uncertainty depends upon the number of data points available to calculate average damages. For many categories, the number of data points is small. Therefore, the extrapolated damages should be interpreted as providing an indication of the potential cost of damages caused by flooding rather than actual figures.

2.3.4 Assessing uncertainty

Colour coding is used to reflect the level of uncertainty associated with data based on its quality and availability. Red represents the most uncertainty and green represents

[1] In standard economic theory, grants are regarded as a transfer. Care is needed to avoid double counting the real economic costs when aggregating across the whole of the economy.

the lowest level of uncertainty. Figure 2.2 is the matrix used to define the data assumptions and uncertainty ratings for each category. This related to definitions for data relate to data quality and data availability and are given along the top row and down the left-hand column of the matrix, with the ratings (low, moderate and high) related to level of uncertainty. Definitions associated with assumptions relate to the basis for the assumptions and factors underlying the assumption. These are given in the bottom row and right-hand column of the matrix.

Data	**Data quality**			**Assumptions**
Data availability	LOW: Data have been validated/ cross-checked externally	MODERATE: Data have been validated/ cross-checked internally	HIGH: No opportunity for cross-checking	**Basis for assumption**
LOW: Data on damages available	L	ML	M	LOW: Damage-cost function developed
MODERATE: Data on number of assets affected available	ML	M	MH	MODERATE: Extrapolation
HIGH: Qualitative data/descriptions only	M	MH	H	HIGH: Expert judgement
Factors underlying assumption	LOW: Data from similar area or same type of impact	MODERATE Data but from different area or impact	HIGH: No or very limited data, or from generic damages (for example, MCM)	**Assumptions**

Figure 2.2 Definitions for data and assumptions and uncertainty ratings

Notes: MCM = Multi-Colour Manual (Penning-Rowsell et al. 2013)

This approach was used as a basis for estimating the range around the best estimate of the costs or damages attributable to the winter 2013 to 2014 floods for each impact category. Table 2.5 gives the percentages used to determine the range around the best estimate for each uncertainty rating in the first instance. The figures used to determine the best estimate are also assessed on an individual basis and expert judgement applied to ensure that the uncertainty associated with these figures is appropriate.

Table 2.5 Percentages used in determining ranges around the best estimate by uncertainty rating

Uncertainty rating	**Percentage used in determining the range (+/-)**
Low	10%
Low–moderate	15%
Moderate	20%
Moderate-high	25%
High	30%

As well as the uncertainty associated with the amount of data obtained to inform the damage estimates, there is also uncertainty associated with the data themselves and the assumptions necessary to be able to use them. The main uncertainties are described below.

Data definitions

- LLFAs have developed their own definitions for what is classed as a flood event. This means there is a lack of consistency between areas in terms of what and how many assets are recorded as being affected.
- In some cases, costs reported in the literature do not state whether they are financial or economic costs. Where the costs relate to repairs, it has been assumed these relate to financial costs and so were adjusted for betterment and VAT. Where the costs relate to operational activities, it has been assumed that these are economic costs and has not been adjusted.

Identification of relevant data

- In cases where local damage information (for example, in the residential properties, businesses and transport categories) is not available, government grants were used in the local approach as a surrogate to provide an indication of the actual costs that may have occurred. These figures are likely to be an underestimate as the actual costs incurred are likely to exceed the grant payments received. The Repair and Renew Grant has been used as an indication of damages, though it is an underestimate. The Repair and Renew Grant is eligible for properties flooded between 1 April 2013 and 31 March 2014, and therefore may provide an inaccurate measure of number of properties flooded. But although Repair and Renew Grant data were obtained at the local level, they were not taken forward as the best estimate – see Section 5 for further details.
- The national approach uses national level data on the costs and impacts of the winter 2013 to 2014 floods. However, it is not always clear whether the information relates to the period that is being assessed in this study (December 2013 to March 2014). Each value has been analysed on its own merit and, where possible, data that specifically refer to the full assessment period were selected and used in the cost estimates. However, this was not always possible given the lack of alternative values deemed suitable under certain categories.
- Every figure used in this report was assessed, and where necessary adjusted, on an individual basis to ensure it was suitable and to reduce the risk of double counting with other categories. This approach ensured that the figures used were as accurate and reliable as possible.
- There are differences in economic cost estimates according to the approach used and the source of data. Some sources quote costs for wider areas, while others report damages for specific locations and assets.

Double counting

- Although every effort was made to ensure that cost data do not overlap (that is, are not included in more than one category), it is possible this occurred for certain data for which limited background information was

provided. A particular issue is the provision of government grants associated with flood response activities, which could be interpreted to fall within multiple categories. For example, police authorities and combined fire authorities can apply to the government's Bellwin Scheme for emergency financial assistance. Therefore, funding received from this scheme could be included under multiple categories.

- For some areas, figures are reported for both repair costs and also grants given. However, it is not always certain how much of the former are covered by the grants, creating a risk of double counting.

Extrapolation

- The extrapolation exercise took the local data obtained to provide an estimate of the average 'unit' cost under each category. This value was then used to extrapolate the costs for each category across all areas for which numbers (for example, number of residential properties flooded, area of agricultural land flooded and so on) had been identified.
- The extrapolation is based on the number of assets flooded under various categories. In the cases of residential properties and businesses, data from LLFAs were obtained. However, this is likely to underestimate the number of properties actually flooded as not all homeowners will have reported the damage. Flood outline data provided by the Environment Agency were also used to estimate the number of properties and assets flooded. However, these data may underestimate or overestimate the number of properties that were flooded internally. A comparison of the flood outline data with data from LLFAs shows that there is no systematic bias to the geographical information system (GIS) data, with figures for some LLFAs being under-reported and figures for other LLFAs being over-reported.

3 Damage estimates

3.1 Damage estimates for the winter 2013 to 2014 floods

Table 3.1 presents the best estimates of the damages by category for England and Wales. It also indicates whether the best estimate is taken from the national, local, or extrapolation from the local approach. This is important as the different approaches have very different levels of uncertainty. Overall uncertainty is also shown in Table 3.1 as the possible range of values. For each category, the most robust figure has been selected to provide a best estimate of the damages caused as a result of flooding during the 2013 to 2014 winter period. However, it was not possible to provide damage estimates for one category, that is, 'other communications', which covers telecommunications.

The overall estimated damages of the 2013 to 2014 floods were £1.3 billion (£1,300 million). This includes both damages incurred by flooding and water-related erosion. Figure 3.1 provides a visual representation of the breakdown of the total damages.

Although every effort was made to obtain reliable quantitative information, there are likely to be data gaps. The estimates in Table 3.1 should therefore be seen as an indication of the likely scale of the costs attributed to the winter 2013 to 2014 floods and not as a definitive damage value.

Table 3.1 Damage data for England and Wales based on best estimates

Impact category	Best estimate (£ million)	% of total	Possible range (£ million)	Source of estimate (national, local or extrapolation of local)
Residential properties	£320	25%	£270–370	Extrapolation of ABI data (national)
Businesses	£270	21%	£230–310	Extrapolation of ABI data (national)
Temporary accommodation	£50	3.9%	£42–57	Extrapolation of ABI data (national)
Motor vehicles, boats, caravans	£37	2.9%	£31–42	Extrapolation of ABI data (national)
Local authorities and local government infrastructure	£58	4.5%	£49–66	Local level data
Emergency services	£3.3	0.26%	£3.3–8.7	Local level data
Flood risk management infrastructure and service	£147	12%	£145–148	Environment Agency data
Utilities: energy	£0.82	0.06%	£0.63–1.0	Local level data
Utilities: water	£29	2.3%	£25–33	Local level data
Transport: road	£180	14%	£91–220	Local and national level data
Transport: rail	£110	9.0%	£93–140	Network Rail data
Transport: ports	£1.8	0.14%	£1.6–2.1	Local level data
Transport: air	£3.2	0.25%	£2.6–3.9	Local level data
Other	No data available			

Impact category	Best estimate (£ million)	% of total	Possible range (£ million)	Source of estimate (national, local or extrapolation of local)
communications (telecom)				
Public health and welfare	£25	1.9%	£25–67	Local level data
Education	£1.6	0.13%	£1.2–2.0	Extrapolation of Local level data
Agriculture	£19	1.5%	£12–25	ADAS data and other national level data
Wildlife sites	£2.4	0.19%	£1.9–3.0	Local level data
Heritage sites	£7.4	0.59%	£5.6–9.3	Extrapolation of local level data
Tourism and recreation	£3.5	0.28%	£2.6–4.4	Extrapolation of local level data
Total	**£1,300**		**£1,000–£1,500**	

Notes: Colours relate to uncertainty rating (see Section 2.3.4).
Values are presented to 2 significant figures, except in the case of the 'Flood risk management and service' category where values are presented to 3 significant figures to differentiate the ranges from the low, best and high estimates.

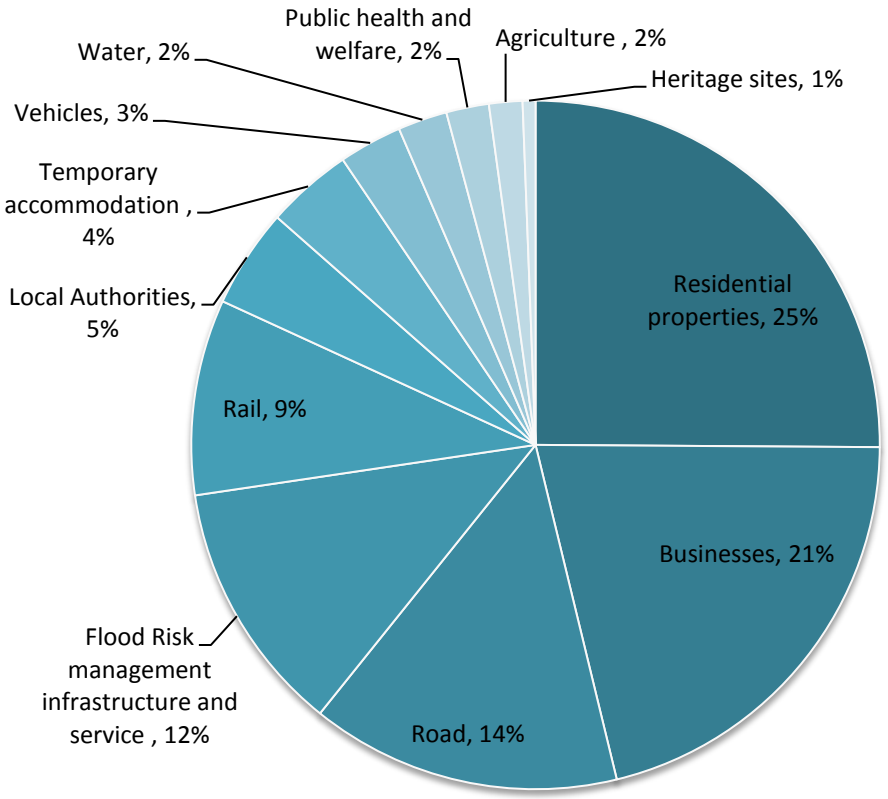

Figure 3.1 Visual representation of proportion of damages in categories making up 1% or more of the total damages

3.2 Damage costs by flood type

The approach to separating damages caused by coastal flooding from those caused by fluvial/groundwater and other flooding is described in Section 2.2.4 and is based on coastal LLFAs (in the case of local data). This approach assumes that the majority of

the damages in coastal LLFAs are attributed to coastal flooding. Although it is recognised that this approach is likely to overestimate damages associated with coastal events, it can be used to provide an indication of the damages that may relate to coastal flooding during the winter 2013 to 2014 floods.

As well as applying this general approach, various other methods were used to disaggregate the national data by flood type. The approaches used are described in each impact category section of this report (Sections 5–24).

Table 3.2 and Figure 3.2 present the estimated damages caused during the 2013 to 2014 winter period by flood type.

Table 3.2 Damage data by flood type

Category	Total (£ million) (range low to high)	Fluvial/groundwater		Coastal	
		Total (£ million)	%	Total (£ million)	%
Residential properties	£320 (£270–370)	£190 (£160–220)	60%	£130 (£110–150)	40%
Businesses	£270 (£230–310)	£100 (£86–120)	37%	£170 (£140–190)	63%
Temporary accommodation	£50 (£42–57)	£30 (£26–35)	60%	£20 (£17- £23)	40%
Motor vehicles, boats, caravans	£37 (£31–42)	£22 (£19–25)	60%	£15 (£12–17)	40%
Local authorities and local government infrastructure	£58 (£49–66)	£20 (£17–23)	35%	£37 (£32–43)	65%
Emergency services	£3.3 (£3.3–8.7)	Disaggregation not possible			
Flood risk management infrastructure and service	£147 (£145–148)	£37 (Range not determined)	25%	£110 (£108–111)	75%
Utilities: energy	£0.82 (£0.63–1.0)	Disaggregation not possible			
Utilities: water	£29 (£25 – 33)	£29 (£24–33)	99%	£0.38 (£0.33–0.44)	1%
Transport: road[1]	£180 (£91–220)	£110 (£55–130)	61%	£70 (£35–84)	39%
Transport: rail[1]	£110 (£93–140)	£5.8 (£4.7–7.0)	26%	£17 (£13–20)	74%
Transport: ports	£1.8 (£1.6–2.1)	£0.001 (£0.001–0.001)	0.1%	£1.8 (£1.6–2.1)	99.9%
Transport: air	£3.2 (£2.6–3.9)	£3.2 (£2.6–3.9)	100%	£0	0%
Other communications (telecom)	No data available				
Public health and welfare	£25 (£25–67)	£15 (£15–40)	60%	£9.8 (£9.8–27)	40%
Education	£1.6 (£1.2–2.0)	£0.71 (£0.53-0.89)	44%	£0.92 (£0.69–1.1)	56%
Agriculture	£19 (£12–25)	Disaggregation not possible			
Wildlife sites	£2.4 (£1.9–3.0)	£0.12 (£0.10–0.15)	5%	£2.3 (£1.8–2.9)	95%
Heritage sites	£7.4	£1.6	21%	£5.9	79%

Category	Total (£ million) (range low to high)	Fluvial/groundwater		Coastal	
		Total (£ million)	%	Total (£ million)	%
	(£5.6–9.3)	(£1.2–2.0)		(£4.4–7.3)	
Tourism and recreation	£3.5 (£2.6–4.4)	£1.5 (£1.2–1.9)	44%	£2.0 (£1.5–2.5)	56%
TOTAL	**£1,300 (£1,000–1,500)**				

Notes: Values are presented to 2 significant figures, except in the case of the 'Flood risk management and service' category where values are presented to 3 significant figures to differentiate the ranges from the best estimate. Therefore the total may not be equivalent to the sum of its constituent parts due to rounding.
[1] It was only possible to disaggregate the direct damages/costs by flood type for these categories (welfare and other costs could not be separated by flood source), and hence the total across coastal and fluvial is lower than the overall total.

The damages caused by coastal flooding may account for a substantial proportion of the damages that occurred during the winter 2013 to 2014 floods for certain categories:

- transport: ports (~100%)
- wildlife sites (95%)
- heritage sites (79%)
- flood risk management infrastructure and service (75%)
- transport: rail (74%)
- local authorities and local government infrastructure (65%)
- businesses (63%)
- tourism and recreation (56%)

However, there are gaps in the local level data. In addition, the approach used to disaggregate the local level data assumes that damages experienced in coastal LLFAs are largely attributable to coastal flooding, which may not be the case in all areas. Hence, the results are highly uncertain and should be interpreted as providing an indication of the potential coastal damages rather than being a definitive estimate.

Table 3.2 demonstrates the high proportion of costs associated with coastal flooding for certain impact categories. Table 3.3 presents the proportion of residential and business properties thought to be affected by the coastal surge in England and Wales).

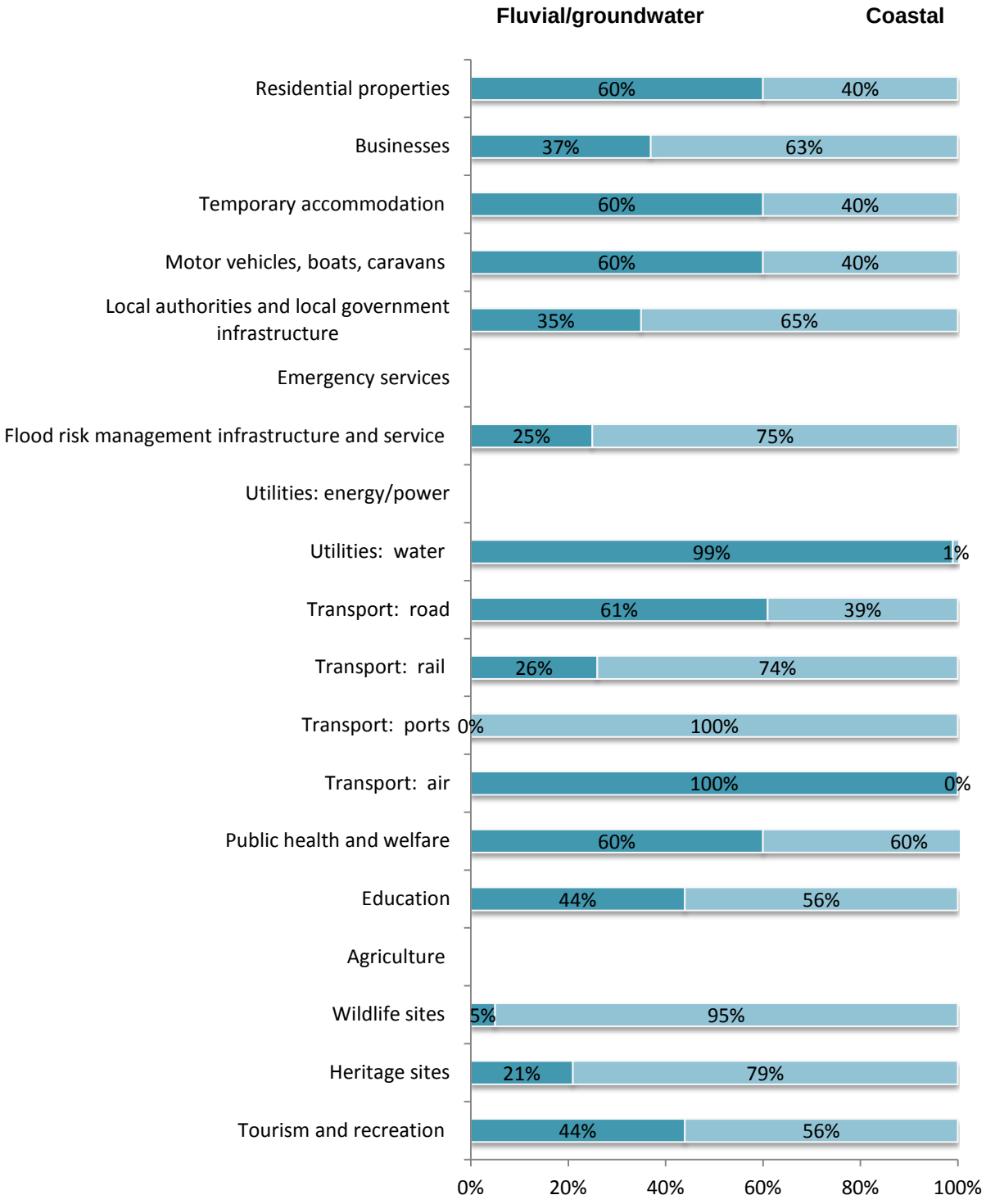

Figure 3.2 Proportion of damages from the winter 2013 to 2014 floods by flood type for each category

Table 3.3 Percentage of residential properties and businesses affected by the coastal surge

Location	% of residential properties flooded due to coastal flooding	% of businesses flooded due to coastal flooding
London	0	0
East Midlands[1]	100	100
East of England	71	90
North East	100	100
North West	71	97
South East	10	37
South West	24	45
West Midlands	0	0
Yorkshire and Humber	75	88
Wales	100	100
Average (mean)	55	65

Notes: Based on data from LLFA Section 19 reports and engagement.

Not all LLFAs differentiated between residential and non-residential in their data. The data gaps were filled using GIS information on flood outlines.

For distribution of LLFAs, see Appendix B for details of which LLFAs are included in each area.

[1] Relates to Lincolnshire only.

3.3 Damage costs for England and Wales

Where possible, the damages have been split for each category to present the costs incurred by England and Wales separately (Table 3.4). Where data relate only to England, this does not mean there were no damages in Wales,, it means no information was available on which to base the damage estimate.

The totals for England and Wales do not include damages from the compensation or revenue costs to Network Rail and the welfare costs attributed to service disruption caused by flooding in the transport: rail category as it was not possible to disaggregate this information. The information in Table 3.4 is presented visually in Figure 3.3.

Table 3.4 Damage data based on best estimates for England and Wales

Category	Total (£ million)	England		Wales	
		Total (£ million)	Percentage of total	Total (£ million)	Percentage of total
Residential properties	£320 (£270–370)	£310 (£270–360)	98%	£6.6 (£5.6–7.6)	2%
Businesses	£270 (£230–310)	£270 (£230–310)	99%	£4.0 (£3.4–4.6)	1%
Temporary accommodation	£50 (£42–57)	£49 (£42–56)	98%	£1.0 (£0.88–1.2)	2%
Motor vehicles,	£37	£36	98%	£0.76	2%

Category	Total (£ million)	England		Wales	
		Total (£ million)	Percentage of total	Total (£ million)	Percentage of total
boats, caravans	(£31–42)	(£30–41)		(£0.65–0.88)	
Local authorities and local government infrastructure	£58 (£49–66)	£58 (£49–66)	100%	£0	0%
Emergency Services	£3.3 (£3.3–8.7)	£3.3 (£3.3–8.7)	100%	No data	0%
Flood risk management infrastructure and service	£147 (£145–148)	£137	94%	£9.5 (£8.1–11)	6%
Utilities: energy	£0.82 (£0.63–1.0)	£0.81 (£0.62–1.0)	99%	£0.006 (£0.005–0.007)	1%
Utilities: water	£29 (£25 – 33)	£29 (£25–33)	100%	£0.02 (£0.017–0.024)	<1%
Transport: Road	£180 (£91–220)	£180 (£91–220)	100%	No data	0%
Transport: Rail[1]	£110 (£93–140)	£18 (£15–22)	81%	£4.2 (£3.3–5.0)	19%
Transport: Ports	£1.8 (£1.6–2.1)	£1.8 (£1.6–2.1)	100%	No data	0%
Transport: Air	£3.2 (£2.6–3.9)	£3.2 (£2.6–3.9)	100%	No data	0%
Other communications (telecom)	No data available				
Public health and welfare	£25 (£25–67)	£24 (£24–66)	98%	£0.51 (£0.51–1.4)	2%
Education	£1.6 (£1.2–2.0)	£1.6 (£1.2–2.0)	100%	No data	0%
Agriculture	£19 (£12–25)	£18 (£12–25)	99%	£0.21 (£0.15–0.27)	1%
Wildlife sites	£2.4 (£1.9–3.0)	£2.3 (£1.8–2.8)	95%	£0.12 (£0.09–0.17)	5%
Heritage sites	£7.4 (£5.6–9.3)	£7.4 (£5.6–9.3)	100%	No data	0%
Tourism and recreation	£3.5 (£2.6–4.4)	£2.9 (£2.2–3.6)	82%	£0.65 (£0.49–0.81)	18%
TOTAL	**£1,300 (£1,000–1,500)**	**£1,200 (£930–1,400)**	**91% (98% of disaggregated data)**	**£28 (£23–33)**	**2% (2% of disaggregated data)**

Notes: Values are presented to 2 significant figures, except in the case of the 'Flood Risk Management and Service' category where values are presented to 3 significant figures to differentiate the ranges from the best estimate. Therefore, the totals may not be equivalent to the breakdown due to rounding.

[1] It has only possible to disaggregate the direct damages/costs by flood type for these categories (welfare and other costs could not be separated by flood source).

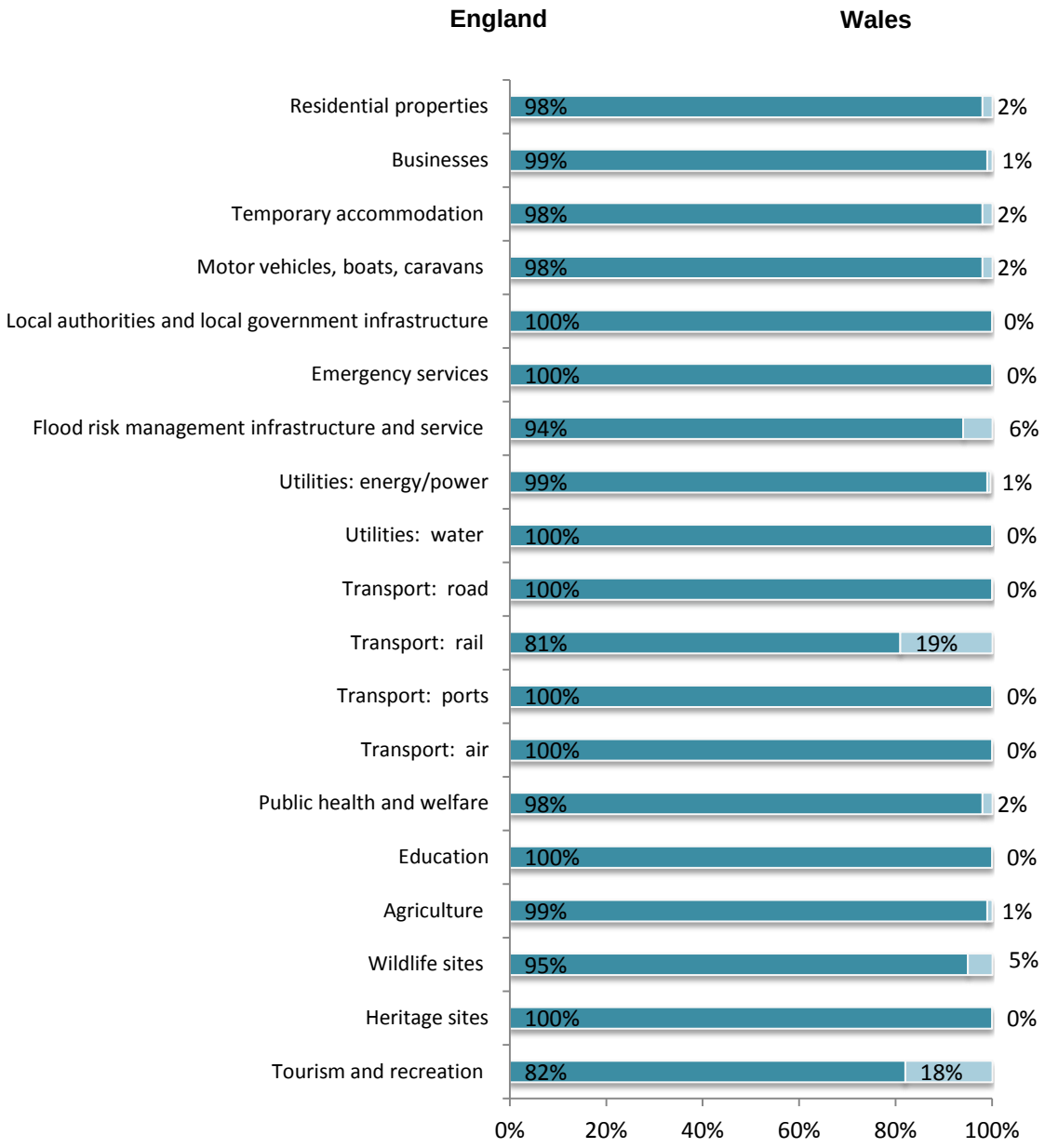

Figure 3.3 Proportion of damages from the winter 2013 to 2014 floods for England and Wales for each category

Notes: Percentages are based on data that could be disaggregated.

3.4 Number of assets affected

Information on the number, type, length, area and so on of assets affected is important in providing the context for the damage estimates. Table 3.5 summarises the data found for each impact category for the national and local approaches.

The figures sourced from the local approach (that is, those related to specific LLFAs) were used in the extrapolation exercise to estimate the potential impacts at the national level. It is important to note that the units vary for some categories in Table 3.5 between the national approach and local approach.

Where data gaps exist, flood outline data were also used to estimate the number of assets that may have flooded in each category. There is a degree of uncertainty with

these figures as some assets within a flood outline may not have flooded. Therefore, these data have only been used where no alternative value was obtained.

Table 3.5 Numbers affected for each impact category

Category	Damage estimates (numbers)			
	Sourced from national data		Sourced from local data	
	Data	Units	Data	Units
Residential properties	8,342	Properties	10,465	Properties
Businesses[1]	4,897	Properties	3,139	Properties
Temporary accommodation[2]	7,000	Households	758	People
Motor vehicles, boats, caravans	5,400	Number	738	Number
Local authorities and local government infrastructure[3]	Data limited		Data limited	
Emergency services[4]	Data limited		993	Incidents attended by emergency services
Flood risk management infrastructure and service [5]	Comprehensive national data set provided by the Environment Agency for all affected Environment Agency and LLFA flood risk management infrastructure			
Utilities: energy[6]	1 million	Customers with disruption due to power outages	124,450	Customers with disruption due to power outages
Utilities: water	Data limited		36	Assets damaged
Transport: road[7]	1,017	Flood incidents recorded by Highways Agency	Based on grants given to each LLFA	
Transport: rail	Numerous rail lines closed, assets affected and services disrupted	Incidents recorded by Network Rail	Data provided on specific locations where lines and stations were closed and services disrupted	Incidents recorded by Network Rail
Transport: ports[8]	Data limited		23	Number of ports affected
Transport: air	Data limited		2	Number of airports affected
Other communications (telecom)	Data limited		Data limited	–
Public health and welfare[9]	Data limited		Damage estimates based on the number of households thought to be suffering with health impacts	
Education[10]	Data limited		39	Educational assets affected
Agriculture	45,000	ha	47,000	ha
Wildlife sites	13,000	ha	7,750	ha
Heritage sites[11]	Data limited		49	Heritage assets affected
Tourism and recreation[12]	6,400,000	Trips affected	1,072	Number of assets affected

Notes:

[1] Where Environment Agency flood outline data were used these include vehicle services, sewage treatment works, shop/store, office, vehicle repair garage, launderette, café/food court, land used for storage, factory/works/mill, warehouse, pub/social club/wine bar, public conveniences, restaurant, kiosk, workshop, showroom, car showroom, extractive/heavy industry, ambient goods warehouse, bank, betting shop, computer centres, hairdressing salon, laboratory, petrol filling station, post office, retail warehouse, road haulage and superstore/hypermarket.

[2] The national data refer to the number of people still unable to return to their homes in August 2014. Not all households evacuated as a result of flooding will have required temporary accommodation.

[3] Environment Agency flood data include car parks, cemeteries/crematoriums, community centres, residential homes, libraries and law courts.

[4] Refers to number of flood incidents attended by the emergency services during the 2013 to 2014 storms.

[5] Refers to the number of shifts worked by Environment Agency staff involved in flood response during the winter 2013 to 2014 floods.

[6] Refers to the number of customers that suffered disruption as a result of flooding during the 2013 to 2014 winter storms.

[7] The national figure refers to the number of flood incidents during the 2013/14 winter storms according to the Highways Agency's Flood Severity Index (FSI). The local data refer to the length of road flooded or damaged by flooding (in km).

[8] Includes ports and harbours where evidence suggests they sustained damage during the 2013 to 2014 winter storms.

[9] Refers to the number of public health assets potentially flooded during the 2013 to 2014 winter storms. Any Environment Agency flood outline data used include surgeries and health centres.

[10] Environment Agency flood outline data used include schools, colleges, universities and nurseries.

[11] Environment Agency flood outline data used include churches.

[12] The national data refer to the number of trips disrupted by severe weather during the 2013 to 2014 winter storms.Environment Agency flood outline data used include mooring wharf/marina, sports and leisure centres, sports ground and playing fields, amusement arcades/parks, beach huts, boarding houses, football grounds, golf courses, hostels, hotels, museums and theatres/cinemas.

3.5 Comparison of the economic costs of the 2007 and 2013 to 2014 floods

The total economic costs associated with the winter 2013 to 2014 floods are estimated at £1.3 billion (£1,300 million) based on the best estimate. This figure could range from £1 billion to £1.5 billion (£1,000 million to £1,500 million); the low to high range is presented to provide an indication of uncertainty within the estimates. The damages resulting from the 2007 summer floods are estimated to be £3.9 billion (£3,900 million) uprated to 2014 values.[2]

The 2007 flood event occurred in the summer period and caused flooding of approximately 55,000 homes. In comparison, the 2013 to 2014 floods occurred in the

[2] Damages from Appendix Table B of the 2007 floods report (Environment Agency 2010) were uprated to 2014 values using the Cost Price Index multiplier 1.223.

winter and are estimated to have directly flooded around 10,000 homes. An important feature of the 2013 to 2014 event was the long duration of flooding in certain areas (such as Somerset) and the multiple flood sources (fluvial, coastal, groundwater and pluvial), which were not as apparent during the 2007 event.

Table 3.6 provides a comparison of the economic costs associated with the 2013 to 2014 floods (best estimate) and those that occurred during the summer 2007 floods.

The chart given in Figure 3.5, which shows the impact categories in decreasing order of magnitude of estimated damages from the 2013 to 2014 floods, highlights the differences between the 2 events.

Residential properties, business and roads were significant damage categories in both events, although their magnitude was much greater in 2007. Other categories (utilities: energy, and public health and welfare) were also more significant in 2007 than in 2013 to 2014.

The 2007 floods resulted in loss of life, which was valued as part of the assessment in addition to the impacts of flooding on mental health. The 2013 to 2014 flood events did not result in any loss of life as a direct result of flooding and therefore the assessment only considers the potential impacts of flooding on mental health. This is considered the main reason for the difference in the public health costs between the 2 events.

In the case of utilities: energy, the supply disruption caused by flooding during the 2007 event was much greater than the 2013 to 2014 event, resulting in higher costs. The approach used to determine the costs of electricity supply disruption during the 2013 to 2014 floods involved the use of an estimated welfare cost per hour of disruption of £3. In the 2007 assessment, the approach used to estimate the cost of disruption was based on a willingness to pay to avoid disruption of £10 per kWh (in 2007 prices), which is equivalent to £50 per day (considering the average household uses 5 kWh of electricity per day) or £2.08 per hour in 2007 prices (or £2.54 uprated to 2014 prices). The estimated welfare costs per hour of disruption used in both the 2007 and this 2013 to 2014 assessment are therefore similar, indicating that the number of customers experiencing electricity supply disruption was greater in the 2007 floods than in the winter 2013 to 2014 floods.

The magnitude of the damages to residential properties and business are high across the 2 events, with residential properties accounting for 25% of damages in 2013 to 2014 and 38% in 2007, and businesses accounting for 21% in 2013 to 2014 and 23% in 2007. The 2007 figure for residential properties is based on figures for 130,000 insurance claims. The 2013 to 2014 figure is based on extrapolations from insurance information of 18,700 flood claims for flooding between 23 December 2013 and 28 February 2014. The business figures are based on the same sources, with 35,000 claims in 2007 compared with 3,100 claims between 23 December 2013 and 28 February 2014, extrapolated to cover the whole flooding period.

The categories with greater damages in 2013 to 2014 are transport in particular rail and flood risk management. The likely reason for this is the damage caused to coastal assets and defences as a result of coastal flooding during the 2013 to 2014 winter storms, which was not a feature of the 2007 event.

Table 3.6 Damage data based on best estimates

Category	Best estimate (£ million)	% of total	Possible range (£ million)	Damages from summer 2007 floods (2014 values)	% of total 2007
Residential properties	£320	25%	£270–370	£1,500	38%
Businesses	£270	21%	£230–310	£910	23%
Temporary accommodation	£50	3.9%	£42–57	£120	3%
Motor vehicles, boats, caravans	£37	2.9%	£31–42	£98	3%
Local authorities and local government infrastructure	£58	4.5%	£49–66	£170	4%
Emergency services	£3.3	0.26%	£3.3–8.7	£5	0%
Flood risk management infrastructure and service	£147	12%	£145–148	£24	1%
Utilities: energy	£0.82	0.06%	£0.63–1.0	£288	7%
Utilities: water	£29	2.3%	£25–33	£110	3
Transport: road	£180	14%	£91–220	£230	6%
Transport: rail	£110	9.0%	£93–140	£44	1
Transport: ports	£1.8	0.14%	£1.6–2.1	Not considered separately	
Transport: air	£3.2	0.25%	£2.6–3.9	Not considered separately	
Other communications (telecom)	No data available				
Public health and welfare	£25	1.9%	£25–67	£340	9%
Education	£1.6	0.13%	£1.2–2.0	£14	0%
Agriculture	£19	1.5%	£12–25	£59	2%
Wildlife sites	£2.4	0.19%	£1.9–3.0	Not considered separately	
Heritage sites	£7.4	0.58%	£5.6–9.3	Not considered separately	
Tourism and recreation	£3.5	0.28%	£2.6–4.4	Not considered separately	
Total	**£1,300**		**£1,000–£1,500**	**£3,900**	

Notes: Colours relate to uncertainty rating (see Section 2).
Values are given to 2 significant figures.

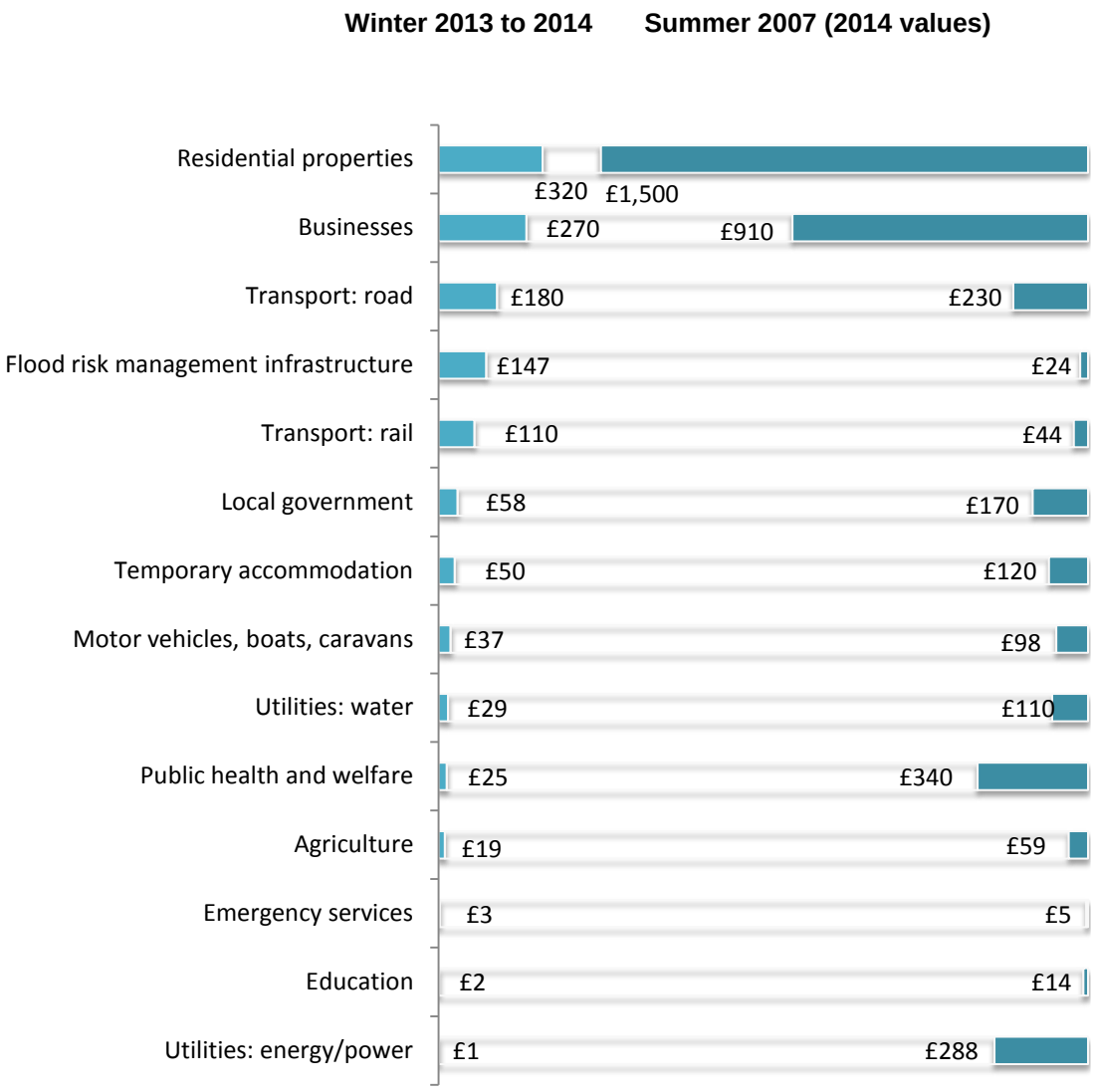

Figure 3.5 Comparison of the damages from the summer 2007 floods and the winter 2013 to 2014 floods for each category (all damages in £ millions)

4 Damages avoided

4.1 What are damages avoided?

In many locations in the winter 2013 to 2014 floods, flood defence assets and actions taken by organisations such as the Environment Agency, local authorities, Internal Drainage Boards (IDBs) and the military helped to reduce flooding and its effects. This resulted in damages that were not incurred due to the presence of flood defences, temporary defences or actions such as evacuations. All of the damages that were not incurred can be counted as 'damages avoided'. They can be divided into 2 types as summarised in Figure 4.1.

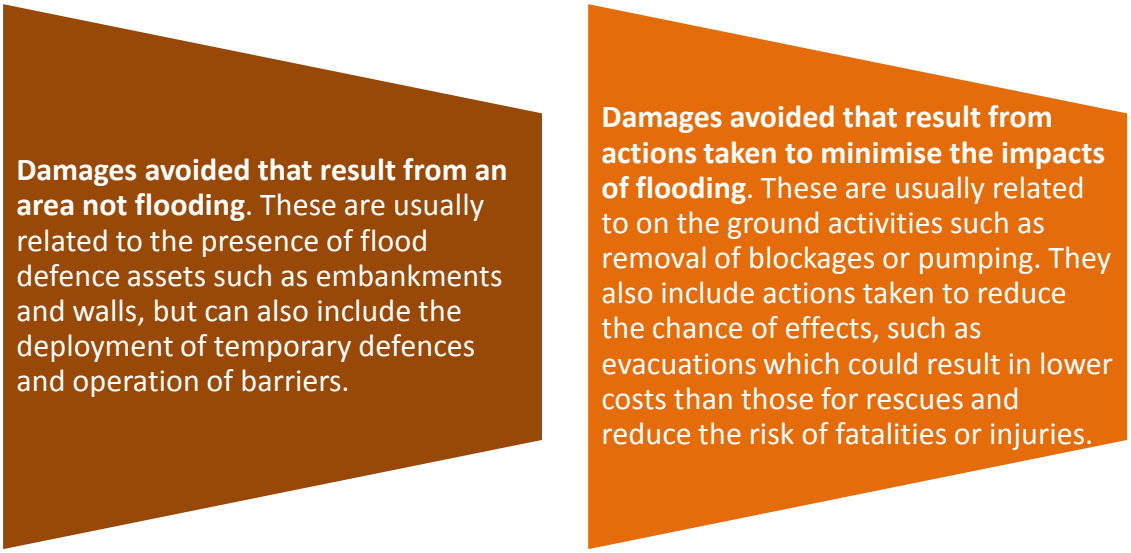

Figure 4.1 Types of damages avoided

The remainder of this section identifies and describes the damages avoided in the winter 2013 to 2014 floods.

4.2 Damages avoided from an area not flooding

4.2.1 Damages avoided by source of flooding

Existing flood defences protected around 1.4 million properties and more than 25,000ha of agricultural land from flooding during the winter of 2013 to 2014 (DCLG 2014a, Environment Agency 2014a) (Figure 4.2).

Table 4.1 gives details of the numbers of properties protected during different events. Around 720,000 properties were found to have been protected from the tidal surge which occurred between 4 and 8 December 2013. This represents just over 50% of the total number of properties protected by flood defences, suggesting that the number of properties protected against fluvial flooding was similar to that protected against coastal flooding.

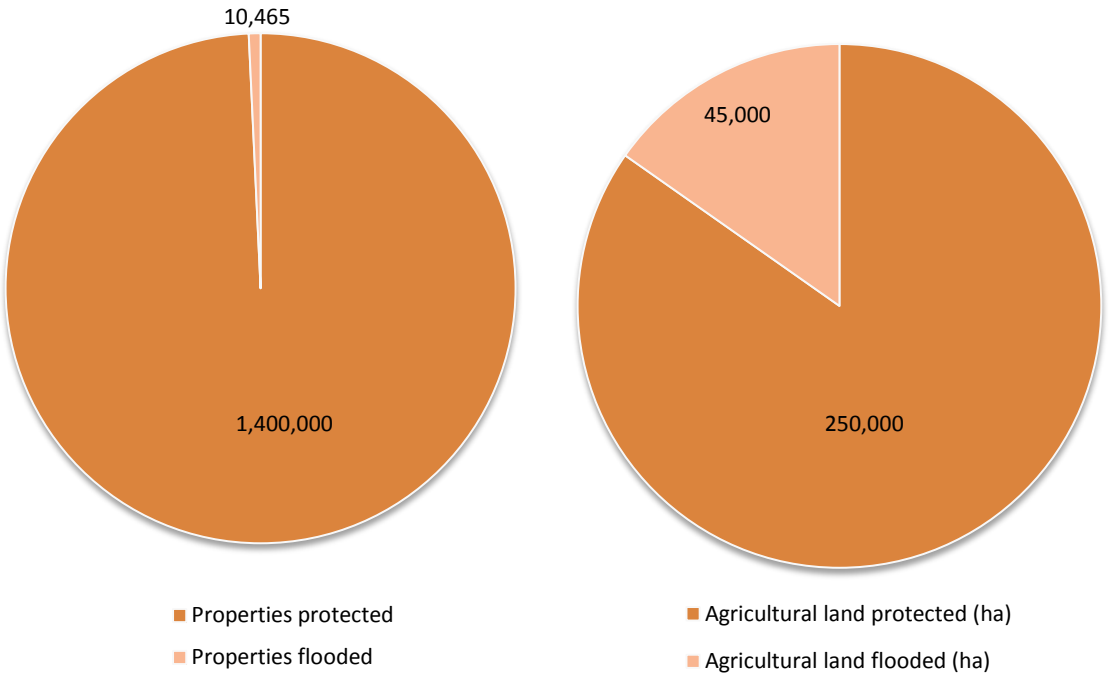

Figure 4.2 Comparison of the number of residential properties flooded and protected and the area of agricultural land flooded and protected

It is not just hard defences that can provide protection to properties. An approach based on use of natural flood risk management in Holnicote, Somerset, is considered to have protected some 40 or more National Trust residences that had flooded during previous events (National Trust, personal communication 2014).

Table 4.1 Summary of properties protected by flood event and type

Flood event	Flood type	Properties protected	Reference
4 December to 8 December	Coastal surge	719,589	Environment Agency (2014e)
4 December to 9 December	Coastal	800,000	Environment Agency (2014f)
Christmas floods (23–31 December 2013)	Fluvial Multiple	88,000	Environment Agency (2014g)
21 December to 31 December	Fluvial	88,373	Environment Agency (2014e)
New Year floods, 1–17 January 2014	Coastal Fluvial Multiple	240,000	Environment Agency (2014f)
Late January/February floods (29 January to 7 March 2014)	Coastal Fluvial	207,000	Environment Agency(2014h)

4.2.2 Locations and assets protected

Information on the number of assets protected is important in providing the context for the damages avoided. Table 4.2 provides a breakdown of the number of assets protected (properties and agricultural land). These figures show the number of properties reported as benefiting from defences, but there is no further information on the magnitude of those benefits. It is also not clear whether some properties could have been counted more than once given the number of repeat flooding incidents that occurred in 2013 to 2014. As a result, the numbers need to be treated with caution.

Table 4.2 Examples of where flood defences protected large numbers of properties and agricultural land

Area	Properties and land protected	Reference
East Coast surge		
Lincolnshire	136,000 properties 222,000ha agricultural land	NAO (2014)
East Anglia (Norfolk, Suffolk and Essex)	68,000 properties	Environment Agency (2014b)
Hull	19,000 properties	Hull City Council (2014)
Yorkshire and the North East	130,000 properties	Environment Agency (2014c)
Somerset	3,500 properties 20,000ha agricultural land	Environment Agency (2014a)
South West coast	91,000 properties	Environment Agency (2014d)
Thames Valley	No specific estimates available for area as whole	–
Wales	24,000 properties (December 2013) 50,000 properties (January 2014) 34,000ha agricultural land	Natural Resources Wales (2014)

The sections below provide more information on the benefits in the areas included in Table 4.2.

4.2.3 East Coast surge

This case study covers the coast of Yorkshire, Lincolnshire, Norfolk, Suffolk and Essex.

In Yorkshire and Humber, an estimated 130,000 properties were protected (Environment Agency 2014c). In Goole, water levels reached up to the top of the defences and resulted in 17,600 people living in the town being protected (Raynor and Chatterton 2014). Tidal defences along the Humber Estuary and managed by the Environment Agency protected 19,000 properties in Kingston upon Hull from flooding (Hull City Council 2014). In Lincolnshire, an estimated 136,000 properties were protected by defences (NAO 2014). A total of 68,000 properties were protected in Norfolk, Suffolk and Essex (Environment Agency 2014a) including 11,000 properties protected between Kings Lynn and Hunstanton (Environment Agency 2014j).

A complication with estimating the benefits provided by defences from coastal flooding is the importance of wind and wave action. The 2013 coastal surge along the East Coast was not accompanied by high winds driving wave action onto the coast. As a result, the flooding was less severe than predicted. In addition, this means that the damages avoided would be lower than if there had been significant wave action. The return periods of the coastal surge are also highly variable along the coast. They have been identified as follows for parts of Norfolk, Suffolk and Essex (Suffolk Coastal District Council 2014):

- Wells-next-the-Sea (1:500)
- Great Yarmouth (1:175)
- Lowestoft (1:200)
- Felixstowe (1:30)
- Holland (1:30)
- Southend (1:15)

4.2.4 South West Coast

This case study covers Devon and Cornwall.

Around 91,000 properties were protected in Devon and Cornwall during the Christmas and New Year floods (Environment Agency 2014d). This compares with 350 properties that were flooded.

The Local Flood Risk Management Strategy prepared by Cornwall Council identifies that there are 5,000 properties at risk from coastal flooding, 12,000 from fluvial flooding and 29,000 from surface water flooding (Cornwall Council 2014a). There were 267 residential properties flooded in the winter floods of 2013 to 2014, and a minimum of 364 properties in total. This does not mean that the remainder were protected from flooding, as there may not have been conditions that would have resulted in all the at-risk properties being affected at once.

4.2.5 Thames Valley

The Jubilee River and Thames Barrier were operated. One of the main factors leading to damages avoided in the Thames Valley was closure of the Thames Barrier. This was closed 50 times in December, January and February. As well as being used to protect central London from tidal flooding, the Thames Barrier was used to prevent high tides coinciding with high flows at Teddington. This helped provide protection to properties in downstream areas (Environment Agency 2014i).

Temporary defences were also deployed in parts of Oxfordshire, Berkshire and Surrey. Recently and even partially completed defences provided protection to several thousand residential and commercial properties, plus other assets including electricity substations (Environment Agency 2014i).

4.2.6 Wales

Existing flood defence assets provided protection for up to 24,000 properties in north Wales from the December 2013 events, while up to 50,000 properties could have flooded during the January storms. The assets also helped protect up to 34,000ha of agricultural land (Natural Resources Wales 2014).

4.2.7 Monetising the damages avoided

The main difficulty with estimating a monetary value for damages avoided is that it is not possible to assume all properties behind flood defences would have flooded if the defence was not in place. In addition, different areas and properties behind flood defences are at different levels of flood risk and therefore the probability of flood events is not known for all locations that did not flood. Hence, the damages avoided due to the presence of defences cannot be estimated without making assumptions or incurring large uncertainties.

A further complication arises in terms of the number of properties reported as being protected from flooding. This may include double counting of some properties from the multiple flood events during the winter; the extent to which properties protected are counted more than once in the totals presented above is not known. As a result, a reliable estimate of the damages avoided in monetary terms is beyond the scope of this report.

To enable the benefits of defences to be estimated, further information would need to be obtained on the return period of flood levels or the coastal surge level at specific locations. The estimate of damages avoided would then need to be based on the benefits provided to properties in those specific locations. Modelling may be needed to reflect how these flood levels would have affected properties in the absence of defences, or from lower defences assuming recent investment had not taken place. Such calculations would require additional research and data to enable them to be made with a reasonable degree of certainty.

4.3 Damages avoided where impacts were reduced

4.3.1 Actions taken to reduce impacts

In many areas, the Environment Agency, IDBs, the military and local councils also put in place temporary measures to protect assets from the flood waters. These activities will have helped to reduce the impacts of flooding and may have helped to reduce flooding in areas that may otherwise have been affected by flooding.

In addition to work carried out immediately before and during flooding, the Environment Agency and other Risk Management Authorities (RMAs) perform ongoing work with high risk communities and emergency partners to prepare for floods. This can help communities to increase their resilience and ability to recover more quickly after a flood event.

Between 1 December 2013 and the end of February 2014, the Environment Agency issued 155 severe flood warnings (danger to life) with 4.2 million flood warnings sent to people with properties in areas at risk of flooding (Environment Agency 2014a). The flood warnings issued by the Environment Agency will have allowed the emergency services (such as police and fire crews) to prepare for and assist with evacuations. These evacuations will have helped to prevent further knock-on effects, such as the need for rescues. RMAs assisted with the implementation of several temporary flood defences which helped to prevent flooding of thousands of properties.

In addition to carrying out evacuations, the emergency services also assisted with preventative measures such as the deployment of pumps to divert flood water. This will have limited the amount of internal flooding to some properties and possibly prevented internal flooding for others. This will have had a knock-on effect; some residents may have been able to remain in their properties (thus reducing the need for evacuations and supplies such as blankets and food) and other emergencies resulting from

flooding, such as electrical fires, will have been avoided. Alerting and assisting residents with evacuations will have prevented people (and pets) from becoming trapped and needing rescuing.

Utility companies laid plans and carried out work to minimise damages, where possible, although this itself will have incurred some upfront costs. When poor conditions are expected, telecommunications providers typically allocate extra engineers and obtain stocks of fuel for emergency generators (Ofcom 2014). Utility companies have also made investment since the floods of 2007 to improve the resilience of their assets.

The case studies below discuss damages that were avoided as a result of actions that were taken locally by RMAs, by the military, by property owners themselves and with the assistance of their local communities and volunteers.

4.3.2 East Coast

There were 33 severe flood warnings issued (9 in Norfolk, 15 in Suffolk and 9 in Essex), resulting in a total of 18,000 people being asked to evacuate. There were also 102 flood warnings (46 in Norfolk, 44 in Suffolk and 12 in Essex) and 40 flood alerts (14 in Norfolk, 12 in Suffolk and 14 in Essex) (Environment Agency 2014a). In Yorkshire and the North East Region, there were 8 severe flood warnings, 64 flood warnings and 19 flood alerts issued (Environment Agency 2014i).

In Norfolk, the Environment Agency also deployed a demountable defence gate to protect properties (Environment Agency 2014a). The army was deployed in Great Yarmouth to help protect communications infrastructure during the coastal surge (BBC News 2014a). It is generally very rare that major switching sites experience flooding, simply because flood risk is considered during planning and such sites may be positioned and then repositioned (Ofcom 2014).

In Lincolnshire, temporary barriers were installed where there was not time to repair defences before the next high tide (NAO 2014). This will have helped prevent repeat flooding.

In Lincolnshire, 203 people from 78 different households received assistance to evacuate with many more self-evacuating. There were also 44 people and 2 pets rescued (Environment Agency 2014l).

More than 200 households were evacuated in the North Norfolk District Council area, with 30 residents and 20 households provided with emergency accommodation (North Norfolk District Council 2014). In Great Yarmouth, 600 people were accommodated in rest centres with £10,000 worth of rest centre equipment being deployed (financial cost). In total, 9,000 residential properties were targeted for evacuation. It is not clear how many people evacuated and stayed with friends or relatives or moved out of the area temporarily, but many people may not have evacuated (Great Yarmouth Borough Council 2014).

In Suffolk, around 100 people attended the local authority rest centres, while others used rest centres run by local community groups (Suffolk County Council 2013).

In Essex, around 2500 homes were evacuated, including homes in 61 streets in Jaywick (BBC News 2013f).

4.3.3 Somerset Levels

Pumping of floodwaters was one of the main actions taken in Somerset to help reduce the impacts. At the height of flooding, more than 100 pumps were used to remove floodwater. This included 18 pumps from the Netherlands (Environment Agency

2014a). In early February, pumps were removing 1.5 million tonnes of flood water per day (Muchan et al. 2015). The Environment Agency also deployed more than 150,000 sandbags and constructed earth bunds to help protect more than 20 properties (Environment Agency, personal communication 2014).

4.3.4 South West Coast

There were 14 severe flood warnings and 82 flood warnings issued in Devon in January and February 2014 (Environment Agency 2014k). In the South West, 25 severe flood warnings were issued (Environment Agency 2014d).

Evacuations took place in many locations, including 59 households in Dawlish and self-evacuation in Torcross (Devon County Council 2014a). Residents in Porthtowan and Bude in Cornwall were advised to leave their homes in February 2014 due to tidal surges, while 4 residents were evacuated from Kingsand, Cornwall, at the height of the storm. Further residents were also evacuated in Portholland and Penzance on 14 February (Andrew 2014).

The voluntary sector in Cornwall played a vital role in the recovery. The Cornwall Community Flood Forum provided volunteer flood wardens who were able to help the statutory services. In addition, Volunteer Cornwall's 'Winter Friends' scheme was deployed for tasks including drain clearing ahead of storms, filling sandbags and cleaning beaches after the storms. Volunteers from local Time Banks helped those directly affected by flooding with clean-up, as well as listening to those affected by flooding as they recounted their experiences (Andrew 2014).

4.3.5 Thames Valley

In the West Thames area, 14 severe flood warnings were issued in February 2014. In addition, 155 flood warnings (22 in December, 63 in January and 70 in February) and 151 flood alerts (59 in December, 60 in January and 32 in February) were issued by the Environment Agency. There were also 13 groundwater flood alerts (11 in January and 2 in February) (Environment Agency 2014i).

As well as issuing alerts, the Environment Agency carried out a range of operational works, daily inspections and blockage removal to help reduce the risk of flooding (Environment Agency 2014i).

Pumps were used to reduce the risk of flooding in a number of locations, while sandbag walls were erected to protect properties and provide additional support to pre-existing flood defence assets (Environment Agency 2014i). Pumps were used in West Berkshire due to the balancing pond from the A34 being very full and at risk of overtopping. This could have resulted in flooding of the A34 and M4, with impacts on the transport network. The pumping also helped protect properties in Chieveley village (Richardson 2014).

The London Borough of Bromley installed pumps to remove excess water following emergency pumping by the fire brigade and Thames Water (Bromley Borough Council 2014). In Oxfordshire, the county council distributed more than 2,000 sandbags to communities including Chalgrove, Henley, Playhatch, South Moreton, Wantage, Watlington, Burcot and Postcombe (Oxford Mail 2014). Sandbags were also used in Buckinghamshire, where the county council set up a sandbag station in Marlow (Buckinghamshire County Council 2014).

Multi-agency support also helped reduce the risk of damages through use of high volume pumps and military assistance in blocking a breach in the Kennet (Richardson 2014).

Ongoing activities by electricity providers include maintaining defences around assets such as substations. Meanwhile, water companies assisted during the flooding with managing water levels. For example, Thames Water provided pumps and water tankers to minimise both the risk and potential extent of sewage flooding (West Berkshire Council 2014). Southern Water had considerable costs for tankers and pumping, with more than 330 staff and 117 tankers involved in the process (Environment Agency 2014i). The company removed excess water from its sewerage system with pumping levels peaking at around 125 million litres of water per day (Environment Agency 2014i).

4.3.6 Wales

During the January storms around 150 properties were protected from internal flooding through the use of temporary local protection measures in the December events and 850 in the January storms (Natural Resources Wales 2014). There were 4 flood alerts, 15 flood warnings and 2 severe flood warnings issued for the coastal surge (4–5 December 2013) and 21 flood alerts, 103 flood warnings and 6 severe flood warnings issued for the period between 2 and 6 January 2014 (Natural Resources Wales 2014).

Evacuation procedures were initiated in a number of locations including Rhyl (December 2013) and Borth, Aberystwyth, Cardigan and areas of Newport (January 2014). In Rhyl, more than 400 properties were advised to evacuate and over 200 people were received at rest centres. Ceredigion Council advised more than 600 properties to evacuate across Borth, Aberystwyth and Cardigan while Newport County Council reported that 450 properties were advised to evacuate in the Crindau Pill area of Newport. Evacuations were also carried out on a number of caravan parks, including 170 residential caravans at Lighthouse Park Estate in Newport (Natural Resources Wales 2014).

4.3.7 Monetising the damages avoided from flood incident management

It is difficult to estimate monetary values for damages avoided as a result of planning and preparation, flood forecasting, warning and due to actions taken on the ground during flood incidents. This is because, while the planning and preparation and forecasting and warning are supported or put in place by the Environment Agency and other agencies, it is the actions of private individuals and businesses in response to these preparations that actually result in the damage reduction. In addition, it is extremely difficult to estimate the economic impacts of all these individual actions for any one single flood event.

Furthermore, it is generally unknown if it was the actions that resulted in flooding impacts being reduced or because the flood itself did not actually threaten the area as predicted. This may have been the case in Windsor, for example, where river levels did not reach the height of a sandbag wall. The same is true of evacuations, which may have helped to avoid fatalities directly linked to flooding and to reduce the number of injuries that occurred. However, what cannot be known is whether any fatalities or a greater number of injuries would have occurred if evacuations had not taken place. In Oxfordshire, the number of residents that needed to be evacuated in January and February 2014 was just 32, compared with 600 in the summer of 2007. The difference is assumed to reflect investment in flood protection schemes and the efficiency of the emergency response (Mackay 2014). There was also a coordinated approach used in Oxfordshire that involved co-location and teleconferencing for rapid and effective sharing of information. Flood defence barriers, including demountable barriers in high risk locations, were put into place quickly (Mackay 2014).

Actions taken deliberately to limit the extent of flooding, or to control where floodwaters went, are also difficult to capture within an estimate of damages avoided. Pumping of floodwaters, seen extensively in Somerset, is likely to have helped reduce the duration of flooding and the extent, but again the reduction in damages that may have resulted are difficult to estimate. In Somerset, the floods are considered to have cost the Environment Agency £12.5 million (financial cost) in relation to response and recovery (personal communication). Elsewhere, Lindsey Marsh IDB incurred costs of around £81,000 from the coastal surge and Bedford Group of Drainage Boards incurred estimated costs of around £110,000 from temporary pumping and workforce/officer man days spent on flood duties (both assumed to represent economic costs) (Bedford Group of Drainage Boards, personal communication 22 December 2014).

4.4 Important uncertainties

Many of the estimates of properties protected are uncertain, with there being a risk that some properties are counted more than once due to the way in which information on properties protected is reported and collated. Without detailed information on the likelihood of flooding, as well as consequence data such as depth and duration, it is very difficult to obtain a reliable estimate of damages avoided. However, it is clear that while the number of properties flooded during the 2013 to 2014 floods is in the region of 10,000, the number of properties protected is more than an order of magnitude greater (minimum of hundreds of thousands protected). So it is not unreasonable to assume the damages avoided are likely to be many times greater than those incurred.

5 Impacts on residential properties

5.1 Summary of findings

Table 5.1 presents the headline figures for residential properties, including estimates of the damages caused to this impact category during the winter 2013 to 2014 floods. The best estimate is £320 million with a range of £270 million to £370 million, based on Association of British Insurers (ABI) claims information for residential properties affected by flooding during the period 23 December 2013 to 28 February 2014. These data were adjusted and extrapolated to include the estimated damages caused by coastal flooding (resulting from tidal surges) in early December 2013. Further details on how the best estimate and range were determined are provided in the following sections.

Table 5.1 Headline findings for residential properties

Finding	Economic damage estimates			
	Best estimate (range)	**% of total monetised damages**	**Uncertainty rating**	**Comments**
2013 to 2014 damages (total)	£320 million (£270 million to £370 million)	25% (of overall total damages)	Low–moderate	Based on national claims, data (extrapolated to include assets affected by coastal as well as fluvial/groundwater flooding) Range estimate based on uncertainty rating
2013 to 2014 damages (England)	£310 million £270 million to £360 million)	98% (of total for category)	Moderate–high	Calculated by determining the proportion of all properties flooded that were located in England (98%) and applying this to the damages estimates
2013 to 2014 damages (Wales)	£6.6 million (£5.6 million to £7.6 million)	2% (of total for category)	Moderate–high	Calculated by determining the proportion of all properties flooded that were located in Wales (2%) and applying this to the damages estimates
2007 damages (2014 values)	£1.5 million	38% (of overall total damages in 2007)	Score: 2 (limiting assumptions)	Based on Environment Agency (2010)
	Best estimate	**Units**	**Uncertainty**	**Comments**
Numbers affected (total)	8,342 to 10,465	Properties	Low / Low–moderate	Lower figure based on national data, higher figures based on local

Finding	Economic damage estimates			
				data
Numbers affected (England)	10,247	Properties	Low–moderate	Based on aggregated data obtained at the local (LLFA) level
Numbers affected (Wales)	218	Properties	Low–moderate	Based on aggregated data obtained at the local (LLFA) level
	Best estimate	**Range**	**Uncertainty**	**Comments**
Damages per asset	£23,000	£6,000 to £52,000	Moderate	Best estimate national claims data Range based on average per property from local approach to average damages per property in Somerset (note that these are all economic costs)

Notes: Values presented to 2 significant figures.

5.2 Determining the best estimate

5.2.1 Number of residential properties affected

Data from the Department of Communities and Local Government (DCLG 2014a) suggest that 8,342 households were flooded. Of these an estimated 2,800 properties (34%) were affected by the coastal surge in December 2013 (Environment Agency 2014f). The ABI recorded 18,700 claims linked to flood events between 23 December 2013 and 28 February 2014 as of 31 March 2014 (ABI 2014a). It is probable that this figure includes multiple claims from the same properties. The National Audit Office (NAO) reported 7,700 homes being flooded (NAO 2014). This is lower than the DCLG value and may represent a difference in definition between 'homes' and 'households' or differences in flood definition (water within the property boundary compared to water across the building threshold).

The map in Figure 5.1 shows the distribution of flooded residential properties based on the information available.

The number of properties affected different regions of England and Wales is given in Table 5.2, which is based on the local approach using information obtained from LLFA Section 19 reports and through direct engagement with LLFAs (considered the most reliable source for local level estimates). Where there was no information on the number of properties flooded at LLFA level, Environment Agency flood outline data were used as an estimate of the number of properties potentially flooded. Where appropriate, the figures from the local approach were compared with the flood outline data to determine the possible source of the flood. In cases where the flood outline data were not available, it was assumed that flooding in coastal LLFAs was caused by coastal flooding and flooding in non-coastal LLFAs was caused by fluvial flooding.

