Gauging the impact of natural hazards: The pattern and cost of emergency response during flood events

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Gauging the impact of natural hazards: the pattern and cost of emergency response during flood events

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Flood risk management policy in the UK is shifting away from simplistic flood defence towards 'living with floods' and 'making space for water', thereby accepting that significant flood damage and disruption will continue into the future. This highlights the need for efficient emergency response to flood events, as the first step towards recovery, yet we know very little about the resources and costs that this involves. This paper evaluates the severe flooding in the UK in autumn 2000, and shows that these costs are widely distributed, both geographically and institutionally. Geographically, they broadly match the incidence of property flooding, but they are much larger than we had hitherto appreciated, at approximately 15 per cent of total economic flood losses. The implication is that we should take this topic more seriously in the future than in the past, not see emergency response to floods and other disasters as a low-cost or even a cost-free option, and ensure that this effort is as effective as possible in facilitating post-event recovery.

key words floods England and Wales response emergency costs economic assessment

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Introduction

The economic impacts of natural hazards such as floods are receiving increasing attention, not least because of the prospect of greater incidence and severity of such events, owing to future climate changes (Centre for Ecology and Hydrology 2001; Hall *et al.* 2003; Evans *et al.* 2004). At the same time there is increasing professional and policy emphasis on 'Living with floods' (Institute of Civil Engineers 2001), 'Preparing for floods' (ODPM 2002), 'Making space for water' (Defra 2004) and 'Living with risk' (UN/ISDR 2004). Such emphasis strongly implies that flood risk – measured as event probability times the consequences – cannot easily be reduced from current levels, let alone from possible higher future levels (Evans *et al.* 2004), owing to environmental, cost and other constraints.

It is therefore increasingly recognized that flood damage and disruption in the UK will continue to be serious, and that strategies are needed to mitigate their potential effects by, *inter alia*, better management of land use (Howe and White 2001; Pottier *et al.* 2005), increasing the effectiveness of warnings (Parker 2004), proper consideration of the 'social costs' of floods (Tapsell *et al.* 2002; RPA/FHRC 2004), and enhancing emergency planning and its associated emergency services (Penning-Rowsell *et al.* 2005). Following severe UK flooding in 1998 and 2000, these strategies are being addressed in government (Johnson *et al.* 2005; Penning-Rowsell *et al.* in press), both by the main central government department concerned (the Department for Environment Food and Rural Affairs – Defra (Defra 2004 2005)) and by the department with oversight of spatial planning (the Office of the Deputy Prime Minster – ODPM (ODPM 2005)).

This is not an issue restricted to flooding. The Civil Contingencies Secretariat was established in 2001 to increase the UK's resilience against 'disruptive

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challenges', and the *Civil Contingencies Act* 2004 places new responsibilities on a new regional multidisciplinary tier of agencies in the event of a serious disaster, including the power to declare a local state of emergency (Cabinet Office 2003; Defra 2004).

In this context, it is surprising how little is known about the resources needed to counter these challenges and thus the costs of the emergency services deployed during floods and other natural disaster events (e.g. see Rosenthal and 't Hart 1998; Mustafa 2003). We would not advocate decision-making based only on a narrow benefit–cost approach (see Tapsell *et al.* 2002; Handmer 2002), but the efficient promotion of this contribution to flood risk management (Environment Agency 2003) is difficult without some insight into these costs. This lacuna also means that comparison with other risk-reducing options to select the best portfolio of actions remains rudimentary.

Some early UK work (Parker *et al.* 1987) suggested that these emergency costs were rather low, at between £99 and £511 per property affected by flooding (1985 prices, or £207–1060 at 2006 prices). But that research was based on scenarios rather than on a systematic analysis of actual flood events, and was undertaken at a time when emergency response procedures – and hence their costs – were more rudimentary than 15 years later. In this paper we present data on the emergency costs incurred during the widespread and severe autumn 2000 floods in England and Wales (Kelman 2001; Howe and White 2002). This was the worst event in the UK since 1947, with approximately 11 000 properties reported as flooded (Environment Agency 2001), although this may be an exaggeration (RPA/FHRC 2004). Damage and disruption were nevertheless widespread and substantial (Kelman 2001; Marsh 2001; Salthouse 2002), and the emergency effort included a wide range of actions including extensive flood warning, temporary protection of large numbers of properties and large-scale evacuation of vulnerable populations. Therefore the event, we suggest, forms a good basis for observing emergency costs.

Conceptually, response can be seen as one element in a comprehensive approach to risk management that emphasizes four processes: risk reduction; promoting readiness; response to the event; and post-event recovery (Norman 2004). Response itself concentrates on damage and loss mitigation – human, economic or environmental – and recovery on either recreating the *status quo ante* or as an opportunity-seeking process leading to the enhancement of the affected area. The developmental approach sees recovery not as the restoration of the past but the planned creation of a new future (Mitchell 2004). That approach is useful, valid and forward looking, but the focus of this paper is restricted to the patterns and cost of damage and loss mitigation, which we see as the essential first part of either type of recovery process.

Emergency response, vulnerability reduction and its costs

Emergency response during a disaster is action taken by official agencies or unofficial bodies – including individuals – generally aimed at mitigating the adverse impacts by reducing the extent of the event, or its severity, or by affecting the 'receptors' of the flood. It can be planned or unplanned, and pro-active or reactive. Those called on in the UK to respond to a flood and to initiate recovery are a varied collection of state and voluntary organizations, generally now operating under the system of 'Commands' ('Bronze', 'Silver' and 'Gold', depending on the severity of the event) which coordinate disaster response and allocate resources to saving lives and reducing damage. These organizations variously operate in the pre-flood stage, with emergency planning and preparedness, during the event in terms of search and rescue and damage minimization, and after the event in the rehabilitation and recovery phase (Table I).