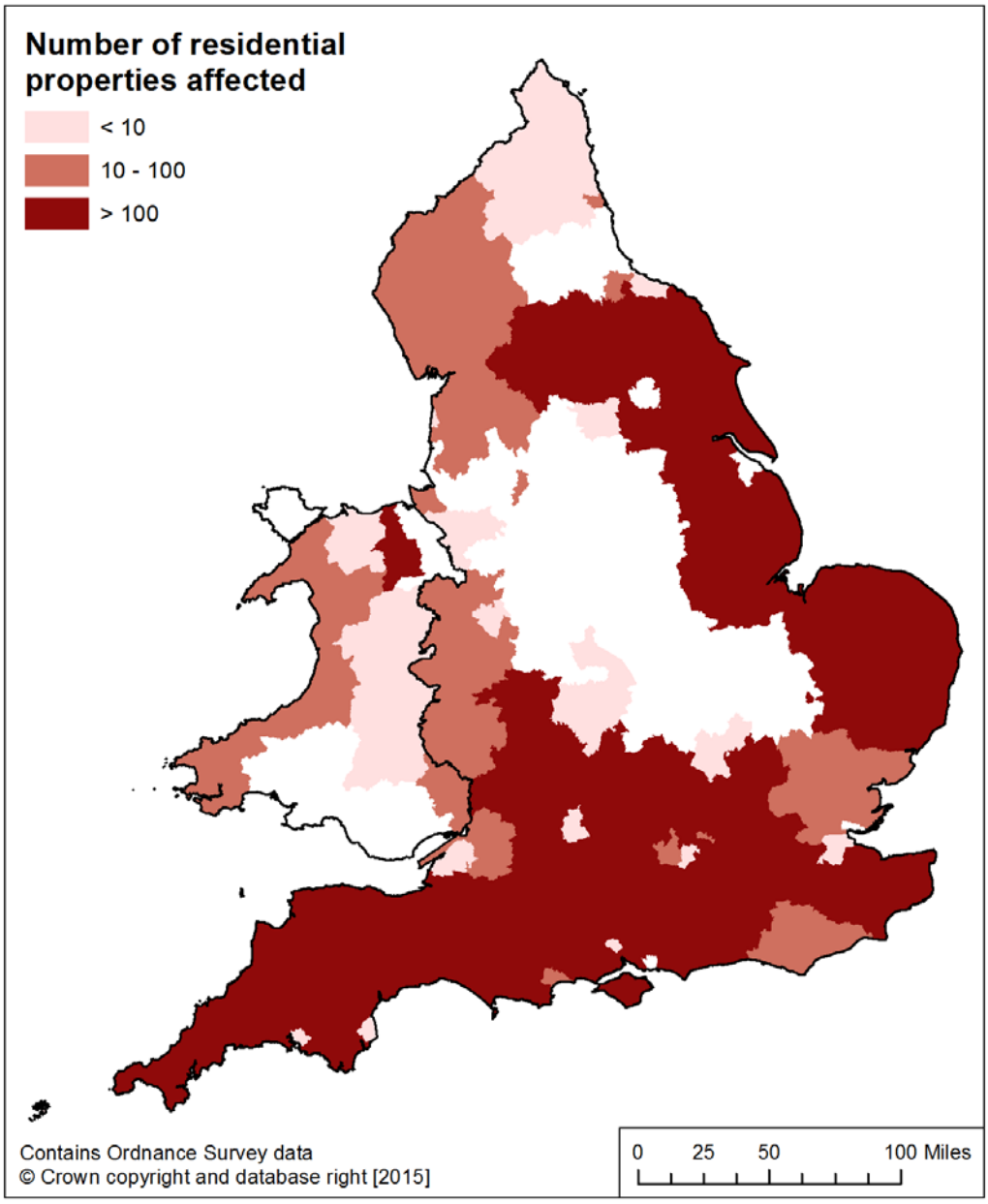

Figure 5.1 Estimated numbers of residential properties flooded for the 72 LLFAs for which data were available

Notes: Only shows where data were available and data may also be incomplete.

The total number of properties shown as having been flooded in Table 5.2 (10,465) exceeds the 8,342 from DCLG and the 7,700 from the NAO.

The largest numbers of properties affected were in the South East, South West, and Yorkshire and Humber. In the South East and South West the flooding was predominantly fluvial, but in Yorkshire and Humber it was mainly due to coastal flooding. Groundwater flooding affected properties across Surrey, West Berkshire, Wiltshire, Hampshire, Dorset and Sussex.

The local data indicate that 4,169 residential properties were affected by coastal flooding; 6,281 from fluvial flooding and 15 from groundwater flooding. However, there is limited separation of groundwater flooding impacts from other flooding. Therefore, it is estimated that a total of 10,465 residential properties flooded during the winter of 2013 to 2014 from all flood sources.

Table 5.2 Geographical breakdown of residential properties affected

Location	Number of properties flooded	% of total properties flooded	Main sources of flooding	Percentage of flooding by main source
London	175	2%	Fluvial: 175	Fluvial: 100%
East Midlands	1,082	10%	Coastal: 1,082	Coastal: 100%
East of England	630	6%	Coastal: 445 Fluvial: 185	Coastal: 71% Fluvial: 29%
North East	334	3%	Coastal: 334	Coastal: 100%
North West	107	1%	Coastal: 76 Fluvial: 31	Coastal: 71% Fluvial: 29%
South East	4,075	39%	Coastal: 394 Fluvial: 3,666 Groundwater: 15	Coastal: 10% Fluvial: 90% Groundwater: <1%
South West	2,157	21%	Coastal: 517 Fluvial: 1,640	Coastal: 24% Fluvial: 76%
West Midlands	221	2%	Fluvial: 221	Fluvial: 100%
Yorkshire and Humber	1,466	14%	Coastal: 1,105 Fluvial: 361	Coastal: 75% Fluvial: 25%
Wales	218	2%	Coastal: 216 Fluvial: 2	Coastal: 99% Fluvial: 1%
Total	10,465	100%	Coastal: 4,169 Fluvial: 6,281 Groundwater: 15	Coastal: 40% Fluvial: 60% Groundwater: <1%

Notes: Based on data from LLFA's Section 19 reports and engagement with LLFAs.

Total may include some businesses as not all LLFAs differentiated between residential and non-residential properties in their data.

Data gaps were filled using GIS information on flood outlines.

Some numbers affected by coastal or fluvial flooding are uncertain as data did not always clearly distinguish between sources of flooding (or gave multiple sources).

Where possible, flood outline data were used to determine the potential source of the floods. In cases where the flood outline data were not available, it was assumed that flooding in coastal LLFAs was caused by coastal flooding and that flooding in non-coastal LLFAs was caused by fluvial flooding.

See Appendix B for details of which LLFAs are included in each area.

5.2.2 Damages to residential properties

The best estimate of the damages to residential properties is based on national level insurance data collated by the ABI on the amount expected to be paid to flooded homeowners in the period 23 December 2013 to 28 February 2014. These data give a total of £276 million (ABI 2014b).

The figure of £276 million represents a financial cost estimate and therefore requires adjustment to determine the economic cost of the damages to residential properties. To convert the financial cost to an economic cost, the approach outlined in Environment Agency (2010) was used. This assumes that 75% of domestic insurance claims are for household contents ('inventory'), with the remaining 25% relating to building structures and fixtures ('non-inventory').

Adjustments were also made to the financial value of insurance claims to allow for the fact that most goods (inventory items) replaced under 'like-for-like' policies are not new. On average, they have a remaining value equivalent to half of their original value and hence half their replacement cost. Thus, the economic cost of damage is taken to be 50% of the financial replacement cost under an 'old' for 'new' policy; this was only applied to inventory items.

A final adjustment was made to both inventory and non-inventory items to remove VAT at 20%.

Adjustment of the financial insurance claim estimate of £276 million gives an economic cost estimate of £140 million (Table 5.3).

Table 5.3 Conversion of ABI insurance cost estimate for residential properties from a financial cost to an economic cost

Stage	Type of cost	Adjustment	Cost estimate
1	Original financial estimate	Original value	£276 million
2	Inventory items (household contents)	75% of claims are for household inventories (75% of Stage 1)	£207 million
3		50% of financial replacement cost – replacing old with new (50% of Stage 2)	£104 million
4		Remove VAT at 20% (divide by 1.2)	£86 million
5	Non-inventory items (building structures and fixtures)	25% of claims are for building structures and fixtures (25% of Stage 1)	£69 million
6		Remove VAT at 20% (divide by 1.2)	£58 million
7	**Total economic cost**	**Stage 4 + Stage 6**	**£140 million**

Notes: Values are presented to 3 significant figures.

The total value of £140 million relates to the period from 23 December 2013 to 28 February 2014, and is considered to exclude the damages resulting from coastal flooding during the tidal surge of early December 2013. It is therefore assumed that the data in Table 5.3 predominantly relate to damages caused by fluvial/groundwater flooding, though it is recognised that some localised coastal flooding to residential properties is likely to have occurred between 23 December 2013 and 28 February 2014.

Using the number of residential properties considered to have been affected by fluvial/groundwater flooding during the winter 2013 to 2014 floods of 6,296 (Table 5.2) and the economic estimate of the costs (Table 5.3) gives an average damage cost per flooded residential property of £23,000 (rounded to 2 significant figures) for the period 23 December 2013 to the 28 February 2014.

This average cost can be used to estimate the potential damages to residential properties affected by coastal flooding in early December 2013. A total of 4,169 properties are estimated to have been affected by coastal floods (Table 5.2). Applying the average damage costs per property of £23,000 to these properties gives an estimate of the damages caused to residential properties from coastal flooding of £95 million.

The total damages to all residential properties from fluvial/groundwater and coastal flood sources is therefore estimated to be £240 million. This is calculated as follows:

Total damages to residential properties (£240 million) = Damages from fluvial/groundwater flooding (£140 million) + Damages from coastal flooding (£95 million) [3]

The total damage estimate of £240 million is based on insurance claims data and currently assumes that all properties flooded during the 2013 to 2014 winter had appropriate household insurance. However, it is likely that a number of affected homeowners did not have home insurance and will not therefore be included in the estimate. Thus, it is necessary to adjust the damage estimate to account for those properties that may have been flooded but did not have insurance.

A recent paper suggests that the average insurance penetration rate for domestic properties in the UK is 75% (Penning-Rowsell 2015). A simple assumption is used that the uninsured 25% would have incurred the same level of damages as the insured 75%. Adjusting the damage estimate of £240 million to account for 75% of insurance penetration for domestic properties gives an estimate of £320 million for damages to residential property caused by the winter 2013 to 2014 floods.

Combining the insurance information with the number of properties considered to have been flooded during the 2013 to 2014 winter period gives an average cost per flooded property of £23,000. However, information from the Somerset region suggests that the financial cost per flooded property there was around £100,000. Converting this to an economic cost gives in an average cost per property of £52,000. Flooding in Somerset during the 2013 to 2014 winter was particularly severe with a long duration (compared with other areas of England and Wales). It is therefore not surprising that the average damages per property in this region are higher than the national average figure used in determining the best estimate. The Annex 1 method statement is a summary of the approach used to develop the best estimate of the damages to residential properties.

5.3 Determining the best estimate range

The data used to provide the best estimate of costs in each impact category were assessed to determine the associated uncertainty. The uncertainty rating was applied based on the availability and quality of the data obtained and the assumptions applied to the data to provide an economic cost estimate. The uncertainty rating was subsequently used to determine the potential range around the best estimate.

This approach was used to determine a range of flood damage costs to residential properties of £270 million to £370 million (Table 5.1). Further details on the methods used to develop the lower and higher ranges are provided below.

5.3.1 Low estimate

Information was obtained from the ABI on the insurable damages incurred at residential properties flooded between 23 December 2013 and 28 February 2014. It was necessary to extrapolate this information to include damages caused by coastal flooding in early December 2013 as well as damages to residential properties that were not insured. The information provided by the ABI was considered to represent a financial cost and was therefore adjusted to convert the damages to an economic cost.

The information provided is from a reliable source and is a national estimate of the insurable costs, suggesting a low uncertainty rating. However, it did not cover the entire 2013 to 2014 winter period. Thus, the data were classified as having a low–moderate uncertainty rating given the extrapolation required and the adjustments made to

[3] The values are presented to 2 significant figures and therefore the total may not be the exact sum of the damage costs due to rounding.

provide an economic estimate of the costs. To reflect this uncertainty, the best estimate (£320 million) was reduced by 15% (see Table 2.5), resulting in a low range estimate of the flood damages to residential properties during the 2013 to 2014 winter period of £270 million.

5.3.2 High estimate

A similar approach was used to obtain an upper range estimate. Reflecting the low–medium uncertainty rating applied to the data, the best estimate (£320 million) was increased by 15% (see Table 2.5), resulting in a high range estimate of the flood damages to residential properties during the 2013 to 2014 winter period of £370 million.

5.4 Damage costs by flood type

This section provides a breakdown of the damage costs to residential properties as a result of the winter 2013 to 2014 floods by flood type. It includes details of the methods used to differentiate the damage costs and the associated uncertainties.

5.4.1 Approach to disaggregating the damage costs

Where appropriate, local data obtained from LLFAs on the number of residential properties considered to have been affected were compared with Environment Agency flood outline data to determine the possible source of the flood. Where flood outline data were not available, it was assumed that flooding in coastal LLFAs was caused by coastal flooding and flooding in non-coastal LLFAs was caused by fluvial flooding.

The local data indicate that 4,169 residential properties were affected by coastal flooding and 6,296 from fluvial/groundwater flooding, giving an estimate of 10,465 residential properties flooded during the winter of 2013 to 2014 from all flood sources (Table 5.2). This breakdown was used to estimate the damages to residential property by flood source.

Fluvial/groundwater flooding

The ABI data used as the basis for determining the best estimate of the damages do not include the flood damages caused by the tidal surge in early December 2013. They were therefore assumed to represent damages caused by fluvial/groundwater flooding only, though it was recognised that some localised coastal flooding may have occurred in the period from 23 December 2013 to 28 February 2014. Adjusting the damage estimate of £140 million and accounting for 75% of insurance penetration for domestic properties gives an estimate of £190 million for flood damages to residential property caused by fluvial/groundwater sources.

Coastal flooding

The ABI data, which predominantly relate to fluvial/groundwater flooding, were extrapolated to include the coastal flood damages caused during the tidal surge in early December 2013.

Table 5.2 indicates that 4,169 residential properties may have been affected by coastal floods. Assuming each flooded property suffered £23,000 worth of damages, and adjusting the estimate to account for 75% insurance penetration for domestic properties, gives an estimate of the total damages caused by coastal flooding of

£130 million. In summary the following calculation was used to determine the best estimate of damages to residential properties caused by coastal flooding:

Coastal damages to residential properties (best estimate) = [Average damage cost per residential property (£23,000 based on ABI data) × Number of properties flooded by coastal sources (4,169)] ÷ 75% (to account for properties that were flooded but not insured).

5.4.2 Summary of damage costs by flood type

Table 5.4 provides a summary of the estimated economic damages to residential properties caused by fluvial/groundwater flooding and coastal flooding during the winter of 2013 to 2014.

Table 5.4 Estimated economic damage costs to residential properties by flood type

Flood source	Economic damage estimates					
	Best estimate	Percentage of total	Low estimate	Percentage of total	High estimate	Percentage of total
All (total)	£320 million	100%	£270 million	100%	£370 million	100%
Fluvial/ groundwater	£190 million	60%	£160 million	60%	£220 million	60%
Coastal	£130 million	40%	£110 million	40%	£150 million	40%

Notes: Values are presented to 2 significant figures and therefore the totals may not be the exact sum of constituent parts due to rounding.

5.5 Damage costs for England and Wales

This section provides a breakdown of the damage costs to residential properties as a result of the winter 2013 to 2014 floods for England and Wales. It includes details of the method used to differentiate the damage costs and the associated uncertainties.

5.5.1 Approach to disaggregating the damage costs

The damages to residential properties were estimated using ABI insurance data and the number of properties considered to have flooded during the 2013 to 2014 winter period. This latter figure was obtained at the local (LLFA) level and can thus be separated for England and Wales (Table 5.2). Of the 10,465 residential properties that flooded, 98% were located in England and 2% in Wales (Table 5.5). This percentage split was applied to the economic damage costs to estimate the damages caused by flooding of residential properties in England and Wales. This approach assumes that the average flood damage cost per property is similar in England and Wales.

Table 5.5 Number of residential properties affected by flooding in England and Wales

Country	Number of properties	Percentage of total
All (total)	10,465	100%
England	10,247	98%
Wales	218	2%

Notes: Based on aggregation of data obtained at the local (LLFA) level.

5.5.2 Damages cost for England and Wales

Table 5.6 provides a summary of the estimated flood damages to residential properties during the winter 2013 to 2014 floods for England and Wales. The approach outlined in Section 5.5.1 provides a best estimate of the damage costs to residential properties during the winter 2013 to 2014 floods for England and Wales of £310 million and £6.6 million respectively.

Table 5.6 Estimated economic damage costs to residential properties in England and Wales

Flood source	Economic damage estimates					
	Best estimate	Percentage of total	Low estimate	Percentage of total	High estimate	Percentage of total
All (total)	£320 million	100%	£270 million	100%	£370 million	100%
England	£310 million	98%	£270 million	98%	£360 million	98%
Wales	£6.6 million	2%	£5.6 million	2%	£7.6 million	2%

Notes: Values are presented to 2 significant figures and therefore totals may not be exact sum of constituent parts due to rounding.

5.6 Uncertainties and assumptions

Although every effort was made to obtain a full suite of data, there are data gaps which will affect the reliability and robustness of the household damage estimates. The main uncertainties are summarised below.

ABI claims data only covered the period from 23 December 2013 to 28 February 2014. As a result they did not capture damages from the coastal surge that occurred in early December 2013. The assumptions made to fill this gap mean that coastal damages are considered the same (per property) as fluvial damages. There are no detailed data available at the local level to check this assumption other than for East Riding of Yorkshire, where per property damages were £39,000. This is 72% higher than the £23,000 per property average. Damages from the coastal surge may therefore be underestimated.

There was also some anecdotal evidence of under-reporting to insurance companies, reflecting reluctance by individuals or businesses to admit to their property being affected due to concerns over increasing insurance premiums or excess levels. However, it is likely that the vast majority of cases were reported as, where possible, information was collected from different sources for each category. Any additional uncertainty caused by claims being lower than actual damages should therefore be small.

The insurance information obtained relates to the period between 23 December 2013 and 28 February 2014. However, it is unclear whether this relates to claims made or properties flooded during this period. For the purposes of this assessment, it is assumed that the insurance data relate to properties that flooded during this period.

The number of properties affected is also uncertain, with some data sources not differentiating between residential and business properties. This makes it difficult to identify the actual number of residential properties affected. The national estimate of 8,342 represents around 80% of the local estimate of 10,465. This gives an indication of the uncertainties surrounding the estimated number of properties affected.

There is also uncertainty associated with the number of properties affected by different flood sources (that is, fluvial/groundwater and coastal floods). Flood outline data were used to determine the likely source of floods for each LLFA area, but where this was not possible, properties affected in coastal LLFAs are assumed to have been affected by coastal floods. This is likely to overestimate the coastal impacts as properties in coastal areas may also have been affected by floods from other sources.

Adjustments were made to convert financial damages to economic damages. These adjustments use generic assumptions that are assumed to be common to all household property damages, such as the proportion of damages that are inventory rather than non-inventory. As a result, there will be uncertainties introduced due to the adjustments. It is difficult to quantify this uncertainty without detail on the breakdown of claims, which was not available.

The adjustment for uninsured properties is also likely to introduce uncertainty into the damage estimates. A simple assumption was used that 75% of flooded properties were insured. The accuracy of this assumption for the areas affected in 2013 to 2014 cannot be determined.

The approach used to estimate the damages to residential properties in England and Wales assumed that the average costs per flooded property were similar across England and Wales. However, the average flood damages incurred to residential properties may not be comparable (that is, the average damages may have been greater in England than Wales or vice versa), which would increase or decrease the proportion of the total damages attributable to each country.

6 Impacts on businesses

6.1 Summary of findings

Table 6.1 presents the headline figures for business properties, including estimates of the damages caused to this impact category during the winter 2013 to 2014 floods. The best estimate is £270 million with a range of £230 million to £310 million is based on ABI claims information for business properties affected by flooding during the period from 23 December 2013 to 28 February 2014. These data were adjusted and extrapolated to include the estimated damages caused by coastal flooding (resulting from tidal surges) in early December 2013. Further details on how the best estimate and range were determined are provided in the following sections.

Table 6.1 Headline findings for businesses

Finding	Economic damage estimates			
	Best estimate (range)	**% of total monetised damages**	**Uncertainty rating**	**Comments**
2013 to 2014 damages (total)	£270 million (£230 million to £310 million)	21% (of overall total damages)	Low–moderate	Based on national claims data (extrapolated to include assets affected by coastal as well as fluvial flooding) Range estimate based on uncertainty rating
2013 to 2014 damages (England)	£270 million (£230 million to £310 million)	99% (of total for category)	Moderate–high	Calculated by determining the proportion of all properties flooded that were located in England (99%) and applying this to the damage estimates
2013 to 2014 damages (Wales)	£4.0 million (£3.4 million to £4.6 million)	1% (of total for category)	Moderate-high	Calculated by determining the proportion of all properties flooded that were located in Wales (1%) and applying this to the damage estimates
2007 damages (2014 values)	£910 million	23% (of overall total damages in 2007)	Source: 2 (limited assumptions)	Environment Agency (2010)
	Best estimate	**Units**	**Uncertainty**	**Source of estimate**
Numbers affected (total)	3,139 to 4,897	Businesses	Moderate / Low-moderate	Lower figure based on local data, higher figures based on national data

Finding	Economic damage estimates			
Numbers affected (England)	3,093	Businesses	Moderate	Based on aggregated data obtained at the local (LLFA) level
Numbers affected (Wales)	46	Businesses	Moderate	Based on aggregated data obtained at the local (LLFA) level
	Best estimate	**Range**	**Uncertainty**	**Source of estimate**
Damages per asset	£82,000	£9,200 to £110,000	Moderate	Best estimate based on national claims data and number of business properties affected Range based on minimum and maximum per business from local approach to average damages per business based on number of businesses flooded and total claims value (note that these are all economic costs)

Notes: Values presented to 2 significant figures.

6.2 Determining the best estimate

6.2.1 Number of business properties affected

DCLG data suggest that 4,897 businesses were affected, including farms (DCLG 2014b). Of these, a total of 1,883 (38%) were directly affected by fluvial flooding (that is, considered to have been 'inundated') (DCLG 2014b) and 3,014 (62%) were affected by coastal flooding. The NAO reported that around 3,200 commercial properties were affected by the floods (NAO 2014). This is lower than the DCLG number, the most likely reason for the difference being that the DCLG figures include farms and fishing businesses. Although it is not clear whether the NAO figures include these types of businesses, it seems likely that they would be included under agriculture instead. Differences may also be due to differences in flood definition (water within the property boundary compared with water across the building threshold).

The map in Figure 6.1 shows the distribution of businesses affected by the floods.

The number of businesses affected by different regions of England and Wales is given in Table 6.2, which is based on the local approach using on information obtained from LLFA Section 19 reports and through direct engagement with LLFAs (considered to be the most reliable source for local level estimates). Where there was no information on the number of businesses flooded at the LLFA level, Environment Agency flood outline data were used to provide an estimate of the number of businesses that were potentially flooded. Where appropriate, the figures obtained from the local approach were compared with the flood outline data to determine the possible source of the flood. In cases where the flood outline data were not available, it was assumed that

flooding in coastal LLFAs was caused by coastal flooding and flooding in non-coastal LLFAs was caused by fluvial flooding.

The type of businesses included in the flood outline data are vehicles services, shop/store, office, vehicle repair garage, launderette, café/food court, land used for storage, factory/works/mill, warehouse, pub/social club/wine bar, public conveniences, restaurant, kiosk, workshop, showroom, car showroom, extractive/heavy industry, ambient goods warehouse, bank, betting shop, computer centres, hairdressing salon, laboratory, petrol filling station, post office, retail warehouse, road haulage and superstore/hypermarket.

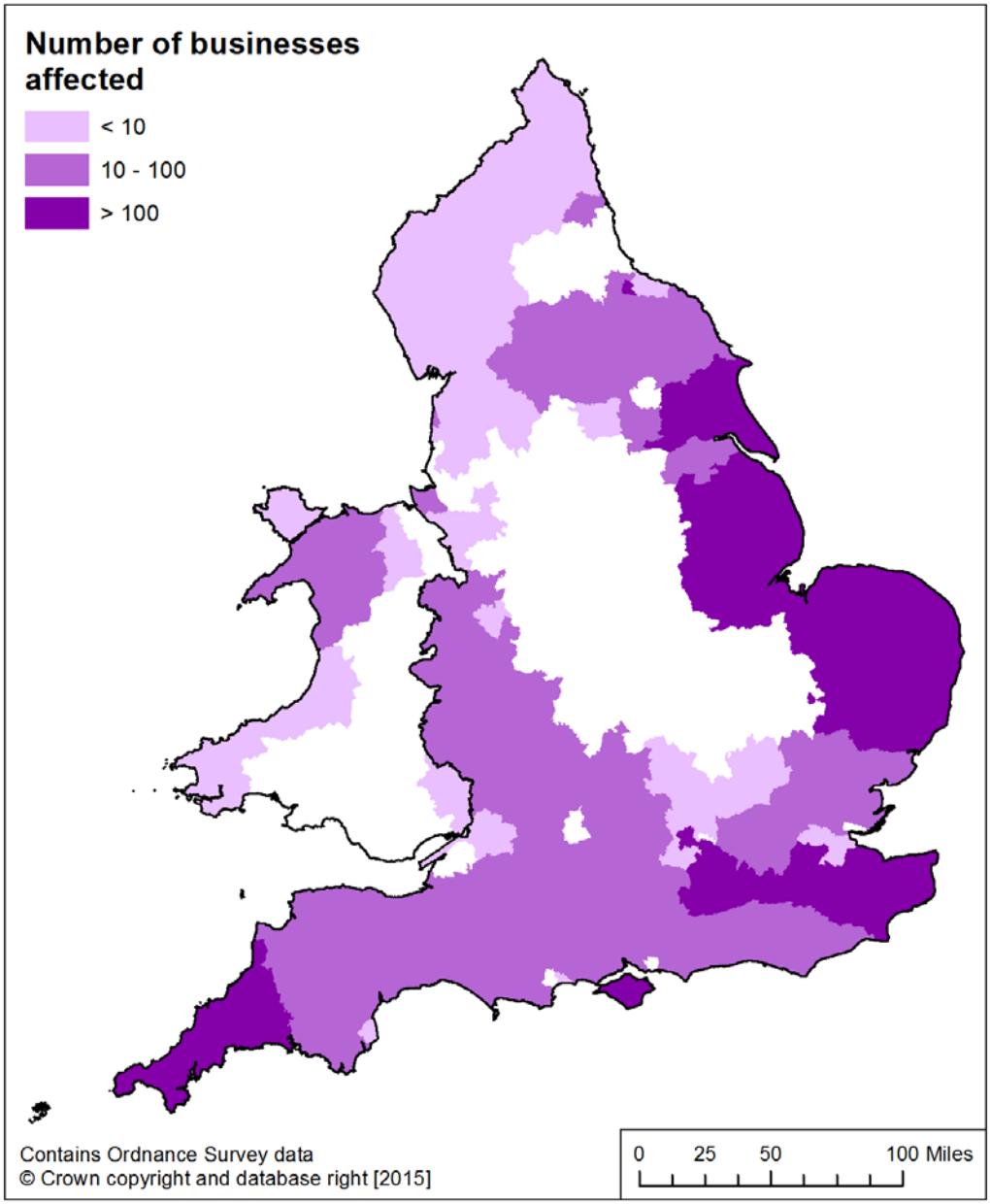

Figure 6.1 Estimated number of businesses flooded for the 66 LLFAs for which data were available

Notes: Only shows where data were available and data may also be incomplete.

Table 6.2 Geographical breakdown of businesses affected

Location	Number of businesses flooded	% of total properties flooded	Main sources of flooding	Percentage of flooding by main source
London	15	<1%	Fluvial: 15	Fluvial: 100%
East Midlands	161	5%	Coastal: 161	Coastal: 100%
East of England	383	12%	Coastal: 343 Fluvial: 40	Coastal: 90% Fluvial: 10%
North East	289	9%	Coastal: 289	Coastal: 100%
North West	72	2%	Coastal: 70 Fluvial: 2	Coastal: 97% Fluvial: 3%
South East	1,094	35%	Coastal: 406 Fluvial: 688	Coastal: 37% Fluvial: 63%
South West	497	16%	Coastal: 225 Fluvial:272	Coastal: 45% Fluvial: 55%
West Midlands	102	3%	Fluvial: 102	Fluvial: 100%
Yorkshire and Humber	480	15%	Coastal: 424 Fluvial: 56	Coastal: 88% Fluvial: 12%
Wales	46	1%	Coastal: 46	Coastal: 100%
Total	3,139	100% (total may not sum to 100% due to rounding)	Coastal: 1,964 Fluvial: 1,175	Coastal: 63% Fluvial: 37%

Notes: Based on data from LLFA Section 19 reports and engagement with LLFAs.
Total may be underestimate as not all LLFAs differentiated between residential and non-residential in their data.
Data gaps were filled using GIS information on flood outlines.
Some numbers affected by coastal or fluvial flooding are uncertain as data did not always distinguish clearly between sources of flooding (or gave multiple sources). Where possible flood outline data were used to determine the potential source of the floods. In cases where the flood outline data were not available, it was assumed that flooding in coastal LLFAs was caused by coastal flooding and flooding in non-coastal LLFAs was caused by fluvial flooding.
See Appendix B for details of which LLFAs are included in each area.

The largest numbers of businesses affected were in the South East, South West and Yorkshire and Humber. As with residential properties, the flooding in the South East was predominantly fluvial, while in Yorkshire and Humber more properties were affected by coastal flooding. In the South West there was a relatively even split between coastal and fluvial flooding.

The local data indicate that 1,964 business properties were affected by coastal flooding and 1,175 from fluvial flooding. Therefore, in total it is estimated that 3,139 business properties flooded during the winter of 2013 to 2014 across all flood sources.

The total of 3,139 businesses affected shown in Table 6.2 is closer to the NAO estimate for numbers of businesses flooded, suggesting the figure is relatively reliable and may be more suitable than the 4,897 figure from DCLG. Compared with the DCLG figure, the difference is an underestimate of 36%, which may account for the inclusion of farmers and fisheries in the DCLG data. However, local level information often does not differentiate between residential and business properties when recording flood events and therefore the figure would be expected to overestimate the total number of properties flooded.

6.2.2 Damages to business properties

The best estimate of the damages to business properties is derived from national level insurance data collated by the ABI on the amount expected to be paid to flooded business owners in the period of 23 December 2013 to 28 February 2014. These data give a total of £149 million (ABI 2014b).

The figure of £149 million represents a financial cost estimate and therefore requires adjustment to determine the economic cost of flood damages to businesses. To convert the financial cost to an economic cost, the approach outlined in Environment Agency (2010) was used. This assumes that 45% of business insurance claims are for commercial contents (inventory), with the remaining 55% relating to building structures and fixtures (non-inventory).

Adjustments were also made to the financial value of insurance claims to allow for the fact that most goods (inventory items) replaced under 'like-for-like' policies are not new. On average, they have a remaining value equivalent to half of their original value and hence half their replacement cost. Thus, the economic damages are taken to be 50% of the financial replacement cost under an 'old' for 'new' policy; this was only applied to inventory items.

A final adjustment was made to inventory (contents) and non-inventory items (building structures and fixtures) to remove VAT at 20%.

Adjustment of the financial insurance claim estimate of £149 million gives an economic cost estimate of £96 million (Table 6.3)

Table 6.3 Conversion of ABI insurance cost estimate for business properties from a financial cost to an economic cost

Stage	Type of cost	Adjustment	Cost estimate
1	Original financial estimate	Original value	£149 million
2	Inventory items (household contents)	45% of claims are for commercial inventories (45% of Stage 1)	£67 million
3		50% of financial replacement cost – replacing old with new (50% of Stage 2)	£34 million
4		Remove VAT at 20% (divide by 1.2)	£28 million
5	Non-inventory items (building structures and fixtures)	55% of claims are for commercial building structures and fixtures (55% of Stage 1)	£82 million
6		Remove VAT at 20% (divide by 1.2)	£68 million
7	**Total economic cost**	**Stage 4 + Stage 6**	**£96 million**

Notes: Values are presented to 2 significant figures.

The total value of £96 million relates to the period from 23 December 2013 to 28 February 2014, and is considered to exclude the damages resulting from coastal flooding during the tidal surge of early December 2013. It is therefore assumed that the data in Table 6.3 predominantly relate to damages caused by fluvial flooding, though it is recognised that some localised coastal flooding to business properties is likely to have occurred between 23 December 2013 and 28 February 2014.

Using the number of business properties considered to have been affected by fluvial flooding during the 2013 to 2014 winter of 1,175 (Table 6.2) and the economic estimate of the costs (Table 6.3) gives an average damage cost per flooded business property

of £82,000 (rounded to 2 significant figures) for the period 23 December 2013 to the 28 February 2014.

This average cost can be used to estimate the potential damages to business properties affected by coastal flooding in early December 2013. A total of 1,964 business properties are estimated to have been affected by coastal floods (Table 6.2). Applying the average damage costs per property of £82,000 to these properties gives an estimate of the economic damages caused to business properties from coastal flooding of £160 million.

The total damage to all business properties from fluvial and coastal flood sources is estimated to be £260 million. This is calculated as follows:

> Total damages to business properties (£260 million) = Damages from fluvial flooding (£96 million) + Damages from coastal flooding (£160 million)[4]

The total damage estimate of £260 million is based on insurance claims data and currently assumes that all businesses flooded during the 2013 to 2014 winter had appropriate insurance. However, some businesses may not have had appropriate insurance to cover the damages caused by the winter 2013 to 2014 floods. Thus, it is necessary to adjust the damage estimate to account for those properties that may have been flooded but did not have insurance.

The 2007 floods assessment (Environment Agency 2010) assumed that 95% of businesses were insured. The same approach was applied to the insurance data obtained for the winter 2013 to 2014 floods, together with the assumption that the uninsured 5% of businesses would have incurred the same level of damages as the insured 95%. Adjusting the damage estimate of £260 million to account for 95% of insurance penetration for businesses gives an estimate of £270 million for damages to business property caused by the winter 2013 to 2014 floods.

The Annex 1 method statement summarises the approach used to develop the best estimate of the damages to businesses.

6.3 Determining the best estimate range

The data used to provide the best estimate of costs in each impact category were assessed to determine the associated uncertainty. The uncertainty rating was applied based on the availability and quality of the data obtained and the assumptions applied to the data to provide an economic cost estimate. The uncertainty rating was subsequently used to determine the potential range around the best estimate.

This approach was used to determine a range of flood damage costs to business properties of £230 million to £310 million (Table 6.1). Further details on the methods used to develop the lower and higher ranges are provided below.

6.3.1 Low estimate

Information was obtained from the ABI on the insurable damages incurred at business properties flooded between 23 December 2013 and 28 February 2014. It was necessary to extrapolate this information to include damages caused by coastal flooding in early December 2013, as well as damages to businesses that were not insured. The information provided by the ABI was considered to represent a financial cost and was therefore adjusted to convert the damages to an economic cost estimate.

[4] The values are presented to 2 significant figures and therefore the total may not be the exact sum of the damage costs due to rounding.

The information provided is from a reliable source and is a national estimate of the insurable costs, suggesting a low uncertainty rating. However, it did not cover the entire 2013 to 2014 winter period. Thus, the data were classified as having a low–moderate uncertainty rating given the extrapolation required and the adjustments made to provide an economic estimate of the costs. To reflect this uncertainty, the best estimate (£270 million) was reduced by 15% (see Table 2.5), resulting in a low range estimate of the flood damages to business properties during the 2013 to 2014 winter period of £230 million.

6.3.2 High estimate

A similar approach was used to obtain an upper range estimate. Reflecting the low–medium uncertainty rating applied to the data, the best estimate (£270 million) was increased by 15% (see Table 2.5), resulting in a high range estimate of the flood damages to business properties during the 2013 to 2014 winter period of £310 million.

6.4 Damage costs by flood type

This section provides a breakdown of the damage costs to business properties as a result of the winter 2013 to 2014 floods by flood type. This includes details of the methods used to differentiate the damage costs and the associated uncertainties.

6.4.1 Approach to disaggregating the damage costs

Where appropriate, local data obtained from LLFAs on the number of business properties considered to have been affected were compared with Environment Agency flood outline data to determine the possible source of the flood. In cases where flood outline data were not available, it was assumed that flooding in coastal LLFAs was caused by coastal flooding and that flooding in non-coastal LLFAs was caused by fluvial flooding.

The local data indicate that 1,175 business properties were affected by fluvial flooding, and 1,964 from coastal flooding, giving an estimate of 3,139 business properties flooded during the winter of 2013 to 2014 from all flood sources (Table 6.2). This breakdown was used to estimate the damages to business properties by flood source.

Fluvial flooding

The ABI data used as the basis for determining the best estimate of the damages to business properties was adjusted to provide an estimate of the economic cost (£96 million) of the damages between 23 December 2013 and 28 February 2014 (Table 6.2). However, these data do not include the flood damages caused by the tidal surge in early December 2013. They were therefore assumed to represent damages caused by fluvial flooding only, though it was recognised that some localised coastal flooding may have occurred in the period from 23 December 2013 to 28 February 2014. Insurance penetration for businesses was assumed to be 95% and therefore an adjustment was made to include the 5% of businesses that were potentially affected but not insured. This resulted in an estimate of the total damage cost to business properties caused by fluvial flooding during the winter of 2013 to 2014 of £100 million.

Coastal flooding

The ABI data, which is considered to predominantly relate to fluvial flooding, were extrapolated to include the coastal flood damages caused during the tidal surge in early December 2013. Adjusting the ABI figure to provide an economic damage cost and assuming 1,175 business properties (Table 6.2) were affected by fluvial flooding gives an average economic damage estimate per flooded property of £82,000.

According to Table 6.2, a total of 1,964 business properties were affected by coastal floods. Assuming each property suffered £82,000 worth of damages results in an estimate of the total damages to business properties caused by coastal flooding of £160 million.

In summary the following calculation was used to determine the best estimate of damages to business properties caused by coastal flooding:

> Coastal damages to business properties (best estimate) (£160 million) =
> Average damage cost per business property (£82,000 based on ABI data)
> × Number of business properties flooded by coastal sources (1,964)

The estimate was adjusted to allow for the 5% of businesses that were potentially affected but not insured. This results in an estimate of the total damage cost to business properties by coastal flooding during the 2013 to 2014 winter of £170 million.

6.4.2 Summary of damage costs by flood type

Table 6.4 provides a summary of the estimated economic damages to business properties caused by fluvial flooding and coastal flooding during the winter of 2013 to 2014.

Table 6.4 Estimated economic damage costs to business properties by flood type

Flood source	Economic damage estimates					
	Best estimate	Percentage of total	Low estimate	Percentage of total	High estimate	Percentage of total
All (total)	£270 million	100%	£230 million	100%	£310 million	100%
Fluvial	£100 million	37%	£86 million	37%	£120 million	37%
Coastal	£170 million	63%	£140 million	63%	£190 million	63%

Notes: Values are presented to 2 significant figures and therefore the totals may not be the exact sum of constituent parts due to rounding.

6.5 Damage costs for England and Wales

This section provides a breakdown of the damage costs to business properties as a result of the winter 2013 to 2014 floods for England and Wales. It includes details of the method used to differentiate the damage costs and the associated uncertainties.

6.5.1 Approach to disaggregating the damage costs

The damages to business properties were estimated using ABI insurance data and the number of properties considered to have flooded during the 2013 to 2014 winter period. This latter figure was obtained at the local (LLFA) level and can thus be separated for England and Wales (Table 6.2). Of the 3,139 business properties that flooded, 99% were located in England and 1% in Wales. This percentage split was applied to the damage costs to estimate the economic damages caused by flooding of business properties in England and Wales (Table 6.5). This approach assumes that the average flood damage cost per business property is similar in England and Wales.

Table 6.5 Number of business properties affected by flooding in England and Wales

Country	Number of properties	Percentage of total
All (total)	3,139	100%
England	3,093	99%
Wales	46	1%

Notes: Based on aggregation of data obtained at the local (LLFA) level

6.5.2 Damage costs for England and Wales

Table 6.6 provides a summary of the estimated flood damages to business properties during the winter 2013 to 2014 floods in England and Wales. The approach outlined in Section 6.5.1 provides a best estimate of the damage costs to business properties during the winter 2013 to 2014 floods for England and Wales of £267 million (£270 million to two significant figures) and £4.0 million respectively.

Table 6.6 Estimated economic damage costs to business properties in England and Wales

Flood source	Economic damage estimates					
	Best estimate	Percentage of total	Low estimate	Percentage of total	High estimate	Percentage of total
All (total)	£270 million	100%	£230 million	100%	£310 million	100%
England	£267 million	99%	£227 million	99%	£307 million	99%
Wales	£4.0 million	1%	£3.4 million	1%	£4.6 million	1%

Notes: Values are presented to 2 significant figures (unless to make clear that constituent parts are combined to provide the total). Therefore totals may not be exact sum of constituent parts due to rounding.

6.6 Uncertainties and assumptions

Although every effort was made to obtain a full suite of data, there are data gaps which will affect the reliability and robustness of the business damage estimates. The main uncertainties are summarised below.

ABI claims data only covered the period from 23 December 2013 to 28 February 2014. As a result they did not capture damages from the coastal surge that occurred in early December 2013. The assumptions made to fill this gap mean that coastal damages are considered to be the same (per property) as fluvial damages. There are no detailed data available at the local level to check this assumption other than for Surrey and Stockton-upon-Tees, where per property damages were £58,000 and £32,000 respectively (though these figures are highly uncertain such that conclusions on uncertainties cannot be drawn).

As for residential properties, there was some anecdotal evidence of under-reporting to insurance companies, reflecting reluctance by individuals or businesses to admit to their property being affected because of concerns over increasing insurance premiums or excess levels. Uncertainty associated with this is greater for businesses than residential properties, as businesses operating from a residential address may be less likely to report flooding. As much as 20% of businesses may be operating from residential properties (personal communication).

The insurance information obtained relates to the period between 23 December 2013 and 28 February 2014. However, it is unclear whether this relates to claims made or businesses flooded during this period. For the purposes of this assessment, it is assumed that the insurance data relate to the businesses that flooded during this period.

As for residential properties, the number of businesses affected is also uncertain with some data sources not differentiating between residential and business properties, making it difficult to identify actual numbers of businesses affected. The local estimate of 3,139 represents around 64% of the national estimate of 4,897. This gives an indication of the uncertainties surrounding the estimated number of businesses affected.

It is not clear what the local level estimates include under the business category. National level DCLG figures include fisheries and agriculture, but whether this is included in the local level information is not clear. If farms and fisheries are included, there is a risk of double counting with the agriculture category

There is a degree of uncertainty around use of the flood outline data as some assets within a flood outline may not have flooded. Therefore, these data were only used where no alternative values were obtained.

Adjustments were made to convert financial damages to economic damages. These adjustments use generic assumptions applied to all business property damages, such as the proportion of damages that are inventory rather than non-inventory. As a result, there will be uncertainties introduced due to the adjustments. It is difficult to quantify this uncertainty without detail on the breakdown of claims, which was not available.

The adjustment for uninsured business properties is also likely to introduce uncertainty into the damage estimates. An assumption was used that 95% of flooded properties were insured. The accuracy of this assumption for the areas affected in 2013 to 2014 cannot be determined.

The approach used to estimate the damages to business properties in England and Wales assumed that the average costs per flooded property were similar across England and Wales. However, the average flood damages incurred to business properties may not be comparable (that is, the average damages may have been greater in England than in Wales or vice versa), which may increase or decrease the proportion of the total damages attributable to each country.

7 Impact on temporary accommodation needs

7.1 Summary of findings

Table 7.1 presents the headline figures for temporary accommodation, including estimates of the costs resulting from this impact category during the winter 2013 to 2014 floods. It includes consideration of costs of evacuating during the flood events as well as the need for replacement accommodation for those households whose properties were flooded and needed to be repaired. The best estimate is £50 million with a range of £42 million to £57 million, based on ABI claims information for alternative accommodation for 2,900 flood affected households during the period of 23 December 2013 to 28 February 2014. These data were extrapolated to include estimated temporary accommodation costs caused by coastal flooding (resulting from tidal surges) in early December 2013. Further details describing how the best estimate and range were determined are provided in the following sections.

Table 7.1 Headline findings for temporary accommodation

Finding	Economic damage estimates			
	Best estimate (range)	**% of total monetised damages**	**Uncertainty rating**	**Comments**
2013 to 2014 damages (total)	£50 million (£42 million to £57 million)	3.9% (of overall total damages)	Low–moderate	Based on national claims data (extrapolated to include households affected by coastal as well as fluvial/ groundwater flooding) Range estimate based on uncertainty rating
2013 to 2014 damages (England)	£49 million (£42 million to £56 million)	98% (of total for category)	Moderate–high	Based on proportion of residential properties flooded in England and Wales
2013 to 2014 damages (Wales)	£1 million (£880,000 to £1.2 million)	2% (of total for category)		
2007 damages (2014 values)	£120 million	3% (of overall total damages in 2007)	Score: 2 (limiting assumptions)	Environment Agency (2010)
	Best estimate	**Units**	**Uncertainty**	**Source of estimate**
Numbers affected (total)	4,820 (758 to 7,000)	Households (758 refers to the number of people received at rest centres)	Moderate–high	Lower figure refers to the number of people received at rest centres (local data) Higher figure refers to the number of households that were reported as
			Moderate	

Finding	Economic damage estimates			
				needing temporary accommodation (DCLG)
Numbers affected (England)	4,720 (742 to 6,854)	Households	Moderate	Based on proportion of households flooded
Numbers affected (Wales)	100 (116 to 146)	Households	Moderate	Based on proportion of households flooded
	Best estimate	**Range**	**Uncertainty**	**Source of estimate**
Costs per household	£10,345	–	Moderate	Best estimate based on national claims data (from ABI) (adjusted to an economic cost)

Notes: Values presented to 2 significant figures.

7.2 Determining the best estimate

7.2.1 Number of households requiring temporary accommodation

Data from the ABI suggest that 2,900 households required temporary accommodation as a result of flooding during the period from 23 December 2013 to 28 February 2014 (ABI 2014a). This figure excludes the damage caused to properties affected by the tidal surge in early December 2013 and omits the potential costs of temporary accommodation resulting from this event. Hence, the figure of 2,900 households requiring temporary accommodation was assumed to predominantly relate to damages caused by fluvial flooding, although it is recognised that some localised coastal flooding to residential properties is likely to have occurred between 23 December 2013 and 28 February 2014.

To estimate the potential costs of temporary accommodation resulting from damages to properties caused by coastal flooding, the proportion of residential properties affected by fluvial flooding that required temporary accommodation was determined and then applied to the number of properties affected by coastal flooding.

Using information obtained from the local (LLFA) approach, it was estimated that 6,296 residential properties were affected by fluvial/groundwater flooding (Table 5.2). Based on the ABI figures of 2,900 households requiring temporary accommodation, this suggests that 46% of residential properties affected by fluvial floods required temporary accommodation. Applying this percentage to the number of residential properties affected by coastal flooding (4,169 from Table 5.2) suggests that 1,920 properties flooded from coastal sources are estimated to have required temporary accommodation. It was therefore assumed that a total of 4,820 households required temporary accommodation during the winter 2013 to 2014 floods.

Although this approach is uncertain, the figure of 4,820 households requiring temporary accommodation as a result of the winter 2013 to 2014 floods is not considered to overestimate the impacts given that information from DCLG (personal communication) suggests that 7,000 households affected by the winter floods were still unable to return to their homes in August 2014. However, assuming that all of these households would have required temporary accommodation is likely to be an overestimate since, in reality; some may have been able to stay with friends or relatives and hence would not

incur temporary accommodation costs. In addition according to DCLG (2014b), this number had reduced to some 758 households in temporary accommodation by November 2014.

Some information on the number of people evacuated either before the flood events (due to warnings being given) or during the events (rescued) was obtained using the local approach, though this was somewhat piecemeal. There appears to be more data on evacuations associated with the coastal surge rather than fluvial flooding (for example, the people evacuated in Lincolnshire, Norfolk, Suffolk and Essex). In Norfolk, residents in 9,000 homes were contacted and advised to evacuate (Broads Authority 2014). Hundreds of residents evacuated their homes in Great Yarmouth, but only 12 homes were flooded (Great Yarmouth Mercury 2014). In Suffolk, 10 rest centres were set up and were used by 177 people, although a higher number of people evacuated themselves and stayed with friends and family (Environment Agency 2014a). It is important to note that these figures relate to people evacuating properties rather than those specifically requiring temporary accommodation as a result of flooding.

Data from the local approach were very limited in terms of the requirement for temporary accommodation as a result of flooding. For example, one household on the Isle of Wight required temporary accommodation for 21 days after their basement flat was flooded (Isle of Wight Council 2014). In north Norfolk, 20 households were provided with temporary accommodation by the council, with 60 households being displaced and asking for help or advice on housing (North Norfolk District Council 2014).

Thus the figure of 4,820 was therefore retained as the best estimate of the total number of households incurring costs for temporary accommodation.

The map in Figure 7.1 shows the distribution of households requiring temporary accommodation based on the information available.

7.2.2 Cost of temporary accommodation

The ABI reported that temporary accommodation costs resulting from flooding of residential properties between 23 December 2013 and 28 February 2014 were £30 million (ABI 2014a). This value has not been converted to an economic cost as details on what the cost includes were not available. For example, rent payments would not include VAT, but use of an agency providing services to locate accommodation would include VAT.

The value of £30 million relates to the period from 23 December 2013 to 28 February 2014 and is considered to exclude the temporary accommodation costs resulting from coastal flooding during the tidal surge of early December 2013. It is therefore assumed that the £30 million figure predominantly relates to costs of temporary accommodation resulting from fluvial/groundwater flooding of residential properties – although again it is recognised that some localised coastal flooding to residential properties is likely to have occurred between 23 December 2013 and 28 February 2014. Based on the number of residential properties (2,900) affected by fluvial/groundwater flooding and requiring temporary accommodation and the economic estimate of the costs of £30 million gives an average temporary accommodation cost per flooded property of £10,000 (rounded to 2 significant figures) for the period from 23 December 2013 to 28 February 2014.

This average cost can be used to estimate the potential temporary accommodation costs for residential properties affected by coastal flooding in early December 2013. A total of 1,920 households are estimated to have required temporary accommodation as a result of coastal flooding. Applying the average cost of temporary accommodation per

property of £10,000 to this figure gives an estimate of the temporary accommodation costs for residential properties affected by coastal flooding of £20 million.

The total estimated temporary accommodation costs to all properties affected by fluvial/groundwater and coastal flood sources during the winter 2013 to 2014 floods are estimated to be £50 million. This is calculated as follows:

> Total cost of temporary accommodation to households (£50 million) = Cost of temporary accommodation from fluvial/groundwater flooding (£30 million) + Cost of temporary accommodation from coastal flooding (£20 million)

The Annex 1 method statement summarises the approach used to develop the best estimate of the cost of temporary accommodation.

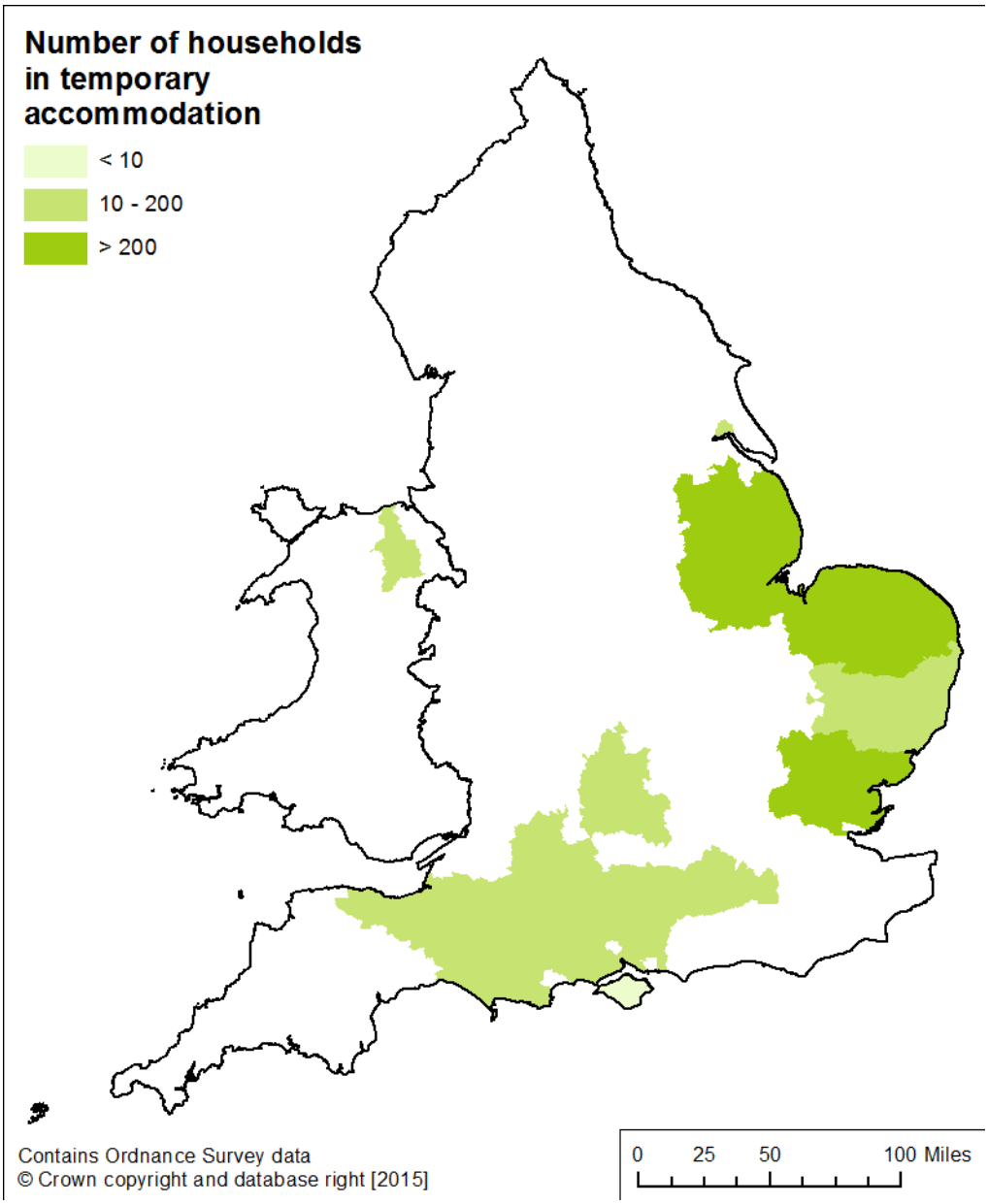

Figure 7.1 Estimated numbers of households in temporary accommodation for the 9 LLFAs for which data were available

Notes: Only shows where data were available and data may also be incomplete.

7.3 Determining the best estimate range

The data used to provide the best estimate of costs in each impact category were assessed to determine the associated uncertainty. The uncertainty rating was applied based on the availability and quality of the data obtained and the assumptions applied to the data to provide an economic cost estimate. The uncertainty rating was subsequently used to determine the potential range around the best estimate.

This approach was used to determine a range of temporary accommodation costs to households affected by flooding of £42 million to £57 million (Table 7.1). Further details on the methods used to develop the lower and higher ranges are provided below.

7.3.1 Low estimate

Information was obtained from the ABI on the cost of temporary accommodation for households flooded between 23 December 2013 and 28 February 2014. It was necessary to extrapolate this information to include temporary accommodation costs resulting from coastal flooding in early December 2013. So although the information provided is from a reliable source and is a national estimate of the insurable costs (suggesting a low uncertainty rating), it did not cover the entire 2013 to 2014 winter period. The data were therefore classified as having a low–moderate uncertainty rating given the need to extrapolate the information. To reflect this uncertainty, the best estimate (£50 million) was reduced by 15% (see Table 2.5), resulting in a low range estimate of temporary accommodation costs resulting from flooding to households during the 2013 to 2014 winter period of £42 million.

7.3.2 High estimate

A similar approach was used to obtain an upper range estimate. Reflecting the low–medium uncertainty rating applied to the data, the best estimate (£50 million) was increased by 15% (see Table 2.5), resulting in a high range estimate of temporary accommodation costs to households affected by flooding during the 2013 to 2014 winter period of £57 million.

7.4 Damage costs by flood type

This section provides a breakdown of the temporary accommodation costs for households resulting from the winter 2013 to 2014 floods by flood type. It includes details of the methods used to differentiate the costs and the associated uncertainties.

7.4.1 Approach to disaggregating the costs

The total figure of costs incurred due to the need for temporary accommodation as a result of flooding to residential properties during the 2013 to 2014 winter period is based on extrapolation of ABI data. Data from the ABI indicated that 2,900 households required temporary accommodation at an estimated cost of £30 million between 23 December 2013 and 28 February 2014. This figure was considered to exclude the temporary accommodation costs resulting from coastal flooding during the tidal surge of early December 2013. It was therefore assumed that the £30 million figure predominantly related to the costs of temporary accommodation resulting from fluvial/groundwater flooding of residential properties, although it is recognised that some localised coastal flooding to residential properties is likely to have occurred between 23 December 2013 and 28 February 2014. This is equivalent to a cost for

temporary accommodation of £10,000 per property (to two significant figures) affected by fluvial/groundwater flooding.

To estimate the costs of temporary accommodation for those properties affected by coastal floods, the average cost per property of £10,000 for fluvial/groundwater flooding was applied to the number of properties estimated to have been affected by coastal flooding (1,920). This gives an estimate of temporary accommodation costs for households affected by coastal flooding of £20 million.

The total estimated temporary accommodation costs to all properties (affected by fluvial/groundwater and coastal flood sources) during the winter 2013 to 2014 floods is estimated to be £50 million. This is calculated as follows:

Total cost of temporary accommodation to households (£50 million) = Cost of temporary accommodation from fluvial/groundwater flooding (£30 million) + Cost of temporary accommodation from coastal flooding (£20 million)

Therefore, 60% of the temporary accommodation costs can be attributed to fluvial/groundwater flooding and 40% to coastal flooding.

7.4.2 Summary of costs by flood type

Table 7.2 provides a summary of the estimated cost of temporary accommodation to households as a result of fluvial/groundwater and coastal flooding during the winter of 2013 to 2014. There are number of uncertainties associated with the data and adjustments used and therefore the figures should be seen as an indication of the likely impacts rather than a definitive estimate.

Table 7.2 Estimated costs of temporary accommodation by flood type

Flood source	Economic damage estimates					
	Best estimate		Low estimate		High estimate	
	Damage	Percentage of total	Damage	Percentage of total	Damage	Percentage of total
All (total)	£50 million	100%	£42 million	100%	£57 million	100%
Fluvial/ groundwater	£30 million	60%	£26 million	60%	£35 million	60%
Coastal	£20 million	40%	£17 million	40%	£23 million	40%

Notes: Values are presented to 2 significant figures and therefore the totals may not be the exact sum of the constituent parts due to rounding.

7.5 Damage costs for England and Wales

This section provides a breakdown of the costs of temporary accommodation resulting from the winter 2013 to 2014 floods for England and Wales. It includes details of the method used to differentiate the damage costs and the associated uncertainties.

7.5.1 Approach to disaggregating the damage costs

The cost of temporary accommodation resulting from flooding of residential properties during the winter 2013 to 2014 floods was determined by using the number of households requiring temporary accommodation according to the ABI (between 23

December 2013 and 28 February 2014) and extrapolating this to include properties affected by coastal flooding in early December 2013.

The number of residential properties considered to have flooded was obtained at the local (LLFA) level and can therefore be separated for England and Wales (Table 7.2). Of the 10,465 residential properties considered to have flooded during the 2013 to 2014 winter period, a total of 10,247 (98%) were located in England and 218 (2%) in Wales. This percentage split was therefore applied to the number of residential properties requiring temporary accommodation and to the total cost of temporary accommodation to provide an estimate of the impacts in England and Wales separately.

7.5.2 Damage costs for England/Wales

Table 7.3 provides a summary of the estimated cost of temporary accommodation to households in England and Wales during the winter of 2013 to 2014. The number of households requiring temporary accommodation is estimated to be 4,720 in England (range 742–6,854) and 100 in Wales (range 16–146). There are number of uncertainties associated with the data and adjustments used, and therefore the figures in Table 7.3 should be seen as an indication of the likely impacts rather than a definitive estimate.

Table 7.3 Estimated costs of temporary accommodation by country

Flood source	Economic damage estimates					
	Best estimate		Low estimate		High estimate	
	Damage	Percentage of total	Damage	Percentage of total	Damage	Percentage of total
All (total)	£50 million	100%	£42 million	100%	£57 million	100%
England	£49 million	98%	£41.5 million	98%	£56 million	98%
Wales	£1.0 million	2%	£880,000	2%	£1.2 million	2%

Notes: Values are presented to 2 significant figures (unless to show the constituent parts in more detail such that they can be distinguished) and therefore totals may not be an exact sum of constituent parts due to rounding.

7.6 Uncertainties and assumptions

There are data gaps in terms of the number of households evacuated, needing temporary accommodation and the time over which they required temporary accommodation. As a result, the damages and number of households affected have moderate to moderate–high uncertainty from the local data. The ABI claims data are considered more reliable, but these only capture costs from 23 December 2013 to 28 February 2014.

One of the main uncertainties with the damage estimates is in the extrapolation from the ABI data to include damages from the coastal surge. The extrapolation is based on the assumption that the requirement for temporary accommodation following coastal flooding is the same as that following fluvial flooding. No data are available to provide a basis for an alternative assumption. Data from Norfolk suggest that a much lower percentage of the properties that were flooded resulted in people requiring temporary

accommodation. However, the reasons for this are not given and thus it is not considered appropriate to use these percentages as being typical of the need for alternative accommodation as a result of coastal flooding. Although the duration of coastal flooding can be shorter than other types of flooding, the damages caused can be considerable resulting in the need for temporary accommodation in certain cases.

No adjustment was made to convert the financial claims data from the ABI to economic data because it was not clear whether VAT and service charges would have been applied. As a result, the damages may overestimate the economic impacts. It is also important to note that people who move out of their properties and stay with family and friends as a result of flooding are not recorded and are therefore not counted.

8 Impacts on motor vehicles, boats and caravans

8.1 Summary of findings

Table 8.1 presents the headline figures for motor vehicles, boats and caravans, including estimates of the damages caused to this impact category during the winter 2013 to 2014 floods. The best estimate is £37 million with a range of £31 million to £42 million, based on ABI claims information for vehicles affected by flooding during the period from 23 December 2013 to 28 February 2014. These data were adjusted and extrapolated to include the estimated damages caused by coastal flooding (resulting from tidal surges) in early December 2013. Further details on how the best estimate and range were determined are provided in the following sections.

Table 8.1 Headline findings for motor vehicles, boats and caravans

Findings	Economic damage estimates			
	Best estimate (range)	**% of total monetised damages**	**Uncertainty rating**	**Comments**
2013 to 2014 damages (total)	£37 million (£31 million to £42 million)	2.9% (of overall total damages)	Low–moderate	Based on national claims data (extrapolated to include assets affected by coastal as well as fluvial/ groundwater flooding) Range estimate based on uncertainty rating
2013 to 2014 damages (England)	£36 million (£30 million to £41 million)	98% (of total for category)	Moderate–high	Based on proportion of residential properties flooded in England and Wales
2013 to 2014 damages (Wales)	£760,000 (£650,000 to £880,000)	2% (of total for category)		
2007 damages (2014 values)	£98 million	3% (of overall total damages in 2007)	Score: 2 (limiting assumptions)	Environment Agency (2010)
	Best estimate	**Units**	**Uncertainty**	**Source of estimate**
Numbers affected (total)	738 to 8,976	Vehicles	Moderate–high / Low–moderate	Lower estimate based on local data, high figure based on ABI data
Numbers affected (England)	723 to 8,789	Vehicles	Moderate–high / Low–moderate	Based on proportion of residential properties flooded
Numbers affected (Wales)	15 to 187	Vehicles		

Findings	Economic damage estimates			
	Best estimate	Range	Uncertainty	Source of estimate
Damages per asset	£4,100	Not available	Low-moderate	Best estimate based on national claims data (from ABI) (adjusted to an economic cost)

Notes: Values presented to 2 significant figures.

8.2 Determining the best estimate

8.2.1 Number of vehicles affected

Data obtained from the ABI suggest that insurers received claims for 5,400 flooded vehicles during the period from 23 December 2013 to 28 February 2014 (ABI 2014b).

Very little information on the impacts of the floods on motor vehicles, boats and caravans was available in the local assessment, particularly in relation to specific damages to vehicles (with damage information only available for one LLFA). However, some anecdotal evidence was obtained on the number of vehicles flooded. It was reported from the Wirral that several cars had been damaged by the tidal surge (BBC News 2013b) and that cars had floated away in Middlesbrough college car park (GazetteLive 2013). In Lowestoft, a car dealership suffered flood damage with almost 300 vehicles damaged (The Lowestoft Journal 2014). In addition, 2 boats sank in West Berkshire (Environment Agency 2014i) and there were damages to caravans in Talybont (Natural Resources Wales 2014).

Given the limited data from local sources the best estimate is therefore based on the national ABI data. However the ABI figure excludes damages caused to vehicles that were affected by the tidal surge in early December 2013. Hence, the figure of 5,400 vehicles damaged by floods was assumed to predominantly relate to damages caused by fluvial/groundwater flooding, although it is recognised that some localised coastal flooding to vehicles is likely to have occurred between 23 December 2013 and 28 February 2014.Extrapolation of the data was therefore necessary to include those vehicles damaged by coastal flooding. This process used the proportion of residential properties affected by fluvial/groundwater and coastal flooding. The total number of residential properties flooded (all sources) during the 2013 to 2014 winter period was estimated to be 10,465, with 6,296 (approximately 60%) and 4,169 (approximately 40%) considered to have been affected by fluvial/groundwater and coastal flooding respectively (Section 5). For the purposes of this assessment, it was assumed that the same proportional split also applied to vehicles. Therefore, the 5,400 vehicles considered to have been affected by fluvial/groundwater flooding was assumed to represent approximately 60% of the total number of vehicles flooded (all sources). This gave the number of vehicles considered to have been affected by coastal flooding as 3,576 (approximately 40%) and the total number of vehicles affected by fluvial/groundwater and coastal sources as 8,976. This figure was taken as the best estimate of the number of vehicles affected during the winter 2013 to 2014 floods.

The map provided in Figure 8.1 shows the distribution of vehicles, boats and caravans affected based on the information available.

8.2.2 Damages to vehicles

Damages to vehicles as a result of flooding during the period from 23 December 2013 to 28 February 2014 were an estimated £22 million (ABI 2014b). It was assumed that the majority of the flooded vehicles were written off as the repair costs are likely to have been significant. It was also assumed that any replacement vehicles purchased would be second-hand and thus not include VAT. The figure of £22 million was therefore assumed to represent an economic cost of the flood damages and was not adjusted.

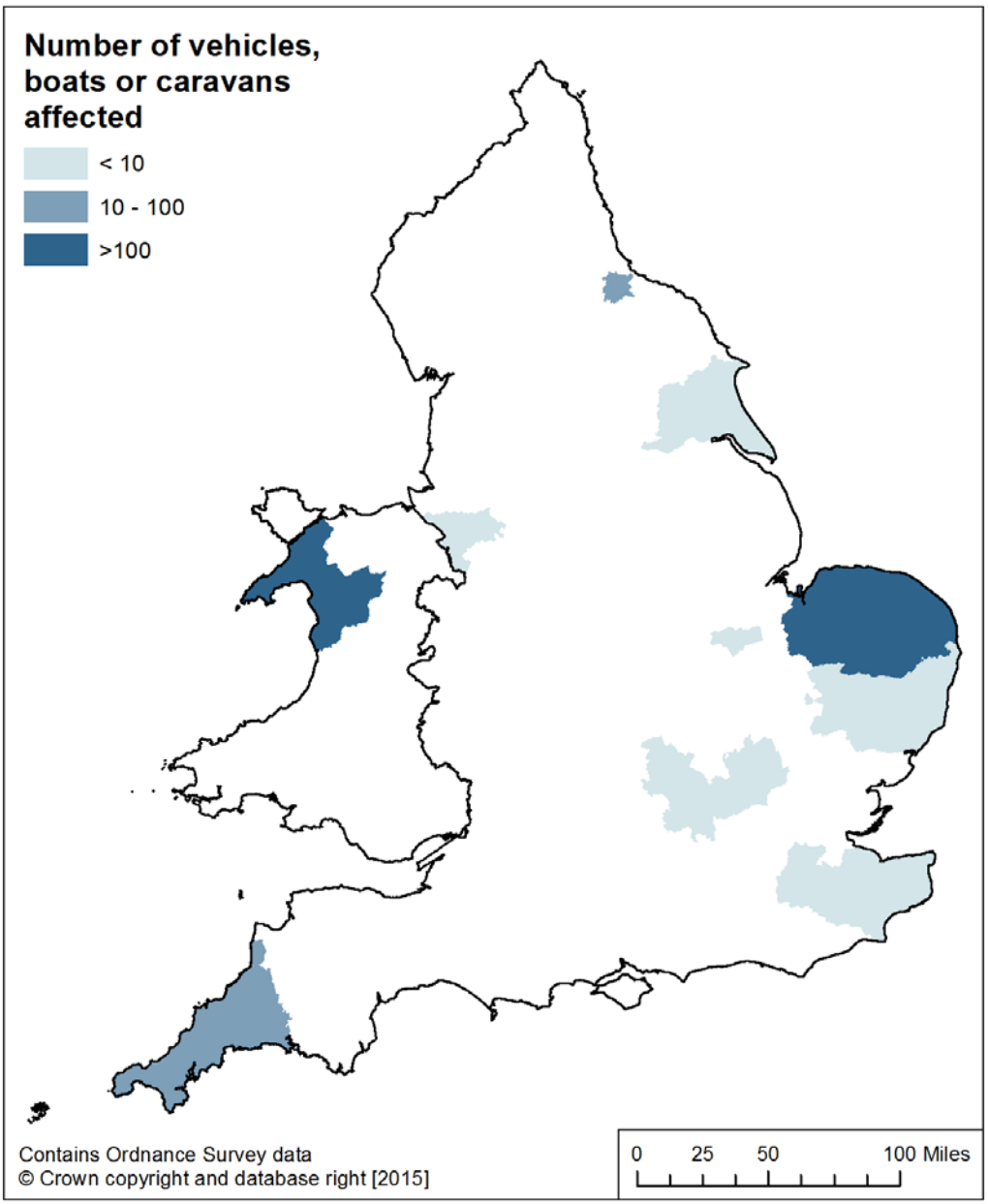

Figure 8.1 Estimated number of vehicles affected for the 13 LLFAs for which data were available.

Notes: Only shows where data were available and data may also be incomplete.

The £22 million figure predominantly relates to damages resulting from fluvial/groundwater flooding of vehicles, although it is recognised that some localised coastal flooding of vehicles is likely to have occurred between 23 December 2013 and 28 February 2014. Assuming that each of the 5,400 insurance claims received for

flooded vehicles related to damage to a single vehicle, and given the total cost of £22 million, this gives in an average cost per vehicle of £4,100 during the period from 23 December 2013 to 28 February 2014.

The total number of vehicles considered to have been affected by flooding during the winter 2013 to 2014 floods is 8,976 (fluvial/groundwater and coastal sources), with 5,400 vehicles (approximately 60%) considered to be affected by fluvial/groundwater flooding and 3,576 (approximately 40%) affected by coastal flooding. Therefore, assuming that 3,576 vehicles were affected by coastal flooding and an average damage cost per vehicle of £4,100 results in an estimate of the damage caused by coastal flooding of £15 million.

The total estimated cost of the damages to vehicles (affected by fluvial/groundwater and coastal flood sources) during the winter 2013 to 2014 floods is estimated to be £37 million. This is calculated as follows:

> Total damages to vehicles (£37 million) = Damages to vehicles from fluvial/groundwater flooding (£22 million) + Damages to vehicles from coastal flooding (£15 million)

The total damage estimate of £37 million is based on insurance claims data and assumes that all vehicles flooded during the 2013 to 2014 winter had appropriate insurance (a legal requirement). Therefore, no adjustment was made to account for under-insurance.

The Annex 1 method statement summarises the approach used to develop the best estimate of the damages to vehicles.

8.3 Determining the best estimate range

As described in Section 2.3.4, the data used to provide the best estimate of costs in each impact category were assessed to determine the associated uncertainty. The uncertainty rating has been designated based on the availability and quality of the data obtained and the assumptions applied to the data to provide an economic cost estimate. The uncertainty rating was subsequently used to determine the potential range around the best estimate.

This approach was used to determine a range of flood damage costs to vehicles of £31 million to £42 million (Table 8.1).

Further details on the methods used to develop the lower and higher ranges are provided below.

8.3.1 Low estimate

It was necessary to extrapolate the information obtained from the ABI on the insurable damages to vehicles affected by flooding between 23 December 2013 and 28 February 2014 to include damages to vehicles from coastal flooding in early December 2013. So although the information provided was from a reliable source and a national estimate of the insurable costs (suggesting a low uncertainty rating), it did not cover the entire 2013 to 2014 winter period. Thus, the data were classified as having a low–moderate uncertainty rating given that extrapolation of the information was required. To reflect this uncertainty, the best estimate (£37 million) was reduced by 15% (see Table 2.5), resulting in a low range estimate of the flood damages to vehicles during the 2013 to 2014 winter period of £31 million.

8.3.2 High estimate

A similar approach was used to obtain an upper range estimate. Reflecting the low–medium uncertainty rating applied to the data, the best estimate (£37 million) was increased by 15% (see Table 2.5), resulting in a high range estimate of the flood damages to vehicles during the 2013 to 2014 winter period of £42 million.

8.4 Damage costs by flood type

This section provides a breakdown of the damage costs to vehicles as a result of the winter 2013 to 2014 floods by flood type. It includes details of the methods used to differentiate the damage costs and the associated uncertainties.

8.4.1 Approach to disaggregating the damage costs

The total figure of damage costs to vehicles affected by flooding during the 2013 to 2014 winter period is based on extrapolation of the ABI data. Using this approach, damages to vehicles as a result of fluvial/groundwater and coastal flooding during the winter 2013 to 2014 floods were estimated at £22 million and £15 million respectively. The total estimated cost of the damages to vehicles (affected by fluvial/groundwater and coastal flood sources) during the winter 2013 to 2014 floods is therefore £37 million. This is calculated as follows:

Total damages to vehicles (£37 million) = Damages to vehicles from fluvial/groundwater flooding (£22 million) + Damages to vehicles from coastal flooding (£15 million)

Therefore, an estimated 60% of vehicle damage costs can be attributed to fluvial/groundwater flooding and 40% to coastal flooding

8.4.2 Summary of costs by flood type

Table 8.2 provides a summary of the estimated damages to vehicles as a result of fluvial/groundwater and coastal flooding during the winter of 2013 to 2014. There are a number of uncertainties associated with the data and adjustments used, and therefore the figures should be seen as an indication of the likely impacts rather than a definitive estimate.

Table 8.2 Estimated damages to motor vehicles by flood type

Flood source	Economic damage estimates					
	Best estimate		Low estimate		High estimate	
	Damage	Percentage of total	Damage	Percentage of total	Damage	Percentage of total
All (total)	£37 million	100%	£31 million	100%	£42 million	100%
Fluvial/ groundwater	£22 million	60%	£19 million	60%	£25 million	60%
Coastal	£15 million	40%	£12 million	40%	£17 million	40%

Notes: Values are presented to 2 significant figures and the totals may not be the exact sum of constituent parts due to rounding.

8.5 Damage costs for England and Wales

This section provides a breakdown of the damages to vehicles resulting from the winter 2013 to 2014 floods for England and Wales. It includes details of the method used to differentiate the damage costs and the associated uncertainties.

8.5.1 Approach to disaggregating the damage costs

Damages to vehicles during the winter 2013 to 2014 floods were determined by using the number of vehicles that flooded according to the ABI (between 23 December 2013 and 28 February 2014) and extrapolating this to include properties affected by coastal flooding in early December 2013. This extrapolation is based on the proportional increase in residential properties affected by fluvial/groundwater flooding compared with all flood sources (including coastal flooding).

The number of properties considered to have flooded was obtained at the local (LLFA) level and can therefore be separated for England and Wales (Table 5.2). The data indicate that, of the 10,465 residential properties that are considered to have flooded during the 2013 to 2014 winter period, 10,247 (98%) were located in England and 218 (2%) in Wales. This percentage split was applied to the number of vehicles damaged by flooding and to the total damage costs to provide an estimate of the impacts in England and Wales separately. This approach assumes that the same proportion of vehicles was affected by flooding in England and Wales as residential properties, and is therefore uncertain.

8.5.2 Damage costs for England/Wales

Table 8.3 provides a summary of the estimated damages to motor vehicles in England and Wales during the winter floods of 2013 to 2014. The number of vehicles damaged is estimated to be 8,789 in England and 187 in Wales.

Table 8.3 Estimated damages to motor vehicles by country

Flood source	Economic damage estimates					
	Best estimate		Low estimate		High estimate	
	Damage	Percentage of total	Damage	Percentage of total	Damage	Percentage of total
All (total)	£37 million	100%	£31 million	100%	£42 million	100%
England	£36 million	98%	£30 million	98%	£41 million	98%
Wales	£760,000	2%	£650,000	2%	£880,000	2%

Notes: Values are presented to 2 significant figures therefore the totals may not be the exact sum of constituent parts due to rounding.

8.6 Uncertainties and assumptions

There are data gaps associated with the local data, both in terms of the number of vehicles affected and the damages incurred as a result of flooding. This resulted in the selection and use of the ABI (national level) data as the best estimate. However, there are also a number of uncertainties associated with the insurance claims information used.

An important uncertainty relates to the assumption that the ABI data represent an economic estimate, which has not been adjusted. It was assumed that the majority of vehicles flooded would be written off and that any replacement vehicles that were purchased would be second-hand and thus the cost would not include VAT. In certain cases, however, flooded vehicles may have been repaired or those that were written off may have been replaced by a new vehicle, resulting in VAT costs. The figures used in the best estimate may therefore overestimate the economic cost of the flood damages to vehicles.

The insurance information obtained relates to the period between 23 December 2013 and 28 February 2014. However, it is not clear whether this relates to claims made or vehicles flooded during this period. For the purposes of this assessment, it was assumed that the insurance data relate to vehicles flooded during this period.

One of the main uncertainties with the insurance claims data is their extrapolation to include damages from the December 2013 coastal surge. This was based on the percentage of residential properties affected by fluvial/groundwater flooding (approximately 60%), which was assumed to represent the same proportion of vehicles affected by fluvial/groundwater flooding. This approach is inherently uncertain as the number of vehicles affected and the amount claimed from insurance companies as a result of flooding during the coastal surge may differ considerably from the pattern of residential properties affected. However, the lack of specific insurance data for the coastal surge period means that it was not possible to check the calculated value against real data.

9 Impacts on local authorities and local government

9.1 Summary of findings

Table 9.1 presents the headline figures for the impact category of local authorities and local government.

Local government (county, district/borough and parish councils) are often in the frontline when it comes to responding to flooding and the associated issues. As Risk Management Authorities, local authorities are involved in both planning and responding to flood risk. They may additionally have assets of their own which are directly affected by floodwaters, whether these are buildings or other structures.

The best estimate of the damages/costs to local authorities resulting from flooding during the winter of 2013 to 2014 is £58 million with a range of £49 million to £66 million. The best estimate is based on information obtained at the local level on:

- flooding impacts to local authority assets
- costs incurred in dealing with flood incidents, providing housing and other services (taking care not to double count with other categories, such as temporary accommodation)
- wider support provided by council officers

Damages that can be specifically related to roads, flood risk infrastructure and educational & recreational facilities are included under the categories of transport: roads, tourism & recreation, flood risk management infrastructure and response, and education to minimise double counting. Where specific costs cannot be broken down into their constituent parts, the risk of double counting with other categories has been managed as far as was possible.

Table 9.1 Headline findings for local authorities and local government

Finding	Economic damage estimates			
	Best estimate (range)	**% of total monetised damages**	**Uncertainty rating**	**Comments**
2013 to 2014 damages (direct damages/costs)	£58 million (£49 million to £66 million)	4.5% (of overall total damages)	Low–moderate	Based on local data at the LLFA level Low and high range estimates are determined based on uncertainty rating
2013 to 2014 damages – England (direct damages/costs)	£58 million (£49 million to £66 million)	100% (of total for category)	Low–moderate	Refers to the proportion of the direct damage costs attributable to England
2013 to 2014 damages – Wales (direct damages/costs)	No data	No data	High	No data
2007 damages (2014 values)	£170 million	4% (of overall total damages	Source: 1 (best of	Environment Agency (2010)

Finding	Economic damage estimates			
		in 2007)	breed)	
	Best estimate	**Units**	**Uncertainty**	**Source of estimate**
Numbers affected	Data limited	Units difficult to define	Not reported	Limited data on number of assets affected
	Best estimate	**Range**	**Uncertainty**	**Source of estimate**
Damages per asset	Not available		Units difficult to define	

Notes: Values presented to 2 significant figures.

9.2 Determining the best estimate

9.2.1 Number of assets affected

Data were obtained at the local level from local authorities, through internet-based research and consultation, on the damages to infrastructure as well as service costs Very limited data were obtained on the number of local authority assets affected by flooding or figures relating to the operational activities carried out in dealing with the effects of the floods (for example, number of staff hours). Therefore, it was not possible to provide an estimate of the number of local authority assets affected or estimates of staff time spent in dealing with the flood impacts.

9.2.2 Direct damages/costs to local authorities and local government infrastructure

This section provides an overview of the types of costs experienced by local authorities and the damages caused to local government infrastructure during the winter 2013 to 2014 floods. Data were collected at the LLFA level and, where appropriate, adjusted to provide an economic cost estimate. The data were then aggregated to provide a total national level estimate of the economic costs of the floods to local authorities.

Impacts on local authority assets

The impacts of flooding on local authority assets during the winter of 2013 to 2014 include effects as a result of:

- impacts from tidal flooding along the east coast of England
- a considerable number of properties being flooded in Boston (Boston Borough Council, personal communication 20 October 2014)
- LLFAs in London experiencing groundwater, pluvial and fluvial flooding
- fluvial and groundwater flooding within the South East (Moon 2014) in addition to coastal flooding (Kent Online website 2013)
- impacts on local government infrastructure in the South West with Plymouth City Council suffering damage to 51 shoreline assets, with a repair cost of £2.9 million (A. Cottam, personal communication December 2014).

These examples are just a sample of the information obtained on the potential costs of damages to local authority infrastructure. Each piece of information was assessed to ensure that it was not double counted with other impact categories and that the figures

represented an economic cost. In the case of damages to local authority assets, a series of adjustments were made to convert financial values to economic estimates.

Information on insurable damages to local authority assets was obtained for some LLFAs. An approach similar to that used for the businesses category (Section 7.2.2) was applied to convert these financial damage costs to an economic estimate. The approach accounts for the damages caused to inventory (contents) and non-inventory (buildings and fixtures) items; it assumed the same proportional split for local authorities as for businesses, that is, 45% of business insurance claims are for commercial inventories (contents) with the remaining 55% relating to building structures and fixtures. Adjustments were also made to the financial value of insurance claims to allow for the fact that most goods (inventory items) replaced under 'like-for-like' policies are not new. On average, they have a remaining value equivalent to half of their original value and hence half their replacement cost. Thus, the economic cost of damage was taken to be 50% of the financial replacement cost under an 'old' for 'new' policy (only applicable to inventory items). A final adjustment was made to both inventory and non-inventory items to remove VAT at 20%.

Table 9.2 provides a summary of the adjustments made for insurable damages to local authority assets to convert them from a financial to an economic cost estimate.

Table 9.2 Conversion of insurable damages to local authorities from a financial cost to an economic cost

Stage	Type of cost	Adjustment
1	Original financial estimate	Original value
2	Inventory items (commercial contents)	45% of claims are for commercial inventories (45% of Stage 1)
3		50% of financial replacement cost – replacing old with new (50% of Stage 2)
4		Remove VAT at 20% (divide by 1.2)
5	Non-inventory items (building structures and fixtures)	55% of claims are for commercial building structures and fixtures (55% of Stage 1)
6		Remove VAT at 20% (divide by 1.2)
7	**Total economic cost**	**Stage 4 + Stage 6**

Other data were obtained on uninsurable damages to local authority assets. In the majority of cases, these damages were considered to represent a financial rather than an economic cost. To convert these damage costs to an economic value, the figures were adjusted to account for betterment. It was assumed that, in the majority of cases, the assets damaged by flooding were part way through their serviceable life. Therefore, repair/replacement of the damaged asset effectively improved the condition of the asset, potentially extending its serviceable life. Hence, it was not deemed appropriate to take the full damage cost as the economic estimate as the old asset is effectively replaced by a new asset (that is, not a like-for-like replacement). To account for this, 50% of the asset damages/repair costs were taken. In addition, any work to repair or replace a damaged asset will incur VAT at 20%. This was therefore removed to provide an economic cost of the flood damages.

The calculation used to convert uninsurable financial damage/repair costs to an economic estimate can be summarised as:

> Economic estimate of uninsurable asset damage/repair costs = Financial estimate of uninsurable asset damage/repair costs × 50% (accounting for betterment) ÷ 1.2 (to remove VAT at 20%)

Impacts relating to dealing with flood incidents

Local authorities were directly involved in dealing with floodwaters and debris. For example, the Transport for Buckinghamshire Operations Hub was called out to 95 flood sites between 23 December 2013 and 13 January 2014 (ITV 2014a), while in Dorset, teams from Bournemouth Borough Council were involved in cleaning up the collapsed cliff at the seafront (ITV 2014b).

In addition, local authorities were called in to deal with issues where it was not clear with whom the responsibility laid. This occurred in Peterborough, where rising levels in the River Nene led to one boat capsizing and another being beached. Significant council officer time was required to resolve the situation (Peterborough City Council, personal communication 27 October 2014).

Some (albeit relatively limited) data were obtained from local authorities on operational costs in dealing with the impacts of the winter 2013 to 2014 floods. This included costs to councils from emergency response as well as medium to long term clean-up activities. Operational costs were considered to exclude staff time costs and to include VAT, and were considered to represent a financial cost. The operational costs were therefore adjusted by removing VAT at 20% to provide an economic cost estimate.

The calculation used to convert operational costs to an economic estimate can be summarised as:

> Economic estimate of operational costs (excluding staff time) = Financial estimate of operational costs ÷ 1.2 (to remove VAT at 20%)

Some limited information was also obtained on staff overtime costs and, specifically, time taken in dealing with the flood events. These were assumed to represent an economic cost and were therefore not adjusted (by removing VAT). It is likely that organisations that responded to the floods (including local authorities) were working to capacity, meaning that time spent dealing with the floods prevented them doing other work (that is, diversion from normal activities). In this case, it was assumed that the impact is the effect on the other tasks that would have been carried out if the staff had not been diverted to dealing with the floods.

Impacts relating to provision of housing and services

Local authorities performed a range of tasks relating to the provision of housing and services including the provision of rest centres, toilet facilities and sandbags.

For example, Buckinghamshire County Council provided 20 Portaloos to a flooded residential park near Iver (Buckinghamshire County Council 2014). Temporary toilets were also provided in parts of Slough by the Borough Council (Slough and South Bucks Observer 2014) and in several streets in Oxfordshire where the drains were overflowing (BBC News 2014b).

In Hull, rest centres were set up and more than 50 residents evacuated from care homes on Victoria Dock Village and Ferensway (Hull Daily Mail 2014). In Tewkesbury in Gloucestershire, an emergency rest centre was set up at the council's Gloucester Road offices (Gloucestershire Echo 2014). In Bournemouth, council officers assisted with the evacuation of Iford Bridge Park homes (Bournemouth Echo 2013). The LLFA subsequently found accommodation for the residents and also supplied items including skips and sandbags (Bournemouth Borough Council, personal communication 28 October 2014). Large numbers of people were also affected in Kent, with over 500 properties in the towns of Sandwich, Seasalter, Faversham and Medway being evacuated (BBC News 2013c).

Practical assistance was also provided to help people cope with the impacts of flooding. For instance, on the Isle of Wight, the council housing officer worked with charities and shops to help gather clothing and toiletry donations for flooded households (Isle of Wight Council 2014). In Kent, the Kent Support and Assistance Service (KSAS) provided 88 flood victims within 44 households across Teston and Yalding with essential cash, goods and services totalling £9,994 (financial cost; note more may since have been provided) (Kent County Council 2014).

Parish councils were also involved. For example, Boughton Monchelsea Parish Council in Kent spent 89 days dealing with the flood emergency, along with costs of £13,878 (financial cost) to protect residents and housing in The Quarries (Environment Agency 2014i).

As highlighted above, some information was obtained from local authorities on the cost of assisting households affected during the winter 2013 to 2014 floods. The costs of this assistance are assumed to include VAT (at 20%) and are considered to represent a financial cost. These were therefore adjusted by removing VAT at 20% to provide an economic cost estimate.

The calculation used to convert operational costs to an economic estimate can be summarised as:

> Economic estimate of the costs associated with the provision of housing and services = Financial estimate of the costs associated with the provision of housing and services ÷ 1.2 (to remove VAT at 20%)

Implications for local authorities' income

Local authority finances had to cover direct actions to deal with the flooding, both in repairing damaged assets and in supporting affected communities. To assist local authorities take remedial action in response to the flood events, the government provided payments from the Bellwin Scheme (Sandford 2015) and the Severe Weather Recovery Scheme to effectively refund local authorities for the costs of measures they may have put in place. Table 9.3 summarises data available for some of the main local authorities involved.

Table 9.3 Bellwin claims for selected local authorities

Council	Bellwin claim	Source
Copeland Borough Council, Cumbria	£130,000	Copeland Borough Council (2014)
Worcester City Council	£51,000	Worcestershire County Council (personal communication 11 November 2014)
Lincolnshire	£123,000	DCLG (2014a)
Herefordshire	£3 million	DCLG (2014a)

Bellwin Scheme and severe weather grant information was obtained for a number of LLFA areas and used to estimate of the potential costs to local authorities of dealing with the winter 2013 to 2014 floods. However, there is uncertainty associated with the use of this grant information as a representation of the flood related costs incurred by local authorities. This is because a cost threshold needs to be reached before the grant payments can be received and the actual costs to local authorities of dealing with the impacts of the floods may exceed the payments. Therefore, in some cases, the use of grant data is likely to underestimate the actual costs incurred by local authorities. Thus, the grant payments have only been used where no information was obtained from local

authorities on specific flood related costs or where the cost information obtained was less than the grant payments.

As it was not possible to determine how the grant money was used by each local authority, the data were assumed to represent an economic cost and were not therefore adjusted.

Best estimate of the direct damages/costs to local authorities and local government infrastructure

The information described above has been obtained at the LLFA level and appropriately adjusted to provide an estimate of the economic costs resulting from the winter 2013 to 2014 floods. This has been aggregated to provide a best estimate of the direct damages/costs to local authorities and local government infrastructure at the national level of £58 million.

The best estimate was created by collating data from all LLLFAs, the data provided was adjusted to remove financial costs and then added up for England and Wales to provide a total of £58 million. The distribution of the damages incurred by local authorities is shown in Figure 9.1. The Annex 1 method statement summarises the approach used to develop the best estimate of the damages/costs to local authorities and local government infrastructure.

9.3 Determining the best estimate range

The data used to provide the best estimate of costs in each impact category were assessed to determine the associated uncertainty (see table 2.5). The uncertainty rating was subsequently used to determine the potential range around the best estimate. Further details on the methods used to develop the lower and higher ranges are provided below.

9.3.1 Low estimate

A considerable amount of information was obtained through research and direct consultation with local authorities on the costs they incurred as a result of the winter 2013 to 2014 floods. Information was also obtained on the grants received by local authorities from the government to assist them in covering these costs. The data are considered to be from reliable sources and were used to provide a national cost estimate (suggesting a low uncertainty rating). However, it was necessary to adjust the costs provided to convert them from financial to economic costs, introducing a degree of uncertainty. In addition, there are likely to be data gaps in the information on the costs incurred, particularly in the case of Wales. Thus, a low–moderate uncertainty rating was considered to denote the uncertainty associated with the data. To reflect this uncertainty, the best estimate (£58 million) was reduced by 15% (see Table 2.5), resulting in a low range estimate of the costs to local authorities and local government infrastructure during the winter 2013 to 2014 floods of £49 million.

9.3.2 High estimate

A similar approach was used to obtain an upper range estimate. Reflecting the low–medium uncertainty rating applied to the data, the best estimate (£58 million) was increased by 15% (see Table 2.5), resulting in a high range estimate of the costs to local authorities and local government infrastructure during the winter 2013 to 2014 floods of £66 million.

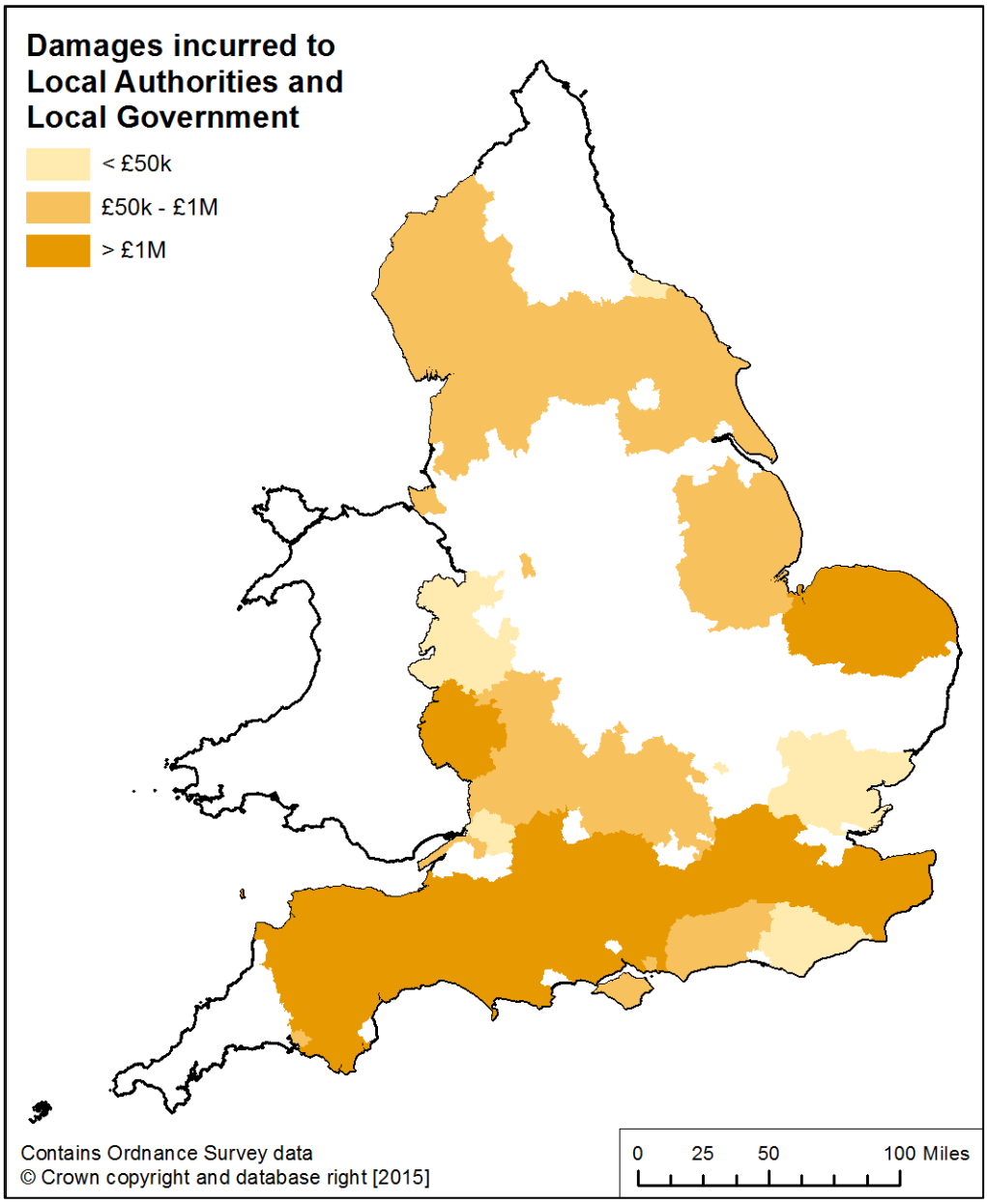

Figure 9.1 Estimated damages to local authorities and local government for the 73 LLFAs for which data were available

Notes: Only shows where data were available and data may also be incomplete.

9.4 Damage costs by flood type

This section provides a breakdown of the damages/costs to local authorities and local government infrastructure as a result of the winter 2013 to 2014 floods by flood type. It includes details of the methods used to differentiate the damage costs and the associated uncertainties.

9.4.1 Approach to disaggregating the damage costs

The disaggregation of damages by flood type assumed that the majority of damages incurred by coastal LLFAs were caused by tidal surges. Although this is clearly a simplification, there was insufficient detail to provide a more sophisticated analysis.

Where the damage figures obtained specify the flood type and do not relate to coastal impacts, these are not included in the damages.

9.4.2 Summary of damages costs by flood type

Table 9.4 provides a summary of damages by flood type for local authorities and local government infrastructure. Around 65% of the damages are considered to relate to coastal damages and the remaining 35% are considered to have occurred as a result of fluvial/groundwater flooding. However, the coastal damages may have been caused by a combination of flooding and water-related erosion.

Table 9.4 Estimated economic damage costs to local authorities and local government infrastructure by flood type

Flood source	Economic damage estimates					
	Best estimate	Percentage of total	Low estimate	Percentage of total	High estimate	Percentage of total
All (total)	£58 million	100%	£49 million	100%	£66 million	100%
Fluvial/ groundwater	£20 million	35%	£17 million	35%	£23 million	35%
Coastal	£37 million	65%	£32 million	65%	£43 million	65%

Notes: Values are presented to 2 significant figures and therefore the totals may not be the exact sum of constituent parts due to rounding.

9.5 Damage costs for England and Wales

No information was obtained on the damages/costs to local authorities and local government infrastructure during the winter 2013 to 2014 floods for Wales. Therefore the damage estimates presented above are for England only.

9.6 Uncertainties and assumptions

Although every effort was made to obtain a full suite of data, there are likely to be data gaps where the lack of information for certain LLFAs will affect the reliability and robustness of the overall estimate of the damages/costs to local authorities and local government infrastructure.

In general, there was a lack of data on the number of local authority assets affected by flooding or figures relating to the operational activities undertaken in dealing with the effects of the floods (for example, number of overtime staff hours). It was not therefore possible to extrapolate damages/costs across those LLFAs for which no data were available. However, it is expected that those LLFAs with the greatest damages did respond to the data requests sent for this study and that any data gaps are likely to be concentrated on those local authorities where the impacts were smaller. As a result, it is likely that the total damages are an underestimate. The extent of this underestimate cannot be quantified but is not expected to be significant.

Adjustments were made to convert financial damages to economic damages. These adjustments use generic assumptions applied to all local authority asset damages/repair costs (such as proportion of damages that are inventory rather than non-inventory for insurable costs). These adjustments will have introduced uncertainties.

10 Impacts on emergency services

10.1 Summary of findings

Table 10.1 presents the headline figures for the emergency services (police, fire and rescue and ambulance services). Involvement in major incidents such as flooding events results in additional costs to emergency services. The best estimate of the costs incurred by emergency services is £3.3 million with a range of £3.3 million to £8.7 million.

Table 10.1 Headline findings for emergency services

Finding	Economic damage estimates			
	Best estimate (range)	**% of total monetised damages**	**Uncertainty**	**Comments**
2013 to 2014 damages (total)	£3.3 million (£3.3 million to £8.7 million)	0.26% (of overall total damages)	Moderate–high	Based on local data at the LLFA level Data were obtained from emergency services on flood related costs and so the low range estimate is also considered to represent the best estimate. The high range estimate is determined based on the uncertainty rating and also includes Ministry of Defence costs.
2013 to 2014 damages (England)	£3.3 million (£3.3 million to £8.7 million	100% (of total for category)	Moderate–high	Based on local data at the LLFA level
2013 to 2014 damages (Wales)	No data	0% (of total for category)	High	
2007 damages (2014 values)	£5 million	0.1% (of overall total damages in 2007)	Score: 1 (best of breed)	Environment Agency (2010)
	Best estimate	**Units**	**Uncertainty**	**Source of estimate**
Numbers affected	993	Incidents attended by emergency services	Moderate	Based on data provided by emergency service providers
Numbers affected (England)	993			
Numbers affected (Wales)	No data		High	No data
	Best estimate	**Range**	**Uncertainty**	**Source of estimate**
Damages per asset	Not available		Units difficult to define	

10.2 Determining the best estimate

10.2.1 Number of assets affected/incidents attended

Dealing with a flooding event often requires extensive assistance from emergency services. These typically include police, fire, ambulance and coastguard services; the military also played a crucial role in the winter 2013 to 2014 flooding. These actions can result in the deployment of specialist equipment, increased staffing requirements and rapid use of supplies. This ultimately leads to additional costs for the emergency services and has the potential to disrupt normal day to day operations. In addition, the assets used by the emergency services can be flooded or damaged, causing further disruption and costs.

Actions by the emergency services during floods can include:

- taking an increased number of calls
- following these calls up with rescues or advice
- setting up road blocks
- carrying out or assisting with evacuations or rescues
- carrying out emergency repairs or providing sandbags/Aqua sacs and pumps
- providing medical care

Requests for information were sent to fire and rescue services, police and ambulance services seeking information on:

- number of flood related incidents attended
- number of assets damaged by flooding
- costs incurred in responding to flooding emergencies during the winter 2013 to 2014 floods

This data gathering exercise was supported by extensive internet research.

Thousands of calls were made to the emergency services concerning flooding. Among them were:

- 249 calls made to 999 in the Isle of Wight between 18 December 2013 and 18 February 2014 requesting a response to flooding related incidents (Isle of Wight Council 2014)
- 600 emergency calls made to the West Sussex Fire and Rescue Service in 24 hours (23–24 December) (Bognor Regis Observer 2013).

Some areas set up dedicated hotlines for anyone with concerns. For example, Essex Police received 323 calls during the tidal surge event through its flooding hotline (Herts and Essex Observer 2013).

Staff were required to work overtime and additional personnel were drafted in to assist with the operations carried out during the floods. For example, a total of 870 Devon and Somerset Fire and Rescue Service personnel were recorded as being deployed to the Somerset floods, assisted by 87 personnel from other fire and rescue services. The Service's personnel were recorded as being deployed to the Somerset floods for a total

of 4,985 hours (with 900 hours attributable to assistance from other fire and rescue services) ((Devon and Somerset Fire and Rescue Service, personal communication 16 December 2014).

In addition to assisting those affected by flooding, the emergency services themselves can be directly affected through damage to assets. This can include flooding to buildings or damage to equipment such as vehicles used in responding to incidents.

For example, the tidal surge seen along the North West coast flooded and damaged several RNLI lifeboat stations including the Blackpool, Lytham (RNLI 2013) and St Bees stations (The Whitehaven News 2014). At Blackpool, the RNLI shop was also flooded and damage to the electrics, doors and equipment was reported. The flooding at Lytham station caused a loss of artefacts and archive documents. The RNLI station at Redcar also flooded during the 2013 tidal surge (Cleveland Fire and Rescue Service, personal communication 6 January 2015).

Although this type of information is useful in helping to put in context the impacts associated with the winter 2013 to 2014 floods, it is quite limited with data typically available for only a small number of LLFA areas.

Data was obtained for 10 LLFA areas indicating that 993 separate flood incidents were attended during the 2013 to 2014 winter period. Although these data relate only to a relatively small number of LLFA areas, and are therefore likely to underestimate the total number of incidents attended, they are the most comprehensive data available and were therefore selected as the best estimate.

10.2.2 Cost to emergency services

To determine the costs incurred in responding to the 2013 to 2014 winter flood events, information at the local/regional level was obtained through internet research and consultation with the emergency services. These data were then aggregated to provide a national estimate of the costs incurred.

Contact was also made with the Ministry of Defence (MoD) regarding its considerable input and assistance in responding to the impacts of the winter 2013 to 2014 floods. The net additional cost to the MoD of assisting with the flood response was on a repayment basis from the Department for Environment, Food and Rural Affairs (Defra), DCLG, HM Treasury and Runnymede Council.

This means that the MoD did not actually spend any money on military response, but reclaimed approximately £4.6 million in net additional costs from other government departments (OGDs). It is possible that OGDs included their payments to the MoD as part of their return under another impact category(for example, local authorities and local government infrastructure) and therefore including this cost figure in the best estimate of the emergency services category might risk double counting (MoD, personal communication 8 December 2014). To reflect this uncertainty, the MoD costs have been included in the high range estimate of the emergency services costs.

The data obtained from the emergency services relate to the costs of attending flood related incidents (including equipment and personnel costs) and for assisting other services during the winter 2013 to 2014 floods; this is particularly relevant to the cost information obtained from fire and rescue services. No information was obtained on flood damages to emergency service assets specifically.

The costs incurred by those emergency services which provided combine to give a best estimate of £3.3 million.

Table 10.2 Costs of attending flood incidents locally and elsewhere

Area	Cost estimates	
	Costs	**Source**
East Midlands	£3,200	East Midlands Ambulance Trust
East of England	£17,000	East of England Ambulance Trust; Bedfordshire Fire and Rescue Service (assisting Surrey)
North East	£16,000	North East Ambulance Service; Cleveland Fire and Rescue Service
North West	£290,000	North West Ambulance Service; Cumbria Fire and Rescue Service; Manchester Fire and Rescue Service
South East	£360,000	South Central Ambulance Service; Buckinghamshire Fire and Rescue Service; East Sussex Fire and Rescue Service (assisting Surrey); Hampshire Fire and Rescue Service
South West	£2.3 million	South West Ambulance Service; Cornwall Fire and Rescue Service ; Devon and Somerset Fire and Rescue Service; also covers costs to police, military and ambulance services; Dorset Police; Dorset Fire and Rescue Service
West Midlands	£210,000	West Midlands Ambulance Service; West Midlands Fire Service; Hereford and Worcester Fire and Rescue Service
Yorkshire and Humber	£80,000	Humberside Fire and Rescue Service
Total	**£3.3 million**	

Notes: Values are presented to 2 significant figures.
Costs for police, fire and rescue and ambulance services
No data were obtained for Wales.

The information on the operational costs of dealing with the winter 2013 to 2014 floods either relates to staff overtime costs or specifically to action taken to deal with the flood events. It is likely that the emergency services were working to capacity, meaning that time spent responding to flood incidents disrupted other activities and prevented other work being performed. It was assumed that the costs relate to the effect on other tasks not undertaken as a result of the floods.

The costs presented in Table 10.2 were considered to represent an economic cost and therefore were not adjusted. Figure 10.1 shows the distribution of costs to the emergency services. Note that the map does not present the same information as given in Table 10.2; Figure 10.1 shows the location where costs were incurred by emergency service providers as many emergency services provided assistance to other areas, particularly the South West. Whereas Table 10.2 presents costs to emergency service providers of attending incidents both locally and elsewhere The Annex 1 method statement summarises the approach used to develop the best estimate of damages to emergency services.

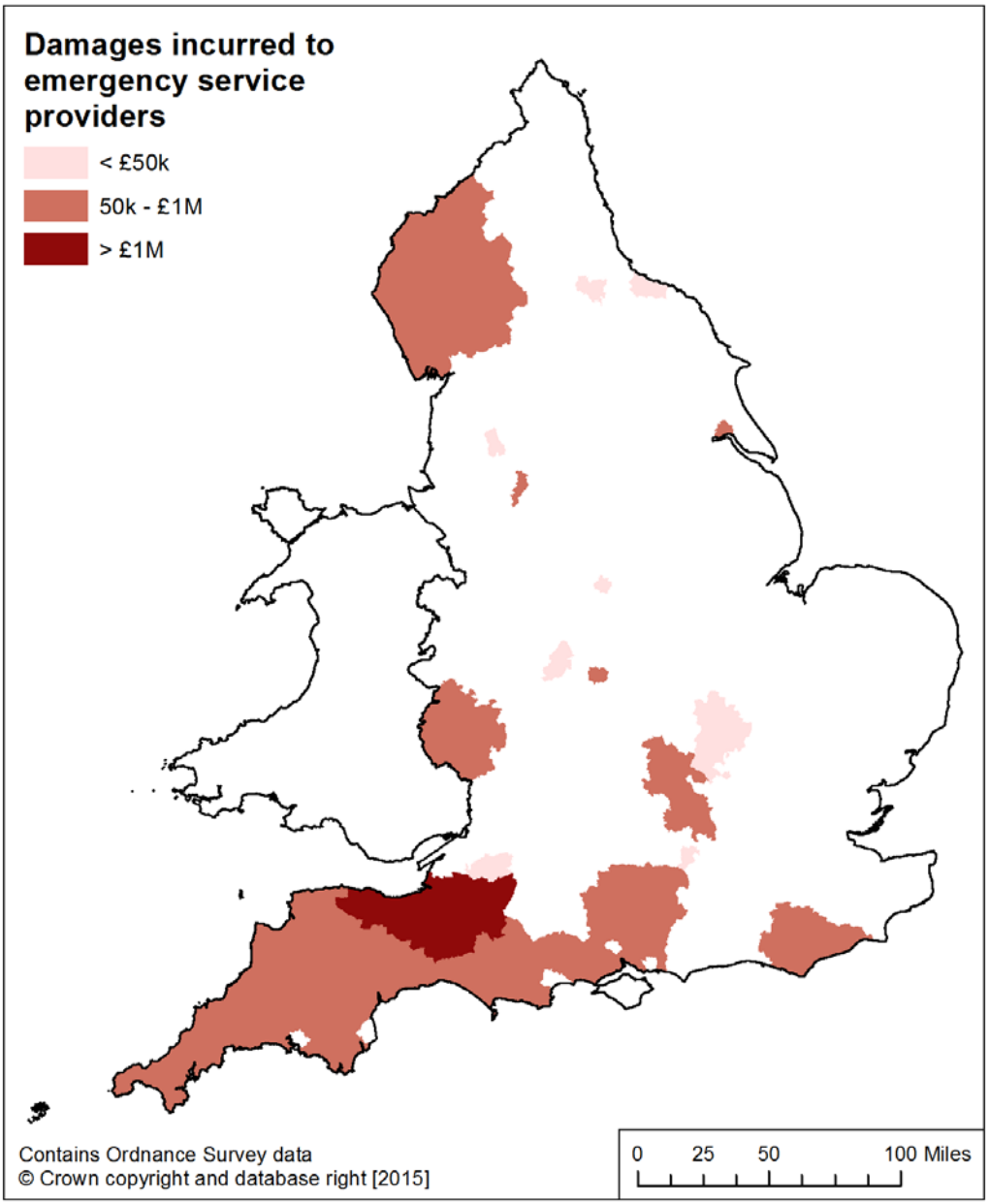

Figure 10.1 Estimated costs to emergency services for the 21 LLFAs for which data were available

10.3 Determining the best estimate range

The data used to provide the best estimate of costs in each impact category were assessed to determine the associated uncertainty. The uncertainty rating was applied based on the availability and quality of the data obtained and the assumptions applied to the data to provide an economic cost estimate. The uncertainty rating was subsequently used to determine the potential range around the best estimate.

This approach was used to determine a range of emergency service costs from responding to flood incidents of £3.3 million to £8.7 million (Table 10.1). Further details on the methods used to develop the lower and higher ranges are provided below.

10.3.1 Low estimate

Information was obtained from fire and rescue, police and ambulance services on the costs incurred in responding to flood incidents during the 2013 to 2014 winter period. Combining the information obtained from individual emergency services provides a low range estimate of £3.3 million. But although responses were received from a number of emergency services, data were not provided from all services. Therefore, the low range estimate may underestimate the costs incurred by emergency services at the national level. However, it was taken as the best estimate to avoid overestimation of the potential costs.

10.3.2 High estimate

Because cost information was not received from all emergency services there are likely to be data gaps. This suggests that the £3.3 million costs used as the best estimate may be an underestimate. It may also be the case that certain emergency services did not incur any flood-related costs, but it was not possible to determine the extent to which this is the case. Therefore, the information was classified as having a moderate–high uncertainty rating given the gaps in the data.

To reflect this uncertainty, the best estimate (£3.3 million) was increased by 25% (Table 2.5), resulting in a high range estimate of the flood-related costs to emergency services during the 2013 to 2014 winter period of £4.1 million.

The net additional cost to the MoD of assisting with the flood response was on a repayment basis, meaning that it did not actually spend any money on military response, but reclaimed approximately £4.6 million in net additional costs from OGDs (MoD, personal communication 8 December 2014). It is possible that OGDs included the payments they made to the MoD as part of their return for another impact category and therefore including this cost figure in the best estimate of the emergency services category may risk double counting. To reflect this uncertainty, the MoD costs were included in the high range estimate of the emergency services costs.

The net additional costs to the MoD of £4.6 million were therefore combined with the £4.1 million high range cost figure for fire and rescue, police and ambulance services (based on the moderate–high uncertainty rating) to provide a final high range estimate of £8.7 million.

10.4 Damage costs by flood type

Disaggregation of the damages by flood type was not possible for this impact category because the information collected was provided predominantly by fire and rescue services. These organisations typically respond to incidents within their own local area. In the winter 2013 to 2014 floods, however, many of the fire and rescue services provided assistance to other areas, particularly the South West. Therefore, it was not possible to separate out the costs incurred to these organisations by location and break costs down by flood type.

10.5 Damage costs for England and Wales

Damage costs were only available for fire and rescue services in England. The total damages of £3.3 million therefore relate entirely to damages within England. It is, however, possible that some services provided assistance across the border in Wales.

10.6 Uncertainties and assumptions

Data are limited and are not available for all emergency services across the country. As a result, the total damages are likely to be underestimating the overall impacts. The MoD costs associated with responding to the winter 2013 to 2014 floods have not been included in the best estimate to avoid potential double counting with the costs in the local authorities and local government infrastructure category. However, there is uncertainty over whether the MoD costs are included in the costs incurred by local authorities. To reflect this uncertainty, the MoD costs were included in the high range estimate of the emergency services costs.

The information obtained on the operational costs of dealing with the winter 2013 to 2014 floods either relates to staff overtime costs or specifically to action taken to deal with the flood events. It is likely that emergency services were working to capacity, meaning that time spent responding to flood incidents disrupted other activities and prevented other work from being carried out. It was therefore assumed that the costs relate to the effect on the other tasks that were not performed due to the floods.

Also, no adjustment is made for VAT for costs incurred by emergency services as it was assumed that these services are exempt from VAT. There is an argument that the taxation element of overtime payments should be deducted as this cost element is transferred back to the government. However, given the uncertainties associated with the figures, this was not done to avoid suggesting a higher level of confidence in the figures than is actually the case.

11 Impacts on flood risk management infrastructure and response to flood

11.1 Summary of findings

Table 11.1 presents the headline figures for the impact category of flood risk management infrastructure and response. This category includes data provided by the Environment Agency on the cost of damage repairs to flood defence infrastructure owned or managed by the Environment Agency and Risk Management Authorities as a result of the winter 2013 to 2014 floods. Information was also obtained on the damages caused to flood risk infrastructure in Wales.

To avoid double counting, the damages to or repairs of flood risk management infrastructure that is the responsibility of local authorities are included, where possible, in this category and not in the local authorities and local government infrastructure category. But where specific costs in the local authorities and local government infrastructure category could not be broken down into their constituent parts, there is a risk of double counting with the figures presented in this impact category.

Local level data relating to the effects of flooding on Internal Drainage Boards and the response and effort provided by responsible organisations (such as the Environment Agency) are also presented to help provide a context to the national costs.

The best estimate of the damages/costs to flood risk management infrastructure in England and Wales resulting from flooding during the winter of 2013 to 2014 is £147 million with a range of £145 million to £148 million. The best estimate is based on the costs (in economic terms) of flood defence repairs provided by the Environment Agency and Natural Resources Wales. Further details on the data collected and how the best estimate and range were determined are provided in the following sections.

Table 11.1 Headline findings for flood risk infrastructure and response

Finding	Economic damage estimates			
	Best estimate (range)	% of total monetised damages	Uncertainty	Comments
2013 to 2014 damages (total)	£147 million (£145 million to £148 million)	12% (of overall total damages)	Low–moderate	Based on data for England (from the Environment Agency) and Wales (from Natural Resources Wales) on costs to repair flood related infrastructure Low and high range estimates are determined based on uncertainty rating

Finding	Economic damage estimates			
2013 to 2014 damages (England)	£137 million	94% (of total for category)	Low	Based on Environment Agency data on repair costs to flood risk infrastructure
2013 to 2014 damages (Wales)	£9.5 million (£8.1 million to £11 million)	6% (of total for category)	Low–moderate	Based on estimates of repairs to flood risk infrastructure from Natural Resources Wales (2014)
2007 damages (£2007)	£24 million	0.6% (of overall total damages in 2007)	Score: (1 best of breed)	Environment Agency (2010)
	Best estimate	**Units**	**Uncertainty**	**Source of estimate**
Numbers affected (total)	890	Number of projects undertaken	Low	Number of projects carried out by the Environment Agency and Risk Management Authorities in response to damage to flood defences
Numbers affected (England)	890			
Numbers affected (Wales)	No data		High	No information available
	Best estimate	**Range**	**Uncertainty**	**Source of estimate**
Damages per asset	Not available	Not available	Not available	Not available

Notes: Values presented to 2 significant figures unless used to differentiate between the best, low and high estimates.

11.2 Determining the best estimate

11.2.1 Number of flood defence repair projects

In their roles as Risk Management Authorities, the Environment Agency, LLFAs, district and borough councils, Highway Authorities, and water and sewerage companies all have responsibilities in managing flood risk. As a result, they are all involved in responding to flooding incidents both in terms of action during the events and reporting afterwards. In addition, many Risk Management Authorities experienced impacts through damages to flood defence infrastructure for which they are responsible.

A total of 890 projects were approved or carried out in England by the Environment Agency and Risk Management Authorities in response to the winter 2013 to 2014 floods, of which 844 were to repair damaged flood defences. Table 11.2 provides a breakdown of the projects by region. Around a quarter of the 890 projects were in Devon and Cornwall. Notably 11 projects were in relation to national flood forecasting.

Table 11.2 Number of projects in England by the Environment Agency and Risk Management Authorities in response to the winter 2013 to 2014 floods

Region	Number of projects
Cambridgeshire and Bedfordshire	12
Cumbria and Lancashire	27
Derbyshire, Nottinghamshire and Leicestershire	19
Devon and Cornwall	217
Essex, Norfolk and Suffolk	81
Hertfordshire and north London	15
Kent and south London	48
Lincolnshire and Northamptonshire	111
National flood forecasting	11
Northumberland, Durham and Teesside	22
Shropshire, Herefordshire, Worcestershire and Gloucestershire	37
Solent and South Downs	60
Staffordshire, Warwickshire and West Midlands	7
Wessex	127
West Thames	19
Yorkshire	77
Total	**890**

Notes Source: Environment Agency

11.2.2 Damages/costs to flood risk management infrastructure and response

Costs in England

Information was also provided by the Environment Agency and other Risk Management Authorities on the total costs to flood risk management infrastructure and services resulting from the winter 2013 to 2014 floods in England. These data were aggregated to provide a national level cost of the damages to flood risk management infrastructure in England. This cost is likely to include damages caused by flooding and water-related erosion.

This information is presented in Table 11.3, which shows that a total of £137.2 million was spent by the Environment Agency and Risk Management Authorities across English regions in carrying out repairs to flood risk management infrastructure and other flood related response costs such as to national flood forecasting. These costs exclude VAT and any betterment,[5] they are therefore considered to represent an economic cost. The map in Figure 11.1 shows the distribution of damages to flood risk infrastructure across England.

[5] Discussions with the Environment Agency suggest that, in the vast majority of cases, betterment was specifically excluded.

Table 11.3 Total approved cost of projects in England by the Environment Agency and Risk Management Authorities to repair flood risk management infrastructure as a result of the winter 2013 to 2014 floods

Region	Approved total (£ million)
Cambridgeshire and Bedfordshire	£1.2 million
Cumbria and Lancashire	£1.3 million
Derbyshire, Nottinghamshire and Leicestershire	£3.8 million
Devon and Cornwall	£21.3 million
Essex, Norfolk and Suffolk	£8.0 million
Hertfordshire and North London	£1.2 million
Kent and South London	£5.9 million
Lincolnshire and Northamptonshire	£11.2 million
National flood forecasting	£0.7 million
Northumberland, Durham and Teesside	£4.8 million
Shropshire, Herefordshire, Worcestershire and Gloucestershire	£4.1 million
Solent and South Downs	£7.2 million
Staffordshire, Warwickshire and West Midlands	£0.4 million
Wessex	£40.2 million
West Thames	£6.2 million
Yorkshire	£19.5 million
Total	**£137.2 million**

Notes: Figures are presented to 1 decimal place.
Source: Environment Agency

Approximately 83% of the costs can be attributed to the Environment Agency and the remaining 17% to other Risk Management Authorities (Table 11.4).

Table 11.4 Total cost to flood risk management infrastructure and service in England resulting from the winter 2013 to 2014 floods by year and responsible organisation

Year	Environment Agency	Other Risk Management Authorities	Total
2013 to 2014	£30 million	£1.5 million	£31 million
2014 to 2015	£84 million	£21 million	£105 million
Total	**£114 million**	**£23 million**	**£137 million**

Notes: Figures presented to 2 significant figures unless used to present sum of the constituent parts.
Source: Environment Agency

Internal Drainage Boards across the country also assisted with emergency repair works to tidal defences and floodwater pumping. Many pumping stations were pressed into

emergency action with additional mobile pumps used and sandbags deployed where necessary (ADA 2014).

Several IDBs incurred costs during the winter floods. For example, Lindsey Marsh IDB incurred costs of around £81,000 (economic cost) from the 5–6 December 2013 tidal surge and the Bedford Group of Drainage Boards incurred estimated costs of around £110,000 (economic cost) from temporary pumping and workforce/officer man days spent on flood duties (Bedford Group of Drainage Boards, personal communication 22 December 2014). IDBs also incurred damage to assets such as buildings and pumps; North East Lindsey IDB had 2 pumping stations at New Holland damaged at an estimated cost of £35,000 (economic cost). These costs are considered to be included in the figures presented in Table 11.4.

During the winter 2013 to 2014 floods, the Environment Agency assisted others in:

- preparing for the floods
- helping to prevent property flooding
- taking calls concerning floods
- distributing sandbags
- clearing debris
- repairing any damage to infrastructure it was responsible for

The Environment Agency issued 131 severe flood warnings, opened up 28 area incident rooms and kept its National Incident Room open for 47 consecutive days (Environment Agency 2014m). Table 11.5 shows the estimated number of shifts by Environment Agency staff during the winter 2013 to 2014 floods.

Table 11.5 Estimated total of 8 hour shifts undertaken by Environment Agency staff during the 2013 to 2104 winter floods

Region or action	Total number of 8 hr shifts
National Incident Room (up to 14 January 2014)	371
Incident Communication Service	1,050
National Media Team and National Communications Support	510
Strategic Management Team Support Group	975
National Technical Team	549
Geomatics	210
East Midlands	2,866
East of England	3,690
North West	5,870
South East	10,596
South West	7,072
Yorkshire and Humber	748
Total	**34,507**

Notes: Total shift numbers calculated as ‘shifts’ x ‘people per shift’. Each shift lasted 8 hours.

Source: Environment Agency (2014m)

Approximately 35,000 shifts (each lasting 8 hours) were worked by Environment Agency staff in responding to the winter 2013 to 2014 floods, highlighting the considerable time and effort required to deal with flood events. The highest number of shifts worked was in the South East region, which is unsurprising given the considerable impacts that occurred. In the East of England, 341 people were involved in the Area's response, with a total of approximately 6,000 staff hours worked (Environment Agency 2014a). Work by those who were not Flood and Coastal Risk Management staff equated to 47% of total Environment Agency staff hours (Environment Agency 2014a).

The figures presented in Table 11.5 are provided to highlight the amount of work required to respond to the winter 2013 to 2014 floods in both a national and regional context. These figures have not been used specifically in determining the costs to flood risk infrastructure.

Costs in Wales

Within Wales, the damage to coastal defences managed by local authorities and Natural Resources Wales during the 2013 to 2014 winter period was estimated to be around £11.4 million (financial cost) (Natural Resources Wales 2014). The figures provided by Natural Resources Wales relate to estimates of the costs of temporary and permanent restoration works to damaged coastal defences. These costs therefore cover the damages caused by both flooding and water-related erosion. The permanent restoration of defences equates to reinstatement of pre-flood conditions rather than betterment to provide improved standards of protection. Therefore adjustment of the figures to account for betterment is not necessary. However, VAT (at 20%) was removed to provide an estimate of the economic costs. A summary of the calculation used to convert the damage/repair costs to an economic estimate is provided below:

> Economic estimate of damage/repair costs = Financial estimate of damage/repair costs ÷ 1.2 (to remove VAT at 20%)

An estimated £9.5 million (in economic terms) was spent on temporary and permanent restoration of coastal defences in Wales damaged during the 2013 to 2014 winter period (Table 11.6). Around 45% of the costs relate to damages caused to coastal defences in Conwy (£4.3 million), with repair costs also exceeding £1 million in both Denbighshire and Ceredigion. The economic cost of coastal defence restoration to Natural Resources Wales is estimated to be £810,000 (9% of the total). The map in Figure 11.1 shows the distribution of damages to flood risk infrastructure across Wales.

Table 11.6 Estimated economic cost of temporary and permanent works restore coastal defences damaged during the winter 2013 to 2014 in Wales

Area/organisation	Estimated economic cost
Local authorities	
Bridgend	£67,000
Cardiff	£21,000
Carmarthenshire	£28,000
Ceredigion	£1,100,000
Conwy	£4,300,000
Denbighshire	£1,500,000
Gwynedd	£640,000

Area/organisation	Estimated economic cost
Isle of Anglesey	£140,000
Monmouthshire	£830
Neath Port Talbot	£540,000
Pembrokeshire	£320,000
The Vale of Glamorgan	£54,000
Natural Resources Wales	
Natural Resources Wales (North)	£700,000
Natural Resources Wales (South West)	£36,000
Natural Resources Wales (South East)	£80,000
Total	**£9,500,000**

Notes: Values presented to 2 significant figures. Source: Natural Resources Wales (2014)

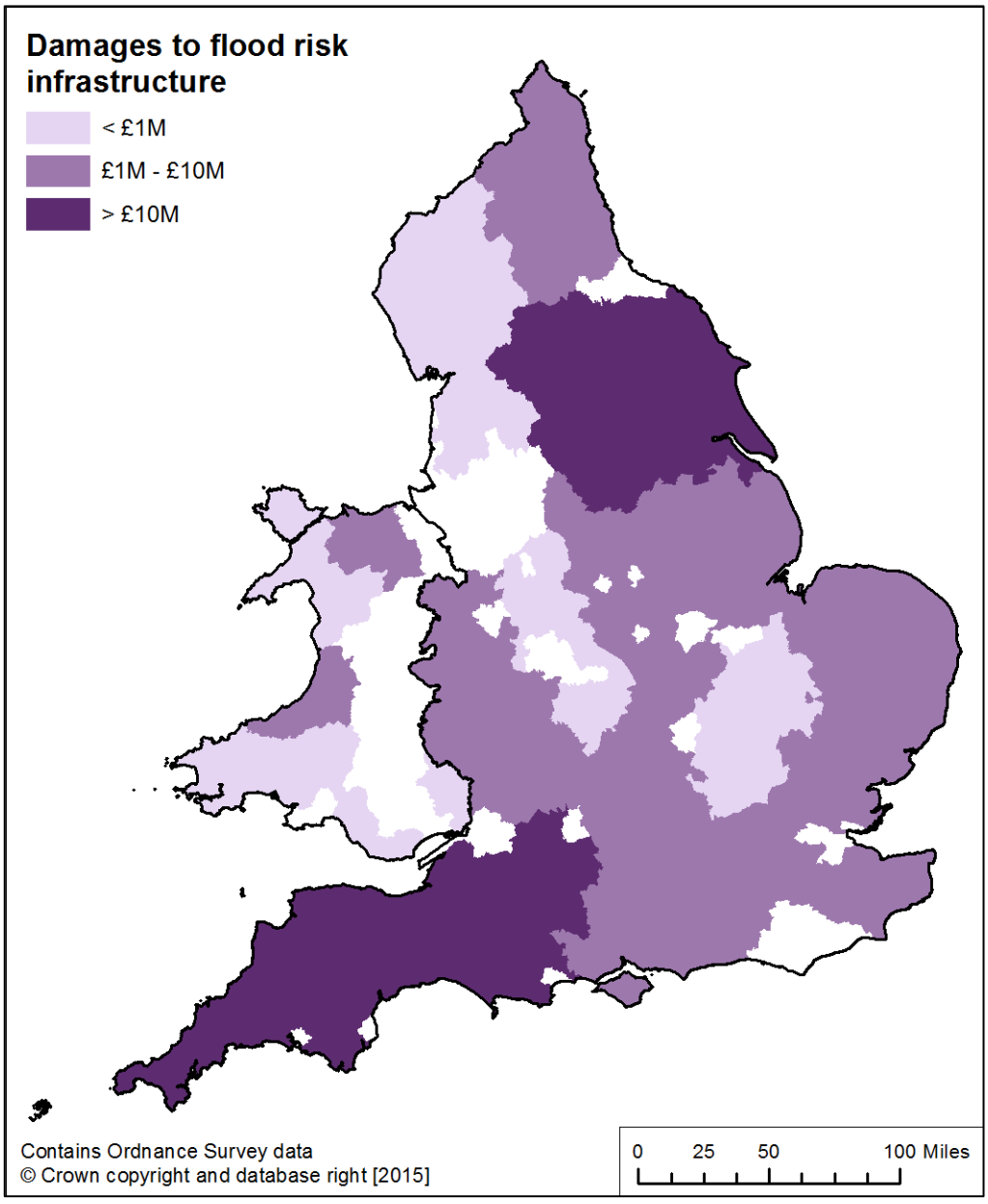

Figure 11.1 Estimated damages to flood risk infrastructure based on Environment Agency information

Estimated total costs in England and Wales

Combining the costs to flood risk management infrastructure and service resulting from the winter 2013 to 2014 floods in England and Wales gives a total cost of £147 million (or £150 million presented to 2 significant figures) (Table 11.7).

The distribution of damages to flood risk infrastructure is shown in Figure 11.1.

The Annex 1 method statement summarises the approach used to develop the best estimate of the costs to flood risk management infrastructure.

Table 11.7 Total economic costs to flood risk infrastructure and service resulting from the winter 2013 to 2014 floods in England and Wales

Area/organisation	Economic cost (£)
England	£137 million
Wales	£9.5 million
Total	**£147 million**

Notes: Values presented to 3 significant figures.
Sources: Environment Agency; Natural Resources Wales (2014)

11.3 Determining the best estimate range

The data used to provide the best estimate of costs in each impact category have been assessed to determine the associated uncertainty. The uncertainty rating was applied based on the availability and quality of the data obtained and the assumptions applied to the data to provide an economic cost estimate.

This approach was used to determine a range of flood or water-related erosion damages to flood risk management infrastructure of £145 million to £148 million (Table 11.1). Further details on the methods used to develop the lower and higher ranges are provided below.

11.3.1 Low estimate

A total of £137 million (in economic terms) was spent on repairing damages to flood risk management infrastructure (managed by the Environment Agency and Risk Management Authorities) resulting from the winter 2013 to 2014 floods. This figure is for actual expenditure on damage repairs and it was therefore not deemed necessary to develop a range around this cost figure.

The cost of repairs to coastal defences in Wales resulting from the winter 2013 to 2014 floods is based on an assessment by Natural Resources Wales. These figures have been adjusted for this study to provide an economic estimate of the total repair costs to local authorities and Natural Resources Wales of £9.5 million. However, the assessment by Natural Resources Wales was prepared in January 2014 and gives the 'best information' available at that time. The report notes that this information was subject to change as the scale of impacts and costs became better understood and evaluated. Thus, there is a degree of uncertainty surrounding these estimates. Also while there is good regional coverage of the potential costs, the report does not state the actual costs incurred. So although cost estimates are available it was not possible

to cross-check them with actual cost data. Consequently, the figures for Wales are classified as having a low–moderate uncertainty rating. To reflect this uncertainty, the best estimate (£9.5 million) was reduced by 15% (see Table 2.5), resulting in a low range estimate for Wales of £8.1 million.

Combining the best estimate of costs to flood risk management infrastructure for England with the low estimate for Wales gave a total low range estimate for the costs in England and Wales of £145 million.

11.3.2 High estimate

A similar approach was used to obtain an upper range estimate. The total cost figure of £137 million for England (Table 11.3) was deemed to be accurate and so it was not appropriate to determine a high estimate.

The coastal defence repair costs obtained from Natural Resources Wales (2014) are estimates and were adjusted to provide an economic cost (removal of VAT at 20%). They were therefore classified as having a low–moderate uncertainty (in line with the uncertainty matrix presented in Section 2.3.4). To reflect this uncertainty, the best estimate (£9.5 million) was increased by 15% (see Table 2.5), resulting in a high range estimate for Wales of £11 million.

Combining the best estimate of costs to flood risk management infrastructure for England with the upper estimate for Wales gave a total high range estimate for England and Wales of £148 million.

11.4 Damage costs by flood type

This section provides a breakdown of the damages/costs to flood risk management infrastructure as a result of the winter 2013 to 2014 floods by flood type for England and Wales. It includes details of the methods used to differentiate the damage costs and the associated uncertainties.

11.4.1 Approach to disaggregating the damage costs

A total of 890 projects were carried out in England by the Environment Agency and Risk Management Authorities in response to the winter 2013 to 2014 floods, with 844 of these projects being to repair damaged flood defences (Table 11.2). A total of 613 (69%) of the 890 projects related to coastal flooding and the remaining 277 projects (31%) related to fluvial flooding (Table 11.8).

Table 11.8 Number of flood risk management infrastructure projects in response to damages caused during the winter 2013 to 2014 in England

Flood type	Number of projects		Total number of projects
	Environment Agency	Other Risk Management Authorities	
Coastal	375	238	**613**
Fluvial	245	32	**277**
Total	**620**	**270**	**890**

Source: Environment Agency

Information provided by the Environment Agency suggests that, of the £137 million spent on flood risk management infrastructure repairs in England, approximately £100 million (73%) can be attributed to damages caused by coastal flooding or water-related erosion and approximately £37 million (27%) to fluvial flooding.

The information obtained from the Natural Resources Wales (2014) refers to costs of repairing damages to coastal defences in Wales. Therefore, all the £9.5 million economic costs can be attributed to coastal flooding or water-related erosion.

11.4.2 Summary of damage costs by flood type

Table 11.9 provides a summary of the costs broken down by flood type for England and Wales.

Table 11.9 Breakdown of costs to flood risk management infrastructure and service in response to damages caused during winter 2013 to 2014 floods by flood type

Country	Flood source	Economic damages					
		Best estimate		Low estimate		High estimate	
		Damage	Percentage of total	Damage	Percentage of total	Damage	Percentage of total
All (total)	All (total)	£147 million	100%	£145 million	100%	£148 million	100%
England	Fluvial	£37.2 million	27%	£37.2 million	27%	£37.2 million	27%
	Coastal	£100 million	73%	£100 million	73%	£100 million	73%
	Total	£137 million	100%	£137 million	100%	£137 million	100%
Wales	Fluvial	–	–	–	–	–	–
	Coastal	£9.52 million	100%	£8.09 million	100%	£10.9 million	100%
	Total	£9.52 million	100%	£8.09 million	100%	£10.9 million	100%

Notes: Values are presented to 3 significant figures and therefore the totals may not be the exact sum of constituent parts due to rounding.
Source: Environment Agency; Natural Resources Wales (2014)

11.5 Damage costs for England and Wales

This section provides a breakdown of the damages/costs to flood risk management infrastructure as a result of the winter 2013 to 2014 floods for England and Wales. It includes details of the method used to differentiate the damage costs and the associated uncertainties.

11.5.1 Approach to disaggregating the damage costs

Information from the Environment Agency indicates that £137 million was spent by the Environment Agency and Risk Management Authorities in England on repairs to flood

risk management infrastructure as a result of damages caused during the winter 2013 to 2014 floods. An economic estimate of the cost of repairs of coastal defence infrastructure (£9.5 million) was determined for Wales using information from Natural Resources Wales (2014).

11.5.2 Damage costs for England/Wales

Table 11.10 provides a summary of damages split between England and Wales for flood risk infrastructure.

Table 11.10 Estimated economic damage costs to the flood risk infrastructure by country

Country	Economic damages					
	Best estimate		Low estimate		High estimate	
	Damage	Percentage of total	Damage	Percentage of total	Damage	Percentage of total
Total	£147 million	100%	£145 million	100%	£148 million	100%
England	£137 million	94%	£137 million	94%	£137 million	93%
Wales	£9.52 million	6%	£8.09 million	6%	£10.9 million	7%

Notes: Values are presented to 3 significant figures and therefore the totals may not be the exact sum of constituent parts due to rounding.

11.6 Uncertainties and assumptions

The information provided by the Environment Agency represents the actual cost of repairs to flood risk infrastructure resulting from damages caused during the winter 2013 to 2014 floods. This information is therefore considered to be reliable.

The costs of coastal defence repairs in Wales are based on estimates from January 2014 provided by Natural Resources Wales. As these estimates could be subject to change, there is a degree of uncertainty associated with them.

The cost estimates for flood risk management infrastructure and service relate to damages caused by both flooding and water-related erosion.

12 Impacts on utilities: energy

12.1 Summary of findings

Table 12.1 presents the headline figures for the impact category of utilities: energy. This category includes estimates of the costs incurred by energy companies in responding to flooding during the 2013 to 2014 winter.

During flood events, there are 2 main types of costs resulting from impacts to utilities:

- direct damage costs incurred by utility companies as a result of flooding of their assets
- welfare costs to customers as a result of service disruption

Limited information was obtained on the direct damages/costs to energy companies, but discussions with the industry suggested that flood related damages/costs were small.

The best estimate of the damages to energy infrastructure as a result of flooding during the winter of 2013 to 2014 is £44,000. This is based on information from a single power company and may therefore underestimate the damages/costs. However, consultation with energy companies suggests that direct damages/costs were small and therefore the figure of £44,000 was retained.

Welfare costs relating to disruption resulting from power outages caused by flooding were determined by estimating the number of customers affected by power outages, the duration of the disruption and through applying a compensation cost per hour of disruption. This approach results in an estimated welfare cost of £780,000 with a range of £580,000 to £970,000. Further details describing how the best estimate and range were determined are provided in the following sections.

Table 12.1 Headline findings for utilities: energy

Finding	Economic damage estimates			
	Best estimate (range)	% of total monetised damages	Uncertainty	Comments
2013 to 2014 damages (direct damages/costs)	£44,000 (Discussions with energy companies suggest flood related damages/costs were small) (£44,000 to £54,000)	0.06% (of overall total damages)	Moderate–high	Based on local data from a power company (1 datum point only, so may underestimate costs. However, discussions with companies suggest that flood related damages/costs were small. Range estimates are determined based on uncertainty rating.
2013 to 2014 damages (welfare costs)	£780,000 (£580,000 to		Moderate–high	Based on an estimate of the number of

Finding	Economic damage estimates			
	£970,000)			customers affected by power outages because of flooding and compensation costs for disruption. Range estimates are determined based on uncertainty rating.
2013 to 2014 damages (total)	£820,000 (£630,000 to £1 million)		Moderate–high	Combination of direct damages/costs and welfare costs
2013 to 2014 damages – England (direct damages/costs)	£40,000 (£40,000 to £50,000)	92% (of total direct damages for category)	Moderate–high	Based on local data and estimating the proportion of costs for England. Range estimates are determined based on uncertainty rating.
2013 to 2014 damages – England (welfare costs)	£770,000 (£580,000 to £970,000)	99.7% (of total welfare costs for category)	Moderate–high	Based on an estimate of the number of customers affected by power outages because of flooding in England and compensation costs for disruption. Range estimates are determined based on uncertainty rating.
2013 to 2014 damages – England (total)	£810,000 (£620,000 to £1.0 million)	99% (of total for category)	Moderate–high	Combination of direct damages/costs and welfare costs for England
2013 to 2014 damages – Wales (direct damages/costs)	£3,700 (£3,700 to £4,600)	8% (of total direct damages for category)	Moderate–high	Based on local data and estimating the proportion of costs for Wales Range estimates are determined based on uncertainty rating.
2013 to 2014 damages – Wales (welfare costs)	£2,000 (£1,500 to £2,400)	0.3% (of total welfare costs for category)	Moderate–high	Based on an estimate of the number of customers affected by power outages because of flooding in

Finding	Economic damage estimates				
					Wales and compensation costs for disruption. Range estimates are determined based on uncertainty rating.
2013 to 2014 damages – Wales (total)	£5,600 (£5,100 to £7,000)	0.7% (of total for category)	Moderate–high		Combination of direct damages/costs and welfare costs for Wales
2007 damages (utilities excluding water – gas and waste water) (2014 values)	£139 million	7.5% (of overall total damages in 2007)	Score: 2–3 (limiting assumptions – gross assumptions)		Environment Agency (2010)
	Best estimate	**Units**	**Uncertainty**		**Source of estimate**
Numbers affected (total)	632,247 (28,231 flood related incidents) (124,450 to 1 million)	Customers with disruption due to power outages	Moderate–high	Moderate	Best estimate is based on data from electricity DNOs, adjusted to account for flood related incidents Low estimate based on local data, high estimate based on national data from DCLG
Numbers affected (England)	627,402 (28,104 flood related incidents)	Customers with disruption due to power outages	Moderate–high		Based on data from electricity DNOs, adjusted to account for flood related incidents and estimating the proportion for England
Numbers affected (Wales)	4,845 (217 flood related incidents)	Customers with disruption due to power outages	Moderate–high		Based on data from electricity DNOs, adjusted to account for flood related incidents and estimating the proportion for Wales
	Best estimate	**Range**	**Uncertainty**		**Source of estimate**
Damages per asset	Not available	N/A	N/A		N/A

Notes: Values presented to 2 significant figures.
DNO = distribution network operator
N/A = not applicable

12.2 Determining the best estimate

12.2.1 Number of customers experiencing power outages

Data were obtained from electricity distribution network operators (DNOs) on the number of customers affected by supply disruptions during the 2013 to 2014 winter period (available in Energypeople 2014). Information specifically relating to flooding incidents was identified only for the area served by UK Power Networks (UKPN). Data for other areas include all outages and hence are likely to overestimate the damages due to flooding alone.

The following electricity DNOs experienced problems in terms of network incidents and interruptions to customer supply:

- UKPN, which covers the east of England, London and the south-east
- Scottish and Southern Energy Power Distribution (SSEPD), which covers the south of England
- Electricity North West Ltd, which operates in the north-west
- Western Power Distribution, which provides the electricity supplies for the Midlands, south-west and Wales
- Northern Powergrid, which serves north-east England, Yorkshire, Humberside and North Lincolnshire

UKPN reported that 17,829 of its customers were affected by safety and flood related incidents (Energypeople 2014). In terms of the 42 incidents directly caused by flooding, 10,341 customers were affected (Energypeople 2014). Comparing these figures with the total number of incidents (1,066) and customers affected (230,859) suggests that around 4.5% of customers were affected by power outages caused by flood related incidents. Thus, flooding incidents did not result in a disproportionate number of customers losing supply when considering all incidents.

SSEPD experienced power losses, with similar numbers of incidents and customers having their supply interrupted to UKPN (Energypeople 2014).

Electricity North West was affected by the Christmas storm on the 27 December 2013 (Energypeople 2014). However, there were also other incidents of supply disruption in the region. On 5 December 2013, bad weather meant that 6,000 homes lost electricity in Cumbria (BBC News 2013d), while 774 customers did not have power in Preesall (Lancashire) (Blackpool Gazette 2013). There was also disruption to electricity supplies in Middlesbrough and Port Clarence, with 10,000 properties losing power on Teesside following the flooding of a substation (BBC News 2013e). On 6 December 2013, the area covered by Northern Powergrid had more than 25,000 properties without power (The Journal 2013). The DNO experienced additional network incidents and supply interruptions over the Christmas period.

For Western Power Distribution, different areas were affected by incidents and supply disruptions at different times. Customers in the South West and South Wales were affected in the run up to Christmas 2013, while those in the East and West Midlands were affected just after Christmas (Energypeople 2014).

Loss of supply caused disruption for homes and businesses, and also those trying to deal with the flooding and poor weather (for example, the emergency services). Customers may have been affected by power outages despite not being flooded themselves.

Table 12.2 provides a summary of the number of customers affected by power outages by region and electricity DNO. As indicated above, a total of 230,859 UKPN customers were affected by power outages during the 2013 to 2014 winter period with 10,341 customers affected by flood related incidents specifically (equivalent to 4.5% of customers affected by all power disruption incidents).

For the purposes of this assessment, it was assumed that the same proportion of electricity customers affected by flood related incidents compared with those affected by all incidents (4.5%) applied to the other electricity DNOs. Therefore, the proportion of 4.5% of the total number of customers affected by power outages was applied to the remaining regions/electricity DNOs to estimate the number of customers who experienced disruptions due to flooding (Table 12.2).

In summary the following calculation was used to estimate the number of customers affected by power outages caused by flooding:

> Number of customers affected by power outages caused by flooding = Number of customers affected by power outages (all incidents) $\times$ 4.5% (based on UKPN data)

Table 12.2 Number of customers affected by power outages (all incidents and flood related incidents)

Region (electricity DNO)	Number of customers affected by power outages		Comments
	All incidents	Flood related incidents	
East of England and east Midlands (UKPN)	230,859	10,341	4.5% customers affected by power outages caused by flooding
North East (Northern Power Grid)	68,340	3,061	Number of customers affected by flooding calculated by taking 4.5% if all customers affected by power outages (using data from UKPN)
North West (Electricity North West)	46,879	2,100	
South East and London (SSEPD)	228,474	10,234	
West Midlands, South West and Wales (Western Power Distribution)	57,695	2,584	
Total	**632,247**	**28,321**	

Source: Energypeople (2014)

The total number of electricity customers affected by power outages during the 2013 to 2014 winter period was to 632,247, with 28,321 estimated to have been affected by flood related incidents (Table 12.2). This was considered to be the best estimate of the flood related impacts to customers and was used to determine the likely welfare impacts associated with electricity disruption (see Section 12.2.3).

The map in Figure 12.1 shows the distribution of households with disruptions to their power supply.

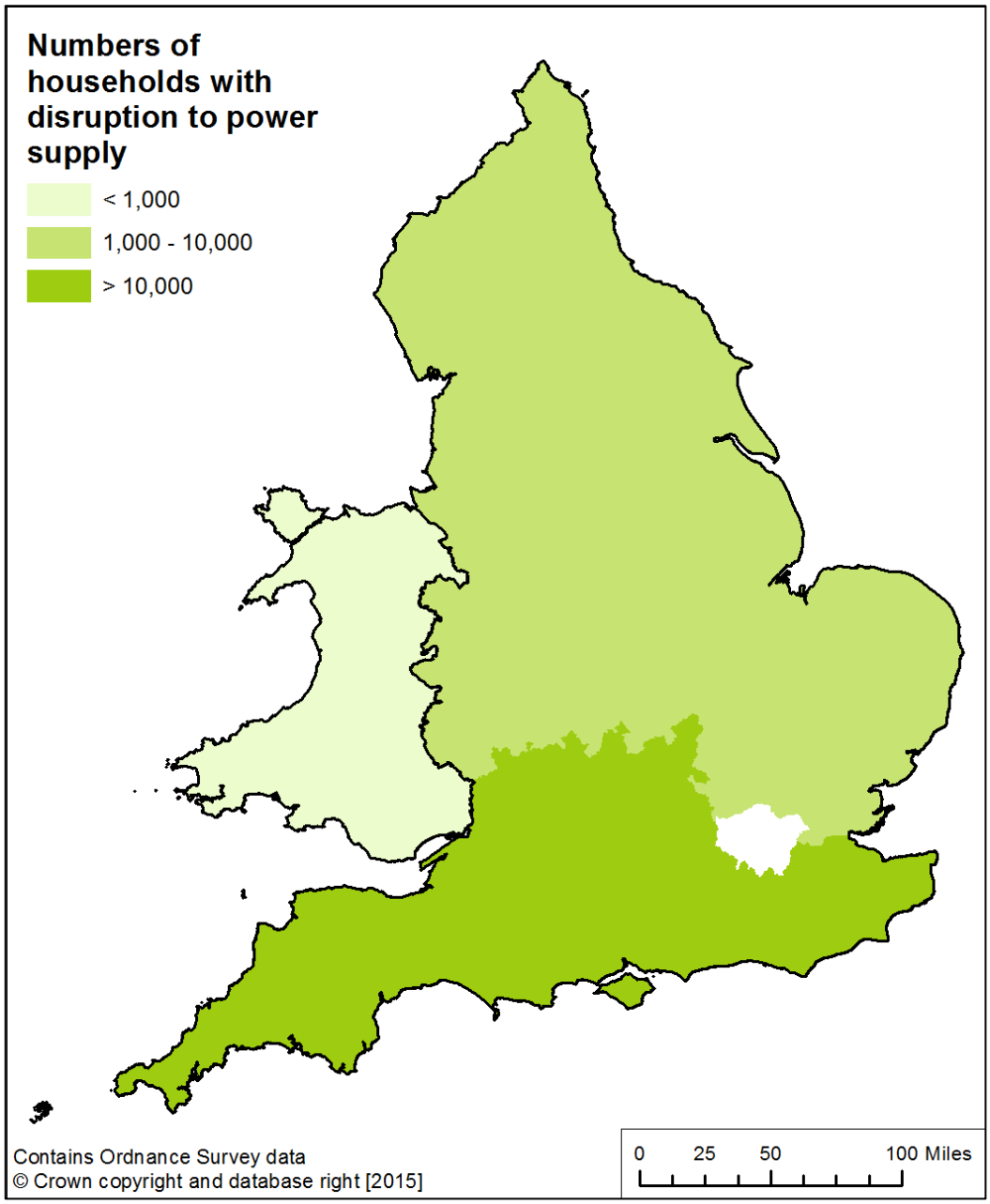

Figure 12.1 Number of customers with disruption due to power cuts for the 24 LLFAs for which data were available

Notes: Only shows where data were available and data may be incomplete.
The map combines local data with calculated information from Table 12.2 only where local data were not available.

12.2.2 Direct damages/costs to energy companies

During the winter 2013 to 2014 floods, utilities operators worked to keep their assets safe from floodwaters and tried to maintain/restore services in flooded areas. Direct impacts on utilities were caused by floodwaters and the tidal surge. For example, the surge disrupted Northern Powergrid assets (Raynor and Chatterton 2014). At Endeavour Wharf in Whitby, an electricity substation was flooded with significant repair work required (Yorkshire Post 2013a). However, assets were also affected in other ways. Saturated ground conditions affected the vulnerability of trees to storm conditions, with knock-on impacts for overhead lines (Energypeople 2014). Overall, impacts on energy assets were limited with just 3 reports of lost production at thermal

and pumped water storage power stations. Of these, one was associated with groundwater flooding; the other 2 events were wind-related (Energy UK 2015).

In addition, there were issues with accessing sites to clean up and restore services following flooding. Indeed, while the flood defences around substations and other assets operated by UKPN generally functioned well, bad weather conditions hindered the ability of the report teams and others to move around and access sites (Energypeople 2014). On some occasions, electricity networks had to be de-energised for safety reasons. This resulted in delays in terms of reconnecting assets and restoring supplies, for example, at Yalding in Kent (Energypeople 2014).

Very limited data were obtained on the direct damages/costs to energy companies during the winter 2013 to 2014 floods. The best estimate of private damages to energy/utilities companies is based on cost data from Western Power and utilities serving Wales and the west of the UK resulting in a total cost of £44,000 (considered to represent an economic cost). This may underestimate the costs incurred, although discussions with energy companies suggest that direct damages/costs caused by flooding were small and thus the figure of £44,000 has been retained.

12.2.3 Welfare impacts from customer disruption

Impacts on assets owned and operated by energy companies can result in disruption to the services provided. This can include loss of electricity to households and businesses, and also to other service providers. Where electricity DNOs covers relatively large areas, they are sometimes able to move staff around or share them with other companies, so that there can be a focus on affected areas. This ensures that supplies are restored quickly. However, the extensive area affected by the winter 2013 to 2014 floods meant that operators either did not have spare staff to move around and provide support, or conditions did not enable staff to travel (Energypeople 2014).

The floods consequently resulted in service disruptions for utility customers across England and Wales. For example, a report from Whitby suggests that one hospital patient had to be transferred to Scarborough after the electricity supply was lost and the hospital had to rely on its generators (Whitby Gazette 2013). In Kent, aggregate suppliers Cemex UK lost all power during the December tidal surge, resulting in the complete closure of the facility affecting Cemex staff (Kent County Council 2014).

Loss of power was also a problem at the port of Immingham where the tidal surge caused damage to substations with a loss of power and IT services for 3 days. This affected railway points and signalling, which in turn disrupted the movement of trains to the Humber International Terminal from where coal and biomass are shipped to inland power stations (Raynor and Chatterton 2014).

Welfare costs to electricity customers experiencing service disruption are estimated by the number of customers affected by power outages, the length of disruption experienced and the welfare costs associated with these disruptions. This section outlines how the welfare costs associated with power outages caused by flooding specifically during the 2013 to 2014 winter were determined.

Estimate of the number of electricity customers affected

The data obtained from electricity DNOs on the number of customers affected by power outages during the 2013 to 2014 winter refer to the number of customers experiencing service disruption caused by all incidents. Based on UKPN data, these data were adjusted for each region to estimate the number of customers affected by power outages caused by flood related incidents only. It is estimated that a total of 28,321 customers experienced supply disruptions as a result of the floods (Table 12.2).

Estimate of the length of service disruption

Box 12.1 provides details of the approach used to estimate the average (median) number of hours each customer was affected by power outages (Table 12.3).

Box 12.1 Estimating number of hours each customer was affected

Data were available from Energypeople (2014) on the number of customers affected by power outages and power outages of more than 48 hours. If it is assumed that the total number of customers affected by power outages relates to a very short duration outage, the number of customers affected for more than 48 hours actually reflects 48 hours and that the worst case relates to one customer, then this gives 3 points that can be plotted on a graph and a trend line can be applied to the data. Plotting the data showed that there was a decline in the number of customers affected and so the trend line was plotted to develop an exponential equation.

The equation derived from the trend line was used to estimate the median number of hours, assumed to be the point at which 50% of customers experienced a shorter delay and 50% experienced a longer delay. This was done by inputting a number for x (number of minutes of power outage) into the formula until the answer was equal to 50% of the total number of affected customers. The number of minutes was then divided by 60 to give the median number of hours.

The result for Electricity North West was applied to the data from Northern Powergrid and Western Power Distribution because this was considered the best fit. This means that the average power outage for the North East, West Midlands, South West and Wales is likely to be overestimated because the number of customers affected was lower than for Electricity North West. Figure 12.2 shows the resultant graph and trend lines, with the formulas derived from the trend lines.

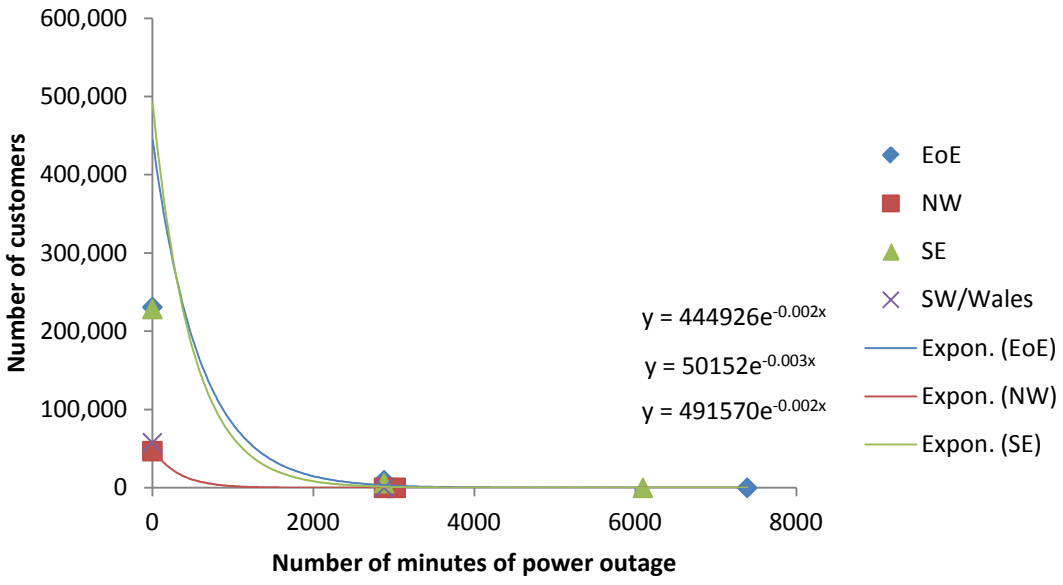

Figure 12.2 Graph showing trend lines and formulas used to calculate median number of hours affected (minutes ÷ 60)

Notes: EoE = East of England; NW = North West; SE = South East; SW = South West; Expon. = exponential

Table 12.3 Number of customers affected by power outages and median number of hours each customer was affected

Region	Number of customers affected by power outages (all incidents)	Number of customers affected by power outages for more than 48 hours	Number of customers affected by power outages (estimated for flood incidents)	Worst case	Median number of hours affected (estimated)
East of England and East Midlands (UK PN)	230,859	9,635 [1]	10,341	154 hours	11
North East (Northern Power Grid)	68,340	No data	3,061	No data	2
North West (Electricity North West)	46,879	22	2,100	63 hours	4
South East and London (SSEPD)	228,474	5,915	10,234	127 hours	12
West Midlands, South West and Wales (Western Power Distribution)	57,695	0	2,584	24 hours 19 minutes	3
Total	**632,247**	**15,572**	**28,321**		

Notes: Median number of hours affected based on application of trend lines.
[1] Total – includes flooding and other weather related incidents
Source: Energypeople (2014)

Estimate of the average welfare costs per hour of disruption

If the electricity supply fails during normal weather conditions, DNOs are required to pay domestic customers £54 in compensation if the power outage lasts for more than 18 hours (UK Power Networks 2010). These figures can be used to provide an estimate of the average cost per hour of disruption of £3, which was calculated as follows:

> Estimate of the average cost per hour of disruption (£3) = Amount paid to domestic customers experiencing supply disruption for more than 18 hours (£54, based on payments to domestic customers) ÷ Number of hours in which payments for electricity supply disruption applies (18 hours, based on outages during normal conditions)

The estimate of disruption costs of £3 per hour is based on payments to domestic customers resulting from power outages during normal weather conditions and is used as a surrogate of the welfare impacts caused to customers by electricity supply disruption during the winter 2013 to 2014 floods rather than any estimate of compensation due.

The approach used here differs from that used in the 2007 assessment (Environment Agency 2010). In the 2007 assessment, the cost of disruption was estimated based on a willingness to pay of customers to avoid disruption of £10 per kWh (in 2007 prices).

This is equivalent to £50 per day (given that the average household uses 5 kWh of electricity per day) or £2.08 per hour (in 2007 prices). Uprating this per hour cost from 2007 to 2014 prices gives a welfare cost of £2.54 per hour. The estimated welfare costs per hour of disruption used in the 2007 assessment and this 2013 to 2014 assessment are therefore similar.

The use of the average cost per hour of disruption of £3 was retained as this applies up-to-date values derived from industry compensation requirements.

Estimate of the welfare costs of electricity supply disruption

The estimates of the number of customers affected by power outages caused by flooding, the average length of the disruption (in hours) and an average cost of disruption per hour were used to estimate the welfare costs by region (Table 12.4). The calculation used to estimate these values is summarised below:

> Estimate of the welfare costs of electricity supply disruption caused by flooding (by region) = Number of customers affected by flood related power outages (by region) × Median number of hours affected (by region) × Estimated welfare costs per hour of disruption (£3)

Table 12.4 Estimated welfare costs of electricity supply disruption caused by flooding

Region (electricity DNO)	Number of customers affected by power outages (flood incidents)	Median number of hours affected (estimated)	Estimated welfare costs per hour of disruption	Estimated welfare costs [1]
East of England and East Midlands (UKPN)	10,341	11	£3	£340,000
North East (Northern Power Grid)	3,061	2		£18,000
North West (Electricity North West)	2,100	4		£25,000
South East and London (SSEPD)	10,234	12		£370,000
West Midlands, South West and Wales (Western Power Distribution)	2,584	3		£23,000
Total	**28,321**			**£780,000**

Notes [1] Values presented to 2 significant figures.

This approach suggests that customers in the South East and London experienced the greatest levels of disruption compared with other regions with £370,000 (47%) of the welfare costs. In total, the welfare costs to customers resulting from power outages caused by flood related incidents during the winter of 2013 to 2014 are estimated to be £780,000.

12.2.4 Best estimate of the costs to energy companies and customers

Table 12.5 provides a summary of the economic cost estimates obtained by aggregating the local level data for the costs to energy companies and the welfare costs to customers associated with electricity supply disruption during the winter 2013 to 2014 floods.

Table 12.5 Best estimate of the economic costs to energy companies and customers

Cost type	Best estimate
Direct damages/costs to energy companies	£44,000
Welfare costs to electricity customers	£780,000
Total costs	**£820,000**

Notes: Values are presented to 2 significant figures.

The best estimate of the costs to energy companies is £44,000 and that for the welfare costs relating to electricity supply disruption caused by flooding is £780,000. Combining these provides a best estimate of the costs utilities: energy of £820,000. Although the figure of £44,000 is based on data from just a single company, discussions with other energy companies suggested that flood damages during the 2013 to 2014 winter period were small.

The Annex 1 method statement summarises the approach used to develop the best estimate of the costs to energy companies and customers.

12.3 Determining the best estimate range

12.3.1 Direct damages/costs to energy companies

As described in Section 2.3.4, the data used to provide the best estimate of costs in each impact category were assessed to determine the associated uncertainty. The uncertainty rating was applied based on the availability and quality of the data obtained and the assumptions applied to the data to provide an economic cost estimate. The uncertainty rating was subsequently used to determine the potential range around the best estimate.

This approach was used to determine a range of direct damages/costs to energy companies as a result of the 2013 to 2014 floods of £44,000 to £54,000 (Table 12.1). Further details on the methods used to develop the lower and higher ranges are provided below.

12.3.2 Low estimate

Consultation with energy companies suggests that the direct damages/costs incurred as a result of the winter 2013 to 2014 floods were small. The best estimate of private damages to energy/utilities companies is based on cost data from Western Power Distribution and utilities serving Wales and the west of the UK, resulting in a total cost of £44,000 (considered to represent an economic cost). This may underestimate the costs incurred and therefore is also considered to represent the low range estimate.

12.3.3 High estimate

As indicated above, the best estimate of the direct damages/costs to energy companies during the winter 2013 to 2014 floods is £44,000. However, this is based on very limited data and may therefore underestimate the costs to energy companies at the national scale. Although consultation with energy companies suggests that the direct costs resulting from the winter 2013 to 2014 floods were small, cost data were only obtained from a single company. Given the limited data obtained, the data were classified as having a moderate–high uncertainty rating. To reflect this uncertainty, the best estimate (£44,000) was increased by 25% (see Table 2.5), resulting in a high range estimate of direct damages/costs to energy companies during the 2013 to 2014 winter period of £54,000.

12.3.4 Welfare impacts from customer disruption

The same approach was used to provide ranges around the best estimate of the welfare impacts from customer disruption resulting from loss of supply. The data used to provide the best estimate of welfare costs were assessed to determine the associated uncertainty. An uncertainty rating of moderate–high was allocated based on the availability and quality of the data obtained and the assumptions applied to the data to provide an economic cost estimate. The uncertainty rating was subsequently used to determine the potential range around the best estimate.

This approach gave a range of welfare costs associated with disruption to electricity supply of £580,000 to £970,000 (Table 12.1). Further details on the methods used to develop the lower and higher ranges are provided below.

Low estimate

The basis of the method used to determine the best estimate of the welfare costs to customers experiencing power outages as a result of flooding relates to the number of customers affected by supply disruption. In the case of the best estimate, the proportion of UKPN customers affected by flood related incidents compared with all incidents (4.5%) was applied to data from other electricity DNOs to estimate the total number of customers experiencing power outages caused by flooding.

This approach is uncertain as it was not possible to cross-check the data to determine whether the same proportion of customers serviced by other DNOs experienced supply disruption from flooding. In addition, the method used to determine the average length of supply disruption introduces uncertainty as does the average cost per hour of disruption (used as a surrogate of the welfare impacts to customers). Thus, the data were classified as having a moderate–high uncertainty rating, given the uncertainty with the figures used and the inability to cross-check against real data. To reflect this uncertainty, the best estimate (£780,000) was reduced by 25% (see Table 2.5), resulting in a low range estimate of the welfare costs to customers associated with supply disruption during the winter 2013 to 2014 floods of £580,000.

High estimate

A similar approach was used to provide an upper range estimate. Reflecting the moderate–high uncertainty rating, the best estimate (£780,000) was increased by 25% (see Table 2.5), resulting in a high range estimate of the welfare costs to customers associated with supply disruption during the winter 2013 to 2014 floods of £970,000.

12.3.5 Overall range of the costs to utilities: energy

Table 12.6 provides a summary of the best estimate and associated ranges of the economic costs to energy companies and welfare costs to customers resulting from supply disruption. The best estimate of the costs to energy companies and welfare costs resulting from disruption is £820,000, with a range of £630,000 to £1.0 million.

Table 12.6 Range of economic costs to energy companies and customers from the winter 2013 to 2014 floods

Cost type	Best estimate	Low estimate	High estimate
Direct damages/costs	£44,000	£44,000	£54,000
Welfare costs	£780,000	£580,000	£970,000
Total costs	£820,000	£630,000	£1.0 million

Notes: Values are presented to 2 significant figures.

12.4 Damage costs by flood type

As highlighted above, very limited information on the direct damages/costs to the energy sector could be obtained.

Energy UK (2015) noted an example of one impact due to groundwater flooding which resulted in suspension of site operations for 12 weeks. Fluvial flood defences were not breached and, although there was a breach caused by the coastal surge along the River Trent, this only affected normal access. Here there were no impacts as access was gained via an alternative route at the rear of site in line with the operator's flood management plan.

The information obtained relating to welfare costs was at the regional scale and therefore it was not possible to differentiate the costs by flood type.

12.5 Damage costs for England and Wales

This section provides a breakdown of the damages/costs to energy companies and welfare costs to customers affected by power outages as a result of the winter 2013 to 2014 floods for England and Wales. It includes details of the method used to differentiate the damage costs and the associated uncertainties.

12.5.1 Approach to disaggregating the damage costs

Direct damages/costs

The best estimate of private damages to energy companies is based on cost data from Western Power Distribution and utilities serving Wales and the west of the UK resulting in a total cost of £44,000 (considered to represent an economic cost). This relates to cost information received from a single energy company and may therefore underestimate the damages/costs experienced. However, consultation with other energy companies suggested that direct damages/costs caused by the winter 2013 to 2014 floods were small.

Western Power Distribution serves the West Midlands and South West of England as well as Wales. To separate the costs for England and Wales, the proportional split of residential properties affected by flooding in the West Midlands/South West of England and Wales was applied to Western Power Distribution's costs (Table 12.7). Of the residential properties that flooded in the West Midlands, the South West and Wales in total, 92% were located in England (that is, the West Midlands and the South West) and 8% in Wales.

Table 12.7 Estimated costs to energy companies from the winter 2013 to 2014 floods for England and Wales

Country	Region	Costs	Percentage of total
All	West Midlands, South West, Wales	£44,000	100%
England	West Midlands, South West	£40,000	92%
Wales	Wales	£3,700	8%

Notes: Values are presented to 2 significant figures and therefore total may not be exact sum of constituent parts due to rounding.

Welfare costs

The estimated welfare costs attributed to customers experiencing power outages during the winter 2013 to 2014 floods are based on regional information obtained from electricity DNOs on the number of customers affected by electricity disruption during the 2013 to 2014 winter.

The information obtained from Western Power Distribution aggregates the number of customers affected by power outages for the West Midlands, the South West and Wales. To separate the costs for England and Wales, the proportion of residential properties affected by flooding in Wales compared with the total number of residential properties affected by flooding in the West Midlands, the South West and Wales was determined (Table 12.8).

Table 12.8 Number of residential properties affected by flooding in the West Midlands, the South West and Wales

Country	Region	Number of properties	Percentage of total
All	West Midlands, South West, Wales	2,596	100%
England	West Midlands, South West	2,378	92%
Wales	Wales	218	8%

Notes: Based aggregation of data obtained at local (LLFA) level.

This percentage split was used to estimate the number of customers served by Western Power Distribution who were affected by power outages caused by flooding in England (2,596) and Wales (217). These estimates, the average length of the disruption (in hours) and an average cost of disruption per hour were used to estimate the welfare costs by country (Table 12.9).

The calculation used to provide the best estimate of the welfare costs of power outages by region is summarised below:

Estimate of the welfare costs of electricity supply disruption caused by flooding (by region) = Number of customers affected by flood related power outages (by region) × Median number of hours affected (by region) × Estimated welfare costs per hour of disruption (£3)

The best estimate of the welfare costs to customers resulting from power outages caused by flood related incidents during the winter of 2013 to 2014 is £770,000 for England and £2,000 for Wales. The same approach was applied to the methods used in Section 12.3.3 to provide low and high range estimates of the welfare costs to customers experiencing supply disruption in England and Wales (Table 12.10).

Table 12.9 Best estimate welfare costs of electricity supply disruption caused by flooding in England and Wales

Region (electricity DNO)	Number of customers affected by power outages (flood incidents)	Median number of hours affected (estimated)	Estimated welfare costs per hour of disruption	Estimated welfare costs[1]
England				
East of England and East Midlands (UKPN)	10,341	11	£3	£340,000
North East (Northern Power Grid)	3,061	2		£18,000
North West (Electricity North West)	2,100	4		£25,000
South East and London (SSEPD)	10,234	12		£370,000
West Midlands South West (Western Power Distribution)	2,367	3		£21,000
Total	28,104	–	–	£770,000
Wales				
Wales (Western Power Distribution)	217	3	£3	£2,000
Total	217	–	–	£2,000
Grand total	**28,321**	**–**	–	**£780,000**

Notes: [1] Values are presented to 2 significant figures and therefore the totals may not be exact sum of constituent parts due to rounding.

Table 12.10 Range of welfare costs of electricity supply disruption caused by flooding in England and Wales

Cost type	Best estimate	Low estimate	High estimate
All (total)	£780,000	£582,000	£970,000
England	£770,000	£580,000	£968,000
Wales	£2,000	£1,500	£2,400

Notes: Values are presented to 2 significant figures (unless to denote sum of constituent parts).

Total costs for England and Wales

Table 12.11 provides a summary of the costs split between England and Wales for the utilities: energy sector separated into direct costs to utility companies and welfare costs to customers affected by power outages during the winter 2013 to 2014 floods.

Table 12.11 Estimated economic costs to the utilities – energy sector by country

Country		Economic damage estimates					
		Best estimate		Low estimate		High estimate	
		Damage	Percentage of total	Damage	Percentage of total	Damage	Percentage of total
Total	Direct	£44,000	100%	£44,000	100%	£54,000	100%
	Welfare	£780,000	100%	£580,000	100%	£970,000	100%
	Total	**£820,000**	**100%**	**£630,000**	**100%**	**£1 million**	**100%**
England	Direct	£40,000	92%	£40,000	92%	£50,000	92%
	Welfare	£770,000	99.7%	£580,000	99.7%	£970,000	99.7%
	Total	**£810,000**	**99.3%**	**£620,000**	**99.2%**	**£1 million**	**99.3%**
Wales	Direct	£3,700	8.4%	£3,700	8.4%	£4,600	8.4%
	Welfare	£2,000	0.3%	£1,500	0.3%	£2,400	0.3%
	Total	**£5,600**	**0.7%**	**£5,100**	**0.8%**	**£7,000**	**0.7%**

Notes: Values are presented to 2 significant figures and therefore totals may not be exact sum of constituent parts due to rounding.

12.6 Uncertainties and assumptions

There is uncertainty relating to damages to utility assets and cost to energy companies as information was only obtained from a single company. Therefore, the flood related damages/costs may be an underestimate. However, consultation with other energy companies suggests that damages/costs caused by the winter 2013 to 2014 floods were minor.

There are also uncertainties associated with the welfare costs relating to disruption of electricity supply. Information obtained from UKPN on the number of customers affected by power outages from all incidents and from flood related incidents during the 2013 to 2014 winter period was obtained. The proportion of customers experiencing electricity disruption caused by flooding compared with all incidents for the UKPN region (4.5%) was applied to data from other DNOs to provide an overall estimate of customers affected by flood induced power outages. This assumption introduces uncertainty as the proportion of customers affected by flood related electricity disruption is likely to vary by region. The resulting welfare costs may therefore under- or overestimate the impacts caused by the disruption.

The welfare costs are based on the average (median) number of hours for which customers did not have an electricity supply. The averages were determined using trend lines, with data from one region being applied to another where appropriate figures are missing. There is uncertainty over the appropriateness of applying data from one region to another, as well as the extent to which the exponential trend lines reflect the reality in terms of median time that customers experienced power outages.

The estimate of disruption costs of £3 per hour is based on payments to domestic customers resulting from power outages during normal weather conditions and is used as a surrogate of the welfare impacts caused to customers by electricity supply disruption during the winter 2013 to 2014 floods. The welfare costs are therefore uncertain and may differ from actual costs experienced as a result of electricity disruption.

To separate the costs for England and Wales, it was necessary to disaggregate the information obtained from Western Power Distribution. This was performed using the proportion of residential properties flooded in Wales compared with the total number of residential properties affected by flooding in the West Midlands, the South West and Wales. This approach is highly uncertain and may under or overestimate the number of customers experiencing power outages in England or Wales.

13 Impacts on utilities: water

13.1 Summary of findings

Table 13.1 presents the headline figures for the impact category of utilities (water). This category includes estimates of damages/costs incurred by water companies during the winter 2013 to 2014 floods. The best estimate is £29 million with a range of £25 million to £33 million. These figures are based on information obtained from water companies, as well as other research at the local (LLFA) level on the damages caused to utility infrastructure. Data were provided by Anglian Water, Cambridge Water, Essex and Suffolk Water, Northumbrian Water, Severn Trent Water, Southern Water, South West Water, Thames Water, Wessex Water, Welsh Water and Yorkshire Water. Further details describing how the best estimate and range were determined are provided in the following sections.

Table 13.1 Headline findings for utilities: water

Finding	Economic damage estimates			
	Best estimate (range)	**% of total monetised damages**	**Uncertainty**	**Comments**
2013 to 2014 damages (total)	£29 million (£25 million to £33 million)	2.3% (of overall total damages)	Low–moderate	Based on local data including data obtained from water companies. Range estimates are determined based on uncertainty rating.
2013 to 2014 damages (England)	£29 million (£25 million to £33 million)	99.9% (of total for category)	Low–moderate	Refers to proportion of total costs attributable to England (£28.49 million). Range estimates are determined based on uncertainty rating.
2013 to 2014 damages (Wales)	£21,000 (£18,000 to £24,000)	0.1% (of total for category)	Low–moderate	Refers to proportion of total costs attributable to Wales. Range estimates are determined based on uncertainty rating.
2007 damages (2014 values)	£110 million	2.8% (of overall total damages in 2007)	Score: 2 (limiting assumptions – gross assumptions)	Environment Agency (2010)
	Best estimate	**Units**	**Uncertainty**	**Source of estimate**
Numbers affected	36	assets affected	Moderate	Based on data from water companies
Numbers affected (England)	32	assets affected	Moderate	Based on data from water companies

Finding	Economic damage estimates			
Numbers affected (Wales)	4	assets affected	Moderate	Based on data from water companies
	Best estimate	**Range**	**Uncertainty**	**Source of estimate**
Damages per asset	Not available		Data limited	

Notes: Values presented to 2 significant figures.

13.2 Determining the best estimate

13.2.1 Number of assets affected

Information requests were sent to water companies to obtain information on the number of assets damaged by flooding and the costs incurred for repairing flood damage and operational costs associated with responding to flood related impacts during the winter of 2013 to 2014. This data gathering exercise was supported by extensive internet research.

Table 13.2 provides a summary of the locations where damages to water utilities infrastructure were identified.

Table 13.2 Locations with known damages to water utilities infrastructure

Region	Details
London	Damages to Kenley WTW from 5 weeks of flooding in February 2014
East Midlands	Damages to 8 water recycling pumping stations and 1 water recycling centre (WTW) in Lincolnshire
East of England	Damages in Bedfordshire, Cambridgeshire, Norfolk (17 water recycling pumping stations) and Suffolk
North East	Damages in Northumberland
North West	Damages estimated
South East	Damages in west Berkshire
South West	Damages in Bath and North East Somerset, Bristol, Devon and Somerset
West Midlands	Damages in Worcestershire (including hiring machinery and specialist staff in Worcester)
Yorkshire and Humber	Damages in Barnsley, Kingston upon Hull and North Yorkshire
Wales	Damages in Carmarthenshire, Flintshire, Gwynedd and Pembrokeshire

Notes: WTW = water treatment works

The local level data (from water companies) were considered the most robust and were aggregated to provide a best estimate of 36 for the number of assets affected by flooding during the 2013 to 2014 winter period.

13.2.2 Costs/damages resulting from flooding

The information obtained from the water companies was a combination of flood damage costs to assets and operational costs associated with responding to flood incidents. In many cases the data provided were converted from financial to economic costs. Each of the cost figures obtained was assessed on an individual basis to ensure they were appropriately adjusted to provide an economic estimate.

Where no breakdown of the flood related operational costs was provided, it was not possible to determine what the costs specifically referred to and thus how these figures should be adjusted. The lack of detail and associated uncertainty on the cost estimates meant it was not appropriate to make any adjustment.

To convert the flood damage costs to an economic value, the figures were first adjusted to account for betterment. It was assumed that, in the majority of cases, the assets damaged by flooding were part way through their serviceable life. Repair or replacement of the damaged asset would have improved its condition, potentially extending its serviceable life. Hence, it was not deemed appropriate to take the full damage cost as the economic estimate as the old asset was effectively being replaced by a new asset (that is, not a like-for-like replacement). To account for this, 50% of the asset damages/repair costs were taken.

In addition, any work to repair or replace a damaged asset incurs VAT. This was removed, assuming a VAT rate of 20%, to provide an economic cost.

A summary of the calculation used to convert financial damage/repair costs to an economic estimate is provided below:

> Economic estimate of asset damage/repair costs = Financial estimate of asset damage/repair costs $\times$ 50% (accounting for betterment) $\div$ 1.2 (to remove VAT at 20%)

Operational costs of dealing with flooding incidents were also provided and included monitoring and responding to flood impacts (for example, pumping, hiring equipment, overtime costs). Where there was sufficient breakdown of the operational costs and thus where a cost was deemed to be financial rather than economic, the figures were adjusted by removing VAT at 20% to provide an economic cost estimate. Staff overtime costs represent an economic cost and were therefore not adjusted for VAT.

Both South West Water and Yorkshire Water provided a breakdown by cost type. In the case of South West Water, 17% of the costs attributed to the winter 2013 to 2014 floods related to expenditure on assets (for example, repairs), with the remaining 83% relating to operational costs; the total economic costs to South West Water were £1.2 million. In the case of Yorkshire Water, 95% of the flood related costs could be attributed to asset repairs and 5% to operational expenditure; the total economic costs to Yorkshire Water were £90,000. Based on this information, it was estimated that the average proportion of flood related expenditure on asset damages/repairs was 56%, with the remaining 44% estimated to relate to operational costs. It is recognised that there is uncertainty associated with this approach as these percentages were based on information from only 2 water companies

Both Thames Water and Southern Water only provided total costs (£19 million and £20 million respectively), with no breakdown of the cost type/element. These total costs were considered to represent a financial cost. The asset damage/repair costs for Thames Water and Southern Water were therefore adjusted to convert them from a financial cost to an economic estimate using the average proportion of costs that are repair costs (56%) versus those that are operational costs (44%). The repair cost figures were adjusted by 50% to account for betterment and to remove VAT (at 20%). A summary of the calculation used to determine a breakdown of the asset

damage/repair costs for Thames Water and Southern Water and to convert these figures to an economic estimate is:

> Economic estimate of asset damage/repair costs to Thames Water and Southern Water = Financial flood related costs × 56% (estimate of the average proportion of spend on asset damages/repairs, based on data from South West Water and Yorkshire Water) × 50% (accounting for betterment) ÷ 1.2 (to remove VAT at 20%)

The calculation used to determine a breakdown of the operational costs for Thames Water and Southern Water and to convert these figures to an economic estimate is:

> Economic estimate of operational costs to Thames Water and Southern Water = Financial flood related costs × 44% (estimate of the average proportion of spend on flood related operational activities, based on data from South West Water and Yorkshire Water)

The economic estimates of the asset damage/repair costs and the operational costs were added together to provide an overall estimate of the economic cost of the floods to Thames Water and Southern Water (approximately £13 million in both cases).

Table 13.3 provides details of the information obtained from water companies on the costs incurred as a result of the winter 2013 to 2014 floods. The figures are presented as economic costs at the regional level.

Table 13.3 Economic costs incurred by water companies during the winter 2013 to 2014 floods (at regional level)

Region	Economic costs	Source/cost details
London	£13 million	Thames Water and Kenley water treatment works
East Midlands	£76,000	Anglian Water (Lincolnshire)
East of England	£370,000	Anglian Water and Essex and Suffolk Water
North East	£39,000	Northumbrian Water and sewer repairs at Warkworth
North West	-	None identified
South East	£13 million	Southern Water
South West	£1.6 million	South West Water: repair of damaged water main caused by flooding in Bristol, repair of partially collapsed culvert in Salcombe. Wessex Water: damages in Somerset
West Midlands	£110,000	Severn Trent Water
Yorkshire and Humber	£110,000	Yorkshire Water; additional costs incurred at Hull Waste Water Treatment Works
Wales	£21,000	Welsh Water
Total	**£29 million**	**Combination of the above costs**

Notes: Values are presented to 2 significant figures and therefore the total may not be exact sum of constituent parts due to rounding.

The aggregated cost information provides a best estimate of the direct damages/costs to the utilities water sector at the national level of £29 million. The map in Figure 13.1 shows the distribution of damages incurred by water companies from the flooding.

The Annex 1 method statement summarises the approach used to develop the best estimate of the damages/costs to the utilities water sector.

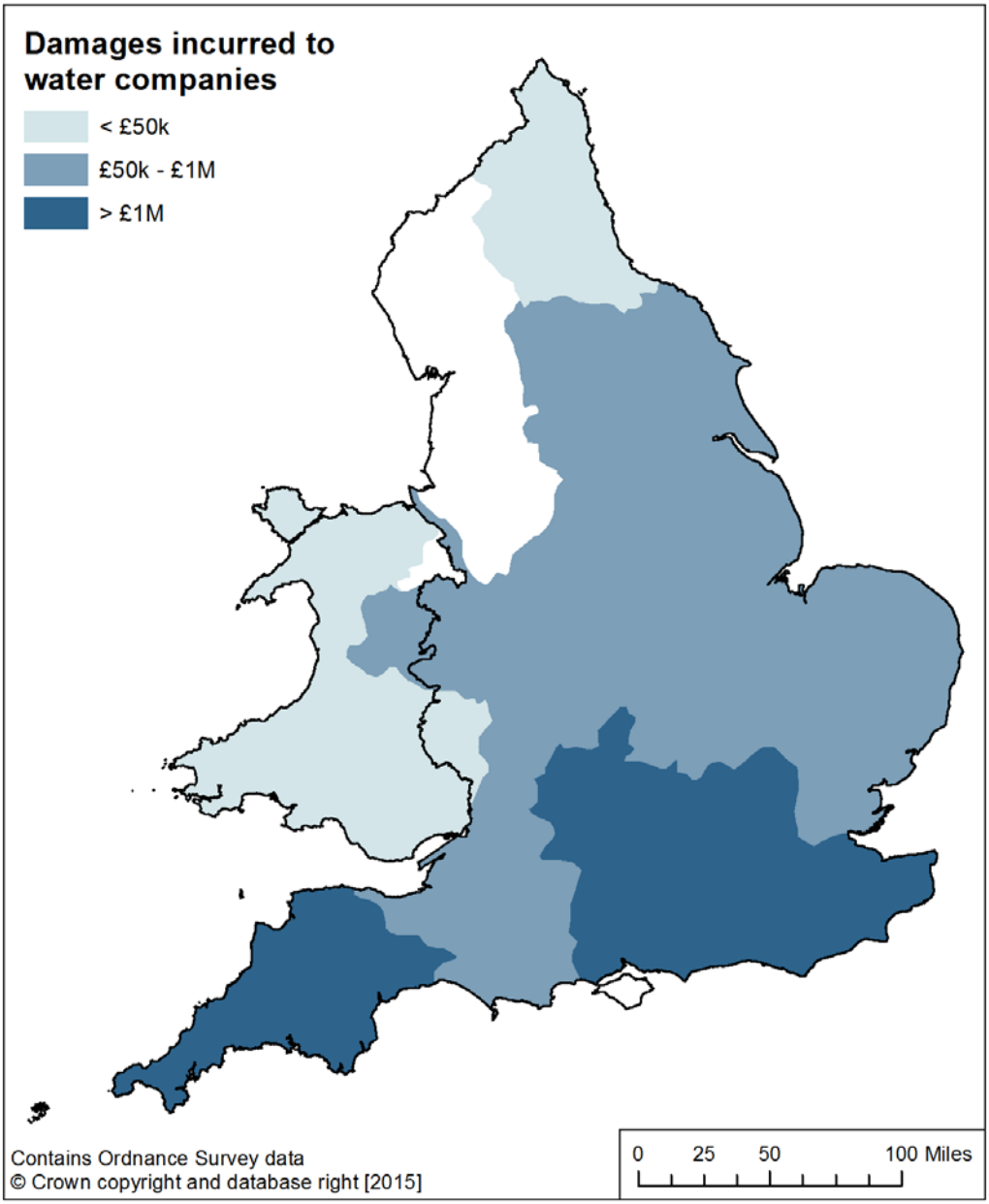

Figure 13.1 Estimated damages to water companies for the 21 LLFAs for which data were available

Notes: Only shows where data were available and data may be incomplete.

13.3 Determining the best estimate range

The data used to provide the best estimate of costs in each impact category were assessed to determine the associated uncertainty. The uncertainty rating was applied based on the availability and quality of the data obtained and the assumptions applied to the data to provide an economic cost estimate. The uncertainty rating was subsequently used to determine the potential range around the best estimate.

This approach was used to determine a range of flood related costs to water companies of £25 million to £33 million (Table 13.1). Further details on the methods used to develop the lower and higher ranges are provided below.

13.3.1 Low estimate

Information was obtained from water companies on the direct damages to infrastructure and operational costs attributed to flooding during the 2013 to 2014 winter period. However, most of the information referred to financial costs and therefore required adjustment (accounting for betterment and removing VAT) to determine the economic costs. Although the approach used is consistent (both within this impact category and across other categories), it does introduce a degree of uncertainty.

It was also necessary to separate the costs provided by Thames Water and Southern Water into direct damages to assets and operational costs so as to convert the figures from a financial to an economic cost estimate. This was done using the average proportion of the total costs for South West Water and Yorkshire Water that relate to direct damages and operational costs and applying this to the total figures provided by Thames Water and Southern Water. This is recognised as an uncertain approach given that the actual direct damage costs and operational costs for Thames Water and Southern Water may differ from those estimated, and because of the variation between South West Water and Yorkshire Water. However, this was deemed to be the most appropriate method allowing conversion of the costs to economic estimates.

Although a considerable amount of data was obtained from reliable sources (suggesting a low uncertainty rating), these data required adjustment to convert them from financial to economic costs. Thus, the data are classified as having a low-moderate uncertainty rating given the assumptions and the adjustments made to provide an economic estimate of the costs. To reflect this uncertainty, the best estimate (£29 million) was reduced by 15% (see Table 2.5), resulting in a low range estimate of flood related damages/costs to water companies during the 2013 to 2014 winter period of £25 million.

13.3.2 High estimate

A similar approach was used to obtain an upper range estimate. Reflecting the low–medium uncertainty rating applied to the data, the best estimate (£29 million) was increased by 15% (see Table 2.5), resulting in a high range estimate of flood related damages/costs to water companies of £33 million.

13.4 Damage costs by flood type

This section provides a breakdown of the damages/costs to the water sector as a result of the winter 2013 to 2014 floods by flood type. It includes details of the methods used to differentiate the damage costs and the associated uncertainties.

13.4.1 Approach to disaggregating the damage costs

The disaggregation of damages by flood type was based on the assumption that the majority of damages incurred by coastal LLFAs were caused by tidal surges. Although this is clearly a simplification, there were insufficient details to perform a more sophisticated analysis. Damages were not included where the damage figures specified the flood type and this did not relate to coastal impacts.

13.4.2 Summary of damages costs by flood type

Table 13.4 provides a summary of damages by flood type for the water sector.

Table 13.4 Estimated economic damage costs to the water sector by flood type

Flood source	Economic damage estimates					
	Best estimate		Low estimate		High estimate	
	Damage	Percentage of total	Damage	Percentage of total	Damage	Percentage of total
All (total)	£29 million	100%	£25 million	100%	£33 million	100%
Fluvial/ groundwater	£28.5 million	99%	£24.3 million	99%	£32.8 million	99%
Coastal	£380,000	1.3%	£325,000	1%	£440,000	1%

Notes: Values are presented to 2 significant figures unless used to indicate that the total is the sum of the constituent parts. Therefore totals may not be equivalent to the types of flooding due to rounding.

13.5 Damage costs for England and Wales

This section provides a breakdown of the damages/costs to water companies (utilities: water) as a result of the winter 2013 to 2014 floods for England and Wales.

13.5.1 Approach to disaggregating the damage costs

Splitting damages between those incurred in England and Wales was based on the damage estimates obtained for each LLFA and then combining those in England and those in Wales to provide total damages. The same was done to separate the numbers of assets damaged in the 2 countries. The information available indicates that, out of a total of 36 water company assets damaged, 4 were in Wales and the remaining 32 were in England.

13.5.2 Damage costs for England/Wales

Table 13.5 provides a summary of damages split between England and Wales for the water sector.

Table 13.5 Estimated economic damage costs to the water sector by country

Country	Economic damage estimates					
	Best estimate		Low estimate		High estimate	
	Damage	Percentage of total	Damage	Percentage of total	Damage	Percentage of total
Total	£29 million	100%	£25 million	100%	£33.3 million	100%
England	£28.9 million	99.9%	£24.6 million	99.9%	£33.2 million	99.9%
Wales	£21,000	0.1%	£18,000	0.1%	£24,000	0.1%

Notes: Values are presented to 2 significant figures unless used to indicate that the total is the sum of the constituent parts. Therefore totals may not be equivalent to the constituent parts due to rounding.

13.6 Uncertainties and assumptions

The majority of the data relating to the costs of the winter 2013 to 2014 floods were provided by water companies and therefore considered to be of good quality. However, it is not clear that the data capture all damages incurred by all water companies. Also, adjustments were made to the figures provided to convert from a financial to an economic cost estimate. Although the approaches used (that is, to adjust for betterment and removal of VAT) are consistent across all of the impact categories, they are uncertain.

14 Impacts on transport: road

14.1 Summary of findings

Table 14.1 presents the headline figures for the impact category of transport (road). This section provides estimates of damages to road infrastructure in England during the winter 2013 to 2014 floods. The best estimate is £180 million with a range of £91 million to £220 million. There was no data available for Wales.

The best estimate is based on information obtained at the local level on flood related damages to roads and grants received by local authorities from the Department for Transport to make repairs to road infrastructure damaged during the December 2013 to February 2014 period. Welfare costs to road users were provided by the Highways Agency and relate to disruption and injury caused by flooding incidents during the 2013 to 2014 winter period (total welfare costs of £1.3 million).

The total economic cost of the winter 2013 to 2014 floods to road infrastructure and to road users is estimated to be £180 million, with a range of £91 million to £220 million (to 2 significant figures).

The costs are considered to relate to damage caused by both flooding and water-related erosion.

To avoid double counting, damages under the local authorities and local government infrastructure category that can be specifically related to roads are included, where possible, in the transport: roads category.

Table 14.1 Headline findings for transport: road

Finding	Economic damage estimates			
	Best estimate (range)	**% of total monetised damages**	**Uncertainty**	**Comments**
2013 to 2014 damages (direct damages/costs)	£179 million	14% (of overall total damages)	Moderate	Based on local data at the LLFA level. Range estimates are determined based on uncertainty rating.
2013 to 2014 damages (welfare costs)	£1.3 million		Moderate	Based on national level data from the Highways Agency.
2013 to 2014 damages (total)	£180 million (£91 million to £220 million)		Moderate	Based on a combination of the above estimates.
2013 to 2014 damages – England (direct damages/costs)	£179 million (£91 million to £220 million)	100% (of direct damages for category)	Moderate	Refers to the proportion of direct damages/costs attributable to England. Range estimates are determined based on uncertainty rating.
2013 to 2014 damages – England (welfare costs)	£1.3 million	100% (of welfare costs for category)		
2013 to 2014 damages –	£180 million	100% (of total for category)		

Finding	Economic damage estimates			
	Best estimate (range)	**% of total monetised damages**	**Uncertainty**	**Comments**
England (total)	(£91 million to £220 million)			
2013 to 2014 damages – Wales (direct damages/costs)	No data	0% (of direct damages for category)	High	Refers to the proportion of direct damages/costs attributable to Wales
2013 to 2014 damages – Wales (welfare costs)	No data	0% (of welfare costs for category)		
2013 to 2014 damages – Wales (total)	No data	0% (of total for category)		
2007 damages (2014 values)	£230 million	6% (of overall total damages in 2007)	Score: 1–3 (road damage (1) best of breed and traffic disruption (3) gross assumptions)	Environment Agency (2010)
	Best estimate	**Units**	**Uncertainty**	**Source of estimate**
Numbers affected	1,017	Flood incidents	Low	Based on national level data from the Highways Agency.
Numbers affected (England)	155	km of road	Moderate	Based on local level information.
Numbers affected (Wales)	5.4	km of road	Moderate	
	Best estimate	**Range**	**Uncertainty**	**Source of estimate**
Damages per asset	Not available	Not available		

Notes: Values are presented to 2 significant figures unless to present the sum of the constituent parts.

14.2 Determining the best estimate

14.2.1 Number of flooded roads/flood incidents

The Highways Agency identified 1,017 flood incidents from the 5 December 2013 to the 31 March 2014. Its Flood Incident Database classifies each incident of flooding and allocates a Flood Severity Index (FSI). The data base also indicated flooding varied in type and impact throughout the network and was most commonly the result of surface water run-off from neighbouring fields and land. Intense rainfall over a short period led to the presence of standing surface water on carriageways, creating a risk of vehicles aquaplaning. However, this was generally short-lived, subsiding when the carriageway drains had time to clear surplus water.

14.2.2 Damages to road infrastructure

Data on the direct damages caused to and/or the costs of repairing road infrastructure were obtained at LLFA level. This information can be split into 2 main types:

- grants received by local authorities to make road repairs
- damage/repair costs to road infrastructure resulting from flooding not covered by grants received

Where necessary the data were adjusted to provide an economic cost estimate and finally aggregated to ascertain a national level estimate of the flood damages caused to road infrastructure. This section provides an overview of the data used and the adjustments made to determine the best estimate.

Severe Weather Recovery grants

The best estimate of the direct damages to the road network from flooding is £179 million (Table 14.1). This estimate is based mainly on the £173 million of funding provided to local authorities by the Department for Transport for severe weather recovery. The Severe Weather Recovery Fund aimed to provide assistance to local authorities in addressing the damages resulting from flooding and severe weather to roads which occurred from the beginning of December 2013 up until early February 2014. It will therefore have covered most of the flooding events during the 2013 to 2014 winter. Allocation of the Severe Weather Recovery Fund by region is shown in Figure 14.1.

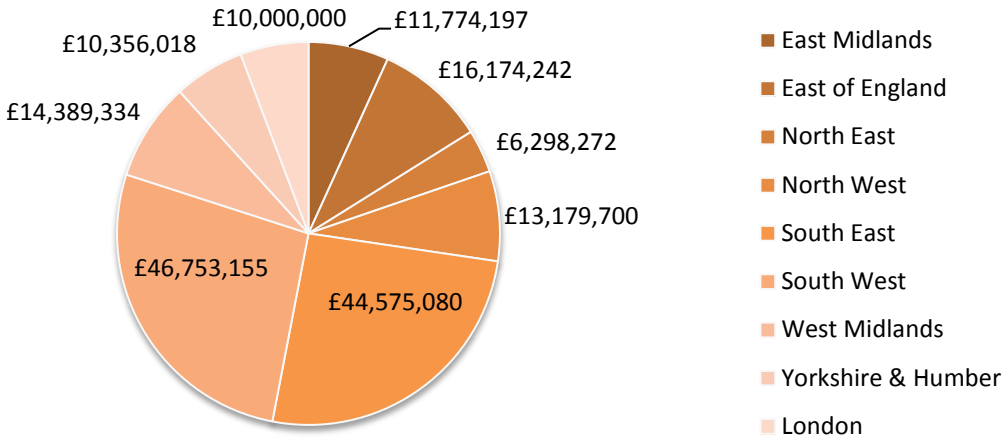

Figure 14.1 Summary of the Severe Weather Recovery Fund paid out by region

Local authorities submitted applications for this fund, specifically to reflect the damages associated with prolonged and repeated flooding. For the purposes of this assessment the grants provided by the Department for Transport were used as a surrogate of the damage costs to roads resulting from flooding. These were assumed to represent an economic cost and were therefore not adjusted as it was not clear how this money was spent in each case (for example, what proportion was spent specifically on road repairs). It was also unclear whether the grants received by local authorities covered the full cost of the road repair work in each case. Given the uncertainty it was not deemed appropriate to adjust these figures. The grant information was only used to represent the damage costs to roads for LLFA areas where no specific information on the actual damages/repair costs incurred was obtained.

The Severe Weather Recovery Fund is separate from the pothole funding allocation. The difficulty for all local authorities was separating the damages associated with winter 2013 to 2014 flooding and those associated with accumulated damages from the 2012 to 2013 floods and the extreme cold of winter 2011 to 2012. In short, how much of inherited damage was as a result of the weakening effect of previous winters. Devon County Council, for example, compiled its bid by only including damage where the road

condition had been described as ‘good’ in summer 2013. It highlighted damages when 5 new potholes per 100 metres had emerged since the summer and excluded where pothole clusters had existed prior to summer 2014. In this way, the £7 million Severe Weather Recovery grant allocated to Devon was differentiated from the £9 million pothole fund.

Figure 14.2 shows the distribution of damages to the road network from the winter 2013 to 2014 floods.

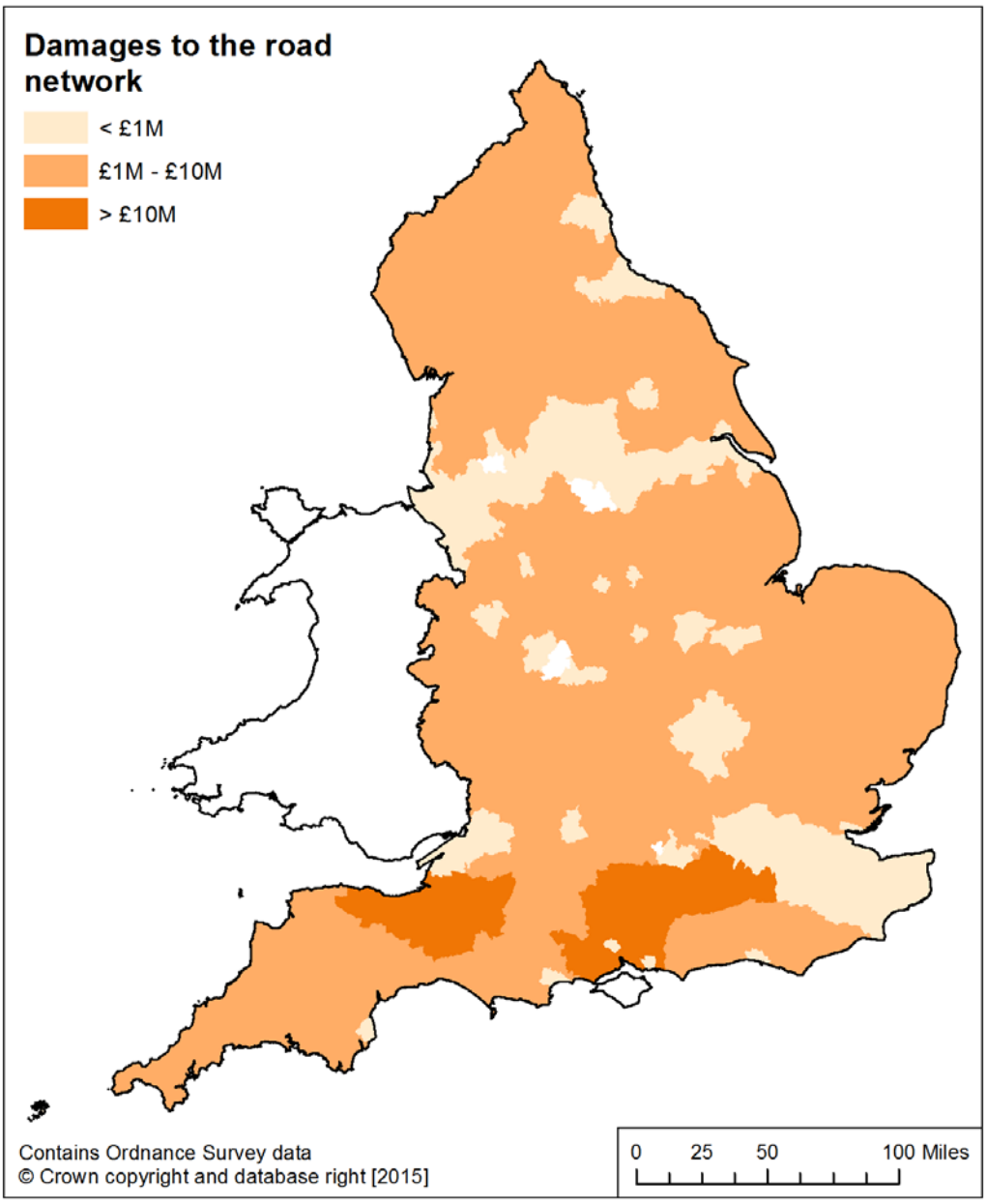

Figure 14.2 Estimated damages to the road network for the 115 LLFAs for which data were available

Notes: Only shows where data were available and data may be incomplete.

Direct damages to road infrastructure not covered under the Severe Weather Recovery Grants

Internet research and consultation with local authorities was carried out to determine the damages caused to road infrastructure during the winter 2013 to 2014 floods at the

local (LLFA) level. The information obtained on the direct damages to roads as a result of flooding is relatively limited, accounting for around £5 million of the £179 million best estimate of the direct damages.

The damage/repair cost information obtained was considered to represent a financial cost and therefore had to be adjusted to provide an estimate of the economic cost. To convert the financial damage costs to an economic value, the figures were first adjusted to account for betterment. It was assumed that, in the majority of cases, the assets damaged by flooding were part way through their serviceable life. Therefore, repair or replacement of the damaged asset effectively improved its condition, potentially extending its serviceable life. Hence, it was not deemed appropriate to take the full damage cost as the economic estimate, as the old asset was being effectively replaced by a new asset (that is, not a like-for-like replacement). To account for this, 50% of the asset damages or repair costs were taken.

In addition, any work to repair or replace a damaged asset would incur VAT. This was removed (using the current VAT rate of 20%) to provide an economic cost of the flood damages.

A summary of the calculation used to convert financial damage/repair costs to road infrastructure to an economic estimate is provided below:

> Economic estimate of damage/repair costs = Financial estimate of damage/repair costs × 50% (accounting for betterment) ÷ 1.2 (to remove VAT at 20%)

14.2.3 Welfare costs

The winter 2013 to 2014 floods caused damages to road infrastructure and also resulted in roads becoming impassable to normal traffic. Disruption to the transport network can affect people's ability to continue with their lives and can affect those living in flooded areas (even if they themselves are not flooded) and those living outside flooded areas who want to travel into or through affected locations. Flooding or water-related erosion can also have indirect consequences where businesses and the public have to make longer and more circuitous journeys.

This section provides an overview of the approaches used to obtain data relating to the welfare costs of disruption to the road network during the winter 2013 to 2014 floods. Due to the anecdotal nature of much of the information gathered from LLFA's the best estimate uses figures derived by the Highways Agency. Though it is recognised this is likely to be an underestimate.

The section below outlines the types of disruption experienced in flooded areas and how the best estimate of the welfare costs has been determined using the Highways Agency Flood Incident Database.

Disruption to road users from local (LLFA) level data

The collation of data on road damage and disruption to road users during the winter 2013 to 2014 floods from a poll of local authorities was sketchy, with most not able to provide specific detail, other than Department for Transport Severe Weather Payment grants (see above). The piecemeal nature of the information obtained from internet research and consultation with local authorities meant it was not possible to use it to determine a best estimate of the welfare costs of disruption. But although much of the

information on disruption impacts is anecdotal in nature, it does provide an indication of the disruption caused to communities as a result of flooding to the road network.

The main extreme weather problems for road users came from various types of flooding and water damage, as well as problems with falling trees during the high winds.

In Somerset, the A631 through Burrowbridge was closed for 12 weeks (Gurner et al. 2014). Some rural areas were affected with routes into and out of villages being closed. This resulted in some villages being cut off, such as Ilchester Mead, Muchelney and Thorney in Somerset, while others faced detours. Residents of Limington, Somerset, initially had a 17 mile detour but were then cut off completely for 36 hours. For several weeks, access to Yeovilton was only possible by escorted vehicle across the airfield (Gurner et al. 2014). Flooding of C and unclassified roads in Herefordshire had a significant impact due to the rural nature of the area (Herefordshire Council, personal communication 5 November 2014). In West Berkshire, a number of areas were effectively cut off due to being surrounded by water. These included (Richardson 2014):

- Purley on Thames
- Eastbury, East Garston and Great Shefford
- Pingewood
- Burghfield Bridge, Holybrook
- Shaw, Newbury

Many coastal authorities were affected by the tidal surge on 5 December 2013. For example, the Newhaven swing bridge was damaged, with some operational impacts ongoing until May, there was flooding in parts of North Lincolnshire that led to the closure of the A1077 Scunthorpe to Immingham road for a week, and close to Stockton-on-Tees, a breach of sea flood defences had to be repaired by the Environment Agency, requiring a consequent closure of the nearby A178 Seaton Carew road for a substantial length of time from 5 December to 31 January, with temporary access provided for 2 weeks over the festive period. This road links the industrial areas of the north of the Borough of Stockton with Hartlepool and is the main access route for the chemical industries in this area. Businesses had to use a 16 mile diversion route while the road was closed. The cost of the disruption is calculated at £3.9 million,[6] without any estimate of the loss of regional gross value added (GVA) from the delays to production at the industrial complexes disrupted.

In Essex heavy rainfall caused severe flooding in February 2014. In Newport, Essex, roads were closed due to severe flooding and a vehicle was trapped in flood water under a railway bridge (Cambridge News 2014a). Severe flooding also affected the M11 around Stansted after the motorway was closed northbound following a multi-vehicle accident (Cambridge News 2014a). In Peterborough, Whittlesey Road (between Whittlesey and Peterborough) flooded, which resulted in the road closing for 23 days over the New Year period (Peterborough Telegraph 2014).

Impacts of the tidal surge in Suffolk were also significant. Transport was disrupted for several days by the failure of the sea defences at Blythburgh, which resulted in closure of the A12 road (the link between Lowestoft and Ipswich) for 36 hours. The following closures also occurred (Suffolk County Council 2014).

[6] Additional value of time and vehicle operating costs were calculated using the approach set out in the Multi-Coloured Manual (Penning-Roswell et al. 2013)

- In Lowestoft, the bascule bridge was closed and traffic lights for the bridge and surrounding area were subject to problems. The A146 Oulton Broad bridge was closed for 6 hours and various other roads were flooded
- In Reydon, the B1127 was closed for 6 hours
- In Snape, the B1069 flooded as a result of overtopping of flood defences which required pumping by the Environment Agency and subsequent closure for 5 days.
- In Felixstowe, approximately 100 tonnes of sand and shingle was deposited on seafront road.
- In Ipswich, the A137 Stoke Bridge and the B1456 flooded.

Also important was the length of time for which some transport links were unavailable. In Hampshire, roads in Hambledon were underwater for 47 days as a result of groundwater flooding, resulting in the village being virtually cut off (BBC News 2014c). In Reading, 2 sections of private road off Southcote Farm Lane were flooded for over 9 weeks with residents at Southcote Mill and its neighbouring apartments being cut off for this period. Residents had to walk though floodwater on foot if they wished to leave their property (Reading Borough Council 2014b).

The battering from coastal storms mainly affected on authorities in the south, the west and Wales, and there were many problems attributed to flooding and erosion. Natural Resources Wales (2014) estimated that 15.5km of roads were affected during the storms, especially in Kinmel Bay (2.85km) and Aberystwyth (2.5km).

Experts at Cardiff University's Understanding Risk Research Group studied the disruption caused by the floods and found that 72% of their directly affected sample reported travel/work disruptions, 55% reported disruptions to essential services, and 62% felt that the impact of the floods on them was a 'fair amount' or a 'great deal'. The most directly affected sample reported high levels of emotions such as anxiety, anger and distress (Capstick et al. 2015).

Some local authorities use value of time (VOT) and vehicle operating cost (VOC) models based on Department for Transport WebTAG data to estimate the approximate resource costs of disruption, using the best available data. This is time-consuming and not something most local authorities have considered and applied. However, the approach was applied in a detailed case study in Devon and Somerset. Devon and Somerset County Councils commissioned a bespoke analysis of the case of the A361 between East Lyng and Burrowbridge where the road was closed for 10.6 weeks (1,776 hours). A normal journey time of 3 minutes, but a diversion route journey time of 39 minutes, resulted in an estimated disruption cost of £3.4 million or a cost of each hour closed equivalent to £150 (Parson Brinkerhoff and Black and Veatch 2015). Two further detailed case studies are provided in Box 14.1 and Box 14.2.

Box 14.1 Economic impact of localised flooding – Wokingham Borough Council

Wokingham Borough Council is a geographically small unitary local authority in the Thames Valley. Large east–west traffic movements within and through the town are mainly via the A329 corridor linking Reading to the west and Bracknell to the east, as well as the wider strategic network via the M4. The A329 corridor is home to two-thirds of the town's 150,000 residents and provides access to 20 primary and 5 secondary schools plus several core employment areas. The town is bordered by the River Thames to the north and north-west, while the River Loddon, a Thames tributary, flows south to north across the predominately east–west highway network.

During the winter of 2013 to 2014, the town was repeatedly affected by flooding from

both rivers between the end of December and the end of February. Flooding also caused the effective closure of Sonning Bridge to through traffic (one of only 2 crossings of the River Thames between Reading and Henley-on-Thames) putting other river crossings in central Reading, already heavily congested at peak times, under extreme pressure.

Flooding at Loddon Bridge caused disruption on the vital A329 corridor at the Loddon Bridge gyratory, affecting access to Winnersh Triangle (including the business park), links to the A329 (M), with traffic backing up onto the M4 at times, and the Park and Ride site. Flooding of the Loddon affected the more southerly A327 before the A329, so the flooding of both effectively closed the east–west highway network and made access to central Reading and the business parks located in and around the town very difficult.

Nearby business parks and the town centre provide employment for 15,000 people. With plans for further expansion, the A329 corridor will support 40% of the housing and job growth over the next 15 years. Problems on the roads were exacerbated when the very high levels of groundwater affected signalling equipment on the Great Western rail line near Maidenhead. This severely restricted the number of trains between Reading and Paddington for a number of days, forcing many rail passengers onto the roads to get to work.

Though not calculated in the source report, the loss of regional and national GVA in the Reading area, through delayed journeys to work and as a result of extensive delays to commuters on the Great Western rail line near Maidenhead, is estimated at in excess of £10 million.

Source: Department for Transport (2014a)

Box 14.2 A303 at Deptford, Wiltshire

The A303 trunk road forms a vital strategic route between the M3 near Basingstoke and the A30 near Honiton in Devon, which in turn links to the M5 at Exeter. As it passes through Wiltshire, the A303 is a mix of single and dual carriageway, with one of the dual carriageway sections located at the junction with the A36 at Deptford.

Following an extended period of heavy rainfall over December 2013 and into January 2014, large volumes of groundwater began to run off from adjacent agricultural land on the edge of Salisbury Plain onto lane 1 of the eastbound A303 just west of its junction with the A36. Due to the exceptionally high groundwater levels in the area and the rate of flow onto the eastbound carriageway, the floodwater overwhelmed the road's drainage system. The eastbound carriageway was closed to traffic just after 7am on 9 January 2014, including the eastbound entry slip road from the A36. Eastbound traffic was diverted into Salisbury and then back to the A303, which added some 12 miles to a road user’s journeys, although there was no queuing of traffic on the A303.

By early evening on 10 January, the Highways Agency had removed the central reservation barrier and established a contraflow on the westbound carriageway, allowing traffic to remain on the A303 and travel through the scene in both directions. Traffic remained unable to join the A303 eastbound from the A36 until 16 January. The contraflow remained in place until late on 21 January, when the groundwater flows had reduced sufficiently to allow the eastbound A303 to safely reopen, some 12 days after it had closed. During this time the contraflow enabled traffic to continue using the A303 without any appreciable delay in either direction.

Source: Department for Transport (2014a)

Disruption to road users from national data from the Highways Agency

The strategic road network (SRN) is largely the responsibility of the Highways Agency, with other non-SRN roads the responsibility of the local authorities. The SRN covers 4,300 miles of road with 4 million vehicle movements each day (Whitehead 2014). It is estimated that 10% of the SRN is vulnerable to flooding (Whitehead 2014).

Recording of flood events in the Highways Agency Drainage Data Management System is now mandatory following the Pitt review recommendations (Pitt 2008).

The Highways Agency identified 1,017 flood incidents from the 5 December 2013 to the 31 March 2014. Its Flood Incident Database classifies each incident of flooding and allocates a Flood Severity Index (FSI) from 1 to 10 where 10 is the most severe. .. Which is then used to help determine associated costs. The criteria used to allocate the flood severity index (FSI) are shown in Table 14.2. The FSI is calculated using the following formula:

$$FSI = A \times B \times C \times D \times 10$$

Table 14.2 Parameters used to calculate FSI on roads

Parameter A – road classification and size						
Class of road	Motorway	All purpose trunk road, dual carriageway, 3 lanes or more	All purpose trunk road, dual carriageway, 2 lanes	All purpose trunk road, single carriageway		
Score	1.0	0.9	0.8	0.7		
Parameter B – average annual daily traffic (AADT) count for one carriageway						
AADT	>25,000	15,000–25,000	<15,000	Unknown		
Score	1.0	0.8	0.6	0.8		
Parameter C – impact on traffic						
Impact	Total closure	At least 1 lane closed	Hard shoulder closed	Congestion only	No impact	Unknown
Score	1.0	0.9	0.6	0.7	0.0	0.8
Parameter D – duration of impact						
Impact	>2 hours	1–2 hours	15 minutes to 1 hour	<15 minutes	Unknown	
Score	1.0	0.9	0.8	0.0	0.8	

Source: Highways Agency

For example, an all-purpose dual carriageway with 2 lanes carrying 15,000 to 25,000 vehicles per day, with at least 1 lane closed for between 15 minutes and 1 hour, gives an FSI of $0.8 \times 0.8 \times 0.9 \times 0.8 \times 10 = 4.6$.

Of the 1,017 flood incidents identified, 991were considered in detail by the Highways agency. Table 14.3 shows the total number of incidents and costs for each FSI score for the winter 2013 to 2104 floods. Table 14.4 summarises the costs associated with motorway disruptions.

Table 14.3 Disruption costs by FSI of incidents winter 2013 to 2014 floods

FSI	Number of incidents	Cost
10	4	£109,558
9	12	£99,757
8	9	£55,788
7	46	£17,305
6	125	£143,817
5	107	£4,939
4	105	£56,384
3	69	0
2	12	0
1	0	0
0	502	£44,115
Total	**991**	**£531,663**

Notes: An FSI rating of 10 relates to the most severe/disruptive events and a rating of 1 relates to the least severe/disruptive events. Source: Highways Agency

Table 14.4 Disruption costs of motorway incidents using FSI in the winter 2013 to 2014 floods

Road	Duration of incident	Cost
M23	23 December 2013 (22:12) to 24 December 2013 (02:00)	£11,234
M45	31 January 2014 (15:51) to 31 January 2014 (18:40)	£56,812 [1]
M11	7 February 2014 (05:37) to 7 February 2014 (07:50)	£7,026
M50	12 February 2014 (18:10) to 13 February 2014 (10:41)	£84,267

Notes: [1] Includes £49,782 injury. Source: Highways Agency.

The Highways Agency calculates the cost of disruption as follows:

Flood incident cost = Delay × £13 (Figure provided by Transport Analysis Guidance UK)

Where:

Delay = 0.5 × Excess demand × Incident duration (hours)

Excess demand = Demand – Road capacity (vehicles per hour)

Table 14.5 shows figures used to determine flood related injury costs.

Table 14.5 Cost per road casualty used by Highways Agency

Casualty severity	Lost output	Human costs	Medical and ambulance	Total
Fatal	£635,500	£1,212,060	£1,096	£1,848,656
Serious	£24,485	£168,423	£14,831	£207,740
Slight	£2,588	£12,325	£1,096	£16,009
Average	£11,357	£41,616	£2,623	**£55,596**

Notes: Costs updated to 2014 values from 2010 using 1.1179 multiplier
Source: Highways Agency, personal communication, 2015

The Highways Agency calculated the cost of user delays and accidents at £1.3 million (£532, 663 disruption costs and £796,512 injury costs). The injury cost figures was provided in personal communications with the Highways Agency whereby they had captured in a database the number of incident incurred and then estimated the associated injury costs.

This modest figure reflects the fact that, of the 991 incidents analysed, the mean duration of disruption was 5.5 hours with a total affected duration of 5,419 hours. In total, 90% of the costs relate to full and partial congestion on the main carriageways.

The disruption and injury costs attributed to the winter 2013 to 2014 floods as calculated using the Highways Agency modelling system are considered to represent the best estimate of the welfare costs.

14.2.4 Best estimate of the damages/costs attributed to flooding of the road network

Table 14.6 provides a summary of the economic cost estimates obtained by aggregating the local level data for the direct damages to road infrastructure and the national level estimate of the disruption and injury costs to road users as calculated by the Highways Agency.

Table 14.6 Best estimate of the economic costs to the transport road sector

Cost type	Best estimate
Direct damages/costs	£179 million
Welfare costs	£1.3 million
Total costs	**£180 million**

Notes: Values are presented to 2 significant figures, unless to illustrate the breakdown by cost type.

The best estimate of the damages/costs to road infrastructure is £179 million (£180 million to 2 significant figures) and welfare costs (relating to flood related disruption and injury) of £1.3 million. Combining these provides a best estimate of the costs of the winter 2013 to 2014 floods to the transport road sector of £180 million to 2 significant figures.

The estimate of the direct damages/costs to roads is likely to include impacts resulting from both flooding and water-related erosion. This will be particularly the case in coastal areas where the coastal surge and storm events caused considerable damage to infrastructure through increased wave action.

The Annex 1 method statement summarises the approach used to develop the best estimate of the damages/costs to the transport road sector.

14.3 Determining the best estimate range

14.3.1 Damages to road infrastructure

As described in Section 2.3.4, the data used to provide the best estimate of costs in each impact category were assessed to determine the associated uncertainty. The uncertainty rating was applied based on the availability and quality of the data obtained

and the assumptions applied to the data to provide an economic cost estimate. The uncertainty rating was subsequently used to determine the potential range around the best estimate.

This approach has been used to determine a range of flood damage costs to road infrastructure of £89 million to £210 million (Table 14.1). Further details on the methods used to develop the lower and higher ranges are provided below.

Low estimate

Information was obtained at the local (LLFA) level on direct damages to road infrastructure as a result of flooding during the 2013 to 2014 winter period. A small amount of cost data relating to direct damages to roads was collected, which required adjustment (to account for betterment and removal of VAT) to convert to economic cost estimates. Although the approach used to convert financial damage costs to assets/infrastructure is consistent (both within this impact category and across other categories) it does introduce a degree of uncertainty.

The majority of the cost data used relates to grants awarded to local authorities by the Department for Transport to assist in dealing with the effects of severe weather damage to roads. This information is available for all LLFAs that received funding and, when combined with the direct damage costs, is considered to provide a good indication of the likely scale of the costs incurred. However, the Severe Weather Recovery grant sought to help local authorities address the damages resulting from flooding and severe weather to roads which occurred from the beginning of December 2013 up until early February 2014. So although these grants will have covered most of the flooding events during the 2013 to 2014 winter, they may also include other weather related damages to roads.

The data were therefore classified as having a moderate uncertainty rating given that the figure for the grants used as a surrogate of the actual costs incurred may include weather related damages in addition to flooding and the adjustments made to the direct damage costs to provide an economic estimate of the costs. A moderate uncertainty rating corresponds to a reduction of the best estimate by 20% to provide a low range estimate (Table 2.5). But to reflect the fact that the grant information used is likely to include both flooding and other weather related damages to roads and the uncertainty associated with this, the best estimate (£179 million) was reduced by 50%. This gave a low range estimate of the flood damages to road infrastructure during the 2013 to 2014 winter period of £89 million.

High estimate

A similar approach was used to obtain an upper range estimate except that the best estimate (£179 million) was increased by 20% in line with standard practice for a moderate uncertainty rating (Table 2.5). This gave a high range estimate of the flood damages to roads during the 2013 to 2014 winter period of £214 million (£210 million to 2 significant figures).

14.3.2 Welfare costs

The best estimate of the welfare costs associated with disruption and injuries caused by flooding to roads during the 2013 to 2014 winter period was determined using the Highways Agency's modelling approach. The calculations are based on high calibre data from the flood incident database and are considered to be high quality. Therefore,

combined with the fact these costs are small considered against the damage costs, it was not considered necessary to determine a range of welfare costs.

14.3.3 Overall range of the costs to the transport road sector

Table 14.7 provides a summary of the best estimate and associated ranges of the economic costs of road infrastructure damages and welfare costs (of disruption and injury) caused by the winter 2013 to 2014 floods. The best estimate is £180 million with a range of £91 million to £220 million.

Table 14.7 Range of economic costs to the transport road sector from the winter 2013 to 2014 floods

Cost type	Best estimate	Low estimate	High estimate
Direct damages/costs	£179 million	£89 million	£210 million
Welfare costs	£1.3 million	£1.3 million	£1.3 million
Total costs	**£180 million**	**£91 million**	**£220 million**

Notes: Values are presented to 2 significant figures, unless to illustrate the breakdown by cost type.

14.4 Damage costs by flood type

This section provides a breakdown of the damages/costs to the road network as a result of the winter 2013 to 2014 floods by flood type. It includes details of the methods used to differentiate the damage costs and the associated uncertainties.

14.4.1 Approach to disaggregating the damage costs

Disaggregation of the damages by flood type was based on the assumption that the majority of damages incurred by coastal LLFAs were caused by tidal surges. Although this is clearly a large simplification, there were insufficient details to allow a more sophisticated analysis. Damages were not included where the damage figures specified the flood type and this did not relate to coastal impacts.

14.4.2 Summary of damage costs by flood type

For the road network, the information obtained was only available at this disaggregated level for direct damages (damages related to roads and grants received by local authorities to make repairs to roads). Welfare damages (disruption and injury caused by flooding) were only available at an aggregated (national) level and therefore it was not possible to separate them out into flood type. Table 14.8 provides a summary of damages by flood type for the road network.

Table 14.8 Estimated economic damage costs to the road network by flood type (direct damages only)

Flood source	Economic damage estimates					
	Best estimate		Low estimate		High estimate	
	Damage	Percentage	Damage	Percentage	Damage	Percentage

Flood source	Economic damage estimates					
		of total		of total		of total
All (total)	£179 million	100%	£89 million	100%	£210 million	100%
Fluvial/ groundwater	£109 million	61%	£55 million	61%	£130 million	61%
Coastal	£70 million	39%	£35 million	39%	£84 million	39%

Notes: Values are presented to 2 significant figures unless to illustrate the breakdown by cost type. Therefore totals may not be equivalent to the types of flooding due to rounding.

14.5 Damage costs for England and Wales

There was no information on roads damaged as a result of flooding for Wales. The damages estimates presented therefore provide damages for England.

14.6 Uncertainties and assumptions

The direct damages to road infrastructure during the winter 2013 to 2014 floods predominantly relate to grants provided by the Department for Transport to local authorities to help them deal with the effects of severe weather damage to roads. It is recognised that these grants may be used in dealing with damages caused by other weather related damages as well as by floods. Therefore, in certain cases the figures may overestimate the impacts that are attributed to flooding specifically. Alternatively, the grants provided may not cover the full costs experienced by local authorities in dealing with flood related road impacts and, in these cases, may underestimate the total costs. These grant figures were used as a proxy to provide an estimate of the likely scale of the costs and where no other flood specific cost information was available. Ranges are provided to highlight the uncertainty associated with the data.

To avoid double counting, damages under the category of local authorities and local government infrastructure that could be specifically related to roads were included, where possible, in the transport: roads category. However, not all of the costs are disaggregated and therefore it was not always clear what the local authority costs specifically relate to (particularly in the case of Bellwin Scheme and Severe Weather Recovery grants). Therefore, there is a potential risk of double counting where costs included in the local authorities and local government infrastructure category relate to road infrastructure damages/repairs.

The best estimate obtained by aggregating data at the local (LLFA) level includes some information on damages/repair costs to road infrastructure. These figures were adjusted to convert from a financial to an economic cost estimate. Although the approaches used (that is, to adjust for betterment and removal of VAT) are consistent across all of the impact categories, they are uncertain.

The welfare costs associated with disruptions and injuries experienced by road users during the winter 2013 to 2014 floods were calculated by the Highways Agency. The data used (based on its flood incident database) are considered to be of high quality and therefore the estimates provided are ‘best of breed’. However, these welfare costs relate to injuries and disruption caused by flooding of the SRN, which is largely the responsibility of the Highways Agency. It was not possible to determine the welfare costs associated with disruption to road users of the non-SRN, which are the responsibility of local authorities. Therefore, the estimated welfare costs are likely to

underestimate the flood related disruption impacts to road users during the 2013 to 2014 winter period. But since the figures from the Highways Agency capture damages on major roads, including motorways, these are expected to include most of the disruption damages.

15 Impacts on transport: rail

15.1 Summary of findings

Table 15.1 presents the headline figures for the impact category of transport: rail. This category includes estimates of direct damages to rail infrastructure in England and Wales during the winter 2013 to 2014 floods. It also includes compensation/revenue costs to Network Rail and estimated welfare costs associated with flood-related disruption to rail users.

The best estimate of the costs to Network Rail, in relation to compensation payments to network operators and revenue losses, is £36 million with a range of £30 million to £41 million. Welfare costs to rail users were provided by Network Rail and relate to disruption to services caused by flooding incidents. The best estimate of the welfare costs is £56 million with a range of £45 million to £67 million.

Direct damages to rail infrastructure were obtained from literature reviews and consultation at the local (LLFA) level. Combining this local level information suggests a best estimate of direct damages/costs to rail infrastructure of £22 million with a range of £18 million to £27 million (in economic terms).

Therefore, the total economic cost of the winter 2013 to 2014 floods (including direct damages to rail infrastructure, costs to Network Rail and rail users) is estimated to be £110 million with a range of £93 million to £140 million (to 2 significant figures).

The costs are considered to relate to damage caused by both flooding and water-related erosion. In some cases, such as at Dawlish, rail infrastructure was damaged by erosion rather than flooding specifically. This information was retained because the effect of erosion, particularly in coastal areas during the tidal surge, was considerable. Consequently, a significant element of the 2013 to 2014 winter storms and government policy inextricably links the impacts of floods and water-related erosion.

Table 15.1 Headline findings for transport: rail

Finding	Economic damage estimates			
	Best estimate (range)	**% of total monetised damages**	**Uncertainty**	**Comments**
2013 to 2014 damages (direct damages/costs)	£22 million (£18 million to £27 million)	9% (of overall total damages)	Moderate	Based on local data obtained at the LLFA level regarding direct damages to rail infrastructure. Low and high range estimates are determined based on the uncertainty rating.
2013 to 2014 damages (compensation/ revenue costs)	£36 million (£30 million to £41 million)		Low–moderate	Based on national data from Network Rail regarding compensation/revenue costs. Range estimates are determined based on uncertainty rating.

Finding	Economic damage estimates			
2013 to 2014 damages (welfare costs)	£56 million (£45 million to £67 million)		Moderate	Based on national data from Network Rail regarding disruption to services. Range estimates are determined based on uncertainty rating.
2013 to 2014 damages (total)	£110 million (£93 million to £140 million)		Moderate	Based on a combination of the above estimates
2013 to 2014 damages – England (direct damages/costs)	£18 million (£15 million to £22 million)	81% (of total for category)	Moderate	Based on local data obtained at the LLFA level regarding direct damages to rail infrastructure in England. Range estimates are determined based on uncertainty rating.
2013 to 2014 damages – England (compensation/ revenue costs)	Could not be disaggregated	–	–	Could not be disaggregated
2013 to 2014 damages – England (welfare costs)	Could not be disaggregated	–	–	Could not be disaggregated
2013 to 2014 damages – England (total)	Could not be disaggregated	–	–	Could not be disaggregated
2013 to 2014 damages – Wales (direct damages/costs)	£4.2 million (£3.3 million to £5.0 million)	19% (of total for category)	Moderate	Based on local data obtained at the LLFA level regarding direct damages to rail infrastructure in Wales. Range estimates are determined based on uncertainty rating.
2013 to 2014 damages – Wales (compensation/ revenue costs)	Could not be disaggregated	–	–	Could not be disaggregated
2013 to 2014 damages – Wales (welfare costs)	Could not be disaggregated	–	–	Could not be disaggregated
2013 to 2014 damages – Wales (total)	Could not be disaggregated	–	–	Could not be disaggregated
2007 damages (2014 values)	£44 million	1.1% (of overall total damages in 2007)	Score: 1 (best of breed)	Environment Agency (2010)

Finding	Economic damage estimates			
	Best estimate	**Units**	**Uncertainty**	**Source of estimate**
Numbers affected	Difficult to express as one figure, details provided on assets and services affected	Varies by type of information provided	Low–moderate	Network Rail
	Best estimate	**Range**	**Uncertainty**	**Source of estimate**
Damages per asset	Not available		No defined units	

Notes: Values are presented to 2 significant figures.

15.2 Determining the best estimate

15.2.1 Number of assets affected/flood related incidents

Information obtained from internet research and consultation suggests that flooding or water-related erosion caused considerable damage to rail infrastructure and subsequent delays to rail services during the 2013 to 2014 winter period. However, the information on the number of assets affected, the length of rail track flooded, the number of flooding incidents and the number of passengers affected was piecemeal in nature and could not be aggregated to provide an overall national level estimate. The information provided in this section therefore outlines some of the most important impacts of flooding to rail infrastructure, providing a context to the costs presented below.

Many sections of the railway network are built in cuttings and tunnels that are lower than the surrounding area making them prone to flooding. Flood water can wash away the ballast which supports the sleepers making the line unsafe until it is re-laid.

The development of land near railways can increase the risk of flooding. If the drainage system is inadequate, rain which previously soaked into the ground may run off tarmac and concrete and straight onto the tracks. When the water level rises above the rails, trains have to reduce their speed, or in extreme cases stop altogether to prevent damage to the train. If the track has a live conductor rail, flooding can cause a short circuit. Points and signalling equipment can fail when water enters their housings and may need replacing before services can resume.

The 2013 to 2014 floods saw unprecedented Atlantic storm activity that severely disrupted services close to coastal areas, especially in Wales and south-west England, notably in Dawlish where the main line connecting Devon to Cornwall was washed away. These impacts were caused specifically by coastal erosion rather than flooding.

The collapse of the sea wall at Dawlish resulted in 7,500 full or part cancellations from 3 February 2014 until 4 April 2014 to and from the west of Exeter St David's (Devon County Council 2014a). In Devon, impacts on railway lines affected mainline services between Exeter and Paddington (closed between 3 and 10 February 2014 due to blockage at Athelney), between Exeter and Bristol (closed from 7 February 2014 to 10 March 2014 due to blockages at Bridgewater) and the Waterloo line from Exeter (due to blockages at Taunton in early February 2014). Flooding at Fordgate in Somerset was a repeat of flooding in 2012, with disruption of services between Bristol Templemeads and Exeter for many weeks. In addition, saturated land over prolonged periods disrupted some lines in south-east England for many days as a result of groundwater flooding. The main centres of disruption are summarised in Table 15.2.

Table 15.2 Main centres of rail disruption resulting from flooding during the winter 2013 to 2014 floods

LLFA	Location	Details
Devon	Dawlish	The Great Western main line through Dawlish was reopened on Friday 4 April 2014, almost 2 weeks ahead of Network Rail's mid-April estimate, but exactly a month after its total destruction.
Hampshire	Botley	Work to rebuild the railway at one of the worst landslips ever seen on the network in Botley took place, with over 2km of access road built to make the work possible.
Kent/East Sussex	Tunbridge Wells – Hastings	The railway between Battle and Robertsbridge was closed for around 2 months. Three serious landslips between early February and late March caused considerable disruption to passenger journeys as trains could not run safely over the damaged railway. Network Rail had hoped to fully reopen the route in early March, but the landslip at Whatlington Viaduct moved again, despite considerable work having taken place to fix it.
Berkshire	Maidenhead – Twyford	Groundwater flooding at Waltham caused lengthy passenger disruption.
Yorkshire	Midland main line (Sheffield – Chesterfield)	Following the landslip blocking the line at Unstone near Chesterfield, initial estimates for repair indicated that train services would be disrupted for 4–6 weeks. However, work on site went better than expected and the line reopened ahead of schedule. Nevertheless, work to fully stabilise the hillside continued for several months and so trains ran at a reduced speed past the site. However, this did not significantly affect journey times
Somerset	Somerset Levels	After many weeks of disruption, the railway between Taunton and Bridgwater reopened on 10 March 2014 with a near normal service reintroduced over affected areas.
Wales	Wales	The Cambrian Coast line between Barmouth and Harlech reopened following a £10 million programme to repair severe damage to the rail infrastructure and sea defences caused by the winter storms (calculated as £4.2 million economic cost). Completed 2 weeks ahead of schedule, the work involved removing 40 tonnes of debris and reinstating 6,000 pieces of 'rock armour' that form the sea defences. As a part of this work Network Rail laid more than 1,000 sleepers, 2,500 tonnes of ballast and 1,400 metres of track.

Network Rail's Annual Return 2014 notes that 'there has hardly been a part of the network that has not been affected' by severe weather (Network Rail 2014, p. 34). At a national level, this contributed to the year's performance being 2.5 percentage points behind Network Rail's target of 92.5%. Heavy rainfall and flooding, including the resulting increase in track faults and an increase in the number of temporary speed restrictions, contributed to long distance train performance being 5.1 percentage points behind the regulatory target with 86.9% of train services arriving on time (Network Rail 2014).

Performance on the main western route (Great Western) was worse than planned in 2013 to 2014, with delay minutes ending the year 279,000 minutes higher than targeted, and worse than in 2012 to 2013. The impact of the weather was the dominant cause of delays worse than target, with the groundwater related flooding at Maidenhead causing 55,000 minutes of delays alone (Network Rail 2014).

Total Network Rail attributed delays to passenger trains increased by 9%, while delays to freight services increased by less than 1% (Network Rail 2014).

The number of rail replacement bus hours increased in 2013 to 2014 as bus services were deployed in areas such as Dawlish where landslides and the tidal surge caused extensive track damage. At the end of 2014, the moving annual average number of rail replacement bus hours was 166,000 hours, worsening by 45 percentage points when compared with 2012 to 2013 (Network Rail 2014).

15.2.2 Direct damages/costs of flooding

Impacts on transport can be divided into those to the operators and those to the users. Transport operators include the organisations responsible for maintenance of the railway assets, as well as those responsible for running the services using those assets (including train operating companies). The impacts of flooding on transport operators can therefore include:

- damages to the assets themselves and any repair costs incurred to restore them so they are available for use
- response to flooding incidents in terms of changes to services, cancellations and delays, and the costs incurred with these.

Research was carried out to identify the direct damages to rail infrastructure resulting from the winter 2013 to 2014 floods at both the local and national levels. Some information on the more notable impacts was obtained but this was relatively limited in nature.

National level data were obtained from Network Rail on the compensation/revenue costs to train operators resulting from flood-related disruption. Further details on the information obtained at local and national levels are provided below.

Damages/repair costs to rail infrastructure

Apart from high profile incidents such as at Dawlish and at Fordgate in Somerset where costs are well documented, the costs of repair and reinstatement of rail infrastructure damages by flooding and water-related erosion are largely 'lost in the local accounting systems' (Network Rail, personal communication February 2015) and are not collated centrally. Table 15.3 presents examples of rail infrastructure damage and disruptions caused during the winter 2013 to 2014 floods, including both financial and economic cost estimates.

Table 15.3 Examples of disruptions to the railway network from the winter 2013 to 2014 floods

Region	Local authority	Location	Affected	Comments
South East	Brighton and Hove	Patcham and Preston Park	Railway	Signalling equipment flooded
South East	Isle of Wight	Ryde	Island Line	21 days £1 million financial cost (£480,000 economic cost) and £60,000 rail replacement (disruption costs)

Region	Local authority	Location	Affected	Comments
South West	Cornwall	Liskeard to Looe	Railway	£3–4 million cost expected (£1.5 million economic cost) two-thirds reduction in rail passenger numbers in Cornwall
South West	Somerset	Fordgate	Railway	Signalling and track: £4 million damages (£1.7 million economic cost) £6–7 million compensation
South West	Devon	Dawlish	Railway	£35 million repair (£15 million economic cost)
Yorkshire and Humberside	East Riding of Yorkshire		Railway	£100,000 damage to rail lines (£42,000 economic cost)
Wales	Wales	Cambrian Coast	Railway	£10 million programme to repair damaged rail infrastructure along the Cambrian Coast line between Barmouth and Harlech (£4.2 million economic cost)
Total				**£22 million (economic costs)**

Notes: Information collected from Section 19 reports from LLFAs, adjusted to reflect the economic cost.
Values are presented to 2 significant figures.

The rail infrastructure damage or repair cost information obtained was considered to represent a financial cost and was therefore adjusted to provide an estimate of the economic cost. To convert the financial damage costs to an economic value, the figures were first adjusted to account for improvements. It was assumed that, in the majority of cases, the assets damaged by flooding or water-related erosion were part way through their serviceable life. Therefore, an asset's repair or replacement was effectively improving its condition and potentially extending its serviceable life. Hence, it was not deemed appropriate to take the full damage cost as the economic estimate as the old asset was effectively being replaced by a new asset (that is, not a like-for-like replacement). To account for this, 50% of the asset damages or repair costs were taken. In addition, any work to repair or replace a damaged asset will incur VAT. This was therefore removed to provide an economic cost of the flood damages.

A summary of the calculation used to convert financial damage/repair costs to rail infrastructure to an economic estimate is provided below:

> Economic estimate of damage/repair costs = Financial estimate of damage/repair costs × 50% (accounting for betterment) ÷ 1.2 (to remove VAT at 20%)

The damage costs resulting from flooding and water-related erosion during the 2013 to 2014 winter period are considerable, particularly in relation to the severed railway line at Dawlish (Table 15.3). Combining the damage costs for rail infrastructure results a total economic cost for England and Wales of £22 million. There are likely to be data gaps and so this may underestimate the damages caused to rail infrastructure during the winter 2013 to 2014 floods.

Cost of compensation to train operating companies

Information was obtained from Network Rail on the compensation payments made to train operating companies affected by flooding or water-related erosion during the 2013

to 2014 winter period. These costs are calculated through complex Schedule 4 and Schedule 8 agreements.

Schedule 4 of the track access contracts between Network Rail and train operators sets out the arrangements for compensation paid to operators when Network Rail takes possession of the network. Schedule 4 costs are for planned disruptions, and costs include replacement buses during planned track disruption. The severe impact of the flooding in certain areas resulted in the introduction of emergency timetables, with disruption therefore being deemed planned rather than unplanned.

Schedule 8 costs are unplanned costs designed to compensate train operators for the financial impact of poor performance (including flooding and severe weather) attributable to Network Rail and other train operators. This is a proxy for revenue loss to the train operating companies and is available for specified time periods by network route geography. The metrics used are minutes and converted monetary losses. For commercial sensitivity, this cannot be separated by train operating companies.

Schedule 4 and Schedule 8 costs include cancelled and delayed journeys. The compensation payments made by Network Rail to rail operators are therefore used as a proxy of the damages/revenue losses caused by flooding or water-related erosion during the 2013 to 2014 winter period.

Total compensation and revenue costs to Network Rail attributable to the winter 2013 to 2014 floods were £36 million; they are assumed to represent an economic cost (Table 15.4). Great Western and Wales were the only routes to incur Schedule 4 (planned service disruption) costs.

Table 15.4 Compensation/revenue costs to Network Rail during the winter 2013 to 2014 floods

Type of cost	Main area routes						Total
	Anglia	London North Eastern and East Midlands	London North Western	South East (Kent and Sussex)	Western (including Wales)	Wessex	
Schedule 4 costs (£)	0	0	0	0	12,031,265	0	**12,031,265**
Schedule 8 costs (£)	289,570	727,528	803,021	4,963,921	15,449,772	1,339,977	**23,573,789**
Total comp./ revenue costs (£)	289,570	727,528	803,021	4,963,921	27,481,037	1,339,977	**35,605,054**

Notes: Values are considered to represent economic costs.
Source: Network Rail

The information from Network Rail on compensation costs was determined using industry methodology. It provides a national level estimate of the costs to network operators resulting from flooding or water-related erosion and is therefore considered to be ‘best of breed’. Thus, this information was used in determining the best estimate.

The map in Figure 15.1 shows the estimated damages to the rail network based on information from Network Rail on damages to the 8 main area routes.

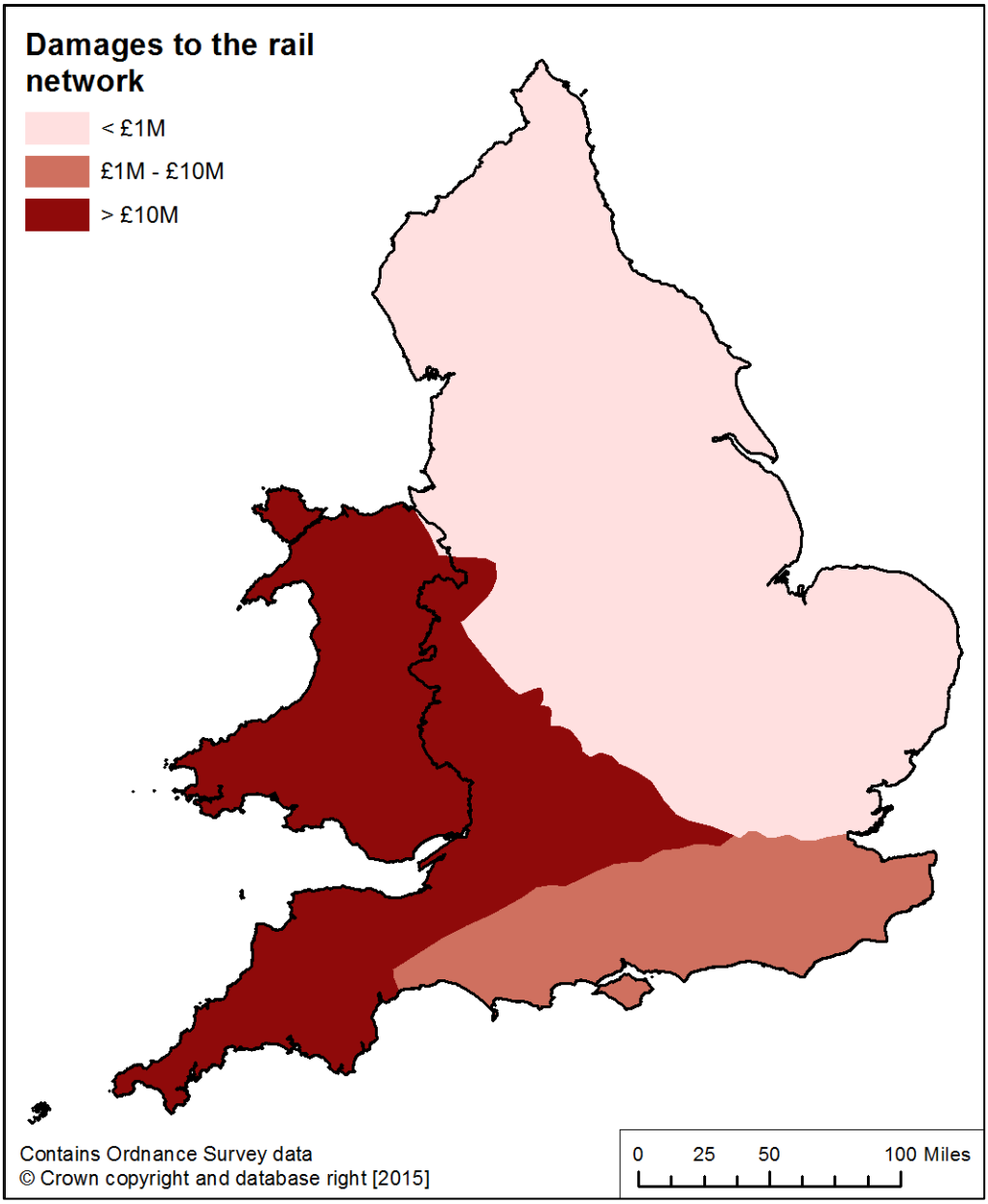

Figure 15.1 Estimated damages to the rail network for the 8 main area routes

Notes: Only shows where data were available and data may also be incomplete.

15.2.3 Welfare costs

The winter 2013 to 2014 floods caused disruptions to rail travel, with a detrimental impact on the welfare of those affected by the delays caused and/or the loss of service. Table 15.5 gives some examples of the disruptions to the railway network that occurred during the winter 2013 to 2014 floods.

Table 15.5 Examples of disruptions to the railway network from the winter 2013 to 2014 floods

Region	Local authority	Location	Affected	Comments
East of England	Suffolk	Lowestoft to Ipswich	Railway station	Closed for 5 days
North East	Middlesbrough	Middlesbrough to Redcar	Railway closed	–
North West	Blackpool	South Shore	Tramway	Starr Gate to Glynn Square
South East	East Sussex	Lewes to Seaford	Railway station	Closed for 3 days
South East	Southampton	Southampton	Railway	Redbridge, Romsey and Southampton diverted for 1 day by Chandlers Ford, adding 25 minutes
South East	West Sussex	Balcombe	Tunnel	London to Brighton Line
South West	Cornwall	Chy-an-dowr, Penzance	Railway	Breach caused closure of branch lines Penzance station closed for 4 weeks
South West	Devon	–	Railway	7,500 full or part time services cancelled to and from Exeter St David's, westward
South West	Somerset	–	Railway	80 trains per day affected between Bristol and Exeter £13 million disruption to passengers, diversions and bus replacement
Wales		Mostyn	Railway	Holyhead to Chester line closed
Yorkshire and Humberside	Sheffield	Unstone	Midland mainline	Closed for 35 days

Notes: Information collected from Section 19 reports from LLFAs.

Estimates of the disruption costs to rail users during the winter 2013 to 2014 floods were provided by Network Rail. The estimate of value of time per delay or cancellation complies with WebTAG transport analysis guidance (Department for Transport 2014b). The estimates were prepared by Network Rail by geographical route and are an estimated ratio of compensation costs, varying by route and type of passenger travelling (for example, leisure or commuter). Use losses stem from additional passenger journey time and reliability losses to rail users, while non-use losses relate to the cost of additional road decongestion and environmental losses resulting from additional non-rail journeys).

The method assumes that passengers will react to a small disruption in much the same way as they react to a large disruption. In reality, a large disruption forces a person to entirely reconsider their travel options and the resultant welfare impact is not therefore easy to understand. The data are only reliable in a regional or national context and a local detailed analysis may produce different welfare losses.

The welfare impacts provided by National Rail relate to costing 'opportunities foregone'. Disruption to rail services may result in people changing their planned activities (that is, deciding not to travel or changing the method used to travel). However, it is assumed that if making a train journey is a preferred choice then any deviation from this planned behaviour will have welfare cost repercussions.

All costs are estimated for flood incidents (as separate from severe weather incidents, which may relate to wind damage, for example, trees on the line) and embankment slips that are water-related.

A summary of the bespoke work on welfare costs is presented in Table 15.6. The results show that the total welfare costs resulting from disruption to the rail network caused by flooding during the 2013 to 2014 winter storms amounted to £56 million (assumed to represent an economic cost).

Table 15.6 Welfare impacts of flood-related disruption to Network Rail services during the winter 2013 to 2014 floods

Type of cost	Main area routes						Total
	Anglia	London North Eastern and East Midlands	London North Western	South East (Kent and Sussex)	Western (including Wales)	Wessex	
Use losses (£)	503,377	788,896	1,065,181	8,067,995	32,573,725	2,119,049	**45,118,223**
Non-use losses (£)	95,088	240,355	260,623	1,425,718	8,578,378	395,296	**10,995,458**
Total welfare (£)	598,465	1,029,251	1,325,804	9,493,713	41,152,103	2,514,345	**56,113,681**

Notes*:* the figures presented in this table are considered to represent economic costs

15.2.4 Best estimate of the damages/costs attributed to flooding of the rail network

Table 15.7 provides a summary of the economic cost estimates of the compensation costs paid by Network Rail to train operators and the welfare costs of disruption caused by flooding or water-related erosion during the 2013 to 2014 winter period. The best estimate is £36 million for the compensation/revenue costs to Network Rail and £56 million for the welfare costs relating to flooding or erosion related disruption. As indicated in Table 15.7, three-quarters of the costs are attributed to routes in the Western area (including Wales).

Table 15.7 Compensation/revenue costs and welfare impacts of flood-related disruption to Network Rail services during the winter 2013 to 2014 floods

Type of cost	Main area routes						Total
	Anglia	London North Eastern and East Midlands	London North Western	South East (Kent and Sussex)	Western (including Wales)	Wessex	
Compensation/revenue costs							
Schedule 4 costs (£)	0	0	0	0	12,031,265	0	**12,031,265**

Type of cost	Main area routes						Total
	Anglia	London North Eastern and East Midlands	London North Western	South East (Kent and Sussex)	Western (including Wales)	Wessex	
Schedule 8 costs (£)	289,570	727,528	803,021	4,963,921	15,449,772	1,339,977	**23,573,789**
Total comp./ revenue costs (£)	289,570	727,528	803,021	4,963,921	27,481,037	1,339,977	**35,605,054**
Welfare costs							
Use losses (£)	503,377	788,896	1,065,181	8,067,995	32,573,725	2,119,049	**45,118,223**
Non-use losses (£)	95,088	240,355	260,623	1,425,718	8,578,378	395,296	**10,995,458**
Total welfare (£)	598,465	1,029,251	1,325,804	9,493,713	41,152,103	2,514,345	**56,113,681**
Total (£) (compensation plus welfare)	**888,035**	**1,756,779**	**2,128,825**	**14,457,634**	**68,633,140**	**3,854,322**	**91,718,735**
Regional	**1%**	**1.9%**	**2.3%**	**15.8%**	**74.8%**	**4.2%**	

Notes: Value presented are considered to represent economic costs.

Table 15.8 provides a summary of the best estimate of the economic costs of direct damages to rail infrastructure, compensation/revenue costs to Network Rail and welfare costs during the winter 2013 to 2014 floods. Combining these provides a best estimate of the costs to the transport rail sector of £110 million (to 2 significant figures).

Table 15.8 Best estimate of the economic costs to the transport rail sector

Cost type	Best estimate
Direct damages/costs to rail infrastructure	£22 million
Compensation/revenue costs to Network Rail	£36 million
Welfare costs	£56 million
Total costs	**£110 million**

Notes: Values are presented to 2 significant figures, unless to illustrate the breakdown by cost type. The sum of constituent parts may therefore not equal the total costs due to rounding.

The Annex 1 method statement summarises the approach used to develop the best estimate of the costs to the transport rail sector.

15.3 Determining the best estimate range

15.3.1 Direct damages/costs of flooding

As described in Section 2.3.4, the data used to provide the best estimate of costs in each impact category were assessed to determine the associated uncertainty. The uncertainty rating was applied based on the availability and quality of the data obtained and the assumptions applied to the data to provide an economic cost estimate. The uncertainty rating was subsequently used to determine the potential range around the best estimate.

This approach was used to determine a range of flood damage costs to rail infrastructure of £18 million to £27 million (Table 15.1). Further details on the methods used to develop the lower and higher ranges are provided below.

Low estimate

Information was obtained at the local (LLFA) level on the damages incurred to rail infrastructure during the winter 2013 to 2014 floods. It was necessary to adjust these cost data to convert them from a financial to an economic cost, thus introducing a degree of uncertainty. In certain cases it was also unclear whether the information referred to actual costs incurred or estimates of the likely damages (cross-checking of data was possible in the majority of cases). Thus, the data were classified as having a moderate uncertainty rating given the inability to cross-check the majority of the data and the adjustments made to provide an economic estimate of the costs. To reflect this uncertainty, the best estimate (£22 million) was reduced by 20% (see Table 2.5), resulting in a low range estimate of the flood damages to rail infrastructure during the 2013 to 2014 winter period of £18 million.

High estimate

A similar approach was used to provide an upper range estimate. The information at the local (LLFA) level on flood damages to rail infrastructure was classified as having a moderate uncertainty rating. Even though information was obtained for a number of crucial sites (including Dawlish), there are likely to be data gaps and the best estimate may underestimate the damages to rail infrastructure at the national level. The moderate uncertainty rating was therefore assigned because of the potential for data gaps, the inability to cross-check the majority of the data and the adjustments made to provide an economic estimate of the costs. To reflect this uncertainty, the best estimate (£22 million) was increased by 20% (see Table 2.5), resulting in a high range estimate of the flood damages to rail infrastructure during the 2013 to 2014 winter period of £27 million.

15.3.2 Compensation/revenue costs

The best estimate was assessed to determine the associated uncertainty and to allocate an uncertainty rating for use in estimating a range. This approach produced a range of compensation/revenue costs to Network Rail of £30 million to £41 million (Table 15.1). Further details on the methods used to develop the lower and higher ranges are provided below.

Low estimate

The information provided by Network Rail on the compensation/revenue costs attributed to the winter 2013 to 2014 floods are based on Schedule 4 and Schedule 8 agreements between Network Rail and the rail operators. These compensation payments were used as a proxy of the damages/revenue losses to train operators caused by flooding or water-related erosion during the 2013 to 2014 winter period. Although the data provided was at the national scale and from a reliable source (suggesting a low uncertainty rating), there is a degree of uncertainty on the extent to which these data reflect damages/revenue losses to train operators caused by flooding or water-related erosion specifically. Thus, the data were classified as having a low–moderate uncertainty rating. To reflect this uncertainty, the best estimate (£36 million) was reduced by 15% (see Table 2.5), resulting in a low range estimate of the compensation/revenue costs attributed to the winter 2013 to 2014 floods of £30 million.

High estimate

A similar approach was used to obtain an upper range estimate. Reflecting the low–moderate rating applied to the data, the best estimate (£36 million) was increased by 15% (see Table 2.5), resulting in a high range estimate of the compensation/revenue costs attributed to the winter 2013 to 2014 floods of £41 million.

15.3.3 Welfare costs

The best estimate was assessed to determine the associated uncertainty and to allocate an uncertainty rating for use in estimating a range. This approach produced a range of welfare costs to rail users of £45 million to £67 million (Table 15.1). Further details on the methods used to develop the lower and higher ranges are provided below.

Low estimate

Network Rail carried out an assessment of the welfare costs associated with service disruption caused by flooding or water-related erosion during the 2013 to 2014 winter period. However, the approach used is uncertain and assumes that passengers will react to a small disruption in much the same way as they react to a large disruption. In reality, a large disruption forces a person to entirely reconsider their travel options and the resulting welfare impact is not therefore easy to understand. Given the estimates and assumptions applied, the data are classified as having a moderate uncertainty rating. To reflect this uncertainty, the best estimate (£56 million) was reduced by 20% (see Table 2.5), resulting in a low range estimate of the welfare costs resulting from rail travel disruption during the 2013 to 2014 winter period of £45 million.

High estimate

A similar approach was used to obtain an upper range estimate. Reflecting the moderate uncertainty rating applied to the data, the best estimate (£56 million) was increased by 20% (see Table 2.5), resulting in a high range estimate of the welfare costs resulting from rail travel disruption during the 2013 to 2014 winter period of £67 million.

15.3.4 Overall range of the costs to the transport rail sector

Table 15.9 provides a summary of the best estimate and associated ranges of the economic costs of direct damages to rail infrastructure, compensation/revenue costs to Network Rail and welfare costs during the winter 2013 to 2014 floods. The best estimate is £110 million with a range of £93 million to £140 million.

Table 15.9 Range of economic costs to the transport rail sector

Cost type	Best estimate	Low estimate	High estimate
Direct damages/costs to rail infrastructure	£22 million	£18 million	£27 million
Compensation/revenue costs to Network Rail	£36 million	£30 million	£41 million
Welfare costs	£56 million	£45 million	£67 million
Total costs	£110 million	£93 million	£140 million

Notes: Values are presented to 2 significant figures, unless to illustrate the breakdown by cost type. The sum of the constituent parts may not therefore equal the total costs due to rounding.

15.4 Damage costs by flood type

The best estimate of the costs to Network Rail (based on compensation/revenue costs) and welfare costs resulting from disruption to Network Rail services during the winter 2013 to 2014 floods are provided at the regional level. It was therefore not possible to separate these costs by type of flood.

However, the direct damage/costs to the rail network as a result of the winter 2013 to 2014 floods were obtained at the local (LLFA) level, making it possible to provide a breakdown of these costs by flood type. This section provides details of the methods used to differentiate these infrastructure damage costs and the associated uncertainties.

15.4.1 Approach to disaggregating the damage costs

The disaggregation of damages by flood type was based on the assumption that the majority of damages incurred by coastal LLFAs were caused by tidal surges or increased wave action. Although this is clearly a simplification, there are insufficient details to allow a more sophisticated analysis. Where damage figures obtained specify the flood type and do not relate to coastal impacts, these were not included in the damages.

15.4.2 Summary of damage costs by flood type

Table 15.10 provides a summary of the direct damages to rail infrastructure during the 2013 to 2014 winter period by flood type. It was not possible to separate the costs to Network Rail (based on compensation/revenue costs) and welfare costs by flood type. Almost three-quarters of the flood or water-related erosion damages can be attributed to coastal sources, with the remaining 26% relating to fluvial/groundwater flooding.

Table 15.10 Estimated economic damage costs to the rail network by flood type

Flood source	Economic damage estimates					
	Best estimate		Low estimate		High estimate	
	Damage	Percentage of total	Damage	Percentage of total	Damage	Percentage of total
Total direct damages	£22 million	100%	£18 million	100%	£27 million	100%
Fluvial/ groundwater	£5.8 million	26%	£4.7 million	26%	£7.0 million	26%
Coastal	£17 million	74%	£13 million	74%	£20 million	74%

Notes: Values are presented to 2 significant figures and therefore totals may not be may not be exact sum of constituent parts due to rounding.

15.5 Damage costs for England and Wales

The cost estimates associated with the winter 2013 to 2014 floods provided by Network Rail are presented at the regional level. The costs for its Western area routes account for 75% of the total costs and include costs for England as well as Wales. Although it can be deduced from the information provided that the costs of flooding impacts in Wales will be lower than the figure of £69 million for the total costs to the Western area routes (Table 15.7), it was not possible to disaggregate these costs by country. There are known to have been flood and water-related erosion impacts to the rail network in the west and south west of England (in particular the damages caused to the railway line at Dawlish) and in Wales (to the Cambrian Coast line between Barmouth and Harlech). However, it was not possible to determine the compensation and welfare cost split for England and Wales as a whole.

Direct damage/costs to the rail network as a result of the winter 2013 to 2014 floods were obtained at the local (LLFA) level and therefore it was possible to provide a breakdown of these costs by country. This section provides a breakdown of the damages/costs to rail infrastructure as a result of the winter 2013 to 2014 floods for England and Wales. It includes details of the method used to differentiate the damage costs and the associated uncertainties.

15.5.1 Approach to disaggregating the direct damage costs

Splitting damages between those incurred in England and Wales was based on the direct damage estimates obtained for each LLFA. Those in England and those in Wales were combined separately to provide total damages for both countries.

15.5.2 Damage costs for England and Wales

Table 15.11 provides a summary of damages to rail infrastructure for England and Wales. Approximately £18 million of the direct damages (81%) can be attributed to England, with the remaining £4.2 million (19%) to Wales. It was not possible to separate the costs to Network Rail (based on compensation/revenue costs) and welfare costs for England and Wales.

Table 15.11 Estimated economic damage costs to the rail network by country

Country	Economic damage estimates					
	Best estimate		Low estimate		High estimate	
	Damage	Percentage of total	Damage	Percentage of total	Damage	Percentage of total
Total direct damages	£22 million	100%	£18 million	100%	£27 million	100%
England	£18 million	81%	£15 million	81%	£22 million	81%
Wales	£4.2 million	19%	£3.3 million	19%	£5.0 million	19%

Notes: Values are presented to 2 significant figures. The total may not therefore be equivalent to the types of flooding due to rounding.
Disaggregation excludes compensation/revenue costs and welfare impacts.

15.6 Uncertainties and assumptions

Data were provided by Network Rail on the compensation costs/revenue costs and welfare costs resulting from service disruption. These are considered to be reliable.

The direct damages to rail infrastructure were obtained at the local (LLFA) level and combined to provide a total estimate of the damages. There are likely to be data gaps and therefore the best estimate may underestimate the damage costs experienced during the winter 2013 to 2014 floods. Also, adjustments were made to the figures to convert from a financial to an economic cost estimate. Although the approaches used (that is, to adjust for betterment and removal of VAT) are consistent across all of the impact categories, they are uncertain.

16 Impacts on transport: ports

16.1 Summary of findings

Table 16.1 presents the headline figures for the impact category of transport: ports. This category includes estimates of damages to ports and harbours during the 2013 to 2014 winter period. These estimates include grants made under the Department for Transport's Small (English) Ports Support Scheme – the 'small ports fund' – to carry out repairs to port and harbour infrastructure damaged by flooding and water-related erosion. The best estimate of the damages to ports is £1.8 million with a range of £1.6 million to £2.1 million (presented to 2 significant figures). Further details describing how the best estimate and range were determined are provided in the following sections.

The best estimate is based on information obtained at the local (LLFA) level on government grants to local authorities from the small ports fund to assist in repairing damages and cost data relating to the damages caused to port infrastructure during the winter 2013 to 2014 floods.

To avoid double counting, flooding and water-related erosion damages to ports and harbours owned by private organisations and local authorities are included, where possible, in the 'transport: ports' category and excluded from the 'businesses' and 'local authorities and local government infrastructure' categories.

Grants from the small ports fund to make repairs to port infrastructure are considered to be in addition to insurable costs and are therefore not considered to be double counted with insurable damages to privately owned ports that may be included in the businesses category. However, direct damage costs/repairs to ports that are owned or managed by private organisations or local authorities may be included in the businesses or local authorities and local government infrastructure categories, respectively, in cases where costs cannot be disaggregated into their constituent parts. This potential for double counting has been managed to the extent possible.

Table 16.1 Headline findings for transport: ports

16.2 Finding	Economic damage estimates			
	Best estimate (range)	**% of total monetised damages**	**Uncertainty**	**Comments**
2013 to 2014 damages (total)	£1.8 million (£1.6 million to £2.1 million)	0.14% (of overall total damages)	Moderate	Based on local data on damages and grants from the small ports fund. Range estimates are determined based on uncertainty rating.
2013 to 2014 damages (England)	£1.8 million (£1.6 million to £2.1 million	100% (of total for category)	Moderate	Refers to the proportion of total costs attributable to England. Range estimates are determined based on uncertainty rating.
2013 to 2014 damages (Wales)	No data	0% (of total for category)	High	No damages found

	Economic damage estimates			
2007 damages (2014 values)	Not calculated	-	No score for ports specifically	Environment Agency (2010)
	Best estimate	**Units**	**Uncertainty**	**Source of estimate**
Numbers affected (total)	23	Number of ports per harbours damaged	Moderate	Based on local data on ports affected by flooding and water-related erosion
Numbers affected (England)	23	Number of ports per harbours damaged	Moderate	Based on local data on ports affected by flooding and water-related erosion
Numbers affected (Wales)	No assets found to have been damaged	No damages found	High	No damages found
	Best estimate	**Range**	**Uncertainty**	**Source of estimate**
Damages per asset	Not available			

Notes: Values presented to 2 significant figures.

16.3 Determining the best estimate

16.3.1 Number of assets affected

Information was collected at the local (LLFA) level on the damages to ports as a result of flooding and water-related erosion. A total of 21 ports and harbours affected during the 2013 to 2014 floods received government assistance through the Department for Transport's Small (English) Ports Support Scheme (DCLG 2014c). In addition, the hovercraft terminal in Portsmouth was affected by the winter storms as thousands of tonnes of shingle was deposited on the terminal apron and Immingham Port was affected by flooding during the December 2013 tidal surge.

The information obtained at the local level was aggregated to provide a national level estimate of 23 ports or harbours affected by flooding or water-related erosion during the 2013 to 2014 winter period.

16.3.2 Damages to ports and harbours

Two main types of cost information at a local (LLFA) level were combined to provide a national level estimate of the impacts.

First, the Department for Transport gave small ports grants to ports and harbours to carry out repairs caused by flooding and water-related erosion during the 2013 to 2014 winter period. Second, specific damage or repair cost information was obtained for one harbour affected by flooding. The latter was equivalent to 4% of the total damages for the impact category, with the remaining 96% relating to small ports grants.

Where necessary, the local level data were adjusted to provide an economic estimate of the costs before being aggregated to give a national level estimate of the flood damages to port infrastructure. This section provides an overview of the data used and the adjustments made to determine the best estimate.

The distribution of damages to ports is shown in the map in Figure 16.1.

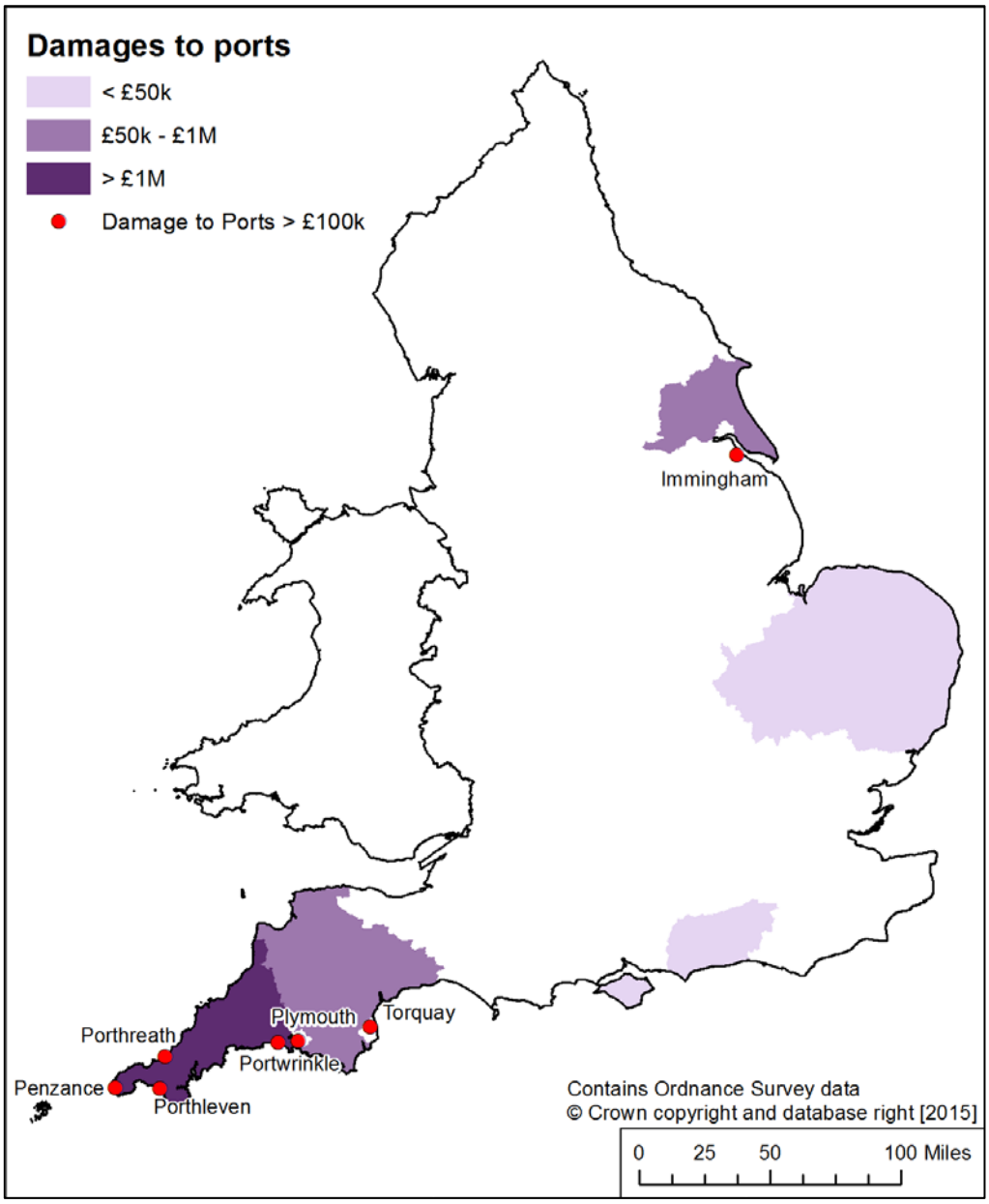

Figure 16.1 Estimated damages to ports for the 8 LLFAs for which data were available

Notes: Only shows where data were available and data may be incomplete.

Small ports fund

The government's small ports fund gave out grants totalling £1.7 million to help repair 21 small ports and harbours across England damaged by the unprecedented storms and surge tides. The majority of the funding went to ports and harbours in the south-west.

Table 16.2 gives details of the specific damages to ports and harbours caused by the winter 2013 to 2014 floods and the amounts they received from the small ports fund.

Table 16.2 Grants from the small ports fund to repair damages from the winter 2013 to 2014 floods

Region	Local authority	Grant amount and description of damage
East of England	Suffolk	**Southwold Harbour:** £15,717 to repair flooding and wash damage to fishing stage, harbour office and Walberswick Quay
East of England	Norfolk	**Wells-next-the-Sea Harbour**: £14,960 to repair damage to outer harbour berms and Inner Harbour berths
South East	Isle of Wight	**Ryde Harbour**: £29,455 to repair paving and concrete walling
South East	West Sussex	**Littlehampton Harbour**: £2,109 repairs to capping beam and wall
South West	Cornwall	**Bude Harbour**: £35,405 to fix holes in breakwater and trailing wall damage; £13,668 to address loss of sand from within the breakwater which led to granite stones being undermined **Mousehole Harbour**: £19,905 to fix partial collapse of old wharf, damage to car park, toilets and railings as well as replacing timbers and equipment related to electricity supply **Newlyn Harbour**: £4,320 for repairs to North Pier roofing and South Pier railings **Penzance Harbour**: £129,674 to fix breach of sea wall, loss of fresh water supply and damaged lighting on Lighthouse Quay and, on South Quay, to repair damage to fresh water break tank, cobbled surface and electrical bollards **Porthleven Harbour**: £434,786 to repair collapse of wall at Fisherman's Quay, to remove large granite blocks partially blocking the sluice and fix damage to the hospital corner wall, loss of capping to harbour head wall and undermining of slipway. A further £66,391 to fix damage caused by wooden baulks to Inner Harbour shifting, damaging roads, ladders and mooring chains **Porthreath Harbour**: £179,363 to repair the collapse of the eastern breakwater and wall above it, with a further £83,431 to address the damage to the forward observation hut on Finger Pier **Portwrinkle Harbour**: £115,000 to fix the collapse of harbour wall and damage to quay surface **St Ives Harbour:** £6,784 to repoint parts of Smeaton's Pier and replace damaged railing on wharf steps **Newquay Harbour**: £2,964 to repair damage to slipway, quay, and landing steps **Par Harbour**: £95,000 to fix damage to the harbour wall and surrounding areas
South West	Devon	**Brixham**: £11,160 for facing masonry at Eastern Quay **Clovelly**: £5,457 to repair keystones dislodged by swell as well as cobbled surfaces, repointing harbour wall and clearing stones blocking access **Paignton**: £18,465 for repairs to foundation toe and fenders at East Quay and landing quay, and £19,250 for repairs to address undercutting of foundations of the

Region	Local authority	Grant amount and description of damage
		East Quay wall **Plymouth City**: £101,250 repairs to steps and quay wall at the commercial wharf at Cattewater Harbour **Torquay Harbour**: £245,950 to repair masonry facing and seaward stairs at Princess Pier and for pontoons at Torquay Town Dock
Yorkshire and Humber	East Riding	**Bridlington**: £56,925 for damage to protective coating on Fish Quay, South Pier

Notes: Fenland District Council in the East of England also received £1,200 to remove silt and debris on a quay.
Source: Department for Transport (2014b)

For the purposes of this assessment, the grants received from the small ports fund were used as a surrogate for the damage costs to ports resulting from flooding and water-related erosion. These were assumed to represent an economic cost and were therefore not adjusted. This grant information was used to represent the damage costs to port infrastructure for LLFA areas only where no specific information on the actual damages/repair costs incurred was obtained. The actual cost of repairs to the port infrastructure may have been higher than the grants received, but it was not possible to determine whether this was the case.

The grants made under the small ports fund to make repairs to port infrastructure were considered to be in addition to insurable costs. They are therefore not considered to be double counted with insurable damages to privately owned ports that may be included in the businesses category.

Direct damages to infrastructure

Internet research and consultation with local authorities was carried out to determine the damages caused to ports and waterways infrastructure during the winter 2013 to 2014 floods at the local (LLFA) level.

The only information obtained related to damages caused to Bude Canal and coastal defences in Cornwall. This damage cost information was considered to represent a financial cost and was therefore adjusted to provide an estimate of the economic cost. To convert the financial damage costs to an economic value, the figures were first adjusted to account for betterment. It was assumed that, in the majority of cases, the assets damaged by flooding were part way through their serviceable life. Therefore, the repair or replacement of the damaged asset effectively improves its condition and potentially extends its serviceable life. Hence, it was not deemed appropriate to take the full damage cost as the economic estimate as the old asset was effectively replaced by a new asset (that is, not a like-for-like replacement). To account for this, asset damages/repair costs were reduced by 50% of the claimed value. In addition, any work to repair or replace a damaged asset will incur VAT. This was therefore removed to provide an economic cost of the flood damages.

A summary of the calculation used to convert financial damage/repair costs to port or waterway infrastructure to an economic estimate is provided below:

> Economic estimate of damage/repair costs = Financial estimate of damage/repair costs $\times$ 50% (accounting for betterment) $\div$1.2 (to remove VAT at 20%)

This approach gives an estimated economic damage to Bude Canal of £79,000 caused by flooding or water-related erosion.

Impacts on port operations, including Immingham Port

Other impacts on ports include disruption to ferries, for example, in Portsmouth where Brittany Ferries cancelled services between Portsmouth and St Malo on 15 February 2014 (Sky News 2014). It is not clear whether this is due to the storm impacts or the tidal surge and flooding. In Devon, the high winds and tidal surges caused loss or cancellation of 48 ferry crossings (Plymouth City Council 2014). Sea connections to the Isles of Scilly were also closed (Cornwall Council 2014b).

In addition, flooding caused impacts to the Port of Immingham, which is operated by Associated British Ports (ABP), the UK's largest and leading ports group. The port and associated supply industries have expanded in recent years and the port currently handles 10% of the UK's seaborne trade amounting to 50 million tonnes annually, including around 30 million tonnes of coal and petroleum products. The port has extensive deep water facilities and the infrastructure to handle a variety of different cargo streams including dry bulks, containers, forest products, general cargoes, liquid bulks and break bulks. The port is nationally important for the electricity supply industry because of the coal and growing volumes of biomass it handles, which are forwarded by rail to power stations located mainly in the Aire and Trent valleys. The port also performs a vital role in the supply chain surrounding the 2 refineries next to the port owned by Phillips 66 and Total, which together represent around 28% of the UK's refining capacity.

The highest flood level at the Port of Immingham was confirmed by the Environment Agency as being 5.31m above Ordnance Datum (AOD), whereas the current resilience level is 4.7m AOD. The port's greatest asset, the main lock pit, was the principal point of entry for flood water in December 2013, as it formed a channel through which the surge tide entered the enclosed dock. Water levels within the dock rose as a result of this inundation to a point where adjacent quaysides were overtopped, with some locations seeing several feet of water. Riverside defences also proved to be inadequate.

There were 3 main types of damages at the port. The first was damages to buildings, cargoes and equipment. The second was damages to transmission infrastructure; 40 substations within the port estate supplying electricity to ABP's facilities as well as its customers' operations were affected. The subsequent power supply disruption had a damaging effect upon all port operations. The third type was damages to transport infrastructure. In particular, points and signalling on critical railway lines serving the Humber International Terminal were affected. Network Rail and ABP engineers worked assiduously at restoring rail connectivity to this facility, which is the entry point for a coal burnt in UK power stations. Crucially, none of the power stations suffered a significant disruption in the supply of coal to their sites, with buffer stocks at the power station allowing for a small hiatus in supply.

Direct damages to ABP are estimated at £10 million to £15 million. However Evidence has also been obtained that suggests the overall costs to port businesses resulting from the disruption might be in the region of £40 million. This figure reflects a loss to local businesses but is not included in this report as it is not possible to identify clearly local versus national losses. Losses to flooded businesses may be compensated through increased business for those businesses unaffected by flooding (a transfer of business elsewhere). It is also anticipated some these damages to businesses were insured and so captured in the businesses category and, to avoid double counting, are s not included in the total for transport: ports.

Other recovery actions by ABP to mitigate the effects of flooding included:

- carrying out a comprehensive review of electrical infrastructure, including a 2-year repair and replace programme which prioritises the main substation and will increase the height of the entire building by 1.5 metres
- protecting impounding pumps from the ingress of water
- spending more than £500,000 on resilience measures to protect port infrastructure
- reviewing all existing capital building projects to ensure flood resilience is built in, for example, substations and electrical infrastructure at the Immingham Renewables Fuel Terminal are to be redesigned mid-project to protect against surge
- ensuring bulk stores are designed and supplied with flood doors
- commissioning a design for new higher lock gates with props and reinforced rams to cater for 1 in 1,000 event (6.5m AOD) at a cost of £3 million with an implementation period of 18 months
- developing a national agreement with generator supply companies to be able to provide instant mobile generators to all critical operations

The costs given above relate to measures to protect or reduce the impact of future flooding on the port and do not refer specifically to damages caused by the 2013 to 2014 flood event. They were not therefore included in the total.

Best estimate of the damages

The information on grant funding and direct damages to infrastructure were obtained at the local (LLFA) level. Where appropriate, the figures were adjusted to provide an economic estimate of the costs. The data were finally aggregated to provide a best estimate of £1.8 million of the damages caused to port and harbour infrastructure during the winter 2013 to 2014 floods at the national scale.

The Annex 1 method statement summarises the approach used to develop the best estimate of the costs to the ports sector.

16.4 Determining the best estimate range

The data used to provide the best estimate of costs in each impact category were assessed to determine the associated uncertainty. The uncertainty rating was applied based on the availability and quality of the data obtained and the assumptions applied to the data to provide an economic cost estimate. The uncertainty rating was subsequently used to determine the potential range around the best estimate.

This approach was used to determine a range of flood damage costs to ports of £1.6 million to £2.1 million (Table 16.1). Further details on the methods used to develop the lower and higher ranges are provided below.

16.4.1 Low estimate

Information was obtained at the local (LLFA) level on damages to port infrastructure during the winter 2013 to 2014 floods. The majority of the costs relate to small ports grants provided by the government to local authorities to assist them in making infrastructure repairs. It is not clear whether the grants cover the full cost of repairs and therefore the best estimate (£1.8 million) is considered to be conservative and may

underestimate the actual costs incurred. The data were classified as having a moderate uncertainty rating because it was not possible to verify whether the grants covered the full cost of the damages and the adjustments made to the direct damages cost to provide an economic estimate.

A moderate uncertainty rating generally corresponds to a reduction of the best estimate by 20% to provide a low range estimate (Table 2.5). But given that the grant information is likely to provide a conservative estimate of the port damages (and is in fact likely to underestimate them), the best estimate (£1.8 million) was only reduced by 10%. This gives a low range estimate of the flood damages to port infrastructure during the 2013 to 2014 winter period of £1.6 million.

16.4.2 High estimate

A similar approach was used to obtain an upper range estimate. As indicated above, the information on direct damage costs and grants was classified as having a moderate uncertainty rating. This rating was assigned because it was not possible to verify whether the grants covered the full cost of the damage repairs and hence if the best estimate underestimates the costs incurred. There are also likely to be data gaps, with no information on the damages caused to ports in Wales. To reflect this uncertainty, the best estimate (£1.8 million) was increased by 20% (see Table 2.5), resulting in a high range estimate of the flood damages to ports during the 2013 to 2014 winter period of £2.1 million.

16.5 Damage costs by flood type

This section provides a breakdown of the damages/costs to ports as a result of the winter 2013 to 2014 floods by flood type. It includes details of the methods used to differentiate the damage costs and the associated uncertainties.

16.5.1 Approach to disaggregating the damage costs

The disaggregation of damages by flood type was based on the assumption that the majority of damages incurred by coastal LLFAs were caused by tidal surges. Although this is clearly a simplification, there are insufficient details to allow a more sophisticated analysis. Damages were not included where the damage figures specified the flood type and this did not relate to coastal impacts.

16.5.2 Summary of damage costs by flood type

Table 16.3 provides a summary of damages by flood type to ports. Because the damages figures have been rounded to 2 significant figures, the small amount of damages from coastal flooding does not affect the overall, rounded figure for fluvial and groundwater flooding.

Table 16.3 Estimated economic damage costs to ports by flood type

Flood source	Economic damage estimates					
	Best estimate		Low estimate		High estimate	
	Damage	Percentage of total	Damage	Percentage of total	Damage	Percentage of total
All (total)	£1.8	100%	£1.6	100%	£2.1	100%

Flood source	Economic damage estimates					
	million		million		million	
Fluvial/ groundwater	£1,200	0.1%	£1,100	0.1%	£1,400	0.1%
Coastal	£1.8 million	99.9%	£1.6 million	99.9%	£2.1 million	99.9%

Notes: Values are presented to 2 significant figures and therefore totals may not be exact sum of constituent parts due to rounding.

16.6 Damage costs for England and Wales

There was no information on ports damaged as a result of flooding in Wales and therefore the damage estimates provide damages for England only.

16.7 Uncertainties and assumptions

As previously discussed, the local level data obtained predominantly relate to the small ports grants from the government to assist ports and harbours in making repairs. These figures were used as a surrogate of the actual damage costs to ports and harbours, and represent the scale of the damages caused to these facilities during the winter 2013 to 2014 floods. However, the grants received may not cover the full cost of the repair works necessary and therefore these figures may underestimate the actual damage cost incurred.

To avoid double counting, flooding and water-related erosion damages to port infrastructure were included, where possible, in the transport: ports category and not in the businesses or local authorities and local government infrastructure categories. The grants from the small ports fund are considered to be in addition to insurable costs, and therefore were not considered to be double counted with insurable damages to privately owned ports that may be included in the businesses category. Where costs could not be disaggregated into their constituent parts, direct damage costs and repairs to ports owned or managed by private organisations or local authorities may be included in the businesses or local authorities and local government infrastructure categories respectively; thus, there is some potential for double counting.

In the case of the Port of Immingham, flooding caused damage to port businesses, with these considered to have been insurable costs included in the businesses category. They were therefore not included under in this category to avoid double counting. However, it is clear that the port was affected by flooding during the 2013 to 2014 winter storms, with detrimental effects for it and its associated businesses.

Despite extensive work to determine the flood damages to ports and harbours, there may have been other facilities that were affected and which are not included in this assessment. For example, the small ports fund was granted to affected facilities in England only; ports in Wales are therefore not included in the assessment.

The figures presented in this section may underestimate the overall damages caused to port infrastructure at the national level.

17 Impacts on transport: air

17.1 Summary of findings

Table 17.1 presents the headline figures for the impact category of transport: air. This category includes an estimate of the direct costs to Gatwick Airport (in terms of lost revenue) resulting from service disruption and welfare costs associated with disruption to passenger travel from flight cancellations caused by flooding during the 2013 to 2014 winter period. Direct costs to Gatwick Airport are not considered to have been captured in the insurable costs in the businesses category and are therefore not double counted.

The total costs attributed to the flooding caused to Gatwick Airport are therefore estimated as £3.2 million with a range of £2.6 million to £3.9 million.

Further details describing how the best estimate and range were determined are provided in the following sections.

Table 17.1 Headline findings for transport: air

Finding	Economic damage estimates			
	Best estimate (range)	% of total monetised damages	Uncertainty	Comments
2013 to 2014 damages (direct costs)	£250,000 (£200,000 to £300,000)	0.25% (of overall total damages)	Moderate	Based on costs from Gatwick Airport resulting from disruption caused by flooding. Range estimates are determined based on uncertainty rating.
2013 to 2014 damages (welfare costs)	£3.0 million (£2.4 million to £3.6 million)		Moderate	Based on number of passengers experiencing delays at Gatwick Airport and the cost of these delays. Range estimates are determined based on uncertainty rating.
2013 to 2014 damages (total)	£3.2 million (£2.6 million to £3.9 million)		Moderate	Based on a combination of the above estimates.
2013 to 2014 damages – England (direct costs)	£250,000 (£200,000 to £300,000)	100% (of direct damages for category)	Moderate	Based on costs from Gatwick Airport resulting from disruption caused by flooding. Range estimates are determined based on uncertainty rating.
2013 to 2014 damages – England (welfare	£3.0 million (£2.4 million to	100% (of welfare costs for category)	Moderate	Based on number of passengers experiencing delays

Finding	Economic damage estimates			
costs)	£3.6 million)			at Gatwick Airport and the cost of these delays. Range estimates are determined based on uncertainty rating.
2013 to 2014 damages – England (total)	£3.2 million (£2.6 million to £3.9 million)	100% (of total for category)	Moderate	Based on a combination of the above estimates.
2013 to 2014 damages – Wales (direct costs)	No data	0% (of total for category)	Moderate	No information available
2013 to 2014 damages – Wales (welfare costs)				
2013 to 2014 damages – Wales (total)				
2007 damages (2014 values)	Not calculated	-	No uncertainty score for air travel specifically	Environment Agency (2010)
	Best estimate	**Units**	**Uncertainty**	**Source of estimate**
Numbers affected	2	Airports flooded	Moderate–high	Data from affected airports (Shoreham, Gatwick; also impacts at Newcastle and Isles of Scilly with services disrupted/cancelled)
	Best estimate	**Range**	**Uncertainty**	**Source of estimate**
Damages per asset	Not available		Damages specific to affected airports	

Notes: Values presented to 2 significant figures.

Impacts on air transport are divided between those incurred by the operators and those by the users. Transport operators include the organisations responsible for maintenance of the assets (airports) as well as those responsible for running the services using those assets (including airlines). The impacts of flooding on transport operators can therefore include:

- damages to the assets themselves and any repair costs incurred to restore them so they are available for use
- response to flooding incidents in terms of changes to services, cancellations and delays and the costs incurred with these.

The main impacts on air travellers from the winter 2013 to 2014 floods were felt at Gatwick Airport. However, flights were also cancelled in Newcastle (ChronicleLive 2013) and the airport at Shoreham, West Sussex, was flooded (BBC News 2013f). Air connections to the Isles of Scilly were closed (Cornwall Council 2014b). However, details on the specific costs and disruption incurred at these three airports were not available. The flood related impacts to Gatwick Airport are considered to be the most significant.

The damages/costs to the air transport sector (Gatwick Airport only) as a result of the winter 2013 to 2014 floods are estimated as follows.

- Direct costs of £250,000 refer to an estimate of the direct costs (loss of revenue) to Gatwick Airport resulting from disruption caused by flooding (Gatwick Airport, personal communication from D. Elson, February 2015). These costs are not considered to be included in the insurable costs in the businesses category and are therefore not double counted.
- Welfare costs of £3.0 million (range £2.4 million to £3.6 million) refer to the estimated cost to passengers resulting from travel delays and disruption caused by flooding.

17.2 Determining the best estimate

17.2.1 Number of airports flooded

The bad weather experienced during the 2013 to 2014 winter storms caused flight delays and cancellations at a number of airports including Newcastle (ChronicleLive 2013) and the Isles of Scilly (Cornwall Council 2014b). However, only 2 airports were specifically affected by flooding during the 2013 to 2014 winter period: Shoreham airport in West Sussex was flooded (BBC News 2013f) along with Gatwick Airport in London (McMillan 2014).

The most significant impacts on air transport were felt at Gatwick Airport, which forms the focus of the assessment. Gatwick Airport is the world's busiest single runway airport and occupies a strategic location in the Greater London area, one of the busiest centres for air transport in the world. The airport is the UK's second busiest by passenger traffic, the tenth largest in Europe for international passengers, and handles approximately 25% of Greater London's traffic. In 2013, 35.4 million passengers passed through Gatwick. Gatwick Airport serves over 215 destinations worldwide with a diversified route network and a broad base of airlines with over 60 carriers operating regularly from the airport (McMillan 2014).

Gatwick's airfield operations were severely affected by the adverse weather late on 23 and early on 24 December 2013. In particular, 3 of the electrical substations serving the airfield were affected by flooding (McMillan 2014).

Flooding of electrical systems supplying Gatwick's North Terminal ultimately led to the cancellation of 72 departing flights, and 73 arriving flights. This resulted in 16,253 passengers experiencing flight cancellations with many more delayed. Overall, 146 of the 188 planned departures for the day were subject to delays of over 30 minutes, with more than 90 experiencing delays of up to 4 hours and around 50 of over 4 hours, with some flights being delayed by up to 13 hours. These delays affected thousands more passengers. The detrimental impact on passengers was magnified by the fact that this occurred on Christmas Eve, with many people wishing to travel to spend Christmas Day with friends and family (McMillan 2014).

River flows at the 3 watercourses, including the River Mole, in the immediate vicinity of the airport were at record levels and affected on the transportation links to and from Gatwick. This resulted in the closure of local roads, but more importantly closure of the main rail link to the airport and the M23 motorway. Although runway facilities operated throughout, facilities in the North Terminal were also affected (McMillan 2014).

The map in Figure 17.1 shows the location of the airports for which damage information is available.

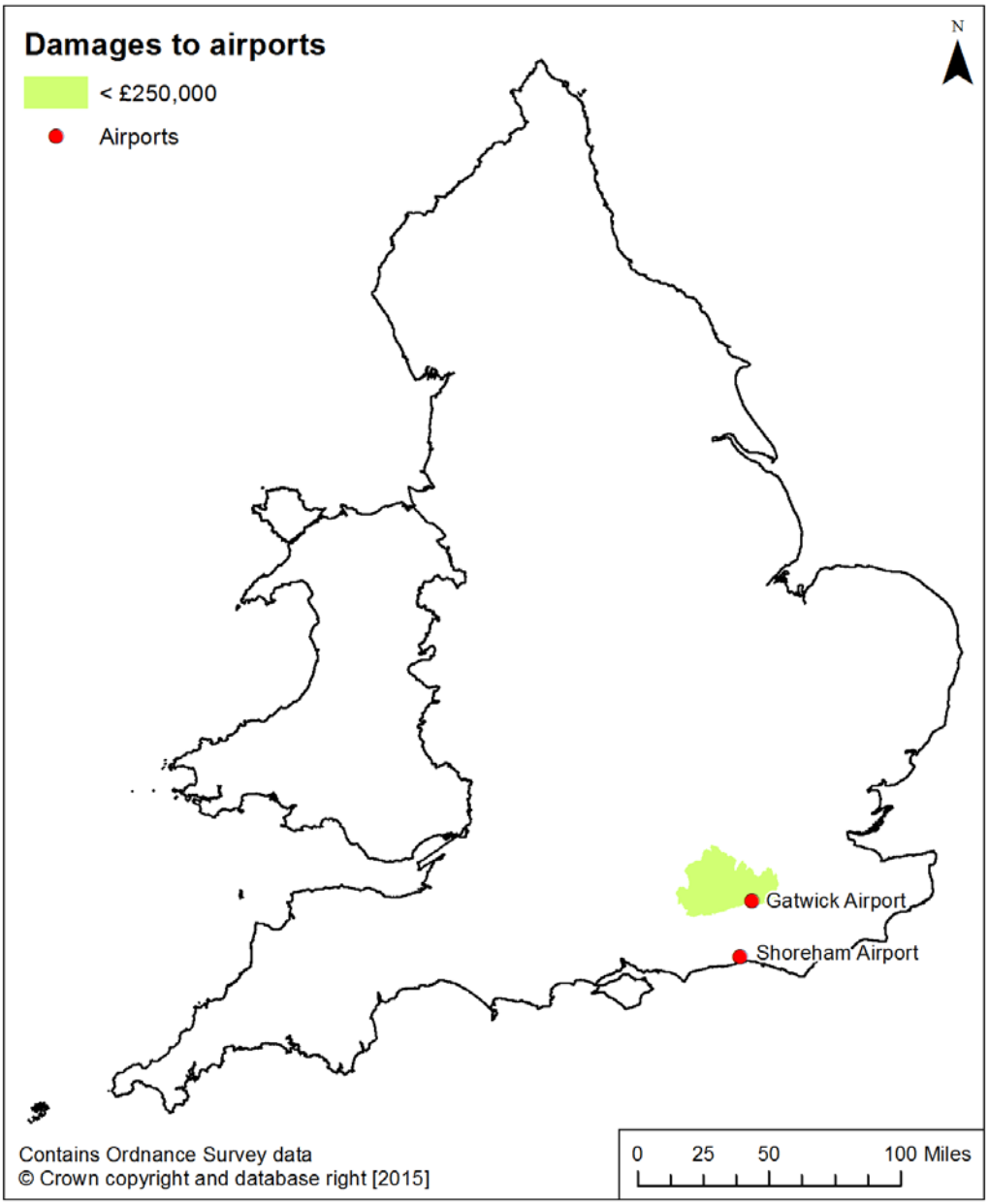

Figure 17.1 Estimated damages to the airport network from flooding for the 1 LLFA for which data were available

Notes: Only shows where data were available and data may also be incomplete.

17.2.2 Impacts on Gatwick Airport

Gatwick Airport Ltd (GAL) was consulted to determine the impact of the winter 2013 to 2014 floods on the airport's operations. GAL did not calculate specifically the cost of direct damage to the electrical failure resulting from flooding of the substations nor the financial loss to the airport, although a day's disruption at the airport with no flights would cost £1 million (personal communication from D. Elson, February 2015). As 70% of the flights were either not affected, or only marginally affected, the costs to GAL were estimated at £300,000 in lost revenue on the day.

A summary of the approach used to estimate the revenue losses experienced by GAL as a result of flooding is as follows:

Financial estimate of the loss of revenue for GAL as a result of flooding (£300,000) = Loss of revenue if all flights were cancelled (£1 million) × 30% (70% of flights were either not affected or only marginally affected during the floods)

This is considered to represent a financial cost and was therefore adjusted (by removing VAT at 20%) to provide an economic cost estimate of lost revenue of £250,000. These lost revenue costs are not considered to be included in the insurable costs in the businesses category and are not therefore double counted.

The calculation used to convert the financial revenue cost to an economic estimate is provided below:

Economic estimate of lost revenue to Gatwick Airport (£250,000) = Financial estimate of lost revenue to Gatwick Airport (£300,000) ÷ 1.2 (to remove VAT at 20%)

GAL indicated that the loss to the airport's reputation was more significant. Recovery costs of £30 million have been set aside (with £10 million already spent) to improve the resilience of airport infrastructure to flooding and improvements to power resilience. The ongoing cost of the increased regulation and governance applied to the airport by the Civil Aviation Authority is also largely unquantifiable as 'it is just an additional task for many managers at GAL' (personal communication with D. Elson, February 2015). Gatwick Airport had previously spent £20 million on flood defence following the change of ownership in 2009 (McMillan 2014). This expenditure was felt to have paid off as the South Terminal – generally considered to be at greatest risk of flooding – did not flood in the winter 2013 to 2014 events.

The prevention of the recurrence of such disruption at the airport is of critical importance, not only because it is a major transport hub but also because it is an important driver of the local, subregional and regional economies. The airport supports 41,700 jobs across London and the south-east, and generates £1,972 million of GVA per year. Gatwick Airport handled 15% of all UK airport passengers in 2011. Passenger numbers are projected to increase from 33.7 million per year in 2011 to 40 million per year by 2021 to 2022 (Optimal Economics 2012).

With strong competition between airports at the UK, European and international level, the recurrence of such disruption could damage the airport's image and reputation as a major international airport and lead to the loss of flight operators and passenger numbers. This would have an adverse knock-on economic effect at the local, subregional and regional levels.

The main sources of disruption due to the failure of the power systems led to the following issues (McMillan 2014).

- Only 2 of the 9 international baggage reclaim belts remained operational.
- There was no power and no lights in the baggage reclaim hall.
- There were no check-in systems operating.
- Flight information screens were out of operation.
- Telephone systems did not work.
- Only out-of-gauge luggage check-in belts were operational.
- The toilet flushing mechanisms on the ground and first floors (that use electronic systems) stopped working.

The best estimate of the direct impact of the 2013 to 2014 floods to GAL is considered to be £250,000, which relates to the economic estimate of revenue losses.

Although GAL has spent a considerable amount on improving flood resilience measures, these do not relate directly to the damages caused by the 2013 to 2104 winter floods and therefore were not used in determining the best estimate.

17.2.3 Welfare costs

In addition to the direct impacts to GAL, flight delays and cancellations caused considerable disruption to air passengers. Flooding of electrical systems supplying Gatwick's North Terminal resulted in 16,253 passengers experiencing flight cancellations (McMillan 2014).

EasyJet was the worst affected carrier and the welfare of its and other operators' passengers was badly affected, with 16 more flights diverted than the next most affected operator which was British Airways (McMillan 2014). Quantifying this disruption is difficult but, under EC Regulation 261/2004, cancellation of flights attracts compensation and the right for passengers to receive meals/refreshments and overnight accommodation should this be required. Compensation payments are paid 'other than as a result of extraordinary circumstances'. Adverse weather is, however, regarded as 'an extraordinary circumstance' and, unlike compensation for delays as a result of adverse weather to the rail network, is only paid if the airline is at fault.

There is no doubt that passengers suffered delay and inconvenience, and as an optimistic assessment of this, a value of €250 or £183[7] (the amount payable under EC Regulation 261/2004 for flights less than 1,500km) might be fairly applied to monetise passenger loss. This compensation cost is used as a surrogate of the welfare impacts experienced by passengers who had flights cancelled due to flooding of Gatwick Airport rather than as an indication of any compensation that may have been due.

To determine the best estimate of the welfare costs to passengers affected by flight cancellations, the compensation payment (€250 or £183) was applied to the number of passengers experiencing flight cancellations due to flooding (16,253) to provide a total welfare cost of £3.0 million.

A summary of the calculation used to estimate the welfare costs to passengers of flight cancellations is provided below:

> Estimate of the welfare costs to passengers affected by flight cancellations due to flooding = Number of passengers affected by flight cancellations due to flooding (16,253) × Compensation payment per passenger (£183, using figures from EC Regulation 261/2004 for flights less than 1,500km)

17.2.4 Best estimate of the impacts attributed to flooding of Gatwick Airport

Table 17.2 provides a summary of the economic cost estimates of the revenue losses to Gatwick Airport and the welfare costs to passengers experiencing flight cancellations during the winter 2013 to 2014 floods. The best estimate of the revenue losses to Gatwick Airport as a result of flooding is £250,000 and welfare costs (relating to flight cancellations) of £3.0 million. Combining these provides a best estimate of the costs of the winter 2013 to 2014 floods to Gatwick Airport of £3.2 million (to 2 significant figures). The Annex 1 method statement summarises the approach used to develop the best estimate of the flood related affected to Gatwick Airport.

[7] According to the conversion rate at the time of writing.

Table 17.2 Best estimate of the economic costs of flooding to Gatwick Airport

Cost type	Best estimate
Direct costs	£250,000
Welfare costs	£3.0 million
Total costs	£3.2 million

Notes: Values are presented to 2 significant figures.

17.3 Determining the best estimate range

17.3.1 Impacts to Gatwick Airport: flood related losses

As described in Section 2.3.4, the data used to provide the best estimate of costs in each impact category were assessed to determine the associated uncertainty. The uncertainty rating was applied based on the availability and quality of the data obtained and the assumptions applied to the data to provide an economic cost estimate. The uncertainty rating was subsequently used to determine the potential range around the best estimate.

This approach was used to determine a range of flood related losses to Gatwick Airport of £200,000 to £300,000 (Table 17.1). Further details on the methods used to develop the lower and higher ranges are provided below.

Low estimate

An estimate of the potential loss of revenue resulting from delayed or cancelled flights of £300,000 was provided by GAL. This is considered to represent a financial loss and was therefore adjusted (by removing VAT at 20%) to provide an economic loss of £250,000. GAL did not specifically calculate the direct damage cost of the flooding and the figure provided on the potential losses is an estimate. Therefore, the costs were classified as having a moderate uncertainty given that the figure provided is an estimate and required adjustment to provide an economic estimate. To reflect this uncertainty, the best estimate (£250,000) was reduced by 20% (see Table 2.5), resulting in a low range estimate of flood-related revenue losses to Gatwick Airport during the 2013 to 2014 winter period of £200,000.

High estimate

A similar approach was used to obtain an upper range estimate. Reflecting moderate uncertainty, the best estimate (£250,000) was increased by 20% (see Table 2.5), resulting in a high range estimate of the revenue losses to Gatwick Airport as a result of flooding during the 2013 to 2014 winter period of £300,000.

17.3.2 Impacts to Gatwick Airport: welfare costs

The best estimate was assessed to determine the associated uncertainty with an uncertainty rating allocated and subsequently used in estimating a range. This approach was used to determine a range of welfare costs to passengers using Gatwick Airport and experiencing delays and cancellations as a result of winter 2013 to 2014 floods of £2.4 million to £3.6 million (Table 17.1). Further details on the methods used to develop the lower and higher ranges are provided below.

Low estimate

The best estimate of the welfare costs to passengers affected by flight cancellations due to flooding at Gatwick Airport was determined by using the compensation amount for cancelled or delayed flights payable to passengers under EC Regulation 261/2004 for flights less than 1,500km (€250) and applying this to the number of passengers affected (16,253 passengers had flights cancelled). This payment was used as a surrogate of the welfare impacts experienced by passengers who had flights cancelled due to flooding of Gatwick Airport. However, it is not clear whether this payment accurately reflects the welfare impacts experienced by passengers and the data were therefore classified as having a moderate uncertainty rating. To reflect this uncertainty, the best estimate (£3.0 million) was reduced by 20% (see Table 2.5), resulting in a low range estimate of the welfare impacts experienced by passengers who had flights cancelled due to flooding of Gatwick Airport during the 2013 to 2014 winter period of £2.4 million.

High estimate

A similar approach was used to obtain an upper range estimate. A moderate uncertainty was assigned to the estimate of the welfare impacts experienced by passengers who had flights cancelled due to flooding of Gatwick Airport. This rating was assigned because it was not possible to verify whether the estimated welfare costs accurately reflected the disruption caused to passengers. In addition, the best estimate accounts only for disruption caused to passengers for cancelled flights, with many more passengers considered to have been affected by delayed flights. To reflect the moderate uncertainty rating, the best estimate (£3.0 million) was increased by 20% (see Table 2.5), resulting in a high range estimate of the welfare impacts experienced by passengers who had flights cancelled due to flooding of Gatwick Airport during the 2013 to 2014 winter period of £3.6 million.

17.3.3 Overall range of the costs to the air travel sector (Gatwick Airport)

Table 17.3 provides a summary of the best estimate and associated ranges of the revenue losses to Gatwick Airport and welfare costs (of flight cancellations) caused by the winter 2013 to 2014 floods. The best estimate of the costs to Gatwick Airport and welfare costs resulting from flight cancellations is £3.2 million, with a range of £2.6 million to £3.9 million.

Table 17.3 Range of economic costs to the air travel sector

Cost type	Best estimate	Low estimate	High estimate
Direct costs	£250,000	£200,000	£300,000
Welfare costs	£3.0 million	£2.4 million	£3.6 million
Total costs	£3.2 million	£2.6 million	£3.9 million

Notes: Values are presented to 2 significant figures.

17.4 Damage costs by flood type

Damages to the air transport sector are considered to be almost entirely fluvial. The damage figures providing the overall total are based solely on damages to Gatwick

Airport (which were due to fluvial flooding) with some damages from flooding of Shoreham Airport (source unclear). It is likely there were other damages which have not been captured, such as impacts to Newcastle Airport and the Isles of Scilly air connection), but these figures were not available. It was also unclear if the impacts on these airports were due to flooding or the weather conditions more generally. Therefore the total figure for damages to air transport given here are attributed to fluvial flooding.

17.5 Damage costs for England and Wales

The cost information obtained on flooding impacts to airports refers solely to Gatwick Airport. There is also qualitative information for Shoreham Airport. Both these airports are in England. No details were obtained on flooding impacts to airports in Wales during the 2013 to 2014 winter period. Therefore, the costs presented above relate to England and Gatwick Airport more specifically.

17.6 Uncertainties and assumptions

Two airports (Gatwick and Shoreham) are known to have been affected by flooding during the 2013 to 2014 winter storms, with information to enable the estimation of damages only available for Gatwick. Flights and services were also cancelled at Newcastle Airport and the Isles of Scilly, but no data on impacts on airlines or passengers were obtained. Damages to Gatwick Airport do not include the costs of repairing assets, as these were not estimated by the airport. In addition, the impact of the delays caused by flooding on the airport's reputation was not quantified. As a result, the flood related damages are underestimated.

Compensation payments have been used to provide an estimate of welfare costs to passengers. The extent to which these payments adequately reflect the impacts felt by passengers is not known, although the timing of the disruption (Christmas Eve) may mean that welfare costs would be higher than average. A range was developed to highlight the potential uncertainty surrounding the best estimate.

18 Impacts on other communications (telecom)

18.1 Summary of findings

For telecommunications, a study by Ofcom into the impact of the winter floods on fixed and mobile sector networks and services found that service providers were generally prepared and able to cope with severe weather (Ofcom 2014). While there was an increase in the average duration of incidents, there was no increase in the average number of incidents over the winter 2013 to 2014 floods period (Ofcom 2014).

Utilities operators worked to keep their assets safe from floodwaters and also tried to maintain or restore services where the flooding occurred. Direct impacts on utilities were caused by floodwaters and the tidal surge. However, no obvious correlation was identified between the locations of telecommunications incidents and levels of rainfall (Ofcom 2014).

Assets were also affected in other ways. Saturated ground conditions affected the vulnerability of trees to storm conditions (Energypeople 2014). Telephone lines were pulled down, for example, at Temple Lock in Buckinghamshire (Environment Agency 2014i). Part of Great Shefford in West Berkshire was also without landline phones in March 2014 due to the BT infrastructure being affected by groundwater (Richardson 2014).

Discussions with Openreach suggested that the losses due to flooding were very small; it is therefore likely that improved infrastructure resilience to flood related damage resulted in limited impacts from the 2013 to 2014 event. As a result, there are no monetary estimates of damages for this impact category.

19 Impacts on public health and welfare

19.1 Summary of findings

Table 19.1 presents the headline figures for the impact category of public health and welfare. This category attempts to monetise the impacts of flooding on mental health, concentrating on households inundated by floodwater.

Based on the approach used by Environment Agency (2010) to estimate damages from the 2007 floods, the impacts of flooding on mental health are estimated at between £25 million and £67 million. There are no damage estimates for the repair of public health assets that may have been flooded. The only information on where such assets may have been affected is taken from the flood extent maps. There were no fatalities directly associated with the flooding, although some deaths did occur due to storms and high seas. Evidence suggests that there were also a small number of injuries. A number of ongoing studies may provide additional information or damage estimates to public health and welfare.

Further details describing how the best estimate and range were determined are provided in the following sections.

Table 19.1 Headline findings for public health and welfare

Finding	Economic damage estimates			
	Best estimate (range)	% of total monetised damages	Uncertainty	Comments
2013 to 2014 impacts (total)	£25 million (£25 million to £67 million)	1.9% (of overall total damages)	High	Estimates based on impacts of flooding on mental health. Low and high estimates determined by varying assumptions on number of households affected.
2013 to 2014 damages (England)	£24 million (£24 million to £66 million)	98% (of total for category)	High	Calculated by determining the proportion of all properties flooded located in England (98%) and applying this to the mental health impacts.
2013 to 2014 damages (Wales)	£510,000 (£510,000 to £1,400,000)	2% (of total for category)	High	Calculated by determining the proportion of all properties flooded located in Wales (2%) and applying this to the mental health impacts.
2007 damages	£340 million	8.7% (of	Score: 3–4	Environment Agency

Finding	Economic damage estimates			
(2014 values)		overall total damages in 2007)	(gross assumption to heroic assumptions)	(2010)
	Best estimate	**Units**	**Uncertainty**	**Source of estimate**
Numbers affected (total)	16	Public health assets potentially flooded	High	Based on flood outline data – not clear if assets were actually flooded or not.
Numbers affected (England)	16	Public health assets potentially flooded	High	Based on flood outline data –not clear if assets were actually flooded or not.
Numbers affected (Wales)	None identified	Public health assets potentially flooded	High	Based on flood outline data.
	Best estimate	**Range**	**Uncertainty**	**Source of estimate**
Damages per asset	Not available		Damages on specific assets not available	

Notes: Values presented to 2 significant figures.

19.2 Determining the best estimate

19.2.1 Impacts of the floods on public health assets

There was a lack of specific information on any potential damages to public health assets. It was therefore not possible to include this element in the best estimate for this category. Indeed it is not clear whether there were any flood related damages to public health infrastructure during the 2013 to 2014 winter period.

Further details of the impacts of the floods on public health are provided in the following sections, including an overview of how monetisation of the impacts of the 2013 to 2014 floods on mental health was estimated.

19.2.2 Impacts linked to fatalities and injuries

Information obtained from internet searches revealed there were no fatalities linked directly to flooding during the winter 2013 to 2014 floods although, sadly, one man is reported to have drowned in Porthleven on New Year's Day 2014 (Andrew 2014). The storms also cost the lives of 3 people in Devon in early January, 2 of whom were washed out to sea (Devon County Council 2014b, Environment Agency 2014g).

In addition there were injuries associated with the floods, including a resident in the village of Kingsand in south-east Cornwall who received a head injury when a wave washed into his property and an elderly lady injured in St Ives when she was washed off her feet on the seafront (Andrew 2014). A policeman was injured while helping the evacuation of residents in Dawlish, suffering a fractured shoulder (Torquay Herald Express 2014) and one resident suffered a fractured wrist in Torcross, Devon (Environment Agency 2014d).

Although the effect of the injuries can be significant for the individuals and families involved, the overall impact of the floods on physical health is considered to be low given the widespread nature of the flooding. As a result the monetary impact of these injuries was not included in the best estimate.

19.2.3 Impacts linked to contaminated floodwaters

Some localised events with the potential to impact public health were reported by Muchan et al. (2015). High water levels surcharged sewers (for example, in the Pang and Lambourn Chalk Valleys in Berkshire and Jurassic limestone in Cirencester) and resulted in floodwaters becoming contaminated. In addition, high groundwater levels brought historic plumes of solvent to the surface (for example, at Harwell in Oxfordshire) and mobilised banned pesticides from the unsaturated zone. There was also an increase in sinkholes (22 across England in February 2014). However, no further details on the effect of these events on public health were obtained and it was therefore not possible to monetise the impacts for inclusion in the best estimate.

19.2.4 Studies on physical and mental health impacts of the 2013 to 2014 event

The social disruption caused by floods can affect the quality of life of individuals and impact on the fabric of affected communities (Gordon, 2004). As well as the physical and health dangers of flood waters, the psychological impact of the emergency and aftermath causes longer term effects that may be exacerbated by stresses such as having to move out of the home, cleaning up, negotiating with insurers and getting damage repaired and goods replaced (RPA, 2005). Even when the 'recovery' phase is over, there may be difficulties caused by living with the ongoing risk, obtaining and paying for insurance and the effect on house prices and community cohesion.

Many studies on the health impacts of the winter floods are still ongoing. Organisations carrying out work to assess these impacts include (Bailey 2015):

- Birmingham University – studying in real-time the factors that enable or inhibit fast and effective flood recovery from the perspectives of businesses, homeowners, local communities and environmental quality
- Public Health England – quantifying the impact of flooding on mental illness, mental health and wellbeing
- Lancaster University and Save the Children UK – conducting a project called ‘Children, Young People and Disasters: Recovery and Resilience’).

The most relevant of these studies is that being conducted by Public Health England in which around 4,000 adults affected by flooding will be studied in the short term and then at annual intervals for 10 years to quantify health impacts now and in the long term (Bailey 2015).

Information on the health impacts of the floods is currently limited. Four surveillance reports published by Public Health England (2014a, 2014b, 2014c, 2014d) found that there was ‘nothing of public health significance to report’ with regard to local flood-related events. The only health concerns highlighted in these reports were from possible overtopping of excess untreated mine water into the Carnon River, but this did not occur.

A study by researchers at the University of Exeter on the health and wellbeing impacts of the winter 2013 to 2014 floods concluded that, although few participants cited

physical health impacts due to the floods, those that did linked these to stress and anxiety caused by having been flooded. Mental health and wellbeing effects were reported by the majority of the study participants in Somerset, both at the community and individual levels, irrespective of flooding experience (Walker-Springett and Butler 2015).

Walker-Springett and Butler (2015) found that individuals who were not flooded reported continued levels of stress and anxiety throughout the event related to not knowing if they would be flooded. For flooded households, the impacts of secondary stressors, such as dealing with insurance companies and performing recovery activities, are often not captured and are difficult to quantify. Yet these factors have been found to affect mental health (Walker-Springett and Butler 2015).

Further to these unquantified impacts, there are also the tensions which arise between flooded communities and those areas that were unaffected. This may negate the positive impacts from the floods of enhanced community spirit which are considered to have positive effects for resilience, stress and wellbeing at the individual level (Walker-Springett and Butler 2015).

19.2.5 Estimation of the mental health impacts of flooding

Paranjothy et al. (2011) examined the prevalence of ailments in a survey carried out in two area badly affected by the 2007 floods. They found that:

- 39% considered that flooding had affected their physical health
- 67% considered that flooding had affected their mental health

A comparison of the levels of symptoms between those who had been flooded and those who had not found that:

- 69% had suffered psychological distress, compared with 14% in the non-flooded group
- 48% had suffered from probable anxiety, compared with 5% in the non-flooded group
- 43% had suffered from probable depression, compared with 7% in the non-flooded group
- 22% had suffered from probable post-traumatic stress disorder (PTSD), compared with 2% in the non-flooded group

The simple assumption that these percentages could apply to the 10,465 households affected by the 2013 to 2014 floods (Table 5.2) would suggest that:

- 4,081 (39%) households could have seen impacts on their physical health
- 7,012 (67%) households could have seen impacts on their mental health, **of which:**
  - 4,838 (69%) households could contain someone suffering from psychological distress, of whom 982 (14%) households would likely already have seen some impact suggesting an increase due to flooding of 3,856 households

However, these figures on the number of households potentially experiencing physical and mental health issues as a result of the 2013 to 2014 floods are based on assumptions from the 2007 event and are therefore uncertain.

The 2007 floods report (Environment Agency 2010) used a value of £261 (uprated to 2014 prices) per household to reflect distress caused by flooding; this is equivalent to £6,400 per household in 2014 prices over 50 years at 3.5%.[8] However, this value is likely to seriously underestimate the impacts.

A possible alternative is to use the costs of treating mental illness or the benefits of the results of such treatment (assuming the benefits of treatment are the same as avoiding the damages in the first place). The Mental Health Foundation identifies the costs of treatment through improved access to psychological therapies as £840 per patient, and the benefits in the first 2 years of £1,300 from extra GDP, £340 in NHS savings and £3,700 in reduced suffering (Cyhlarova et al. 2010). This gives a total of £6,200 per household affected over 2 years or £3,100 per year (all values uprated to 2014 prices). It is assumed that these impacts could last for 2 years such that economic impacts are estimated at £6,200.[9] This calculation suggests that the approach used in the 2007 floods report (Environment Agency 2010) may provide an appropriate estimate.

The damages caused due to increased impacts on mental health can therefore be estimated based on:

- 3,856 households as the number of those potentially additionally affected (this assumes that any one household could suffer from more than one symptom)
- a cost of £6,400 per household affected – or consistency with the approach used for the 2007 floods (Environment Agency 2010)

A summary of the four-stage calculation used to estimate the number of households experiencing an increase in psychological distress due to flooding (3,856) is provided below:

Estimate of the number of households experiencing an increase in psychological distress due to flooding (3,856) =

(1) Multiply the number of households affected by flooding (10,465 based on local level data) by 67% (it is assumed that 67% of households flooded had their mental health affected, based on paper by Paranjothy et al. 2011). This gives 7,012 households having seen impacts on mental health as a result of flooding.

(2) Multiply the answer from (1) by 69% (the proportion of households with someone suffering from psychological distress due to flooding, based on paper by Paranjothy et al. 2011). This gives 4,838 households with someone suffering from psychological distress due to flooding.

(3) Multiply the answer from (1) by 14% (the proportion of households with someone already suffering from psychological distress (not flood related), based on paper by Paranjothy et al. 2011). This gives 982 households with someone already suffering from psychological distress (not flood related).

(4) Subject the answer from (3) from the answer from (2). This gives 3,856 households experiencing an increase in psychological distress due to flooding.

Using the estimate of 3,856 households experiencing an increase in psychological distress due to flooding during the 2013 to 2014 winter period and assuming a welfare cost of £6,400 per household gives a total mental health cost of £25 million (presented to 2 significant figures).

[8] Assuming the sum of the discount factors from years 0 to 49, that is, 24.495.
[9] Using the sum of the discount factors over years 0 and 1 of 1.966 (using HM Treasury's discount rate of 3.5%)

A summary of the calculation used to estimate the impact of flooding on mental health is provided below:

> Estimate of the impact of the 2013 to 2014 floods on mental health (£25 million) = Estimate of the number of households experiencing an increase in psychological distress due to flooding (3,856) × Estimate of the impact of flood related distress per household (£6,400)

19.3 Determining the best estimate range

19.3.1 Impacts of flooding on mental health

A range of welfare costs to people experiencing mental health impacts as a result of winter 2013 to 2014 floods of £25 million to £67 million has been determined. Further details on the methods used to develop the lower and higher ranges are provided below. In this case, the best estimate was classified as having a high uncertainty rating

Low estimate

The best estimate of the impacts to mental health resulting from the winter 2013 to 2014 floods was determined by estimating the number of households experiencing an increase in psychological distress due to flooding (3,856) and using an average welfare cost of distress of £6,400 per household. This gives an estimate of the total mental health costs caused by the 2013 to 2014 floods of £25 million. This low estimate is also used as the best. The Annex 1 method statement summarises the approach used to develop the best estimate of the mental health impacts resulting from the floods.

High estimate

The upper estimate was determined using a similar approach to that used to calculate the low range estimate. However, the high range estimate assumes that all 10,465 households affected by the winter 2013 to 2014 floods experienced psychological distress. Assuming that 10,465 households were affected with an average welfare cost of distress of £6,400 per household (assuming that value includes an adjustment for the percentage likely to be affected) gives an upper estimate of the mental health impacts resulting from flooding of £67 million.

A summary of the calculation used to provide the upper estimate of flooding impact on mental health is provided below:

> Upper estimate of the impact of the 2013 to 2014 floods on mental health (£67 million) = Estimate of the number of households affected by flooding (10,465 assuming that all households flooded experienced an increase in psychological distress) × Estimate of the impact of flood related distress per household (£6,400)

19.4 Damage costs by flood type

This section provides a breakdown of the costs to public health as a result of the winter 2013 to 2014 floods by flood type. It includes details of the methods used to differentiate the damage costs and the associated uncertainties.

19.4.1 Approach to disaggregating the damage costs

The impacts on mental health resulting from the winter 2013 to 2014 floods were determined by estimating the number of households experiencing an increase in psychological distress due to flooding (3,856 in the low range and best estimate and 10,465 in the high range estimate) and using an average welfare cost of distress of £6,400 per household.

These estimates are based on the number of residential properties considered to have flooded. Of the 10,465 residential properties considered to have flooded during the 2013 to 2014 winter period, 6,296 (60%) were affected by fluvial/groundwater flooding and 4,169 (40%) were affected by coastal flooding (Table 5.2). This percentage split was applied to the total mental health costs (all households affected) to estimate the impacts caused by fluvial/groundwater and coastal flooding separately. This approach assumes that mental health is equally affected by fluvial/groundwater flooding and coastal flooding (that is, that the impact of fluvial/groundwater and coastal flooding on mental health are similar).

19.4.2 Damages costs by flood type

Table 19.2 provides a summary of the mental health impacts by type of flood during the 2013 to 2014 winter period. Using the approach outlined above gives a range for the impact costs for fluvial/groundwater and coastal flooding of £15 million to £40 million and £9.8 million to £27 million respectively. In both cases the low range estimate was selected as the best estimate to avoid overestimation of the impacts.

Table 19.2 Estimated costs of mental health impacts resulting from fluvial/groundwater and coastal flooding during the 2013 to 2014 winter period

Flood source	Cost estimates					
	Best estimate	Percentage of total	Low estimate	Percentage of total	High estimate	Percentage of total
All (total)	£25 million	100%	£25 million	100%	£67 million	100%
Fluvial/ groundwater	£15 million	60%	£15 million	60%	£40 million	60%
Coastal	£9.8 million	40%	£9.8 million	40%	£27 million	40%

Notes: Values are presented to 2 significant figures and therefore the totals may not be the exact sum of constituent parts due to rounding.

19.5 Damage costs for England and Wales

This section provides a breakdown of the impacts to public health as a result of the winter 2013 to 2014 floods for England and Wales. It includes details of the method used to differentiate the damage costs and the associated uncertainties.

19.5.1 Approach to disaggregating the damage costs

The mental health impacts of the winter 2013 to 2014 floods were estimated using the number of residential properties considered to have flooded during this period and applying an average welfare cost of £6,400 per household. The number of properties

considered to have flooded was obtained at the local (LLFA) level and can therefore be separated for England and Wales.

Of the 10,465 residential properties considered to have flooded during the 2013 to 2014 winter period, 10,247 (98%) were located in England and 218 (2%) in Wales (Table 5.2). This percentage split was therefore applied to the total mental health costs (all households affected) to provide an estimate of the impacts in England and Wales separately. This approach assumes that the mental health impacts were similar in both England and Wales.

19.5.2 Damage costs for England/Wales

Table 19.3 provides a summary of the mental health impacts during the winter 2013 to 2014 floods for both England and Wales. The approach outlined above gives a range of the impact costs applicable to England and Wales of £24 million to £66 million and £510,000 to £1.4 million respectively. In each case the low range estimate was selected as the best estimate to avoid overestimation of the impacts.

Table 19.3 Estimated costs of mental health impacts during the 2013 to 2014 winter period in England and Wales

Flood source	Cost estimates					
	Best estimate	Percentage of total	Low estimate	Percentage of total	High estimate	Percentage of total
All (total)	£25 million	100%	£25 million	100%	£67 million	100%
England	£24 million	98%	£24 million	98%	£66 million	98%
Wales	£510,000	2%	£510,000	2%	£1.4 million	2%

Notes: Values are presented to 2 significant figures and therefore the totals may not be the exact sum of constituent parts due to rounding.

19.6 Uncertainties and assumptions

There are uncertainties over the impacts to mental health during the winter 2013 to 2014 floods due to the number of assumptions that had to be made. The most important assumptions relate to the number of households experiencing psychological distress as a result of flooding and the impact (in monetary terms) of this distress. The range of damages linked to mental health impacts (£25 million to £67 million) gives an indication of the level of uncertainty. Some ongoing studies may provide further information that will enable some of these assumptions to be revised such that a more reliable estimate of impacts on public health and welfare can be made.

20 Impacts on education

20.1 Summary of findings

Table 20.1 presents the headline figures for the impact category of education. This category includes details of the impacts of flooding on educational assets such as schools and colleges during the 2013 to 2014 winter period. The best estimate is £1.6 million, with a range of £1.2 million to £2.0 million.

The best estimate was determined by extrapolating local data using a damage per asset figure (in economic terms) of £42,000 and applying this to the number of educational assets considered to have been affected by flooding. It was not possible to obtain any national level data on flooding damages and therefore extrapolation of the local level data was considered to provide the most reliable figure (albeit uncertain). Further details describing how the best estimate and range were determined are provided in the following sections.

In the 2007 floods assessment (Environment Agency 2010), the main economic impact of the floods related to the loss of learning resulting from the closure of educational facilities (based on an estimate of 400,000 pupil days lost). This information was obtained from parliamentary reports; however similar reports were not available when producing this 2013 to 2014 assessment. Therefore, it was not possible to estimate the potential impact of the winter 2013 to 2014 floods on the loss of learning experienced by students.

To avoid double counting, the cost of damages or repairs to educational assets as a result of the flooding are included, where possible, in the education category rather than the local authorities and local government infrastructure category. The risk of double counting with the local authorities and local government infrastructure category where specific costs could not be broken down into their constituent parts has been managed to the extent possible.

Table 20.1 Headline findings for education

Finding	Economic damage estimates			
	Best estimate (range)	**% of total monetised damages**	**Uncertainty**	**Comments**
2013 to 2014 damages (total)	£1.6 million (£1.2 million to £2.0 million)	0.13% (of overall total damages)	Moderate–high	Based on extrapolation of local data using an average damage estimate per educational asset. Range estimates are determined based on uncertainty rating.
2013 to 2014 damages (England)	£1.6 million (£1.2 million to £2.0 million)	100% (of total for category)	Moderate–high	Refers to the proportion of total costs attributable to England. Range estimates are determined based on uncertainty rating.

Finding	Economic damage estimates			
2013 to 2014 damages (Wales)	No data	0% (of total for category)	High	No damages found
2007 damages (2014 values)	£14 million	0.4% (of overall total damages in 2007)	Score: 3-4 (gross assumptions – heroic assumptions)	Environment Agency (2010)
	Best estimate	**Units**	**Uncertainty**	**Source of estimate**
Numbers affected (total)	39	Number of education assets affected	Moderate–high	Based on local data and flood outline data.
Numbers affected (England)	39	Number of education assets affected	Moderate–high	Based on local data and flood outline data.
Numbers affected (Wales)	No assets found to have been damaged	No damages found	High	No damages found
	Best estimate	**Range**	**Uncertainty**	**Source of estimate**
Damages per asset	£42,000	Based on a single data point	High	Based on local damage data from a single data point (note that this refers to an economic cost).

Notes: Values presented to 2 significant figures.

20.2 Determining the best estimate

20.2.1 Number of educational assets flooded

Internet research and consultation was conducted to determine the number of educational assets (schools, colleges, universities and so on) affected by flooding during the 2013 to 2014 winter period.

Information obtained at the local (LLFA) level and the use of Environment Agency flood outline data suggest that a total of 39 educational assets were affected. This includes 5 schools in Saffron Walden in Essex (Cambridge News 2014a), 4 in Lowestoft in Suffolk that were closed due to access roads being flooded (Osman 2014) and 6 in Tewkesbury on Gloucestershire (BBC News 2014a). In North Lincolnshire, Gunness and Burringham Church of England Primary School was flooded due to the tidal surge and alternative temporary accommodation was found at the Riddings Infant School (Gunness and Burringham Primary School 2014).

Flooding also resulted in operational impacts for educational facilities, in addition to direct damages. For example, Caversham Children's Centre in Reading was closed due to water levels affecting the toilets, which could not be flushed (Reading Borough Council 2014a). In West Berkshire, the main causes of school closures were poor road conditions and flooding in and around school sites, although no schools actually flooded. The impacts may have been greater had the timing of the floods not coincided, to some extent with half-term (Simmonds 2014). In Hertfordshire, access to the school of St Clement Danes was more difficult as students were forced to either walk in nearby fields or through the flood, although the flood at times became impassable to both vehicles and pedestrians) (McCloy Consulting 2014).

For the purposes of this assessment, the figure of 39 educational assets affected was assumed to represent the number of assets directly affected by flooding during the winter 2013 to 2014 floods and was therefore taken as the best estimate. These data include schools, colleges, universities and nurseries, but it was not possible to differentiate between them. Although some of the assets included in the flood outline data may not have actually flooded, it was not possible to determine whether or not this was the case for each individual site. The flood outline data were therefore used in cases where no alternative information was available.

The map in Figure 20.1 shows the distribution of educational assets flooded.

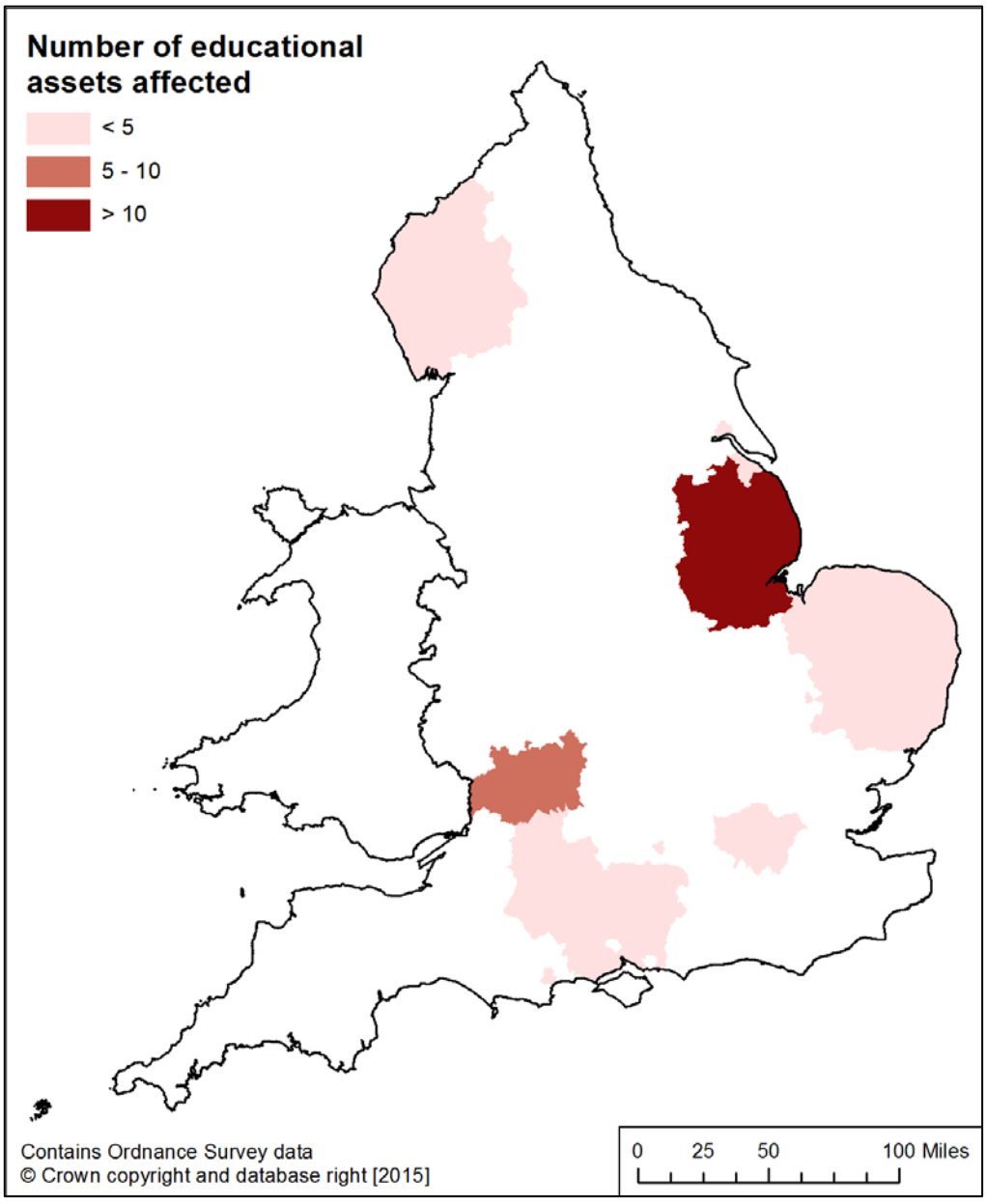

Figure 20.1 Number of educational assets damaged for the 12 LLFAs for which data were available

Notes: Only shows where data were available and data may also be incomplete.

20.2.2 Damages to educational assets from flooding

Despite research to determine the damage costs of the winter 2013 to 2014 floods on educational assets, a cost figure was obtained for only one site.

Flood repairs at Vernham Deane School in Andover amounted to approximately £100,000 (Hampshire County Council 2014). To convert this financial damage cost to an economic value, the figure was adjusted to account for betterment. It is assumed that an asset damaged by flooding was part way through its serviceable life. Therefore, repair or replacement of the damaged asset effectively improves the condition of the asset, potentially extending its serviceable life. Hence, it was not deemed appropriate to take the full damage cost as the economic estimate as the old asset is effectively replaced by a new asset (that is, not a like-for-like replacement). To account for this, 50% of the asset damage/repair cost was taken. In addition, any repair work will incur VAT. This was therefore removed to provide an economic cost of the flood damages. Adjusting the financial figure by 50% to account for betterment and removing VAT (at 20%) gives an economic cost estimate of the damages/repairs of £42,000.

A summary of the calculation used to convert financial damage/repair costs to educational assets to an economic estimate is provided below:

> Economic estimate of damage/repair costs = Financial estimate of damage/repair costs × 50% (accounting for betterment) ÷ 1.2 (to remove VAT at 20%)

This figure of £42,000 was applied to the number of educational assets flooded from the local data and flood outline data (assumed to be 39) to provide an overall economic damage estimate of £1.6 million.

The calculation used to determine the best estimate of the flood related damages to educational assets during the 2013 to 2014 winter period is provided below.

> Economic estimate of the flood damages to educational assets (£1.6 million, best estimate) = Average cost of damages per asset (£42,000, based on a single data point) × Number of assets considered to have flooded (39, based on local data and flood outline data)

However, this approach produces an uncertain figure for 2 main reasons. First, it was not always clear from the data (particularly in the case of the flood outline data) whether educational assets were flooded themselves or whether access issues due to flooding prevented them for operating as normal. Second, the damages caused to educational assets may differ from the £42,000 figure used in the calculation and thus it may over or underestimate the actual damages caused by flooding. However, this is considered to represent the best estimate given the lack of any national level data and the very limited damage information obtained from the local approach.

The Annex 1 method statement summarises the approach used to develop the best estimate of the damages to educational assets resulting from the floods.

20.3 Determining the best estimate range

As described in Section 2.3.4, the data used to provide the best estimate of costs in each impact category were assessed to determine the associated uncertainty. The uncertainty rating was applied based on the availability and quality of the data obtained and the assumptions applied to the data to provide an economic cost estimate. The uncertainty rating was subsequently used to determine the potential range around the best estimate.

This approach was used to determine a range of flood damage costs to educational facilities of £1.2 million to £2.0 million (Table 20.1). Further details on the methods used to develop the lower and higher ranges are provided below.

Low estimate

The damage costs associated with the flooding of one school were converted to provide an economic cost estimate. This figure was then extrapolated to determine the potential damages caused by flooding to other educational facilities considered to have been affected during the winter 2013 to 2014 floods. This is an uncertain approach given that flood related damages are likely to vary depending on the facility affected and the extent and duration of the impact. Given the extrapolation and the adjustments made to provide an economic estimate of the costs, the data were classified as having a moderate–high uncertainty rating. To reflect this uncertainty, the best estimate (£1.6 million) was reduced by 25% (see Table 2.5), resulting in a low range estimate of the flood damages to educational facilities during the 2013 to 2014 winter period of £1.2 million.

High estimate

A similar approach was used to obtain an upper range estimate. The information on flood damages to a school in Hampshire was converted to an economic cost and extrapolated to provide an estimate of the potential costs to educational facilities at the national level. These data were assigned a moderate-high uncertainty rating because damages to individual assets/facilities are likely to differ from costs used in the extrapolation (it was not possible to verify whether the costs used provide a representative value for damages incurred). It was also not clear in all cases whether an educational asset was actually flooded or whether flooding prevented access to it. To reflect this moderate–high uncertainty rating, the best estimate (£1.6 million) was increased by 25% (see Table 2.5), resulting in a high range estimate of the flood damages to educational facilities during the 2013 to 2014 winter period of £2.0 million.

20.4 Damage costs by flood type

This section provides a breakdown of the damages to educational assets as a result of the winter 2013 to 2014 floods by flood type. It includes details of the methods used to differentiate the damage costs and the associated uncertainties.

20.4.1 Approach to disaggregating the damage costs

The disaggregation of damages by flood type was based on the assumption that the majority of damages incurred by coastal LLFAs were caused by tidal surges. Although this is clearly a simplification, there were insufficient details to allow a more sophisticated analysis. For educational assets, the estimate of damages comes from extrapolation of estimates based on a unit cost of £42,000 per educational asset (based on a single data point) for each LLFA. This was then broken down into coastal and inland LLFAs to determine the damages caused by coastal flooding.

20.4.2 Summary of damage costs by flood type

Table 20.2 provides a summary of damages by flood type to educational assets.

Table 20.2 Estimated economic damage costs to educational assets by flood type

Flood source	Economic damage estimates					
	Best estimate		Low estimate		High estimate	
	Damage	Percentage of total	Damage	Percentage of total	Damage	Percentage of total
All (total)	£1.6 million	100%	£1.2 million	100%	£2.0 million	100%
Fluvial/ groundwater	£710,000	44%	£530,000	44%	£890,000	44%
Coastal	£920,000	56%	£690,000	56%	£1.1 million	56%

Notes: Values are presented to 2 significant figures and therefore totals may not be exact sum of constituent parts due to rounding.

20.5 Damage costs for England and Wales

The lack of no information on educational assets damaged as a result of flooding in Wales in the winter 2013 to 2014 floods means that the damage estimates presented above relate to England only.

20.6 Uncertainties and assumptions

The LLFA level data suggest that 39 educational assets were flooded during the 2013 to 2014 winter period. However, the information obtained was not always sufficiently detailed to determine whether an educational asset itself had flooded or whether access to the facility had been affected by flooding. This was especially true of the flood outline data and so these data were only used where there was no alternative information.

An important uncertainty associated with the best estimate of total damages relates to the extrapolation of the £42,000 estimate for a school in Hampshire to all 39 educational assets considered to have flooded. The flood damages to other educational assets are likely to differ, with some incurring costs that are lower or considerably higher than this £42,000 estimate. The overall damage estimate for educational assets is therefore uncertain.

To avoid double counting, the costs of damages/repairs to educational assets as a result of flooding were included, where possible, in the education category and not in the local authorities and local government infrastructure category. However, where specific costs could not be broken down into their constituent parts, there was a risk of double counting with the local authorities and local government infrastructure category.

It was not possible to estimate the cost of learning days lost to students as a result of flooding to educational assets as per the 2007 floods assessment (Environment Agency 2010). This was because parliamentary reports similar to those on the impact of the 2007 floods on education were not available for this 2013 to 2014 assessment. Therefore, it was not possible to estimate the potential impact of the winter 2013 to 2014 floods on the loss of learning experienced by students.

21 Impacts on agriculture

21.1 Summary of findings

Table 21.1 presents the headline figures for the impact category of agriculture. This category provides estimates of the costs to farmers as a result of flooding during the 2013 to 2014 winter period. The category also includes flood related costs to the Forestry Commission. The best estimate of the economic cost of damages to the agriculture sector is £19 million, with a range of £12 million to £25 million.

The best estimate is based on data obtained from ADAS (2014), which is supported by:

- selected farmer interviews in Somerset and the upper Thames area on damages to agricultural land in England
- flood related damages to Forestry Commission assets
- an estimate of the damages caused to agricultural land in Wales

Most of the costs incurred by farmers were considered to be uninsured costs because they related to loss of expected income from crops and livestock production rather than damage to property (ADAS 2014). However, some the damages caused by flooding were insurable and therefore there is some risk of double counting with the businesses category as the insurance costs included in the businesses category are not broken down by sector.

Table 21.1 Headline findings for agriculture

Finding	Economic damage estimates			
	Best estimate (range)	% of total monetised damages	Uncertainty	Comments
2013 to 2014 damages (total)	£19 million (£12 million to £25 million)	1.5% (of overall total damages)	Moderate	Based on a national level estimate of flood damages to England (from ADAS 2014), flood related costs to the Forestry Commission (England) and an estimate of damages for Wales.
2013 to 2014 damages (England)	£18 million (£12 million to £25 million)	99% (of total for category)	Moderate	Based on a national level estimate of flood damages to England from ADAS (2014) and flood related costs to the Forestry Commission (England).
2013 to 2014 damages	£210,000	1% (of total for category)	Moderate–high	Based on estimates of the

Finding	Economic damage estimates				
(Wales)	(£150,000 to £270,000)				area of agricultural land flooded in Wales and a cost per ha of £425.
2007 damages (2014 values)	£59 million	1.5% (of overall total damages in 2007)	Score: 2 (limiting assumptions)		Environment Agency (2010)
	Best estimate	**Units**	**Uncertainty**		**Source of estimate**
Numbers affected (total)	45,000 (45,000 to 47,000)	Hectares	Low–moderate	Moderate	Low estimate based on national data for England (from ADAS 2014) and for Wales (Natural Resources Wales 2014). High estimate based on local (LLFA) level data for England added to high estimate from national data for Wales.
Numbers affected (England)	44,000 (44,000 to 46,000)	Hectares	Low–moderate	Moderate	Low estimate based on national from ADAS (2014). High estimate based on local (LLFA) level data.
Numbers affected (Wales)	500 (360 to 640)	Hectares	Moderate–high		Low estimate based on figure from Natural Resources Wales (2014), but considered to be an underestimate. High estimate based on assumption.
	Best estimate	**Range**	**Uncertainty**		**Source of estimate**
Damages per asset	£425	£310 to £425	Low–moderate		ADAS (2014) and farmer interviews in Somerset and upper Thames area (note that these refer to economic costs)

Notes: Values presented to 2 significant figures.

21.2 Determining the best estimate

21.2.1 Area of agricultural land flooded

National level data for England indicate that an estimated 44,400ha of agricultural land flooded during the period between late December 2013 and the end of March 2014 (Table 21.2). Flooding was concentrated in 2 main areas, the Somerset Levels and Moors and the Upper and Middle Thames Catchment

Flooding was also dispersed across a number of other areas, including Bristol, Exeter, the south coast, and the Severn, Wye and Usk valleys (grouped together as 'Other' in Table 21.2).

About 65% of the flooded areas in England contained grassland. Longer duration flooding (periods exceeding 4 weeks in the worst affected areas) occurred mainly on grassland, especially in Somerset.

Table 21.2 Estimated agricultural flooding in winter 2013 to 2014 in England by region, land use and duration

Area	Area flooded (ha)	% of flood area	Land type		Duration of flooding	
			Grass (ha)	Arable and other (ha)	More than 15 days (% of area)	Less than 15 days (% of area)
Somerset Levels and Moors	13,300	30%	10,700	2,600	57%	43%
Thames	13,000	29%	6,600	6,400	68%	32%
Other[1]	18,100	41%	10,500	7,600	57%	43%
Total	44,400	100%	27,800	16,600	60%	40%

Notes: Based on ADAS (2014) using Environment Agency flood mapping for winter 2014 event and Defra (2010) for land use data.
Values are rounded to 2 significant figures.
[1] Other: Bristol, Exeter, south coast and the Severn, Wye and Usk valleys.

A total of 360ha of farmland is reported as having flooded in Wales (Natural Resources Wales 2014. Tidal flooding in Wales caused 'damage to property, fences, equipment, silage bales and hundreds of hectares of productive agricultural land' (Natural Resources Wales 2014). According to the National Farmers' Union (NFU), the most severe coastal flooding of farmland was over 200ha in Pensarn, Llanbedr, with damage to grassland and loss of 120 sheep. The salinity of the flood waters further damaged and delayed the recovery of agricultural grasslands compared with freshwater flooding (Natural Resources Wales 2014). Unlike in England, there is no evidence of major agricultural damages in Wales at the national scale.

For the purposes of this assessment and to allow for under reporting, a best estimate of 500ha of agricultural land was assumed to have been affected by flooding in Wales during the 2013 to 2014 winter storms (range of 360ha to 640ha). This excludes flooding of extensively grazed areas in coastal sites of scientific interest (SSSIs) where impacts are likely to have been small.

Combining the estimates of agricultural land affected by flooding in England (44,400ha) and Wales (500ha) gives a best estimate of the total area flooded during the 2013 to 2014 winter period of 45,000ha (rounded to 2 significant figures).

Aggregating data obtained at the local (LLFA) level provides an estimate of the area of agricultural land affected by the winter 2013 to 2014 floods in England of approximately 46,000ha. Using the high range estimate of area of agricultural land flooded in Wales (640ha) and combining this with the figure for England gave a high range estimate of the area of agricultural land affected in England and Wales of 47,000ha (rounded to 2 significant figures). The map in Figure 21.1 shows the distribution of agricultural land affected in England.

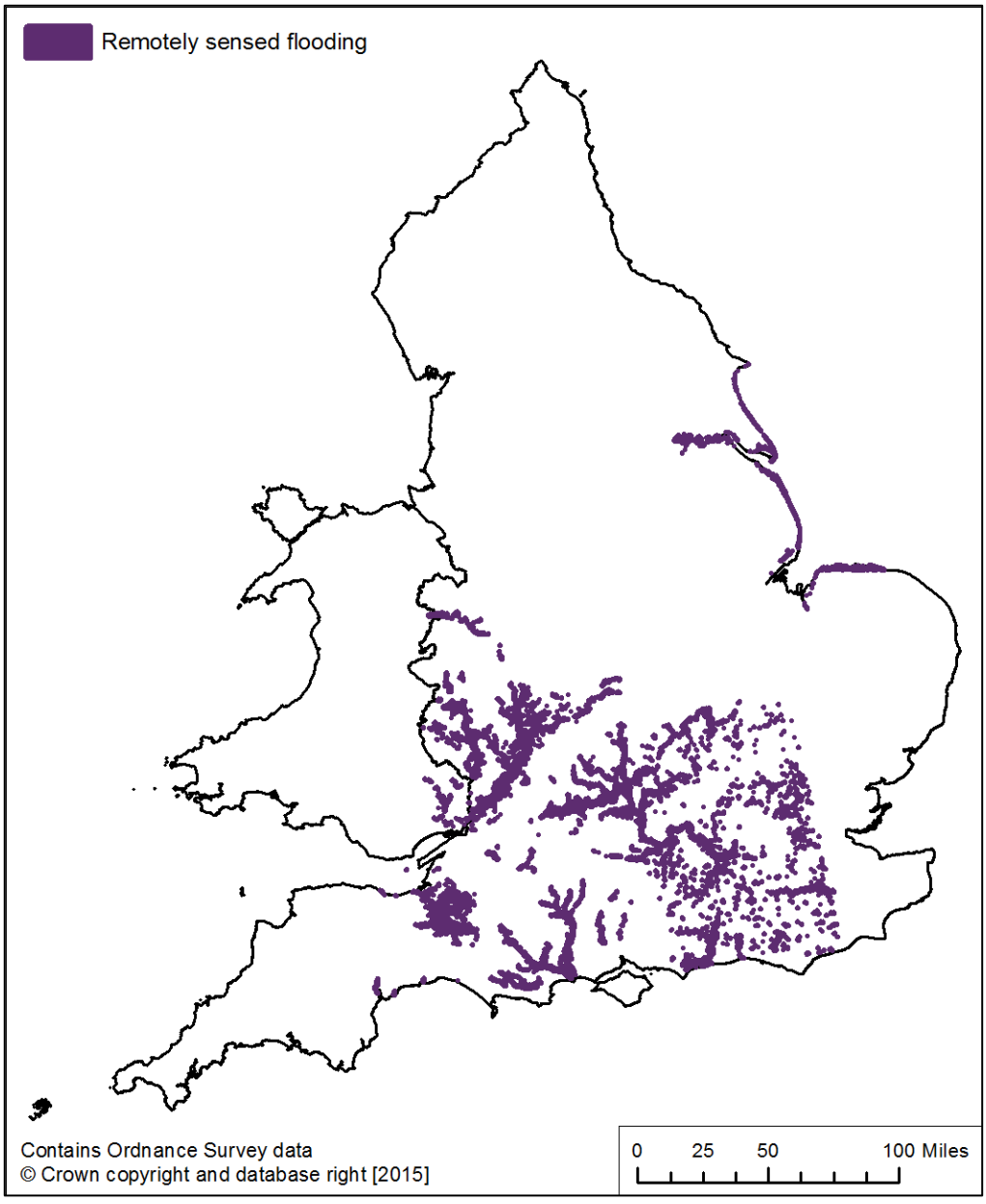

Figure 21.1 Estimated area of land in England affected by flooding based on aerial photographs

Notes: Land is predominantly agricultural.

The agricultural impacts of flooding are predominantly felt by land owners, land managers, insurance companies and agricultural supply and service agents.

Agricultural floods not only damage assets but can also have a negative impact on production and output. Given the annual production cycle of most agricultural production systems, losses in output due to one-off floods cannot be easily substituted by domestic production elsewhere in the economy. Although winter floods are not as

damaging as those that occur in spring or summer, the unusually long duration of the winter 2013 to 2014 floods in some areas increased damages and delayed recovery.

This section provides details of how the flood damages to agricultural land in England and Wales were determined.

Flood damages to agriculture in England

National level estimates based on secondary data sources (ADAS 2014) give a total economic cost for agricultural flood damage in England of £18 million, which equates to £425 per ha flooded. ADAS combined information on the location, timing and duration of flooding in England during the winter 2013 to 2014 period provided by the Environment Agency with information on agricultural land use obtained from Agricultural Census Data for 2010. Estimates of the economic value of agricultural flood damage by different land uses and in total were obtained by ADAS using the nationally agreed methods for Flood and Costal Erosion Risk Management cost benefit analysis (known as the Multi-Coloured Manual) for the economic appraisal of flood and coastal risk management (Penning-Rowsell et al. 2013), supported by information from regional agricultural advisors.

These high level estimates of flood damage were corroborated by farm level assessments carried out in 2 of the most seriously affected areas:

- Somerset Levels and Moors – drawing on estimates from the Somerset Drainage Board Consortium (Morris 2014)
- upper Thames in Oxfordshire – from interviews carried out for this study

These 2 sources used personal interviews with 19 farmers seriously affected by flooding in the 2 areas.

About 70% of the estimated costs of the winter 2013 to 2014 agricultural flood damage cost in England are associated with production losses, and the remainder with damage to assets and infrastructure. It is estimated that less than 5% of total flood damage costs were insured costs.

The high level estimates of the different types of agricultural impacts from the floods in England are shown in Table 21.3.

Table 21.3 High level estimates of the impacts on agriculture of the winter 2013 to 2014 floods in England

Impact type	Damage	Estimated range
Arable	£6.9 million	£5.5 million to £8.2 million
Grassland	£1.7 million	£1.4 million to £2 million
Livestock	£4.1 million	£2.1 million to £6.2 million
Other	£5.6 million	£2.8 million to £8.4 million
Total	£18.3 million [1] (£18 million to 2 significant figures)	£11.8 million to £24.8 million (£12 million – £25 million to 2 significant figures)

Notes: Values are presented to 2 significant figures at 2014 prices
[1] Reported in ADAS (2014) as totalling £18.9 million.

Defra provided a £10 million Farming Flood Recovery Fund to compensate for uninsured non-output losses such as damage to grassland and fences. Farmers applied for a total of £6.3 million of this sum, with 32% and 16% of the amount applied for under this scheme coming from farmers in Somerset and Gloucestershire respectively (Rural Payments Agency, personal communication 29 January 2015). These figures refer to the total grant applications; the actual amount paid will be less than this figure as not all applications were successful or only part of the funding applied for was granted. As of 31 October 2014, a total of £5.1 million from the Farming Flood Recovery Fund had been approved and granted to applicants (DCLG 2014c).

The damage costs implied by the Farming Flood Recovery Fund are already accounted for in the estimates of damage costs at the national level shown in Table 21.3. However, the payments from the fund confirm the regional distribution of agricultural flood costs, much of it associated with fluvial flooding of livestock farming in the west of England, and the impact on field infrastructure and field drainage systems. The distribution of funds between regions and themes will help to inform priorities for improving resilience to future flooding.

The main sources of winter floods affecting farming were:

- fluvial flooding associated with peak flows
- surface flooding associated with overland run-off
- groundwater flooding – and associated water logging

Coastal areas also reported tidal and storm surges leading to inundation of farm land. Note that farm income support and agri-environment payments received by farmers were not affected by the 2014 winter floods.

The estimates of the agricultural damages during the winter 2013 to 2014 floods (£18 million at £425 per ha flooded) compare with the agricultural damage of summer flooding in 2007 at £50 million over 42,000ha at about £1,190 per ha in 2007 prices (£58.5 million and £1,390 per ha in 2014 prices).[10] Seasonality of flooding is an important determinant of agricultural damage costs. The agricultural costs of occasional floods are generally lower in winter than in the more productive spring and summer periods, but much depends on land use.

Forestry Commission England identified a total of £580,000 of damage associated with storms, flooding and land slippage caused by flooded ground following exceptional rainfall during winter 2013 to 2014. An estimated £180,000 of the £580,000 damages caused to Forestry Commission assets were directly attributable to flooding, with damages caused to buildings (£50,000), damages to roads and tracks (£30,000) and dam failure and repairs (£100,000) (R. Gazzard, personal communication April 2015). These values were assumed to represent economic costs based on details provided by the Forestry Commission. This estimate of forestry damage accounts for approximately 1% of estimated total agriculture and forestry flood damage costs in England.

Combining the estimates of damages to agricultural land during the 2013 to 2014 floods from ADAS (2014) with information from the Forestry Commission gives an overall best estimate of the impacts in England of £18.47 million (£18 million to 2 significant figures).

Flood damages to agriculture in Wales

As outlined above, it is estimated that 500ha of agricultural land in Wales was affected by flooding during December 2013 and January 2014. Applying the average damage

[10] Using GDP deflators at market prices (HM Treasury 2014)

costs of £425 per ha for England to the area affected in Wales, provides a best estimate of flood damages to agricultural land of approximately £210,000 (to 2 significant figures). The Farmers' Union of Wales identified agricultural losses of between £300 per ha and £400 per ha due to freshwater flooding of 30ha for over 3 weeks following the failure of an earth embankment at Holywell in Flintshire (Natural Resources Wales 2014), which is similar to the average estimated costs for England.

The average cost of flooding per hectare of agricultural land for England was therefore used to estimate the costs for Wales. The calculation used to determine the best estimate of £210,000 of the flood damages to agricultural land in Wales is:

> Estimate of the damage costs to agricultural land in Wales (£210,000, best estimate) = Area of agricultural land affected by flooding in Wales (500ha, best estimate based on information from Natural Resources Wales (2014)) × Average damage cost per hectare of agricultural land for England (£425 per ha based on data from ADAS (2014))

Flooding damages to agriculture in England and Wales

Combining the estimates of the damages caused by the winter 2013 to 2014 floods to agricultural land in England and Wales gives a total cost of £18.7 million (£19 million presented to 2 significant figures) (Table 21.4). The estimates of the damage costs for England were corroborated by personal interviews with 19 farmers in Somerset and Oxfordshire (upper Thames). The values presented in Table 21.4 are therefore considered to be the best estimate of the flood damages to agricultural land.

Table 21.4 High level estimates of the impacts on agriculture of the winter 21013 to 2014 floods in England and Wales

County	Details	Estimated economic costs (2014 prices)
England	Agricultural impacts from ADAS (2014)	£18.3 million
	Forestry Commission damages	£180,000
Wales	Estimated agricultural damages using average cost per ha from ADAS (2014) [1]	£210,000
Total		**£18.7 million**

Notes: Values are presented to 2 significant figures, unless used to present the sum of the constituent parts.
[1] Information for Wales based on Natural Resources Wales (2014) and applying an average unit cost per ha of agricultural land affected of £425.

The Annex 1 method statement summarises the approach used to develop the best estimate of the damages to agricultural land resulting from the floods.

21.2.2 Flood damages to agriculture (regional impacts)

This section provides an overview of flooding impacts during the 2013 to 2014 winter period at the regional level and help to contextualise the best estimate of the flood damages to agricultural land at the national scale.

Agricultural impacts in Somerset

Within Somerset, 11,500ha of land were inundated by 65 million cubic metres of water (Sedgemoor Citizens Advice Bureau 2014). A more detailed area-specific assessment of the winter flood impacts on farming in the Somerset Levels and Moors was made for this study based on interviews with 11 farmers, carried out in connection with an ongoing flood impact assessment for Somerset Drainage Boards Consortium. This assessment estimated costs at about £5.7 million (±£1.5 million), equivalent to £410 per ha flooded (Morris 2014).

Over 80% of damage costs were associated with the dairy and livestock sector, namely lost production of grass for feed, loss of livestock output and sales, and costs of restoring damaged pastures. Less than 5% of agricultural damage costs were insured.

The winter floods delayed recovery from the severe summer flooding that affected the area in 2012. The long duration floods (8–12 weeks in the lowest lying areas) severely damaged or completely destroyed large areas of 'improved' agricultural grassland such that it required re-seeding. Semi-native grasslands (on an estimated 40% of the area) withstood flooding, but gave reduced yields. Arable crops were lost and re-seeded with spring crops where possible.

An additional cost associated with the evacuation of between 11 and 14 farms was estimated at a further £300,000 to £500,000. It was reported that 12 livestock farmers had to be completely evacuated and over 1,000 cattle and 250 sheep re-housed, often across several other locations and in the midst of calving and lambing (Sedgemoor Citizens Advice Bureau 2014).

Agricultural impacts in the upper Thames catchment

In the Thames catchment, contact with NFU representatives and interviews in person or by telephone with 8 farmers confirmed the type and extent of impacts of the floods. The damage costs to farming in the upper Thames followed a similar pattern to that of Somerset – damage varied according to land use and duration of flooding. The upper Thames catchment includes a greater proportion of arable (mainly cereal) farming and relatively more intensive grassland production than Somerset. As a result, unit damage costs tend to be proportionately higher. Flooding of more than 2 weeks on winter sown cereal crops generally led to re-seeding with spring cereals. Flooding of more than 4 weeks on improved grassland generally required complete or partial re-seeding, but relatively favourable conditions during the remainder of 2014 assisted recovery.

Other areas with agricultural impacts

Within Lincolnshire, poultry farms supplying the 2 Sisters Food Group were flooded by the tidal surge, costing the company more than £500,000 (Food Manufacture 2014). In Suffolk, the tidal surge caused around 7 breaches in flood defences, leading to 500–700ha of land being flooded and subject to salt contamination (NFU 2013). In Yorkshire and Humber, the tidal surge is considered to have led to flooding of 7,000ha of agricultural land on both banks of the River Humber (Raynor and Chatterton 2014).

Wider impacts

Many of the farmed areas affected by 2014 winter flooding in Somerset and the upper Thames have been subject to flooding in recent years, notably in 2000, 2007 and 2012. Discussion with livestock farmers indicated a heightened degree of preparedness for flooding in 2013 to 2014, especially regarding maintained stocks of winter feed. In

some areas, such as Somerset, livestock numbers had been reduced in 2012 to accommodate reduced availability of grazing and winter feed, such that the impact of the 2013 to 2014 floods was partially attenuated. However, grasslands reseeded (sometimes twice) following 2012 floods were again destroyed in 2014 and some farmers showed a reluctance to reseed during the year until favourable conditions became more likely.

In discussions, farmers affected by the 2013 to 2014 winter floods expressed concern about a perceived increase in flood risk, whether due to changes in climate, land use, and/or river and land drainage management. Many farmers perceived reductions in the standard of maintenance by responsible organisations to be an important contributory factor.

Repeat and long duration flooding in Somerset has challenged the financial viability of some of the more intensive farming businesses that depend on the Somerset Levels and Moors for summer grazing and winter feed. Less intensive farms, especially those participating in high level agri-environment stewardship programmes, have been less exposed. Farmers in the upper Thames catchment questioned the viability of cereal production in the face of increased risk of winter flooding. In some cases, this has encouraged farmers to consider alternative farming systems and land uses, linked to environmental stewardship and/or provision of flood services, in areas where flooding makes commercial farming difficult.

The 2013 to 2014 winter floods did not affect agricultural commodity and food prices at the regional and national scale, other than seasonal rises in fodder and forage prices in Somerset: less than 0.5% of the UK grass and arable area were flooded. There were good harvest conditions and crop yields overall in 2014, especially for fresh produce. Agricultural prices in the UK are largely determined by international prices. Increased global supplies, together with some levelling of demand, led to a reduction in 2014 of post-harvest prices for bulk agricultural commodities. UK domestic prices for cereals, for example, fell by about 25% towards the end of 2014 from the high prices (£150–160 per tonne for wheat) that had prevailed during the preceding 5 years.

21.3 Determining the best estimate range

21.3.1 Flood damages to agriculture

A range of flood damages to agriculture and forestry of £12 million to £25 million (to 2 significant figures) was calculated. Further details on the methods used to develop the low and high ranges are provided below.

The best estimates of agricultural damages caused by flooding for England and Wales were classified as having a moderate and moderate–high uncertainty rating respectively. However, the information obtained from ADAS (2014) and Natural Resources Wales (2014) were deemed to provide the most appropriate approaches for reflecting the range.

Low estimate

A low range estimate of the damages to agriculture and forestry in England of £12 million during the winter 2013 to 2014 floods (Table 21.3) was determined using data from ADAS (2014) and the Forestry Commission (R. Gazzard, personal communication April 2015). In the case of Wales, information from Natural Resources Wales (2014) indicated that 360ha of agricultural land flooded during the 2013 to 2014 winter period. A low range estimate of the agricultural damages caused by flooding in Wales was

calculated using the average damage costs per hectare of agricultural land for England (£425 per ha) and applying this to the 360ha of land affected.

This gave a low range estimate of flood damages to agricultural land in Wales during the 2013 to 2014 winter period of £153,000.

The calculation used to determine the low range estimate of the flood damages to agricultural land in Wales is provided below:

> Estimate of the damage costs to agricultural land in Wales (£153,000, low estimate) = Area of agricultural land affected by flooding in Wales (360ha, based on data from Natural Resources Wales (2014)) × Average damage cost per hectare of agricultural land for England (£425 per ha, based on data from ADAS (2014))

The damage cost estimates for Wales were added to the estimate for England to provide a total low range economic estimate of the damages to agricultural land in England and Wales of £12.1 million (£12 million presented to 2 significant figures).

High estimate

An upper range estimate of the damages to agricultural land in England of £25 million during the winter 2013 to 2014 floods (Table 21.3) was obtained by combining data from ADAS (2014) and the Forestry Commission (R. Gazzard, personal communication April 2015). To develop a high range estimate of the damages to agricultural land in Wales, it was assumed that 640ha was affected instead of the 500ha used in determining the best estimate. An upper estimate of the agricultural damages caused by flooding in Wales has been calculated by using the average damage costs per hectare of agricultural land for England (£425 per ha) and applying this to the 640ha of land affected in Wales.

This gave a high range estimate of flood damages to agricultural land in Wales during the 2013 to 2014 winter period of £272,000. This higher estimate is sufficient to allow for possible additional impacts of salinity on agricultural land and known livestock fatalities.

The calculation used to determine the high range estimate of the flood damages to agricultural land in Wales is provided below:

> Estimate of the damage costs to agricultural land in Wales (£272,000, high estimate) = Area of agricultural land affected by flooding in Wales (640ha) × Average damage cost per hectare of agricultural land for England (£425 per ha, based on data from ADAS (2014))

The agricultural damage costs associated with the winter 2013 to 2014 floods for England (£25 million) and Wales (£272,000) were combined to provide an upper range estimate of £25.3 million (£25 million presented to 2 significant figures).

21.4 Damage costs by flood type

The main sources of flooding affecting farming during the 2013 to 2014 floods were:

- fluvial sources associated with peak flows (as identified in Somerset and the Thames catchment)
- surface flooding associated with overland run-off
- groundwater flooding – and associated water logging

Fluvial flooding was therefore considered to be the predominant cause of the flood related damages to agricultural land during the 2013 to 2014 winter period. However, coastal areas also reported tidal and storm surges leading to inundation of farm land, with evidence obtained for damages in coastal areas (for example, East Anglia and Lincolnshire). The use of national level data means it was not possible to separate the flood damages to agricultural land by flood type/source.

21.5 Damage costs for England and Wales

This section provides a breakdown of the damages to agricultural land as a result of the winter 2013 to 2014 floods for England and Wales. It includes details of the method used to differentiate the damage costs and the associated uncertainties.

21.5.1 Approach to disaggregating the damage costs

The damages incurred to agricultural land in England as a result of the winter 2013 to 2014 floods are based on data obtained from ADAS (2014) and the Forestry Commission. The damage costs that relate to flooding of agricultural land in Wales were calculated by applying the average cost per hectare of affected farm land for England (£425 per ha) to the area of land considered to have been affected in Wales, a best estimate of 500ha based on information from Natural Resources Wales (2014).

21.5.2 Damage costs for England/Wales

Table 21.5 provides a summary of the flood damages to agricultural land during the winter 2013 to 2014 floods split between England and Wales.

Table 21.5 Estimated economic damage costs to agricultural land by country

Country	Economic damage estimates					
	Best estimate		Low estimate		High estimate	
	Damage	Percentage of total	Damage	Percentage of total	Damage	Percentage of total
Total	£18.7 million	100%	£12.1 million	100%	£25.3 million	100%
England	£18.5 million[1]	99%	£12.0 million	99%	£25.0 million	99%
Wales	£210,000	1%	£150,000	1%	£270,000	1%

Notes: [1] includes forestry related damage (of £180,000)
Values are presented to 2 significant figures, unless presenting the sum of the constituent parts. Therefore totals may not be exact sum of constituent parts.

21.6 Uncertainties and assumptions

Agricultural impacts of flooding in England and Wales are based on high level assessments of flood areas, flood duration, land use and standard estimates of damage to crops, livestock and farm assets and services. They are supported in England by interviews with affected farmers – 11 in Somerset and 8 in the upper Thames catchment. However, there remains uncertainty regarding actual areas flooded, with this highlighted by the ranges around the best estimate.

22 Impacts on wildlife sites and associated assets

22.1 Summary of findings

Table 22.1 presents the damage estimates for the impact category of wildlife. This category includes estimates of the damages caused to wildlife sites in England and Wales as a result of the winter 2013 to 2014 floods. The estimates also include funds provided by Natural England to repair flood related damages as well as Natural England flood management (staffing) costs and Higher Level Stewardship flood compensation payments to farmers to provide an overall best estimate of the flood damages/costs.

The best estimate for England and Wales of damages to wildlife sites during the winter 2013 to 2014 floods is £2.4 million, with a range of £1.9 million to £3.0 million (presented to 2 significant figures). Further details describing how the best estimate and range were determined are provided in the following sections.

Impacts on wildlife sites can result from direct flooding of the sites themselves and the assets that support them, including assets that help the sites to achieve their wildlife objectives and assets such as visitor facilities. This affects staff members, including site managers, farmers, volunteers and site visitors. Flooding of utility services can also affect wildlife sites in terms of inducing potential facility closures. Flooding of transport links can also cause disruption/closures as access for staff might be restricted. Equally, volunteers staffing visitor facilities may feel that their efforts are better used helping with the flood response effort and therefore may not be available to staff the sites, leading to temporary closures.

Information included in this category is not considered to be double counted in other categories. In a survey of 30 wildlife sites, 26 reported flood damages during the 2013 to 2014 winter period. However, 2 of these sites experienced damages that were not the responsibility of wildlife site management to rectify. These costs were borne by other responsible authorities such as the Environment Agency and local government; they were not attributed to the wildlife category to avoid double counting with the local authorities and local government infrastructure or flood risk management and response categories. In addition, it was estimated that around 50% of the flood related costs to wildlife sites were insurable. However, these were not included in the businesses category, and therefore not double counted. The Higher Level Stewardship payments are only included under the wildlife category and are therefore not double counted with the agriculture category.

Table 22.1 Headline figures for wildlife sites

Findings	Economic damage estimates			
	Best estimate (range)	**% of total monetised damages**	**Uncertainty**	**Comments**
2013 to 2014 damages (total)	£2.4 million (£1.9 million to £3.0 million)	0.19% (of overall total damages)	Moderate	Combination of data obtained for England and Wales
2013 to 2014 damages	£2.3 million	95%	Moderate	Based on local data of damages to 24

Findings	Economic damage estimates				
	Best estimate (range)	**% of total monetised damages**	**Uncertainty**		**Comments**
(England)	(£1.8 million to £2.8 million)	(95% to 94%) (of total for category)			surveyed wildlife sites, Natural England recovery fund and High Level Stewardship payments and extrapolation of the damages to non-surveyed sites.
2013 to 2014 damages (Wales)	£120,000 (£87,000 to £170,000)	5% (5% to 6%) (of total for category)	Moderate–high		Based on area of wildlife sites flooded (1,000ha) and assuming damages of £116 per ha (based on costs for England).
2007 damages (2014 values)	Not specifically reported	-	Score: not reported		Environment Agency (2010)
	Best estimate	**Units**	**Uncertainty**		**Source of estimate**
Numbers affected (total)	10,250 (7,750 to 13,000)	ha	High	Moderate	Based on combination of best estimates of area of wildlife sites flooded in England (9,250ha) and Wales (1,000ha). Low estimate is based on a combination of low estimates of area of wildlife sites flooded in England (7,000ha) and Wales (750ha) (high uncertainty). High estimate based on combination of high estimates of area of wildlife sites flooded in England (11,500ha) and Wales (1,500ha) (moderate uncertainty).
Numbers affected (England)	9,250 (7,000 to 11,500)	ha	High	Moderate	Calculated from data provided from the Environment Agency on area of land flooded. Low estimate based on Somerset only (so high uncertainty) and high estimate based on information from the Environment Agency (moderate

Findings	Economic damage estimates			
	Best estimate (range)	**% of total monetised damages**	**Uncertainty**	**Comments**
				uncertainty).
Numbers affected (Wales)	1,000 (750 to 1,500)	ha	High	Based on information obtained from Natural Resources Wales. Low estimate determined by taking 25% of the best estimate. High estimate determined by adding 50% to the best estimate[1]
	Best estimate	**Range**	**Uncertainty**	**Source of estimate**
Damages per asset	£116 per ha	£116 per ha to £288 per ha	Moderate	Based on local data on damages to 24 surveyed wildlife sites on flood related damages. Low range excludes capital and revenue costs linked to visitor centres. High range includes capital and revenue costs linked to visitor centres (note these refer to economic costs)

Notes: Values presented to 2 significant figures.
[1] This range is justified due to the high degree of uncertainty in the estimates areas for Wales

22.2 Determining the best estimate

22.2.1 Area of land affected by floods

Limited information was available on the area of wildlife sites affected by flooding during the 2013 to 2014 winter period. The map in Figure 22.1 shows the distribution of flooding to designated sites.

Data gathered suggests some 7,000ha of wildlife sites in Somerset were flooded or subject to high water levels (Environment Agency 2014n). In addition information from the Environment Agency suggests that a total of 11,500ha of wildlife sites in England were subject to flooding, but the areas actually flooded within the sites could not be confirmed; the distinction between the total area of 'wildlife sites' that were flooded and actual 'areas flooded' on wildlife sites was not made. Taking 7,000ha as the minimum area within wildlife sites that was actually subject to flooding and 11,500ha as the maximum area gives a mean of 9,250ha that is used as the best estimate (from the data available) of the area of wildlife sites actually flooded during the 2013 to 2014 winter period in England.

Wildlife organisations responsible for 30 wildlife sites in England were consulted, of which 26 sites reported flooding on 6,506ha (50% of total area of the 26 sites) and 24 sites reported flooding and financial damage on 5,923ha (48% of the total area of the 24 sites) during the 2013 to 2014 winter period. Thus, flood related damages were found to occur on approximately 50% of the total area of wildlife sites that reported some flooding.

Consultation with Natural Resources Wales (personal communication, 2015) suggested that 1,000ha of designated wildlife sites probably flooded during the 2013 to 2014 winter storms, with potential damage to site features and infrastructure that required restoration expenditure. This figure was taken as the best estimate given the lack of any definitive data on areas of wildlife sites affected by flooding.

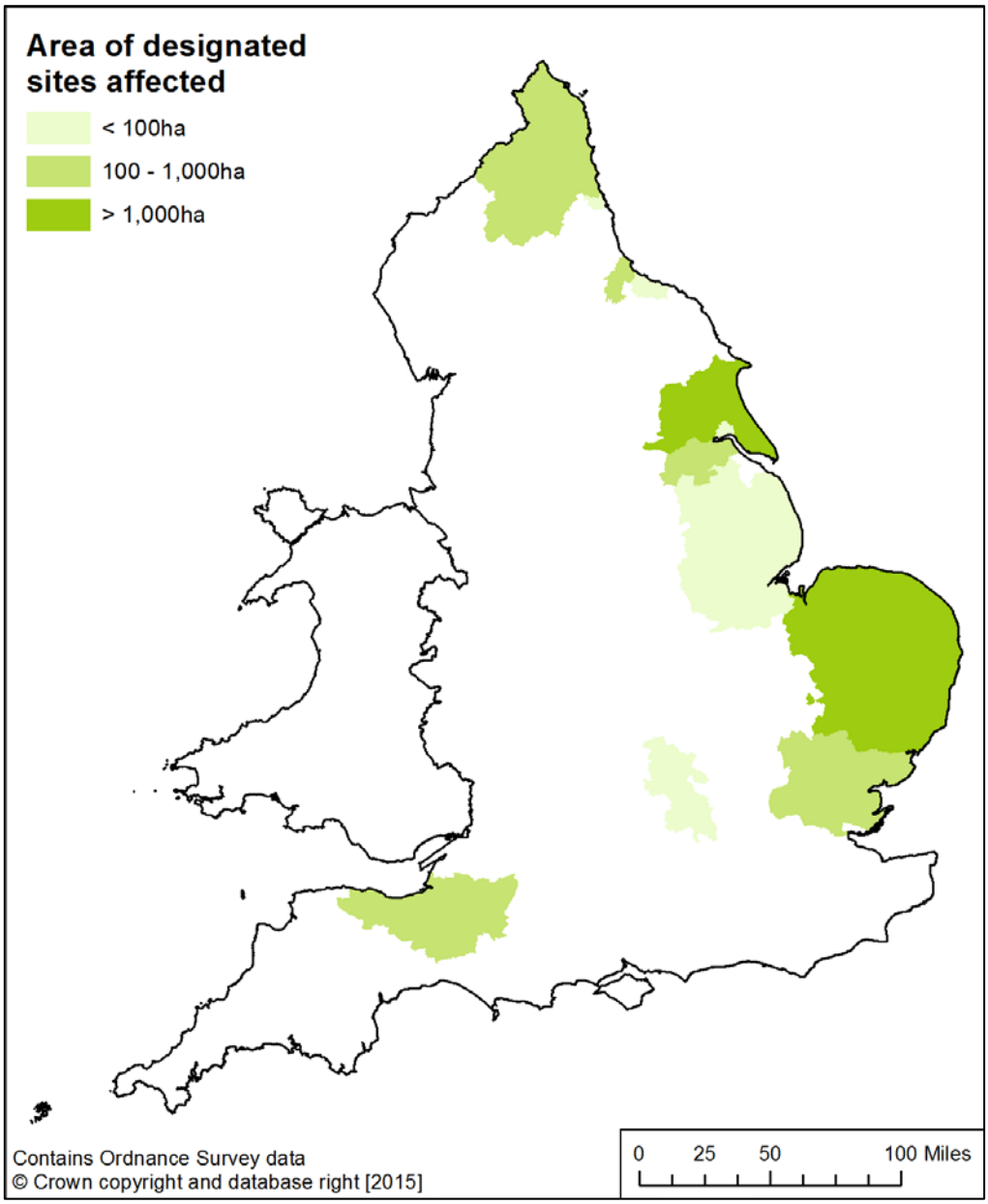

Figure 22.1 Area of wildlife designated land flooded based on flood outline data

Note: Only shows where information was available and information may not be complete. Presents data by LLFA, whereas the main sites affected were in coastal areas in the east.

22.2.2 Impact of flooding on wildlife sites in England

Extensive research and consultation was conducted with Natural England, the National Trust, regional wildlife trusts and the Royal Society for the Protection of Birds (RSPB) to determine the impacts of the winter 2013 to 2014 floods on wildlife sites and associated assets in England. Further details of the different types of information obtained are provided in the following sections.

Impact of flooding on wildlife sites

National and regional organisations responsible for wildlife projects and the management of wildlife sites were contacted to determine the extent of damages to wildlife sites in England and one site on the Welsh border.

Information was sought on:

- site details
- flood characteristics
- financial impacts on physical assets and operating revenues and costs
- impacts on visitors and broad ecological effects

Information, backed up by e-mail and telephone conversations, was obtained from 30 wildlife sites, of which 26 reported flood damages. To avoid double counting, the estimates of damages for the wildlife sector do not include damages that can be attributed to other sectors such as flood defence infrastructure or general public rights of way, and where responsibility for their reparation lies elsewhere.

The National Trust also provided an inventory of costs and insurance claims for flood and storm damage for the south-west and Welsh coastal areas from which only damage attributable to flooding was included. In a number of reported cases of site damage to National Trust property, about 50% of damage costs were covered by insurance. These insurable costs were considered to be in addition to those included in the businesses category and were therefore not considered to be double counted.

Estimated total financial damage costs for the 24 wildlife sites reporting flood damage during the 2013 to 2014 winter period were £2.4 million (presented to 2 significant figures) (Table 22.2). Where appropriate, these financial costs were adjusted for betterment using a default value of 50% of the financial cost and exclusion of relevant taxes.

Approximately 90% of these costs related to damages to physical assets (mainly buildings, hides and walkways), with the remaining 10% relating to operating costs (mainly loss of net revenues from sales and services on site) and additional labour costs.

The flood damage costs were particularly high due to the tidal surges along the eastern coastline of Lincolnshire and Norfolk between 5 and 7 of December 2013. Financial costs of about £1.3 million were incurred on Lincolnshire Wildlife Trust sites, mainly due the complete loss of visitor and educational facilities that are now being replaced. Economic losses on these sites alone are estimated at approximately £1 million. Box 22.1 provides a summary of the flooding impacts to Lincolnshire Wildlife Trust sites.

Table 22.2 Summary of the winter 2013 to 2014 flood damage costs to 24 designated wildlife sites in England

Type of cost	Financial costs	Percentage of total financial costs	Economic costs	Percentage of total economic costs
Damage to physical assets[1]				
Buildings	£1,300,000	53%	£960,000	56%
Equipment	£110,000	4%	£80,000	5%
Facilities	£11,000	0.5%	£6,000	0.4%
Infrastructure	£330,000	14%	£180,000	10%
Water control	£400,000	16%	£200,000	12%
Other	£46,000	2%	£46,000	3%
Total	**£2.2 million**	**90%**	**£1.5 million**	**88%**
Loss of revenues and extra operating costs				
Labour[2]	£72,000	3%	£64,000	4%
Services	£25,000	1%	£25,000	1%
Net revenue loss[3]	£150,000	6%	£150,000	8%
Total	**£250,000**	**10%**	**£240,000**	**14%**
Grand total	**£2.4 million**	**100%**	**£1.7 million**	**100%**

Notes: All values are presented to 2 significant figures and therefore numbers may not exactly sum due to rounding.
Based on 24 wildlife sites reporting damages (out of 30 contacted) operated by Natural England, the National Trust, the Wildlife Trusts, RSPB and local authorities.
[1] Financial costs: asset loss based on reported depreciated value where available, otherwise actual or estimated cost of repair of replacement (excluding VAT). Economic costs: asset loss based on reported depreciated value where available or remaining value at 50% of replacement cost (betterment) (excluding all taxes)
[2] National Insurance removed from labour costs where reported.
[3] Net cost of sales based on costs exclusive of VAT and other taxes where relevant.

The total economic estimate of £1.7 million of the damages to the wildlife sites (Table 22.2) was divided by 24 sites to determine the average economic flood damage cost of £71,000 per site (Table 22.4). The total combined area of the 24 wildlife sites was 12,268ha. Dividing the total damage costs of these 24 sites by their total area gives a cost per ha 'of wildlife site' affected by flooding of £139 per ha. Attributing costs to the subareas on these 24 sites reported as actually inundated (5,923ha) gives an average economic cost per ha of 'flooding on wildlife sites' of £288 per ha.

These costs in Table 12.2 are skewed by the high cost of damages to visitor centres in Lincolnshire Wildlife Trust sites. Removing the capital and revenue losses linked to visitor centres reduces the economic costs to £56 per ha (total area) and £116 per ha (flooded area only) across the 24 sample sites reporting onsite damage (as indicated in Table 22.4). Given that 90% of costs are associated with the loss of physical assets; alternative assumptions regarding displacement effects on lost visitor trade do not substantially change the estimates of average costs. The assessment here does not

account for the value of lost benefits accruing to recreational and educational visitors. Neither does it include an allowance for additional compensation to farmers on wildlife sites, and unattributed compensation costs and extra staff time incurred by Natural England.

Box 22.1 Impacts of flooding on visitor centres, Lincolnshire Wildlife Trust

Damage costs were particularly high where visitor centres and associated facilities were affected. The tidal surge in early December 2013 caused the flooding of 3 Lincolnshire Wildlife Trust sites, resulting in financial costs of over £1.3 million. Adjusting this figure provides an economic cost of £1.1 million after allowance for betterment and displacement effects (Table 22.3). Almost 90% of the costs related to damage to physical assets, mainly visitor and educational facilities. Losses were also incurred in terms of disruption to onsite activities and loss of net revenues from sales and educational programmes during 2014 and into 2015. Further details of the flood impacts on the 3 wildlife sites are given in Appendix C.

Table 22.3 Flood damage costs on visitor centres, Lincolnshire Wildlife Trust

Site	Damages to physical assets	Revenue loss, net of costs	Total
Gibraltar Point [1]	£1 million	£150,000	£1.2 million
Far Ings	£130,000	£10,000	£140,000
Donna Nook	£39,000	£9,000	£48,000
Total	£1.2 million [2]	£170,000	£1.3 million
Adjustment for remaining value	£920,000 [3]	£160,000 [4]	£1.1 million

Notes: all values presented to 2 significant figures, therefore numbers may not exactly sum due to rounding
Based on data from Lincolnshire County Council and Lincolnshire Wildlife Trust
[1] Excludes damages to 2 residential properties on site
[2] Based on insured value, replacement costs or net book value where data available
[3] Based on remaining value or net book value where available and excluding VAT
[4] Excludes National Insurance on wage costs. This estimate reduces to £60,000 if 50% net sales losses are offset elsewhere.

Figures 22.2 and 22.3 show the damaged facilities and their temporary replacements.

Figure 22.2 Gibraltar Point visitor and educational centre awaiting demolition and replacement, March 2015

Figure 22.4 Gibraltar Point temporary visitor facilities and catering, March 2015

Table 22.4 Estimated average costs of damage incurred during the winter 2013 to 2014 floods on 24 wildlife sites in England

	Including visitor centre impacts		Excluding visitor centre impacts[1]	
Type of cost	**Financial costs**	**Economic costs**	**Financial costs**	**Economic costs**
Average total cost per flood site	£101,000	£71,000	£48,300	£28,700
Average cost per ha flooded (all site)	£198 per ha	£139 per ha	£94 per ha	£56 per ha
Average cost per ha flooded (flooded area only)	£411 per ha	£288 per ha	£196 per ha	£116 per ha

Notes: All values are presented to 3 significant figures and therefore numbers may not exactly sum due to rounding.
Based on a survey of 24 wildlife sites reporting flood damages during the 2013 to 2014 winter period covering 12,268ha in total for which 5,923ha reported to have flooded (48%).
Financial estimates exclude VAT; remaining values based on reported depreciated values or replacement cost.
Economic costs are adjusted for remaining value at 50% of replacement cost and exclusion of VAT and National Insurance (10% of cost) where relevant.
The assessment excludes lost benefits to users of visitor and education days.
[1] Excluding visitor and education centre related costs where they occur for the same 24 sites.

Extrapolating the damages to include non-surveyed wildlife sites

The mean area of wildlife sites in England affected directly by flooding during the 2013 to 2014 winter period was estimated to be 9,250ha in England (see Section 22.2.1). For the purposes of this assessment, it was assumed that an additional 2,744ha of wildlife area was affected by the winter 2013 to 2014 floods other than on surveyed sites. This figure was obtained by determining the difference between 9,250ha, considered to be the best estimate of the area of wildlife sites subject to flooding (see above) from data from secondary sources and the 6,506ha of actually flooded area on the 26 surveyed wildlife sites (total area 13,056ha, of which about 50% actually flooded).

The average economic cost of £116 per ha of wildlife site (flooded area only, excluding visitor centre costs) from Table 12.4 was applied to the 2,744ha to provide an estimate of the additional economic damage costs experienced by wildlife sites included in the survey (£290,000). Based on data from the surveyed sites, this figure was weighted by 0.91 to account for areas of wildlife sites that flooded but did not incur damages (5,923ha ÷ 6,506ha, see Section 22.3.1).

Natural England flood related funds

Natural England provided £500,000 from its flood recovery fund to wildlife organisations whose sites were affected by the winter 2013 to 2014 floods (Table 22.5) Payments made to farmers under the Higher Level Stewardship (HLS) scheme to

reinstate damaged ecological assets under the terms of their agreements were also identified. Many of the payments from the Natural England fund were linked to:

- visitor access (36% of total payments)
- restoration of damaged flood defences and water control structures (23%)
- grassland and fencing (21%)

Around 80% of disbursement costs were associated with coastal and tidal flooding. Some of the disbursements relate to expenditures reported by sites surveyed for this study and are included in Table 22.2. For example, of the £91,900 disbursed to North Lincolnshire Wildlife Trust, £90,200 were compensated costs at Alkborough Flats, North Lincolnshire, according to the site manager. Similarly, a proportion of the damage costs reported by RSPB were compensated by £120,000 disbursed to the RSPB under the fund. It was therefore assumed that the bulk of the £500,000 payments were accounted for in the estimates from sites where damage was reported to be most severe. The only exception is the costs for Yorkshire Wildlife Trust where specialist vehicles were purchased to enable access. On this basis, it is reasonable to assume that approximately £100,000 (20%) of the £500,000 fund was for losses not covered in the estimates derived from the surveyed sites given in Table 22.2.

Natural England also paid a total of £63,900 (excluding VAT at 20%) to farmers to fund flood recovery work under their HLS agreements, especially for grassland restoration, and repairs to water control and field infrastructure. This comprised £10,392 for 4 HLS agreements in the Humber and North Lincolnshire, and £53,511 for 4 HLS agreements in Norfolk and Suffolk. HLS compensation payments were made elsewhere, including Somerset, but these are unquantified.

The winter 2013 to 2014 flood event imposed an additional burden on Natural England regional and centre staff, estimated by Natural England at £128,400 based on records (excluding local site managers). This cost relates to extra time commitments, compensated by extra leave entitlements or the displacement of other duties, and is considered to represent an economic cost. There is likely to be a high level of under reporting and therefore the figure above is regarded as an underestimate.

Ecological impacts of the floods

Evidence from Natural England and other wildlife organisations from their assessments of the ecological impacts of the winter floods suggests that site impacts varied in both scale and duration. Most negative impacts appear to have been short-term ones and recovery is underway, partly in response to actions taken. In the case of Somerset, while the long duration of flooding led to fluctuations in wildlife numbers, breeding patterns and locations for some species, many aspects of wetland nature have recovered well (Natural England 2014).

Responses from the survey of site managers on 26 flooded wildlife sites also indicated that ecological impacts were for the most part low and short term. Saline flooding of coastal salt marshes and sites with brackish waters has had limited impact, although temporary loss of fish, small mammals and infant seals were reported. There was some damage to dune systems and coastal margins where these were vulnerable to storm surges.

The biggest negative and longer term impacts have been caused by saline inundation of coastal freshwater habitats. Some of these are now on course for conversion to intertidal/saltmarsh, which is probably more sustainable in the longer term but could increase the scarcity of freshwater coastal sites for wildlife.

Table 22.5 Disbursements under Natural England's flood recovery fund for the winter 2013 to 2014 floods

Costs	Disbursements by organisation										Grand total	% of total
	RSPB	National Trust	Yorkshire WLT	Lincolnshire WLT	North Lincolnshire WLT	Norfolk WLT	Suffolk WLT	Kent WLT	Natural England	Natural England Nature Reserves		
Flood defences or water management infrastructure	£50,000	£4,250	-	-	£6,900	£3,000	£7,000	-	-	£45,000	**£120,000**	**23%**
Access and reserve infrastructure	£60,000	£10,500	-	£25,000	£58,000	-	£4,000	£8,500	-	£16,000	**£180,000**	**36%**
Grazing/livestock Infrastructure	£10,000	£9,500	£26,000	-	£27,000	£12,000	£3,300	£12,000	-	£7,000	**£110,000**	**21%**
Visitor facilities	-	-	£1,700	-	-	-	-	-	-	-	**£1,700**	**0.3%**
Bird watching hides	-	-	£10,000	-	-	£4,000	-	£1,000	-	-	**£15,000**	**3%**
Rubbish and debris clearance	-	£2,000	-	-	-	-	-	-	-	£4,300	**£6,300**	**1%**
Tree damage and clearance	-	-	-	-	-	-	-	-	-	£12,000	**£12,000**	**2%**
Somerset flood plans	-	-	-	-	-	-	-	-	£5,000	-	**£5,000**	**1%**
Other [1]	-	-	£55,000	-	-	-	-	-	-	-	**£55,000**	**11%**
Total	**£120,000**	**£26,000**	**£93,000**	**£25,000**	**£92,000**	**£19,000**	**£14,000**	**£21,000**	**£5,000**	**£85,000**	**£500,000**	**100%**
Percentage of total	**24%**	**5%**	**19%**	**5%**	**18%**	**4%**	**3%**	**4%**	**1%**	**17%**	**100%**	

Notes: All values are presented to 2 significant figures and therefore numbers may not exactly sum due to rounding.
[1] 'Other' refers to a specialist vehicle required by Yorkshire Wildlife Trust to enable it to adapt to the loss of the road along the Spurn peninsula.
WLT = Wildlife Trust

It was not possible to monetise the ecological impacts attributed to the winter 2013 to 2014 floods as part of this assessment. Previous actions have reduced the vulnerability of some sites to flooding. For example, initiatives by the RSPB using 'designer spillways' on tidal sites has reduced the vulnerability of flood control assets in restored inter-tidal areas. It is clear from the responses of site managers that the experience of the winter 2013 to 2014 floods has informed decisions about increasing the resilience of wildlife sites to flooding with respect to ecology, site infrastructure and visitor access.

Summary of flooding impacts in England

Drawing on the above, the best estimate of the identified quantifiable economic costs attributable to the 2013 to 2014 floods on wildlife sites in England are £2.3 million (as indicated in Table 22.6). The inclusion of additional costs for those sites that may have been affected but not surveyed (shown in Table 22.6) increases the site based estimates of average costs per ha in Table 22.4 by about 15%.

Table 22.6 Best estimate of the total economic cost of the winter 2013 to 2014 flood damage to wildlife sites in England

Type of cost	Best estimate	Comments
Damage costs on surveyed wildlife sites	£1.7 million	Based on adjusted economic costs derived from survey of 24 wildlife sites recording damages.
Additional damage costs funded by Natural England recovery fund	£100,000	Based on Natural England disbursements. Includes costs that are not included in the cost estimates of damages to the 24 surveyed sites.
Additional HLS flood compensation payments	£64,000	Based on HLS disbursements for 8 affected HLS holders in 2 regions
Additional Natural England flood management costs (staffing)	£130,000	Based on Natural England returns. Note that additional site labour costs are included above. Likely to be a high level of under reporting.
Total (based on available data)	**£2 million**	**Combination of the above costs**
Damage costs on non-surveyed wildlife sites	£290,000	Site surveys covered 26 sites in England reporting flood damage with 6,506ha of actual flooded area, 80% on coastal sites; 24 of these sites reported flood damage that was the responsibility of site managers (excludes coastal defences and paths), equivalent to 5,923ha, that is, 91% of total flooded areas. Environment Agency reported flooding of between 7,000 and 11,500ha of wildlife areas in England. Assuming a mean estimate of 9,250ha, an additional unreported 2,744ha (9,250 ha minus 6,506ha) of wildlife area is assumed to have flooded. Therefore the damages were calculated by assuming that an additional 2,744ha of wildlife sites were affected by flooding, a cost per hectare of wildlife site affected of £116 and adjusting the estimate by 0.91 to account for areas on wildlife sites that flooded but did not incur damages.
Total	**£2.3 million**	**Based on costs obtained from available data and extrapolated costs for non-surveyed wildlife sites**

Notes: All values are presented to 2 significant figures and therefore the numbers may not exactly sum due to rounding. Data relate to England but do include damages to one RSPB site in Denbighshire on the Wales–England border.

The Annex 1 method statement summarises the approach used to develop the best estimate of the damages to wildlife sites resulting from the floods.

22.2.3 Impact of flooding on wildlife sites in Wales

As in England, most of the impacts of the winter 2013 to 2014 floods in wildlife sites in Wales were associated with coastal tidal surges. Flooding was reported on 37 designated wildlife sites (mainly SSSIs) and 10 associated Special Areas of Conservation (Natural Resources Wales 2014).

There was no information on the cost of damage to physical assets, although damage to hides, walkways and signage was reported on a number of sites such as Newborough Warren and Yngs Llanddwyn National Nature Reserve, Anglesey. No damage was reported to visitor or educational centres.

According to information from Natural Resources Wales (personal communication, 2015), around 1,000ha of designated wildlife sites probably flooded with potential damages to site features and infrastructure that required restoration expenditure.

To determine the best estimate of the damage costs of flooding to wildlife sites in Wales, the estimated area affected (1,000ha) was multiplied by the unit cost of damages per hectare (excluding visitor centre costs) derived from the English sites. This gave an estimated economic cost of £120,000 (to 2 significant figures) attributable to flooding to wildlife sites in Wales.

The calculation used to estimate of the flood damages to wildlife sites is as follows:

> Estimate of the flood damage costs to wildlife sites in Wales (£120,000, best estimate) = Area of wildlife site affected by flooding (1,000ha, based on information from Natural Resources Wales (2015)) x Damage cost per hectare of wildlife site (£116 per ha, derived from data obtained for England)

22.2.4 Impact of flooding on wildlife sites in England and Wales

The estimates for England and Wales were combined to provide a best estimate of the flood damage costs to wildlife sites in England and Wales during the 2013 to 2014 winter period of £2.4 million (Table 22.7).

Table 22.7 Best estimate of the total economic cost of the winter 2013 to 2014 flood damage to wildlife sites in England and Wales

Type of cost	Best estimate	Comments
Total for England	£2.3 million	Based on costs obtained from available data and extrapolated costs for non-surveyed wildlife sites
Estimated damages to wildlife sites in Wales	£120,000	Around 1,000ha of wildlife site was affected by flooding (Natural Resources Wales, personal communication 2015). The area affected was multiplied by the damages per hectare based on data for England (£116 per ha)
Total (England and Wales)	**£2.4 million**	**Sum of damage costs for England and Wales**

Notes: All values presented to 2 significant figures and therefore numbers may not exactly sum due to rounding.

22.3 Determining the best estimate range

22.3.1 Impact of flooding on wildlife sites

Table 22.8 shows that the best estimate of the flood damages to wildlife sites in England and Wales was £2.4 million, with a range of £1.9 million to £3.0 million (presented to 2 significant figures). The best estimates of damages to wildlife sites caused by flooding for England and Wales were classified as having a moderate and moderate–high uncertainty rating respectively.

These range of values for the uncertainty analysis for this impact category are based on a critical review of the data sources on which the best estimates are made, and specific identified sources of uncertainty relating for example to areas directly affected by flooding to particular cost components such as visitor centres and facilities and visitor and local economy impacts. The approach outlined below is deemed the most appropriate to reflect the range given the variety of information used in determining the best estimate. Further details on the methods used to develop the low and high range estimates are provided in the 'Comments' column of Table 22.8.

Table 22.8 Best estimate and ranges of the total economic cost of winter 2013 to 2014 flood damage to wildlife sites in England and Wales

Type of cost	Best estimate	Low estimate	High estimate	Comments
Damage costs on surveyed wildlife sites	£1.7 million	£1.4 million	£2.1 million	Based on adjusted economic costs derived from survey of 24 wildlife sites recording damages. Range based on 25% remaining value of damaged assets (low) or 75% (high) as opposed to 50% used to determine the best estimate where actual depreciated accounts-based values are not known.
Additional damage costs funding by Natural England recovery fund	£100,000	£70,000	£130,000	Based on Natural England disbursements. Includes costs that are not included in the cost estimates of the damages to the 24 surveyed sites. Range allows for errors in matching site and Natural England fund data.
Additional Higher Level Stewardship (HLS) flood compensation payments	£64,000	£58,000	£85,000	Based on HLS disbursements for 8 affected HLS holders in 2 regions. Low range adjusted to allow for possible betterment (-10%). High range reflects under accounting in other regions (+33%) and an additional £21,000 including administration costs.
Additional Natural England flood management costs (staffing)	£130,000	£100,000	£190,000	Based on Natural England returns. Note that additional site labour costs are included above. Low range has been adjusted to account for possible over attribution to flooding (-20%). High range adjusted to account for likely high level of under reporting (+50%).
Total (based on	£2 million	£1.6	£2.5	Combination of the above costs.

Type of cost	Best estimate	Low estimate	High estimate	Comments
available data)		million	million	Range reflects uncertainty of assumptions on site-based costs e.g. remaining value and betterment.
Damage costs on non-surveyed wildlife sites	£290,000	£220,000	£360,000	Site surveys covered 26 sites in England with 6,506ha of actual flooded area, 80% on coastal sites; 24 of these sites reported flood damage that was the responsibility of site managers (excludes coastal defences/paths), equivalent to 5,923ha, that is, 91% of total flooded areas. Environment Agency reported flooding of between 7,000ha and 11,500ha of wildlife sites in England were subject to flooding. It was not known how much of these site areas actually flooded. Assuming a central estimate of 9,250ha, an additional unreported 2,744ha (9,250ha minus 6,506ha) of wildlife area assumed to have flooded at a cost per hectare of wildlife site affected of £116, adjusted by 0.91 to account for areas on wildlife sites that flooded but did not incur damages. Range reflects 'additional' area estimates ±25%, 2,060ha (low) to 3,430ha (high) based on range of area flooded.
Total (England)	**£2.3 million**	**£1.8 million**	**£2.8 million**	Based on costs obtained from available data and extrapolated costs for non-surveyed wildlife sites. Range mainly reflects uncertainty related to site's physical damage.
Estimated damages to wildlife sites in Wales	£120,000	£87,000	£170,000	Natural Resources Wales indicated that around 1,000ha of wildlife sites were affected by flooding. The area of wildlife site affected (1,000ha) was multiplied by the damages per hectare based on data for England (£116 per ha). Low range estimate of area flooded is 750 ha (-25% of best estimate). High range estimate of area flooded is 1,500ha (+50% of best estimate).
Total (Wales)	**£120,000**	**£87,000**	**£170,000**	See cell above
Total (England and Wales)	**£2.4 million**	**£1.9 million**	**£3.0 million**	

Notes: All values are presented to 2 significant figures and therefore numbers may not exactly sum due to rounding.

22.4 Damage costs by flood type

This section provides a breakdown of the damages to wildlife sites as a result of the winter 2013 to 2014 floods by flood type. It includes details of the methods used to differentiate the damage costs and the associated uncertainties.

22.4.1 Approach to disaggregating the damage costs

Of the 24 surveyed sites in England that reported onsite flood damages, 22 involved mainly tidal flooding of coastal and estuarine sites. These sites accounted for around 80% of the total flooded areas and approximately 95% of total estimated economic costs for the English wildlife sector. As noted earlier, much of the damage costs to wildlife sites in the winter 2013 to 2014 floods were associated with damage to visitor related infrastructure on coastal sites. Most of the impacts on wildlife sites in Wales were also associated with coastal surges, but the types of damages are uncertain.

For the purposes of estimating the damages caused by flood type, was assumed that 95% of damages to wildlife sites in England and Wales were caused by coastal flooding with the remaining 5% attributable to other flood sources (fluvial, groundwater and so on). The best estimate of flood damages to wildlife sites in England and Wales is uncertain, as is the proportion of these costs related to coastal flooding and other flooding sources. The figures presented in Table 22.9 indicate the damages by flood type rather than a definitive cost breakdown.

22.4.2 Summary of damage costs by flood type

Table 22.9 summarises the damages to wildlife sites in England and Wales.

Table 22.9 Damage costs to wildlife sites in England and Wales by flood type

Flood source	Economic damage estimates					
	Best estimate		Low estimate		High estimate	
	Damage	Percentage of total	Damage	Percentage of total	Damage	Percentage of total
All (total)	£2.4 million	100%	£1.9 million	100%	£3.0 million	100%
Fluvial/ groundwater	£120,000	5%	£95,000	5%	£150,000	5%
Coastal	£2.3 million	95%	£1.8 million	95%	£2.9 million	95%

Notes: Values are presented to 2 significant figures

22.5 Damage costs for England and Wales

This section provides a breakdown of the damages to wildlife sites as a result of the winter 2013 to 2014 floods for England and Wales. It includes details of the method used to differentiate the damage costs and the associated uncertainties.

22.5.1 Approach to disaggregating the damage costs

The damages incurred at wildlife sites in England were obtained by:

- collecting information on damages to 24 wildlife sites
- determining the additional damage cost funding provided by the Natural England through its recovery fund
- determining the additional HLS compensation payments
- determining additional Natural England flood management costs (staffing)

- using unit costs to estimate the damages to non-surveyed sites

Combining these data gave an economic cost of damages to wildlife sites in England during the 2013 to 2014 floods of £2.3 million, with a range of £1.8 million to £2.8 million (presented to 2 significant figures).

The flood damage costs to wildlife sites in Wales during the 2013 to 2014 winter period were determined by assuming that 1,000ha of sites were affected with damages amounting to £116 per ha (based on the unit costs determined for England). The best estimate of the flood damages to wildlife sites in Wales is £120,000, with a range of £87,000 to £170,000 (presented to 2 significant figures).

22.5.2 Damage costs for England and Wales

Table 22.10 provides a summary of the flood damages to wildlife sites during the winter 2013 to 2014 floods split between England and Wales.

Table 22.10 Estimated economic damage costs to wildlife sites by country

Country	Economic damage estimates					
	Best estimate		Low estimate		High estimate	
	Damage	Percentage of total	Damage	Percentage of total	Damage	Percentage of total
Total	£2.4 million	100%	£1.9 million	100%	£3.0 million	100%
England	£2.3 million	95%	£1.8 million	95%	£2.8 million	94%
Wales	£120,000	5%	£87,000	5%	£170,000	6%

Notes: Values are presented to 2 significant figures

22.6 Uncertainties and assumptions

Limited data were obtained on the area of wildlife sites directly affected by flooding during the 2013 to 2014 winter period. The figure provided for Somerset (7,000ha) and the area affected in England (11,500ha) are therefore uncertain. A further 1,000ha of designated sites in Wales are considered to have flooded with damage to physical assets, but the true extent remains unknown.

Storm and flood damage occurred concurrently in the winter of 2013 to 2014, especially on coastal sites. Where possible, wind related storm damage, especially damage to trees and buildings, was excluded from the damage estimates.

Estimates of economic damages are based on reported financial losses (about half of which were reported to be insured), which have been adjusted to allow for remaining value and to account for taxes where relevant. Disruption to the 'business' activities of wildlife site was measured as a loss of net revenue. Some of this may have been displaced elsewhere, but because less than 6% of estimated total costs are attributed to this, the uncertainty is likely to be small.

All efforts were made to ensure there was no double counting of impacts where there are overlaps with other categories. For example, the cost of flood recovery funding for wildlife was subtracted from site-based damage estimates.

Drawing on information from primary and secondary data sources, the best estimate of wildlife damages in England and Wales is £2.4 million, with a range of £1.9 million to £3.0 million mainly associated with the uncertainty on the extent and value of damages.

23 Impacts on heritage

23.1 Summary of findings

Table 23.1 presents the headline figures for the impact category of heritage. This category includes economic estimates of the damages caused to heritage assets during the winter 2013 to 2014 floods. The best estimate is £7.4 million, with a range of £5.6 million to £9.3 million.

The best estimate was determined by extrapolating local data using a damage per asset figure of £290,000 and applying this to the number of heritage assets considered to have been affected by flooding but for which no specific damage costs were available. It was not possible to obtain any national level data on flooding damages to heritage infrastructure and therefore, extrapolating the local level data was considered to provide the most reliable figure (albeit uncertain).

Some of the damages to heritage infrastructure are likely to have been caused by water-related erosion in addition to or as opposed to flooding directly. This information was retained as the effect of erosion, particularly in coastal areas during the tidal surge, was a significant element of the winter 2013 to 2014 floods and government policy inextricably links the impacts of floods and water-related erosion. Further details describing how the best estimate and range were determined are provided in the following sections.

Some of the damage information relating to insurable costs were adjusted to provide an economic estimate. These insurable costs are considered to be in addition to those included in the businesses category and are therefore not considered to be double counted.

Table 23.1 Headline findings for heritage

Finding	Economic damage estimates			
	Best estimate (range)	**% of total monetised damages**	**Uncertainty**	**Comments**
2013 to 2014 damages (total)	£7.4 million (£5.6 million to £9.3 million)	0.59% (of overall total damages)	Moderate–high	Based on extrapolation of local data using an average damage estimate per heritage asset. Range estimates are determined based on uncertainty rating.
2013 to 2014 damages (England)	£7.4 million (£5.6 million to £9.3 million)	100% (of total for category)	Moderate–high	Refers to the proportion of total costs attributable to England.
2013 to 2014 damages (Wales)	No damages found	0% (of total for category)	High	No damages found
2007 damages (2014 values)	Not specifically calculated	Not available	Not reported	Environment Agency (2010)
	Best estimate	**Units**	**Uncertainty**	**Source of estimate**

Finding	Economic damage estimates			
Numbers affected	49	Number of heritage assets affected	Moderate–high	Based on local data and flood outline data.
Numbers affected (England)	49	Number of heritage assets affected	Moderate–high	Based on local data and flood outline data.
Numbers affected (Wales)	No assets found to have been damaged	No damages found	High	No damages found
	Best estimate	**Range**	**Uncertainty**	**Source of estimate**
Damages per asset	£290,000	Based on local data for which information on both number of assets damaged and damage costs is available	Moderate–high	Based on local data (from 9 LLFA areas), but considered to be uncertain (note that this refers to an economic cost).

Notes: Values presented to 2 significant figures.

23.2 Determining the best estimate

23.2.1 Number of heritage assets affected

Information at the local (LLFA) level was obtained on the number of heritage assets affected during the winter 2013 to 2014 floods. Environment Agency flood outline data were used to fill gaps in this information.

Aggregating the information obtained from 15 LLFAs gave a best estimate of 49 heritage assets are considered to have been affected by flooding during the 2013 to 2014 winter period.

It is recognised that some of the assets included in the flood outline data may not have actually flooded. However, it was not possible to determine whether or not this was the case for each individual site. Therefore, the flood outline data were used only in cases where no alternative information was available and account for 33% of heritage assets considered to have been flooded.

23.2.2 Damages to heritage assets

This section provides an overview of the types of costs experienced by the heritage sector with a particular focus on the damages caused by flooding during the 2013 to 2014 winter period. Data were collected at the LLFA level and, where appropriate, adjusted to provide an economic cost estimate. The data were then aggregated and extrapolated to provide a total estimate of the economic costs of the floods to heritage sites.

Internet research and consultation with local authorities and other organisations was conducted to determine the impacts of the 2013 to 2014 floods on heritage assets. Information from English Heritage indicates that, in terms of visitor impacts, heritage sites on the coast appear to have been unaffected by winter storm events in 2013 to 2014, or closed for the season. For heritage assets outside the direct control of English Heritage,[11] although it passed lists of assets potentially affected to the relevant local

[11] English Heritage only directly administers Grade 1 or 2* listed buildings. Grade 2 listed buildings are managed by local authorities.

authorities, it had not received any information back on the cost of subsequent mitigation or repairs

However, there are known to have been flooding impacts to heritage assets as a result of the winter 2013 to 2014 floods. In Cornwall, the impacts of the floods were well recorded (Andrew 2014), providing an indication of the types of impacts the floods had on heritage sites. For example, the floods caused structural damage to a large number of historic assets, including listed harbours, iconic designated features and the causeway across to St Michael's Mount. Damage was also recorded to features important to the UNESCO World Heritage Site and the harbour at Portreath. In addition to the damage caused by the floods to man-made assets, submerged peat deposits were exposed at Mounts Bay, exposing them to damage and desiccation. At least one World War I submarine was also exposed and damage was done to an Iron Age hill fort, a Scheduled Monument. It is likely that the damages caused to these assets were as a result of water-related erosion rather than flooding.

Damage information was obtained for 9 LLFA areas. Each piece of information was assessed to ensure it was not counted in other impact categories and to ensure that the figures represented an economic cost. In the case of damages to heritage assets, a series of adjustments were made to convert financial values to economic estimates.

However it should be stressed no attempt was made to estimate any permanent damages to the intrinsic value of these heritage sites, because such sites could be considered priceless given their often irreplaceable nature. Instead this section only seeks to estimate repair costs to these assets and where relevant their associated visitor facilities.

Information on insurable damages to heritage assets was obtained for some LLFAs. These insurable costs predominantly relate to damages to visitor centres and associated facilities and are considered to be in addition to those included in the businesses category and are therefore not considered to be double counted. However, there is a risk of some double counting since the damages from insurance claims for businesses were not disaggregated.

To convert these financial insurable damage costs to an economic estimate, an approach similar to that used in the businesses category was taken and based on that outlined in Environment Agency (2010). The approach accounts for the damages caused to inventory (contents) and non-inventory (buildings and fixtures) items and assumes the same proportional split for heritage assets as for businesses, that is, 45% of business insurance claims were for commercial inventories (contents) with the remaining 55% relating to building structures and fixtures. Adjustments were also made to the financial value of insurance claims to allow for the fact that most goods (inventory items) replaced under 'like-for-like' policies are not new. On average, they have a remaining value equivalent to half of their original value and hence half their replacement cost. Thus, the economic cost of damage was taken to be 50% of the financial replacement cost under an 'old' for 'new' policy (this is only applied to inventory items). A final adjustment is made to both inventory (contents) and non-inventory items (building structures and fixtures) to remove VAT at 20%.

Table 23.2 provides a summary of the adjustments made for insurable damages to heritage assets to convert from a financial to an economic cost estimate.

Other data were obtained where it was not clear whether the damages to heritage assets were insurable or not. In these cases, the damages were considered to represent a financial rather than an economic cost. To convert these damage costs to an economic value, the figures were adjusted to account for betterment. It was assumed that, in the majority of cases, the assets damaged by flooding were part way through their serviceable life. Repair or replacement of the damaged asset would

effectively improve its condition, potentially extending its serviceable life. Hence, it was not deemed appropriate to take the full damage cost as the economic estimate as the old asset was effectively replaced by a new asset (that is, not a like-for-like replacement). To account for this, 50% of the asset damages/repair costs were taken. In addition, any work to repair or replace a damaged asset will incur VAT. This was therefore removed (using the current VAT rate of 20%) to provide an economic cost of the flood damages.

Table 23.2 Conversion of insurable damages to heritage assets from a financial cost to an economic cost

Stage	Type of cost	Adjustment
1	Original financial estimate	Original value
2	Inventory items (commercial contents)	45% of claims are for commercial inventories (45% of Stage 1)
3		50% of financial replacement cost – replacing old with new (50% of Stage 2)
4		Remove VAT at 20% (divide by 1.2)
5	Non-inventory items (building structures and fixtures)	55% of claims are for commercial building structures and fixtures (55% of Stage 1)
6		Remove VAT at 20% (divide by 1.2)
7	**Total economic cost**	**Stage 4 + Stage 6**

A summary of the calculation used to convert the financial damage/repair costs to an economic estimate is provided below:

> Economic estimate of asset damage/repair costs = Financial estimate of asset damage/repair costs × 50% (accounting for betterment – that is, replacing an old asset with a new one) ÷ 1.2 (to remove VAT at 20%)

Once the financial costs had converted to economic estimates, the data were aggregated to give an estimate of the flood damages to heritage assets of £2.7 million. However, this only refers to costs for 9 LLFA areas and is considered to be an underestimate of the total (national) impact.

To account for this underestimate, the information obtained on the flood damages to heritage assets was used to provide an estimate of the average damage costs per asset. First, the damage costs for each LLFA were divided by the number of assets affected (damage/cost information was obtained for 33 assets) to provide an average cost per LLFA (where sufficient information was available). Second, the mean of the flood damage costs per asset for all LLFA areas was determined to provide a national level estimate of the average flood damage cost to heritage assets during the winter 2013 to 2014 floods (£290,000).

This average damage figure of £290,000 was applied to the 16 heritage assets known to have been affected by flooding but for which no specific damage cost information was available. These extrapolated costs (£4.6 million) were combined with the damage costs obtained at the LLFA level to provide an overall best estimate of the economic damages to heritage assets during the winter 2013 to 2014 floods of £7.4 million. The calculation used to determine the best estimate of the flood related damages to heritage assets during the 2013 to 2014 winter period is provided below:

> Economic estimate of the flood damages to heritage assets (£7.4 million, best estimate) = [Average cost of damages per asset (£290,000, based on local level data for 9 LLFAs with data on both number of assets affected and cost) × Number of assets considered to have flooded but for which no

cost information was available (16 assets)] + Damage costs to heritage assets (£2.7 million, based on local level data)

This approach produces an uncertain figure for 2 main reasons. First, it is not always clear from the data, particularly in the case of the flood outline data, whether heritage assets were directly flooded or whether access problems due to the flooding prevented them for operating as normal. Information from English Heritage suggested that flood damages to heritage assets at the national scale were likely to be small, but evidence at the local level suggested that some sites were affected.

Second, many heritage sites are unique. The damages caused may differ from the £290,000 figure used in this calculation, and thus may over or underestimate the actual damages caused by flooding. The adjustment for betterment was applied mainly to reflect the life of assets needing repair to reflect that these repairs might have been brought forward rather than suggesting that the heritage sites have a 'residual' life.

However, the figure obtained from this approach was considered to represent the best estimate given the lack of any national level data and the very limited damage information obtained from the local approach. The Annex 1 method statement summarises the approach used to develop the best estimate of the damages to heritage assets resulting from the floods.

23.3 Determining the best estimate range

The data used to provide the best estimate of costs in each impact category were assessed to determine the associated uncertainty. The uncertainty rating was applied based on the availability and quality of the data obtained and the assumptions applied to the data to provide an economic cost estimate. The uncertainty rating was subsequently used to determine the potential range around the best estimate.

This approach was used to determine a range of flood damage costs to heritage assets of £5.6 million to £9.3 million (Table 23.1). Further details on the methods used to develop the lower and higher ranges are provided below.

23.3.1 Low estimate

Damage costs associated with flooding of heritage assets during the 2013 to 2014 winter period were obtained at the local (LLFA) level and adjusted to provide economic cost estimates. This information was combined to provide a total estimate of flood damages to heritage assets of £2.7 million. However, this figure refers only to costs for 9 LLFA areas and is therefore considered to be an underestimate of the total (national) impacts. An average damage cost per heritage asset (£290,000) was determined and applied to the 16 heritage assets known to have been affected by flooding but for which no specific damage cost information was available. These extrapolated costs were combined with the damage costs obtained at the LLFA level to provide an overall best estimate of the economic damages to heritage assets during the winter 2013 to 2014 floods of £7.4 million.

This is an uncertain approach given that flood related damages are likely to vary depending on the asset affected and the extent and duration of the impact. Thus, the data were classified as having a moderate–high uncertainty rating given the extrapolation and the adjustments made to provide an economic estimate of the costs. To reflect this uncertainty, the best estimate (£7.4 million) was reduced by 25% (see Table 2.5), resulting in a low range estimate of the flood damages to heritage assets during the 2013 to 2014 winter period of £5.6 million.

23.3.2 High estimate

A similar approach was used to obtain an upper range estimate. The data obtained on flood damages to heritage assets were converted to economic costs and extrapolated to provide an estimate of the potential costs at the national level. These data were assigned a moderate–high uncertainty rating because damages to individual heritage assets are likely to vary, given that many assets are unique, and hence the costs incurred are likely to differ from figure used in the extrapolation; it was not possible to verify whether the costs used represent the actual damages incurred. It was also not clear whether all the heritage assets were flooded directly or whether flooding restricted access, preventing them from operating as normal. Therefore, a moderate–high rating was considered to represent the uncertainty associated with the best estimate. To reflect this uncertainty, the best estimate (£7.4 million) was increased by 25% (see Table 2.5), resulting in a high range estimate of the flood damages to heritage assets during the 2013 to 2014 winter period of £9.3 million.

23.4 Damage costs by flood type

23.4.1 Approach to disaggregating the damage costs

The disaggregation of damages by flood type has been based on the assumption that the majority of damages incurred by coastal LLFAs were caused by tidal surges. Although this is a simplification, there are insufficient details to enable a more sophisticated analysis. Damages were not included where the damage figures specified the flood type and this did not relate to coastal impacts.

For heritage assets, the estimates of damages came from extrapolation of estimates based on a unit cost of £290,000 per heritage asset for each LLFA. This was broken down into coastal and inland LLFAs to determine damages from coastal flooding.

23.4.2 Summary of damages costs by flood type

Table 23.3 provides a summary of damages to heritage assets by flood type

Table 23.3 Estimated economic damage costs to heritage assets by flood type

Flood source	Economic damage estimates					
	Best estimate		Low estimate		High estimate	
	Damage	Percentage of total	Damage	Percentage of total	Damage	Percentage of total
All (total)	£7.4 million	100%	£5.6 million	100%	£9.3 million	100%
Fluvial/ groundwater	£1.6 million	21%	£1.2 million	21%	£2.0 million	21%
Coastal	£5.9 million	79%	£4.4 million	79%	£7.3 million	79%

Notes: Values are presented to 2 significant figures and therefore totals may not be equivalent to the types of flooding due to rounding.

23.5 Damage costs for England and Wales

There was no information on heritage assets damaged as a result of flooding in Wales. The estimates above are therefore damages for England only.

23.6 Uncertainties and assumptions

No national level information was obtained on the total number of heritage assets affected by the winter floods. Local level data provide an indication of the number of heritage assets flooded and include Environment Agency flood outline data in cases where there was no specific information on flooded assets. Where data gaps exist, flood outline data were used to estimate the number of assets that may have flooded in each category, although for heritage this only includes churches. There is a degree of uncertainty with these figures as some assets within a flood outline may not have flooded. Therefore, these data were only used where there was no alternative value.

Storm and flood damage occurred concurrently, especially on coastal sites. Where possible, wind related damage (especially damage to trees and buildings) was excluded from flood related costs. Some of the damages included will refer to water-related damages as well as flooding.

To estimate the damages caused to heritage assets at the national scale, local level data were extrapolated. This involved determining an average damage cost per asset and applying average cost this to the sites known to have been affected but for which no specific cost information had been obtained. This approach produces an uncertain total cost estimate because many heritage sites are unique and therefore the damages caused are likely to differ. Thus, the extrapolated figure may under or overestimate the damages caused to heritage infrastructure.

24 Impacts on tourism and recreation

24.1 Summary of findings

Table 24.1 presents the headline figures for the impact category of tourism and recreation. This category includes economic estimates of damages to tourism and recreation assets, including holiday cottages, beach huts and other tourism infrastructure. The best estimate is £3.5 million, with a range of £2.6 million to £4.4 million.

The best estimate was determined by extrapolating local data using a damage per asset figure of £3,800 and applying this to the number of tourism assets considered to have been affected by flooding but for which no specific damage costs were available. This is uncertain because the actual damages to tourism and recreation assets are likely to vary depending on the asset affected and the damage caused. However, this approach attempts to incorporate damages on assets for which no specific cost information was obtained to provide an overall estimate. It was not possible to obtain any national level data on flooding damages to tourism and recreation assets, and therefore extrapolating the local level data was considered to provide the most reliable figure (albeit uncertain).

Consideration has also been given to the regional impacts of flooding on the tourism industry and the effect this had on visitor trips and activities. Although, the regional impacts were considerable in some areas it has not been possible to monetise these as it is unclear to what extent the effects of flooding had on tourism (and the losses incurred) at the national scale.

It is likely that some of the damages to tourism and recreation infrastructure were caused by water-related erosion in addition to, or as opposed to, flooding directly. This information was retained as the effect of erosion, particularly in coastal areas during the tidal surge, was a significant element of the winter 2013 to 2014 floods and government policy inextricably links the impacts of floods and water-related erosion. Further details describing how the best estimate and range were determined are provided in the following sections.

The damages for this impact category relate to private and publically owned assets and, where possible, were only included in the tourism and recreation category to avoid double counting with other categories. However, detailed information was not available in many cases on the breakdown of costs included in the businesses and local authority and local government infrastructure categories. This meant it was not possible to determine the costs that were included or excluded, and therefore, there is a risk of double counting with these categories.

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Table 24.1 Headline findings for tourism and recreation

Finding	Damage estimates			
	Best estimate (range)	**% of total monetised damages**	**Uncertainty**	**Source of estimate (national, local or extrapolation of local)**
2013 to 2014 damages (total)	£3.5 million (£2.6 million to £4.4 million)	0.28% (of overall total damages)	Moderate–high	Based on extrapolation of local data using an average damage estimate per asset. Range determined based on uncertainty rating.
2013 to 2014 damages (England)	£2.9 million (£2.2 million to £3.6 million)	82% (of total for category)	Moderate–high	Refers to the proportion of total costs attributable to England. Range determined based on uncertainty rating.
2013 to 2014 damages (Wales)	£650,000 (£490,000 to £810,000)	18% (of total for category)	Moderate–high	Refers to the proportion of total costs attributable to Wales. Range determined based on uncertainty rating.
2007 damages (2014 values)	Not specifically reported	-	Score: not reported	Environment Agency (2010)
	Best estimate	**Units**	**Uncertainty**	**Source of estimate**
Numbers affected (total)	1,072 6.4 million	Assets within flood extent. Trips disturbed	Moderate–high / Moderate	Based on local data and flood outline data. Visit England (2014) for trips disturbed
Numbers affected (England)	979	Assets within flood extent	Moderate–high	Based on local data and flood outline data.
Numbers affected (Wales)	93	Assets within flood extent	Moderate–high	
	Best estimate	**Range**	**Uncertainty**	**Source of estimate**
Damages per asset	£3,800	-	Moderate–high	Based on local data (from 5 LLFA areas), but considered to be uncertain (note that this refers to an economic cost)

Notes: Values presented to 2 significant figures.

24.2 Determining the best estimate

24.2.1 Number of assets affected/trips disturbed

Information was obtained at the LLFA level on the number of tourism and recreational assets affected during the winter 2013 to 2014 floods. Environment Agency flood outline data were used to fill gaps in the information collected at the local level. A total of 1,072 assets were considered to have been affected by flooding; 571 of these were obtained from GIS flood outline data (shown as being within flooded areas) during the 2013 to 2014 winter period.

The map in Figure 24.1 shows the distribution of tourism assets affected by the winter 2013 to 2014 floods.

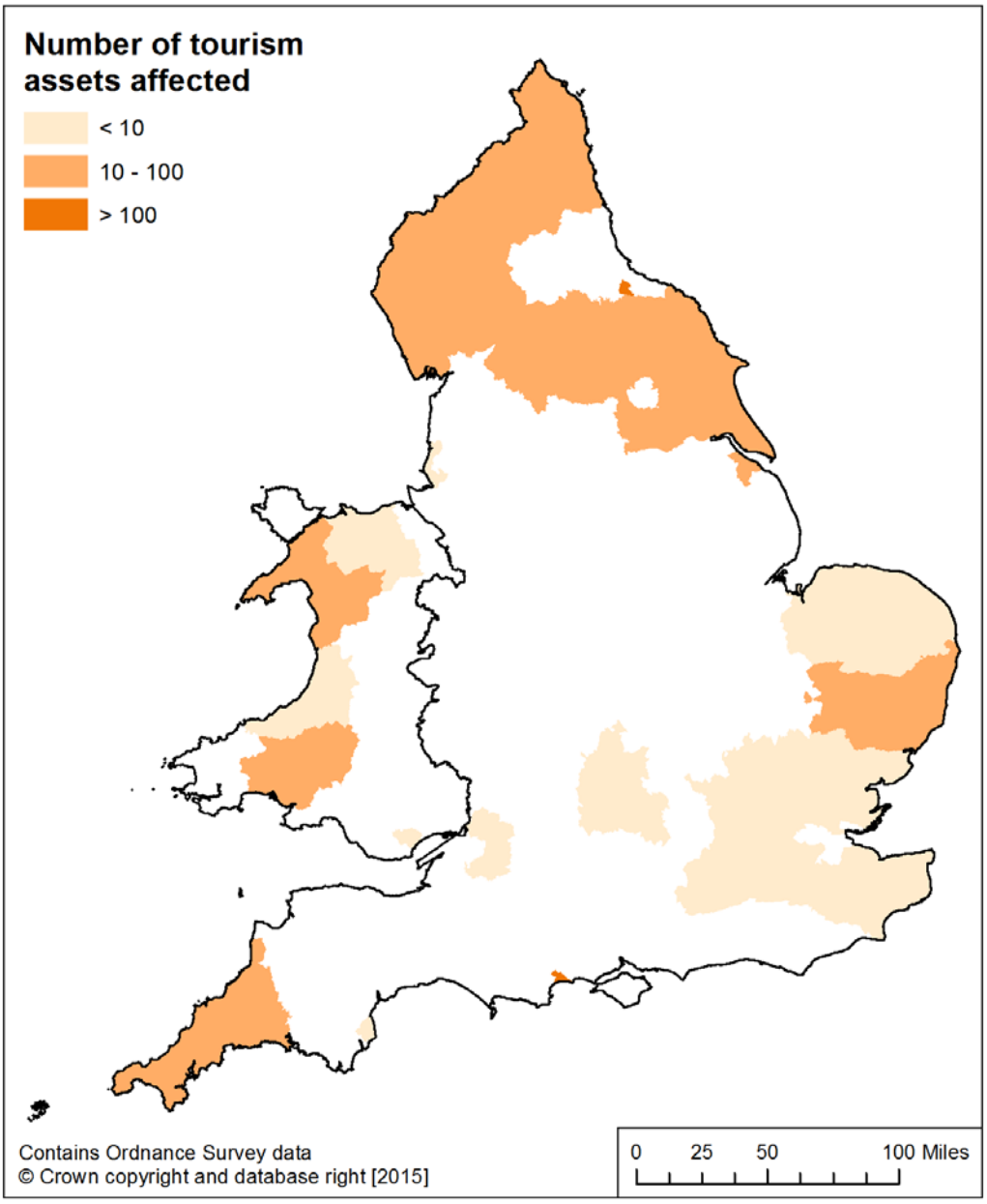

Figure 24.1 Number of tourism assets affected for the 29 LLFAs for which data were available

Notes: Only shows where data were available and data may also be incomplete.

Some of the assets included in the flood outline data may not have actually flooded, but it was not possible to determine whether or not this was the case for each individual site. Therefore, the flood outline data were only used in cases where no alternative information was available.

National level information from Visit England indicates that an estimated 6.4 million people had recreational trips disturbed by severe weather during the winter 2013 to 2014 floods (Visit England 2014). It is not clear to what extent the expenditure associated with these trips, were lost for good, were just delayed, or replaced by visiting other locations or by expenditure on other goods and services. It is also unclear what proportion of these trips was disrupted as a result of flooding specifically. Due to this uncertainty it was not attempted to estimate national losses from trip disruptions. Though it is recommended this could be an area for further study and investigation.

24.2.2 Impacts on tourism and recreation

Data were collected at the LLFA level and, where appropriate, adjusted to provide an economic cost estimate. The data were then aggregated and extrapolated to provide a total national level estimate of the economic costs of the winter 2013 to 2014 floods to tourism and recreation.

Damages to tourism and recreation assets

Numerous seafronts were affected due to the coastal surge and subsequent storms including Lowestoft, Southend, Cromer, Thorpeness, Southwold, Felixstowe, Southsea, Portsmouth, Whitehaven, Blackpool, Seaham, Cullercoats, Bournemouth, Teignmouth, Bideford, Woolacombe, South Milton Sands (Devon) and in numerous locations in Cornwall (Godrevy, St Ives, Newquay, Port Gaverne, Pont Quay, Porthbeor Beach, Roseland, Sandymouth Beach, Strangles Beach, Towan, Portledden Cove).

At Bournemouth, 387 beach huts were damaged (Bournemouth Borough Council 2014). The Sea Life Centre at Hunstanton in Norfolk was flooded and had to evacuate thousands of fish to Weymouth after power to the life support system was lost (BBC News 2014a). At Hightown in Sefton on Merseyside, the sea overtopped the revetment and flooded the sailing club (Sefton Council, personal communication 5 November 2014). In Wales, the coastal path was damaged in 70 locations, generating financial repair costs of £340,000 (Natural Resources Wales 2014). There were also impacts on the South West Coast Path and numerous public rights of way.

Information on damages to tourism and recreation assets was obtained for 13 LLFA areas. Each piece of information was assessed to ensure that, where possible, it was not counted in other impact categories and that the figures represented an economic cost. But as indicated above, there were examples of flood related damages to private and publically owned infrastructure. In the case of privately owned assets, damages caused by flooding may be insurable and potentially included in the businesses category. Damages to publically owned assets may be included in the local authority and local government infrastructure category. In many cases, detailed information was not available on the breakdown of costs included in the businesses and local authority and local government infrastructure categories. This meant it was not always possible to determine which costs were included or excluded, and therefore there is a risk of double counting with these categories.

In the case of damages to tourism and recreational assets, a series of adjustments were made to convert financial values to economic estimates. To convert these damage costs to an economic value, the figures were first adjusted to account for

betterment. It was assumed that, in the majority of cases, the assets damaged by flooding were part way through their serviceable life. Repair or replacement of the damaged asset effectively improves its condition, potentially extending its serviceable life. Hence, it was not deemed appropriate to take the full damage cost as the economic estimate as the old asset was effectively replaced by a new one (that is, not a like-for-like replacement). To account for this, 50% of the asset damages/repair costs were taken. In addition, any work to repair or replace a damaged asset will incur VAT. This was therefore removed to provide an economic cost of the flood damages.

A summary of the calculation used to convert the financial damage/repair costs to an economic estimate is provided below:

> Economic estimate of asset damage/repair costs = Financial estimate of asset damage/repair costs × 50% (accounting for betterment) ÷ 1.2 (to remove VAT at 20%)

Information on damages to tourism and recreation assets was obtained for only 13 LLFA areas and the calculated economic estimate was therefore considered to be an underestimate of the total (national) impacts.

To account for this underestimate, the local (LLFA) level information obtained on the flood damages to tourism and recreational assets was used to provide an estimate of the average damage costs per asset. First, the damage costs for each LLFA were divided by the number of assets affected to provide an average cost per LLFA (where sufficient information was available). Second, the mean of the flood damage costs per asset for all LLFA areas was determined to provide a national level estimate of the average flood damage cost per asset of £3,800 during the winter 2013 to 2014 floods.

This average damage figure of £3,800 was applied to the 582 assets known to have been affected by flooding but for which no specific damage cost information was available. These extrapolated costs were combined with the damage costs obtained at the LLFA level to provide an overall best estimate of the economic damages to tourism and recreation assets during the winter 2013 to 2014 floods of £3.5 million.

The calculation used to determine the best estimate of the flood related damages to tourism and recreation assets during the 2013 to 2014 winter period is provided below:

> Economic estimate of the flood damages to tourism and recreation assets (best estimate) = [Average cost of damages per asset (£3,800, based on local level data for 5 LLFAs with data on both number of assets affected and cost) × Number of assets considered to have flooded but for which no cost information was available (582 assets)] + Damage costs to tourism and recreation assets (based on local level data)

The result produced by this approach is highly uncertain because it was not always clear from the data (particularly in the case of the flood outline data) whether assets were directly flooded or whether flooding restricted access to them, preventing them operating as normal. In addition, the average damages per asset (£3,800) used to extrapolate the costs may not accurately reflect the damages caused to tourism and recreation assets. The use of this figure may therefore under or overestimate the actual damages caused by flooding. However, this was considered to represent the best estimate given the lack of any national level data and the very limited damage information obtained from the local approach.

Tourism/recreation sector visitor losses

As discussed earlier in the section. In addition to direct damages to assets, the winter 2013 to 2014 floods also resulted in regional losses to the tourism and recreation

sector, particularly in areas that were affected over a considerable period of time or where transport links were disrupted. For example, disruption to the railway line at Dawlish is thought to have contributed to a reduction in visitor numbers to Cornwall resulting in a loss to the local economy (Cornwall Council 2014b). The extensive and prolonged flooding in Somerset during the 2013 to 2014 winter period is also considered to have resulted in a loss of regional income due in part to a reduction in visitors (BBC News 2014d).

However, there is a lack of evidence as to how much of the losses incurred were losses to the nation as a whole rather than at the local level. It may be that the tourism recreation trips/activities that were disrupted because of flooding in a particular region (resulting in a subsequent loss of income) took place in another part of the country or funds planned to be spent on these visits were transferred to other goods and services. In such cases the loss of income to one region may be transferred as an increase in income to other regions and businesses. Thus, a regional loss of income may not necessarily equate to a loss at the national level.

In addition, the bad weather and storms experienced during the winter 2013 to 2014 period were a combination of flooding, erosion and wind – all of which contributed to the impacts to, and losses experienced by, the tourism and recreation industry. It is therefore difficult to strip out the losses to the tourism and recreation sector that relate to flooding and water-related erosion specifically.

Given the above, estimating the tourism recreation losses at the national level that can be attributed to flooding or water-related erosion is highly uncertain and could not be done within the scope of this study. Therefore, losses to the tourism and recreation sector resulting from the winter 2013 to 2014 floods were not included in the best estimate.

The Annex 1 method statement presents the approach used to obtain the best estimate of damages for tourism and recreation.

24.3 Determining the best estimate range

The data used to provide the best estimate of costs in each impact category were assessed to determine the associated uncertainty. The uncertainty rating was applied based on the availability and quality of the data obtained and the assumptions applied to the data to provide an economic cost estimate. The uncertainty rating was subsequently used to determine the potential range around the best estimate.

This approach was used to determine a range of flood damage costs to tourism and recreation assets of £2.6 million to £4.4 million (Table 24.1). Further details on the methods used to develop the lower and higher ranges are provided below.

24.3.1 Low estimate

Damage costs associated with flooding of tourism and recreation assets during the 2013 to 2014 winter period were obtained at the local (LLFA) level and adjusted to provide economic cost estimates. This information was combined to provide a total estimate of flood damages to tourism and recreation assets of £1.3 million. However, this figure refers only to costs for 13 LLFA areas and was therefore considered to be an underestimate of the total (national) impacts. An average damage cost per asset (£3,800) was determined and applied to the tourism and recreation assets known to have been affected by flooding but for which no specific damage cost information was available. These extrapolated costs were combined with the damage costs obtained at

the LLFA level to provide an overall best estimate of the economic damages to tourism and recreation assets during the winter 2013 to 2014 floods of £3.5 million.

This is an uncertain approach because flood related damages are likely to vary depending on the asset affected and the extent and duration of the impact. Thus, the data were classified as having a moderate–high uncertainty rating given the extrapolation and the adjustments made to provide an economic estimate of the costs. To reflect this uncertainty, the best estimate (£3.5 million) was reduced by 25% (see Table 2.5), resulting in a low range estimate of the flood damages to tourism and recreation assets during the 2013 to 2014 winter period of £2.6 million.

24.3.2 High estimate

A similar approach was used to obtain an upper estimate. As indicated above, the data obtained on flood damages to tourism and recreation assets were converted to economic costs and extrapolated to provide an estimate of the potential costs at the national level. These data were assigned a moderate–high uncertainty rating because damages to individual assets are likely to vary and hence the costs incurred are likely to differ from the figure used in the extrapolation; it was not possible to verify whether the costs used represent the actual damages incurred. Therefore, a moderate–high rating was allocated and was considered to represent the uncertainty associated with the best estimate. To reflect this uncertainty, the best estimate (£3.5 million) was increased by 25% (see Table 2.5), resulting in a high range estimate of the flood damages to tourism and recreation assets during the 2013 to 2014 winter period of £4.4 million.

24.4 Damage costs by flood type

This section provides a breakdown of the damages to the tourism and recreation sector as a result of the winter 2013 to 2014 floods by flood type. It includes details of the methods used to differentiate the damage costs and the associated uncertainties.

24.4.1 Approach to disaggregating the damage costs

The disaggregation of the damages by flood type was based on the assumption that the majority of damages incurred by coastal LLFAs were caused by tidal surges. But although this is a simplification, there were insufficient details to allow a more sophisticated analysis. Damages were not included where the damage figures specified the flood type and this did not relate to coastal impacts.

For tourism and recreation assets, the estimates of damages come from extrapolation of estimates based on a unit cost of £3,800 per asset for each LLFA. This was broken down into coastal and inland LLFAs to determine damages from coastal flooding.

24.4.2 Summary of damages costs by flood type

Table 24.2 provides a summary of damages by flood type to tourism and recreation assets.

Table 24.2 Estimated economic damage costs to heritage assets by flood type

Flood source	Economic damage estimates					
	Best estimate		Low estimate		High estimate	
	Damage	Percentage of total	Damage	Percentage of total	Damage	Percentage of total
All (total)	£3.5 million	100%	£2.6 million	100%	£4.4 million	100%
Fluvial/ groundwater	£1.5 million	44%	£1.2 million	44%	£1.9 million	44%
Coastal	£2.0 million	56%	£1.5 million	56%	£2.5 million	56%

Notes: Values are presented to 2 significant figures and therefore totals may not be equivalent to the types of flooding due to rounding.

24.5 Damage costs for England and Wales

This section provides a breakdown of the recreation and tourism damages/costs as a result of the winter 2013 to 2014 floods for England and Wales. It includes details of the method used to differentiate the damage costs and the associated uncertainties.

24.5.1 Approach to disaggregating the damage costs

Splitting damages between those incurred in England and Wales was based on the damage estimates obtained for each LLFA and then combining those in England and those in Wales to provide total damages.

24.5.2 Damage costs for England and Wales

Table 24.3 provides a summary of damages split between England and Wales for tourism and recreational assets.

Table 24.3 Estimated economic damage costs to tourism and recreation assets by country

Country	Economic damage estimates					
	Best estimate		Low estimate		High estimate	
	Damage	%	Damage	%	Damage	%
Total	£3.5 million	100%	£2.6 million	100%	£4.4 million	100%
England	£2.9 million	82%	£2.2 million	82%	£3.6 million	82%
Wales	£650,000	18%	£490,000	18%	£810,000	18%

Notes: Values are presented to 2 significant figures and therefore totals may not be presented as exact sum of constituent parts due to rounding.

24.6 Uncertainties and assumptions

Flood outline data were used to estimate the number of assets that may have flooded. There is a high degree of uncertainty with these figures as some assets within a flood outline may not have flooded. Therefore, these data were used only where no alternative value was obtained. For tourism and recreation, the assets included in the flood outline data are mooring wharf/marinas, sports and leisure centres, sports grounds and playing fields, amusement arcade/parks, beach huts, boarding houses, football grounds, golf courses, hostels, hotels, museums and theatres or cinemas.

Each piece of information was assessed to ensure that, where possible, it was only included in this category. The damages included relate to private and publically owned assets and, where possible, were only included in the tourism and recreation category to avoid double counting with other categories. However, detailed information was not available in many cases on the breakdown of costs included in the businesses and local authority and local government infrastructure categories. This meant it was not possible to determine the costs that were included or excluded and therefore there is a risk of double counting with these categories.

Where possible, damages are based on information collected from LLFAs. However, extrapolation was used to extend the damage estimates to cover those areas for which no estimate of damages was provided. The average damages per asset were used as the basis for the extrapolation, but the variability of tourism and recreational assets and the impacts on them means that the average value is uncertain. The average damages per asset (£3,800) used to extrapolate the costs may not accurately reflect the damages caused to tourism and recreation assets. The use of this figure may therefore under or overestimate the actual damages caused by flooding.

25 Conclusions and recommendations

25.1 Conclusions

The best estimate for the economic damages in England and Wales from the winter 2013 to 2014 floods is £1,300 million, with a range of £1,000 million to £1,500 million to take account of uncertainty within the estimates. The assessment of uncertainty used to inform the range is based largely on the availability and quality of the data available on damages and on the number and type of assets affected.

One of the most important gaps is the lack of primary data on flood damages, especially for major impact categories such as residential and business properties. The importance of having high quality primary data on the actual damages incurred on which to base the estimates of total damages cannot be overstated. For this study, primary data were generally limited in quantity, detail and coverage of sectors affected by flooding. For this reason, there is considerable uncertainty associated with the assumptions necessary to enable damages to be estimated.

It is on these topics – data and assumptions – that the recommendations for future work are based. The aim is to identify those actions that could help to reduce uncertainty in the estimation of flood damages for future events, as well as supporting the appraisal of actions to reduce future flood risk.

25.2 Recommendations for reducing uncertainty with data

25.2.1 The need for primary data

A major source of uncertainty is the lack of primary and disaggregated data on insurance claims. This affects some of the most significant categories in terms of overall damages – residential properties, private businesses, temporary accommodation, and motor vehicles, boats and caravans. These categories together make up 53% of the damages under the best estimate. Although the uncertainty with the insurance data overall is rated low–moderate, the lack of disaggregation makes it difficult to assess if there is double counting. This was excluded as far as was possible. However, without specific details of what the insurance data include, it is difficult to be confident that damages on some categories such as ports, education, heritage, and tourism and recreation are not captured to some extent under the insurance claims for private businesses. In addition, levels of under-insurance and betterment are not reported. The availability of disaggregated information from the insurance industry would improve future estimates of flood damages.

Insurance claims were not the only aspect where there were issues with data collection. The time and effort needed to obtain much of the data used in this report reflects the fact that recording of damages caused by flooding is not a high priority for many organisations. Although the LLFA initiative adopted for this study was successful in many areas, the collection and type of information obtained is variable and patchy – as illustrated by Section 1.3 ‘What is a flood?’ which includes differing definitions of flood events which trigger collection of information. Some large organisations such as the Highways Agency and Network Rail have senior members of staff dedicated to

climate change and resilience who have information on flood damages. However, many large organisations providing public services do not currently appear to have facilities to collect and record flood information. There are currently no arrangements in place requesting that this type of information be recorded and likewise the format for how the data should be documented. Enquiries for data for this study prompted a number of organisations to assemble data on flood costs to inform future management; for example, Forestry Enterprises said it would set up a system for monitoring the impact of natural events, including flooding. Incorporation of this kind of information into standard operating procedures of organisations would make data collection easier.

In the study on the 2007 floods (Environment Agency 2010), a detailed survey of 84 seriously affected farms was carried out using research council funding. This informed the Multi-Coloured Manual and supported the estimates of flood damage using a high level assessment for agriculture (as has been used by ADAS in its study on the impact of the 2013 to 2014 floods). The project team for the current study interviewed 15–20 farmers to determine impacts and to help reduce uncertainty for damages for the agricultural sector. More could have been pursued for this category, but this was considered disproportionate given the uncertainties associated with some of the other categories (in particular, residential and non-residential properties which make up a much greater proportion of the overall damages).

The importance of primary data collection to support impact assessment cannot be understated. However, for this major area of public funding, the actual database on which to assess damage estimates, and the efficacy of flood risk management interventions, remains surprisingly limited and selective in its coverage. This is something that needs to be addressed to help improve the robustness and reliability of future estimates. Indeed, major flood events such as in winter 2013 to 2014 provide opportunities for deriving estimates of flood damage costs by major impact category based on actual observation rather than on assumptions of the value of assets on which many of the estimates in the Flood and Costal Erosion Risk Management costs benefit analysis methods (described in the Multi-Coloured Manual) are currently based. In major areas of impact, it would be useful to assess how current standard estimates of flood damage align with actual damage costs, including allowance for risk reduction measures on the one hand and the full costs of disruption on the other. This is the approach Swiss Re uses in evaluating damages in Europe and would contribute to improving the costs benefit analysis methods currently utilised.

The development of data sharing agreements is likely to be the most important step that can be taken to improve the basis on which the damage estimates are made. For the 2013 to 2014 study, great effort was made to try to obtain data from data holders. If there were agreements and data champions in place, this information could be provided in both a timely and efficient manner. This would improve the robustness of the results and enable better interrogation of data in terms of unit values for type of flood, duration and differences between locations. For example, the most complete datasets in terms of assets affected has come from LLFAs. Indeed the accumulation of information to inform adaptation from a range of organisations, especially LLFAs and land-based no-governmental organisations, proved particularly useful for this study.

This type of information was much more distributed for the study on the 2007 floods (Environment Agency 2010) and has resulted in reliable estimates of the number of properties affected – although estimates of damages to homes and businesses are less certain due to the lack of disaggregated insurance data. In addition, such data allow information to be built up from the local data. If all data were available at the local level, there would be a greater opportunity for presenting outputs more regionally than is currently possible. In addition, it may then be more straightforward to assess differences between floods from different sources, such as fluvial versus coastal. The data currently available are insufficient to allow this level of interrogation for most

categories. If there were opportunities for greater sharing of disaggregated data, then there would be the basis for assessing whether there are regional differences in damages or difference in damages between different sources of flooding.

The progress made in the local government sector with the establishment of LLFAs highlights the advantage of designated responsibility for data assembly on flood damages. The improved quality of information on numbers and types of private and commercial properties affected, however, is less well supported by data on the costs of damages incurred. The main source of potentially accessible information here is held by the insurance sector. There is a clear opportunity to require the insurance sector to make data on flood related damage costs available to support public inquiries, not least because flood risk management is a crucial policy domain and one from which the insurance industry draws benefit from public investment and cooperation.

Furthermore, major flood damage costs arise in sectors providing critical infrastructure and services, notably transport and utilities. These involve a mix of corporate and quasi-government organisations that provide important public services in which disruption as well as asset damage is a major source of impact. This study revealed a need to establish data sharing agreements with such organisations, whereby data on major flood impacts are assembled and made available to support public policy in flood risk management on the protection of critical services and infrastructure. This would be of mutual benefit, potentially helping those organisations to formulate flood risk reduction strategies.

One approach to support data sharing agreements could be to develop ‘post disaster needs assessments’ as used in mainland Europe. This can take the form of a template showing what type of information needs to be collected and in what form. The work to convince organisations holding useful data for estimating flood damages could then be done during development of the template rather than following a flood event. The quality and consistency of the information collected across different organisation should also be higher, this improves the reliability and robustness of results produced.

25.2.2 Use of GIS data

Experience of GIS data for the winter 2013 to 2014 floods suggest that these data may not be reliable and there is no systematic bias that can be easily accounted for. Uncertainty over the number of properties flooded in each LLFA, for example, was as likely to be over as underestimated in the GIS data compared with the numbers of assets affected reported by the LLFAs themselves.

A major difficulty with using GIS data is that the information is assembled from different sources, some from on the ground reports and others from satellite imagery. GIS data clearly have the potential to provide rapid estimates of the location and number of assets affected, but the experience from this study shows that there needs to be on-the-ground checking to confirm what was actually flooded.

25.3 Recommendations for reducing uncertainty with assumptions

There are 3 main uncertainties associated with assumptions been made in this study:

- difficulty in identifying how regional impacts could result in impacts at the national level – this was particularly important for categories such as tourism and recreation

- lack of information obtainable within the timescale for this study on what the impacts actually are – this was particularly important for categories such as public health where flooding takes place over a long period of time
- difficulty in identifying the benefits of defences and hence what damages were avoided due to the presence of flood risk management assets and the actions taken to reduce flood risk during the events

25.3.1 Difficulty in identifying how regional impacts may be felt nationally

Many local authorities identified impacts on their local economies due to the effects of the winter 2013 to 2014 floods. These included areas in Cornwall and Devon that were affected by the erosion of the rail line at Dawlish, or in Somerset where extensive and prolonged flooding was perceived to have resulted in a reduction in the number of visitors. There is little evidence to suggest these local impacts had a knock-on effect at the national level. However, the probability these damages are likely to result in transfers (where other areas of the country benefited or the purchases of other goods and services were made) may underestimate national losses.

Further study is needed to investigate the extent to which the local losses may be important at the national level. This may need to involve discussions with affected businesses as well as tourists to explore what the impacts were, and how long they have persisted. Perception of the flooded areas may also be important from the perspective of prospective visitors. There was no evidence for this flood event that local impacts on agriculture affected food supply and prices at the regional or national scale.

25.3.2 Lack of de-aggregated, individual, information on the impacts of flooding

A number of studies are ongoing that are surveying and engaging with communities that experienced flooding in 2013 to 2014. These include:

- Cardiff University study on public perceptions of flooding and climate change (funded by the Economic and Social Research Council)
- Birmingham University study on real-time examination of the social, economic and environmental dimensions of flood recovery and resilience (funded by the Economic and Social Research Council)
- Exeter University study on the 2013 to 2014 winter flood and policy change (funded by the Economic and Social Research Council)
- Public Health England open cohort study to examine the mental health and wellbeing effects of flooding

These studies did not report fully within the timescale of this study and thus it was not possible to draw conclusions from the work, although interim findings were available in some cases. When the ongoing studies report their findings, it will be useful to compare the outcomes, especially in terms of improving understanding of the social, psychological and health impacts of flooding. The findings can be compared with the assumptions made in this report to assess what changes might be needed to better reflect the actual impacts of flooding on people.

The results of the ongoing studies will also help to inform future assessments of the impacts of flood events and an analysis of the outputs across all of the studies would be very useful in this regard.

As noted earlier, there continues to be a shortage of data on individual (de-aggregated) damage costs in many crucial impact sectors, including the residential and commercial sectors. Major flood events of the type seen in winter 2013 to 2014 provide an opportunity to correct for this. It is recommended that Defra considers priorities for data acquisition and management for flood risk management in important impact sectors and develops a strategy accordingly. This may involve setting up data management protocols in preparation for the next major flood event.

25.3.3 Difficulty in identifying the benefits of defences

As well as all the locations that were flooded in winter 2013 to 2014, there were also many locations that were not flooded as a result of the presence of flood defences or actions to avoid flooding by responding organisations such as the Environment Agency, emergency services, local authorities and the military, as well as non-governmental organisations and volunteers. In addition, there were areas where damages were reduced due to actions such as early warning of flooding and measures taken to reduce exposure to damage as well as post recovery measures. It was not possible within this study to quantify and monetise the damages avoided by the presence of defences or actions taken.

The estimate of damages avoided due to the presence of defences can be estimated from the known or recorded flood level and the standard of protection of the defences. However, the nature of a flood event means that flood levels can vary significantly along a river or coastline. As a result, the assets that would be flooded without the defences can also vary considerably. The way that information on assets protected is currently generated does not take account of the linkages along floodplains, such that there is a risk of double counting of benefits along a river catchment. Recent studies have begun to explore some of these issues such as linking defence crest levels to standards of protection, but this would need to be done systematically for all flood defences to be useful to a study assessing the damages avoided.

To assess the damages avoided, further information would be needed on flood levels at all locations that did not flood. It may also be necessary to undertake modelling to identify which assets would have been flooded without defences. A simpler approach could be to use flood extents from the project appraisal reports prepared when the defences were proposed (assuming these are relatively recent) or to use the Environment Agency flood maps adjusted for the significance of the event that was avoided. If the number of assets that would have flooded without the defences is known along with the depth to which they would have been flooded and duration, it is then a reasonably simple task to use the agreed Flood and Costal Erosion Risk Management costs benefit analysis methods to estimate the damages avoided.

Identifying and quantifying the damages avoided from actions taken to reduce the impacts of flooding is more difficult. This is because it is unlikely to be a simple task to assess what the impacts would have been without the action. There may be exceptions such as the erection of temporary defences, where the damages avoided could be calculated in a similar manner to those associated with permanent defences. The benefits from actions such as opening weirs or clearing trash screens are harder to quantify. Damages avoided from flood warnings can be estimated using approaches set out in the agreed Flood and Costal Erosion Risk Management costs benefit analysis methods, but these may benefit from further examples of ‘ground truthing’ what actions people actually took in response to the warning. Such information may need to be gathered shortly after a flood warning has been issued.

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List of abbreviations

ABI	Association of British Insurers
ABP	Associated British Ports
ADA	Association of Drainage Authorities
AOD	above Ordnance Datum
CEH	Centre for Ecology and Hydrology
DCLG	Department of Communities and local government
Defra	Department for Environment, Food and Rural Affairs
DNO	distribution network operator
ESI	electricity supply industry
FSI	Flood Severity Index
GAL	Gatwick Airport Limited
GDP	gross domestic product
GIS	geographical information system
GP	general practitioner
GVA	gross value added
HLS	Higher Level Stewardship
IDB	Internal Drainage Board
LEP	Local Enterprise Partnership
LLFA	Lead Local Flood Authority
LRF	Local Resilience Forum
MoD	Ministry of Defence
NFU	National Farmers Union
NHS	National Health Service
NAO	National Audit Office
OGD	other government department
PTSD	post-traumatic stress disorder
RMA	Risk Management Authority
RNLI	Royal National Lifeboat Institution
RSPB	Royal Society for the Protection of Birds
RSPCA	Royal Society for the Prevention of Cruelty to Animals
SRN	Strategic Road Network
SSEPD	Scottish and Southern Energy Power Distribution

SSSI	Site of Special Scientific Interest
UKPN	UK Power Networks
VAT	Value Added Tax
WLT	Wildlife Trust

Glossary

Betterment	Replacing an old or used asset with a new one.
Damages	Any costs that are incurred due to the effects of flooding.
Economic costs	Costs that have been adjusted, for example, by removal of VAT to represent ‘actual’ damages.
Exchequer costs	Costs that are paid for out of the public purse.
Financial costs	Unadjusted costs associated with damages including taxes, unadjusted insurance claims, and unadjusted repair and damage costs.
Private sector costs	Costs borne by businesses and companies, or by private individuals.
Welfare costs	Costs borne by society or where there are effects on society.

Appendix A: Summary of engagement

A total of 641 individuals and organisations were contacted. In many cases, several people within each organisation were contacted before the one best placed to provide a response was found. Over 900 emails were sent. A total of 392 responses with information were received; responses ranged from those providing cost information, those who were not affected, and those who do not collect the information or who do not have this information at the moment. A total of 184 individuals and organisations responded with data on the impacts of the floods.

Table A1.1 Contacts by category (single category contacts)

Impact category	Responded with information	Responded to say there were no costs	Responded to say they don't collect this	Not yet responded
Businesses	Chambers of Commerce (1)	Chambers of Commerce (1)	Chambers of Commerce (9)	Chambers of Commerce (44)
	LEPs (3)	LEPs (2)	LEPs (13)	LEPs (22)
Temporary accommodation	Shelter			
Motor vehicles, boats, caravans				SMMT The AA The RAC
Emergency services: fire and rescue, ambulance, police, military, caring services	Fire and Rescue Service (17)		Fire and Rescue Service (5)	Fire and Rescue Service (24)
	LRFs (4)	LRF (7)	LRF (9)	LRF (14)
	Association of Ambulance Chief Executives MoD Avon and Somerset Constabulary	Maritime and Coast Guard Authority	Association of Chief Police Officers Chief Fire Officers Association	National Police Coordination Centre
Flood risk management infrastructure and service	IDBs (16)	IDBs (43)		IDBs (65)
Utilities: water and energy, infrastructure and services	Water companies (10)	Water companies (3)		Water companies (7)
		Energy companies (1)	Energy companies (1)	Energy companies (2)
	National Grid Ofgem	United Utilities		Ofwat
Transport: road, rail and air transport infrastructure and services	ABP Immingham Highways Agency Gatwick Airport			British Ports Association Network Rail UK Harbour Masters
Other communications (telecom)				Ofcom Openreach

Impact category	Responded with information	Responded to say there were no costs	Responded to say they don't collect this	Not yet responded
	NHS Area Teams (1)	NHS Area Team (1)	NHS Area Team (1)	NHS Area Team (10)
Public health and welfare	Cardiff University		Joseph Rowntree Foundation Public Health England London School of Hygiene and Tropical Medicine	Royal Devon and Exeter NHS Foundation Trust
Education	Department of Education		Ofsted	
Voluntary sector and community based actions				Salvation Army Voluntary Sector Civil Protection Forum
Agriculture	NFU Black and Veatch Somerset Levels Agricultural Flood Recovery Project FWAG South West			Centre for Ecology and Hydrology Forest Enterprises Forestry Commission Farming and Wildlife Somerset
Wildlife sites	National Trust Natural England RSPB Wildlife Trusts			
Heritage sites			English Heritage	
Tourism and recreation	Visit England		Department for Culture, Media and Sport	
Other			RSPCA	

Notes: FWAG = Farming and Wildlife Advisory Group
LRF = Local Resilience Forum
SMMT = Society of Motor Manufacturers and Traders

Table A2.2 Other contacts (multi category)

Organisation	Responded with information	Responded to say there were no costs	Responded to say they don't collect this	Not yet responded
Council	12	1		12
LLFA	84	58	9	22
Insurance companies	2			8
Others	ABPmer Central Association of Agricultural Valuers ABI DCLG British Red Cross Country Land and Business Association		ADA Canal and Rivers Trust Ciria Flood Forecasting Centre Flood Hazard Research Centre Local Government Association Weathernet	ADEPT Inland Flood Group National Flood Forum Royal Voluntary Service St John's Ambulance Victim Support Birmingham University University of Exeter

Appendix B: LLFAs by region

	LLFA	
Region	**Suffered flood damage**	**Did not suffer flood damage**
London	Barking and Dagenham	Barnet
	Bexley	Croydon
	Brent	Greenwich
	Bromley	Hammersmith and Fulham
	Camden	Hillingdon
	City of London	Kensington and Chelsea
	Ealing	Kingston upon Thames
	Enfield	Lewisham
	Hackney	Newham
	Haringey	Sutton
	Harrow	Waltham Forest
	Havering	
	Hounslow	
	Islington	
	Lambeth	
	Merton	
	Redbridge	
	Richmond upon Thames	
	Southwark	
	Tower Hamlets	
	Wandsworth	
	Westminster	
East Midlands	Derby	Derbyshire
	Leicestershire	Leicester
	Lincolnshire	Northamptonshire
	Nottingham	Nottinghamshire
	Rutland	
East of England	Bedford	
	Central Bedfordshire	
	Cambridgeshire	
	Essex	
	Hertfordshire	
	Luton	
	Norfolk	
	Peterborough	
	Southend-on-Sea	
	Suffolk	
	Thurrock	

	LLFA	
Region	**Suffered flood damage**	**Did not suffer flood damage**
North East	Durham	Darlington
	Gateshead	Middlesbrough
	Hartlepool	
	Newcastle upon Tyne	
	North Tyneside	
	Northumberland	
	Redcar and Cleveland	
	South Tyneside	
	Stockton-on-Tees	
	Sunderland	
North West	Blackburn with Darwen	Bolton
	Blackpool	Bury
	Cheshire East	Halton
	Cheshire West and Chester	Rochdale
	Cumbria	Salford
	Knowsley	St. Helens
	Lancashire	Stockport
	Liverpool	Warrington
	Manchester	Wigan
	Oldham	
	Sefton	
	Tameside	
	Trafford	
	Wirral	
	Bracknell Forest (no properties flooded but other impacts)	
South East	Brighton and Hove	
	Buckinghamshire	
	East Sussex	
	Hampshire	
	Isle of Wight	
	Kent	
	Medway	
	Milton Keynes	
	Oxfordshire	
	Portsmouth	
	Reading	
	Slough	
	Southampton	
	Surrey	
	West Berkshire	
	West Sussex	
	Windsor and Maidenhead	
	Wokingham	

	LLFA	
Region	**Suffered flood damage**	**Did not suffer flood damage**
South West	Bath and North East Somerset	
	Bournemouth	
	Bristol	
	Cornwall	
	Devon	
	Dorset	
	Gloucestershire	
	Isles of Scilly	
	North Somerset	
	Plymouth	
	Poole	
	Somerset	
	South Gloucestershire	
	Swindon	
	Torbay	
	Wiltshire	
West Midlands	Coventry	Birmingham (were some impacts across wider Birmingham LEP)
	Dudley	Staffordshire
	Herefordshire	Wolverhampton
	Sandwell	
	Shropshire	
	Solihull	
	Stoke-on-Trent	
	Telford and The Wrekin	
	Walsall	
	Warwickshire	
	Worcestershire	
Yorkshire and Humber	East Riding of Yorkshire	Barnsley
	Kingston upon Hull	Bradford
	Leeds	Calderdale
	North East Lincolnshire	Doncaster (road damages only, may not have been flooding related)
	North Lincolnshire	Kirklees
	North Yorkshire	Sheffield
	Rotherham	
	Wakefield	
	York	

	LLFA	
Region	**Suffered flood damage**	**Did not suffer flood damage**
Wales	Bridgend	Blaenau Gwent
	Cardiff	Caerphilly
	Carmarthenshire	Merthyr Tydfil
	Ceredigion	
	Conwy	
	Denbighshire	
	Flintshire	
	Gwynedd	
	Isle of Anglesey	
	Monmouthshire	
	Neath Port Talbot	
	Pembrokeshire	
	Powys	
	Rhondda Cynon Taff	
	Swansea	
	The Vale of Glamorgan	
	Torfaen	
	Wrexham	

Appendix C: Case study on impact on wildlife

This case study provides an overview of the financial and economic impact of the December 2013 tidal surge on 3 Lincolnshire Wildlife Trust coastal sites with information provided by Sarah Jane Smith (Lincolnshire Wildlife Trust) and Sean Kent (Lincolnshire County Council).

The 3 sites considered are Gibraltar Point, Far Ings and Donna Nook. The 2 visitor centres at Gibraltar Point and Far Ings were flooded and paths, tracks, gates, fencing, noticeboards and information huts were damaged. Further details on the impact of the floods on each of the sites are provided in the following sections.

C.1 Gibraltar Point

Gibraltar Point covers an area of 471.5ha and has Ramsar, Special Protection Area, Special Area of Conservation and National Nature Reserve designations.

Flooding severely damaged the visitor centre and cafe, the residential educational centre containing classrooms and 21 study bedrooms, and a residential facility for volunteer workers. The site and the buildings located at the visitor centre, including the coastguard observation tower, are owned by Lincolnshire County Council (LCC). The visitor centre was extensively refurbished in 2006 in collaboration with Lincolnshire Wildlife Trust (LWLT), drawing on grant aid. The flood damage caused means that these facilities have been written off and the majority will be demolished. They will be replaced by a new visitor centre and cafe, raised to avoid future damage with this estimated to cost £1.1 million. The coastguard tower will also be repaired and retained. There are also plans to construct alternative education facilities on another part of the site. The damage and replacement costs have been shared by LCC and LWLT, and both parties have submitted insurance claims.

C1.1 Damages to assets

Lincolnshire County Council

LCC has submitted an insurance claim of £405,000 (before £10,000 excess) for losses incurred at the visitor centre, including £55,000 repairs to retained buildings. Therefore £350,000 is attributable to building loss, much of it involving aged property, and hence valued at 50% remaining value giving a £175,000 loss. A further £55,000 has been budgeted (in 2015) for demolition costs. Rebuilding the facilities on higher ground is costing £1.1 million, but this is an improved facility with a large element of betterment. The total loss to LCC is £460,000 (£405,000 + £55,000) with the economic cost allowing for remaining value determined as £285,000 (£175,000 + £55,000 + £55,000) all excluding VAT (at 20%).

Lincolnshire Wildlife Trust

LWLT has submitted insurance claims for losses incurred to property on site, namely damage to the assets of the 2006 refurbishment. The estimates here are based on ‘net book (remaining) value’ obtained from LWLT accounts (net of VAT). The costs of the flood damages to LWLT are therefore estimated as follows:

- buildings: £471,000 (LWT share only)
- equipment: £4,300
- exhibits: £40,000
- shop: £6,500
- café: £3,000

This gives a total of £524,800 excluding VAT (some items are zero VAT rated). In addition, retail stock, food stock, contents and sundry items were lost and insurance claims were made on a replacement basis for which a cost of £30,000 is assumed (excluding VAT). Total unadjusted loss for LWLT is therefore £555,000, excluding VAT.

LWLT received £35,000 from the Natural England recovery fund for Gibraltar Point, including provision of a mobile catering vehicle.

C1.2 Revenue loss and extra costs

LWLT also experienced revenue losses and additional costs associated with the damages caused by the December 2013 flooding and the subsequent closure of facilities. These are detailed below.

- Education fees lost: £96,000 less savings in costs £46,000. Net loss is therefore £44,000.
- Retail sales: £55,000 less costs of sales £25,000. Net loss is therefore £30,000.
- Café revenue loss: £100,000 less cost of sales £50,000. Net loss is therefore £50,000.
- Car park: expected revenue was £11,000 and actual revenue received was £6,000. Net loss is therefore £5,000.
- Temporary toilet hire: £600 per month for 12 months (minimum) results in costs of £7,200 with total costs of £136,000.
- Three staff members were made redundant because of closure of activities.
- Additional costs of clean up and staff and volunteer time were incurred, including displacement of other tasks. A 6 month funded internship mainly helped recovery with a full-time equivalent cost estimate of £17,000 (across 3 sites, of which £10,000 can be allocated to Gibraltar Point).

Combining these cost estimates gives total economic costs/losses of £150,000 (presented to 2 significant figures). Revenue losses from trading will continue until the new centre is open (2016). The loss of residential income on this site is permanent. The visitor facility currently operates out of a Portacabin supplied by LCC and catering van purchased post-surge by LWLT with help from Natural England's recovery fund.

C.2 Far Ings

The Far Ings site covers an area of 86ha and has Ramsar, Special Protection Area, Special Area of Conservation, SSSI and National Nature Reserve designations.

Far Ings is situated on the south bank of the Humber Estuary and is a major east–west flyway for migrating birds. The nature reserve and the education and visitor centre were

flooded by the storm surge on the evening of 5 December 2013 when water overtopped the Humber Bank. The damage to the visitor centre was more severe than initially thought and it was closed until August 2014. Total economic costs to LWLT at Far Ings are estimated at around £68,000. The breakdown of the costs is detailed below.

C.2.1 Damage to assets

Flood damages to buildings and educational equipment at Far Ings amounted to £100,000 and £20,000 respectively (based on an insurance claim of £120,000). The remaining book value of these assets was £55,000 (46%). In addition, flood damages to hides costs £5,000 to repair or reinstate. Therefore, the total damages (in economic terms) to assets amounted to £60,000.

C.2.2 Revenue loss and extra costs

LWLT also experienced revenue losses and additional costs associated with the damages caused by the December 2013 flooding at the Far Ings site. These are detailed below.

- Education fees lost: £2,000 less savings in costs £1,000. Net loss is therefore £1,000.
- Retail sales: £8,000 less costs of sales £4,000. Net loss is therefore £4,000.
- Additional costs of clean up and staff and volunteer time were incurred, including displacement of other tasks. A 6 month funded internship mainly helped recovery with a full-time equivalent cost estimate of £17,000 (across 3 sites, of which £3,000 can be allocated to Far Ings).

The total costs due to revenue loss and additional costs amount to £8,000.

C.3 Donna Nook

The Donna Nook site covers an area of 392.4ha and has Ramsar, Special Protection Area, Special Area of Conservation, SSSI and National Nature Reserve designations.

The reserve consists of dunes, slacks and inter-tidal areas and is popular during the winter seal breeding season, with 60,000 visitors in November to December inclusive. The December 2013 tidal surge severely disrupted the breeding colony and the site was inaccessible to visitors.

Total damages to Donna Nook are estimated at £47,500. The breakdown of these is detailed below.

C.3.1 Damage to assets

Flood damages to a Portacabin and access paths is estimated to have cost £20,000 based on net book (remaining) value. In addition, walkways, fences and gates required repair and replacement costing £19,000 (adjusted by 50% to account for remaining value). Therefore the total damages to assets at Donna Nook are estimated to be £39,000.

C.3.2 Revenue loss and extra costs

LWLT also experienced revenue losses and additional costs associated with the damages caused by the December flooding at the Donna Nook site. These are detailed below.

- Retail sales: £12,500 less costs of sales £6,000. Net loss is therefore £6,500.
- Additional costs of clean up and staff and volunteer time were incurred, including displacement of other tasks. A 6 month funded internship mainly helped recovery with a full-time equivalent cost estimate of £17,000 (across 3 sites, of which £2,000 can be allocated to Donna Nook).

Total revenue loss and extra costs for Donna Nook are therefore estimated at £8,500.

C.4 Cost incurred at the LWLT sites

The total financial damage to physical assets at the 3 sites considered in this case study is estimated at £1.2 million based on reported remaining value (excluding VAT at 20%) and repair and reinstatement costs (including VAT at 20%). A further £165,000 worth of costs were incurred due to lost net revenues and additional costs during 2014. Revenue losses will continue at Gibraltar Point through 2015 until the completion of the new centre planned for 2016. Adjusting to economic prices (excluding VAT at 20% where it applies and assuming a 50% remaining value on physical assets to reflect 'betterment' except where remaining book values are used) gives an economic estimate of physical damage of £922,000, plus £163,000 loss of net revenue (after adjustment for National Insurance costs) for the 3 sites.

Over 80% (£130,000) of losses in operating revenues and costs were associated with loss of net revenue from sales and educational services. Some of this loss was probably offset by relocation of trade and educational activities elsewhere in the immediate vicinity or beyond, but the extent of this is unknown. Temporary accommodation was found in local hotels for some study groups, but others were cancelled. Visitor numbers dropped, as did associated sales, but some of these items, such as catering revenues, may have been picked up elsewhere in nearby towns such as Skegness. The Lincolnshire coastal wildlife trust sites have unique qualities that reduce their substitutability for some visitors and for some types of expenditure especially in the short term. It is possible, however, that between 50% and 75% of loss of wildlife site-based trade might have been offset elsewhere during 2014, reducing the estimate of economic losses in net revenue to between £60,000 and £90,000 respectively, instead of £160,000 (above). The true extent remains unknown.[12]

A summary of the costs attributable to the 3 LWLT sites affected by the tidal surge in December 2013 is provided in Table C.1. This indicates that the total economic costs of damages/losses caused by the winter 2013 to 2014 floods are £1.1 million.

[12] The assumption that disruption to business is offset by 90% equivalent replacement elsewhere in the economy is considered too severe an assumption for unique wildlife sites and their services.

Table C.1 Summary of the winter 2013 to 2014 flood damage costs to wildlife site visitor centres at LWLT sites

Site	Damages to physical assets	Revenue loss, net of costs	Total
Gibraltar Point[1]	£1 million (£460,00 to LCC and £560,000 to LWLT)	£150,000	£1.2 million
Far Ings	£130,000	£10,000	£140,000
Donna Nook	£39,000	£9,000	£48,000
Total	£1.2 million [2]	£170,000	£1.3 million
Adjustment for remaining value	£920,000[3]	£160,000[4]	£1.1 million

Notes: All values are presented to 2 significant figures and therefore totals may not exactly sum due to rounding.
Based on data from LCC and LWLT.
[1] Excludes damages to 2 residential properties on site.
[2] Uses remaining book value where available, otherwise 50% of replacement costs is assumed as a remaining value.
[3] Based on remaining value or net book value where available and excluding VAT (at 20%).
[4] Excludes National Insurance on wage costs (at 10%). This estimate reduces to £60,000 if 50% net sales losses are offset elsewhere.

C.5 Other impacts

C.5.1 Visitor impacts

The 3 LWLT sites attract many visitors throughout the year, particularly to view migratory breeding wildfowl and the colonies of breeding seals. Educational services are also provided, especially to school age children and students. It is estimated that visitor and educational days dropped by 25% and 48% respectively during the year beginning November 2013 (Table A3.2) and can be directly related to the flood impacts. The loss of visitor and educational 'days' on site may in some cases have been substituted by visits and courses elsewhere. However, the uniqueness of the sites and the problems of short-term rescheduling probably mean that non-replaced losses were around 50% of normal visit and educational days.

Table C.2 Expected versus estimated actual visitors and education days at 3 LWLT sites affected by tidal surges in December 2013

Site	Expected (non-educational) visitor numbers per year[1]	Estimated actual visits for 2013 to 2014 year[1]	Expected educational days per year[1]	Estimated actual educational days for 2013 to 2014 year[1]
Gibraltar Point[1]	200,000	180,000	3,000	1,000
Far Ings	60,000	30,000	2,000	1,000
Donna Nook	60,000 (Nov/Dec only)	30,000 (Nov/Dec only)	1,000	900
Total	**320,000**	**240,000**	**6,000**	**2,900**
Percentage change in visitors versus expected visitors		**-25%**		**-48%**

Notes: Sourced from LWLT
[1] 12 months beginning November unless states

C.5.2 Ecological impacts

The ecological impacts of the tidal surges on the sites were relatively small and short term. There was some damage to the coastal dunes system but, for the most part, saline tolerant vegetation recovered quickly. The biggest negative impact involved the effect of saline inundation on freshwater habitats, flora and fauna at Gibraltar Point in particular. The sites appear to be recovering well without permanent damage. Repeat flooding of this kind would, however, lead to serious loss of valued freshwater coastal ecological features that complement adjoining saline and brackish marshes, a diversity that gives these sites particular appeal.

Breeding colonies of seals were disrupted, with some fatalities, but full recovery is likely.

The impact of the tidal floods on the loss of visitor and educational benefits has not been assessed here. There was, however, an estimated reduction of 80,000 visitor days and 3,100 educational days on the 3 sites during 2013 to 2014 (Table C.2).

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