Hazard literature and policies are focusing more on receptor vulnerability as ideas have moved away from 'defending' a population and its assets against a hazard and towards a more balanced combination of tackling both the probability of an event and managing its consequences for the communities at risk (Defra 2004; Evans *et al.* 2004; Red Cross/Red Crescent 2004). Vulnerability in this respect is a complex and contested concept (Few 2003; Green 2004), but here we see it as a function of both susceptibility – how easily is the human system damaged – and its resilience – how easily can it recover from a damaging event (Beck and Franke 1996; Green 2004). Given evidence that susceptibility to flood damage is not declining, and indeed may be rising owing to increasingly sophisticated technologies and larger numbers of consumer durables at risk (Green 2003), the importance of response in enhancing resilience and therefore

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Table I A typology of institutional emergency actions and their significance in different phases of a flood event

	Phases of a flood event and the importance of response functions			
Emergency response functions/actions	*Prior to the flood event*	*During the flood event*	*After the flood event*	*Main responsible agents in the UK*
Awareness raising	Medium	High	Low	Environment Agency; local authority emergency planners
Promoting safety	Low	High	–	Environment Agency; police
Damage/impact reduction	–	High	–	Environment Agency; police; fire brigade; local authorities
Flood defence infrastructure protection	Low	High	Medium	Environment Agency; local authorities
Promoting public recovery	–	Low	High	Local authorities; voluntary organizations (e.g. WRVS); commercial salvage and recovery companies
Repairing damaged infrastructure	–	Low	High	Environment Agency; local authorities

reducing individual and community vulnerability is proportionately increasing.

Therefore, as stressed by Rosenthal and Bezuyen (2000), the efficiency with which the emergency response systems operate is becoming more important in determining the vulnerability of communities to the disasters that they face. Moreover, if other options are taken to reduce the impacts of disasters, including engineered structural options, then the economic benefits of that form of risk mitigation include the reduction in the costs incurred by the organizations responsible for managing disaster events and in the recovery process (MAFF 1999; Defra 2003). Information on these costs is therefore also useful in this broader policy context.

Authorities and bodies in the UK providing emergency services include local authorities, the police authorities, the fire services, ambulance operations, the Environment Agency, voluntary services and – occasionally – the armed forces (Table I). Within local District, County or Unitary Authorities, the departments involved can include social services, emergency planning, highways and the engineering departments. To assess the true national economic cost of these emergency services (i.e. their resource cost), as opposed to the financial impact on the organizations involved, means examining the marginal impact of a particular event rather than the total costs of the whole service. Extra social services staff time and materials may be required, for example, but the cost of tackling any emergency is not the total cost of social services provision for the duration of the event. This is clearest when staff are specifically employed to manage emergencies (e.g. in the fire services), but care has been taken throughout this research to separate fixed costs from marginal costs (Parker *et al.* 1987) and only to include the latter when assessing emergency response costs.

Estimating emergency services and related losses: the 'Bellwin' claim system

Given the number and complexity of organizations involved in large-scale emergencies, surveying them all directly to determine the costs of their efforts is likely to result in a patchy response. Fortunately, however, the Office of the Deputy Prime Minister (ODPM)[1] collects information on emergency costs incurred by local authorities and some others during major events.

This is done because the organizations active in the flood response and recovery phases – including the police and the fire services – are allowed to recoup a proportion of their costs for designated events from central government under what is termed the 'Bellwin' process (as defined in section 155(4) of the *Local Government and Housing Act* 1989). The Bellwin system is based on the government's judgement that prudent authorities should budget annually to cover a proportion of the costs of emergencies from their own resources and reserves. Central government expects such contingency budgets to be about 0.2 per cent of total

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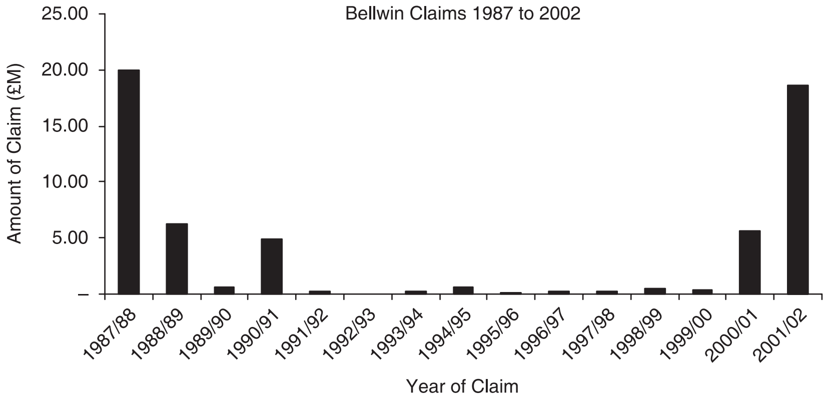

Figure 1 The distribution of Bellwin claims through time, showing the peaks for the 1987 windstorm event in southern England and the autumn 2000 flood event

budgets and this figure determines these authorities' Bellwin 'thresholds'. Claims are only allowed – and sums paid out by central government – against costs incurred in excess of this amount.

The DETR triggered the Bellwin process during the autumn 2000 flood events in financial year 2000/01, as it had after the 1987 windstorm event (Figure 1) (Hewitt 1997). This was done to compensate local authorities in England in respect of the storms, floods and other adverse weather conditions that involved damage or danger to life or property between 1 October and 31 December 2000. A similar trigger was initiated by the National Assembly for Wales. Bellwin payments for 1998/99 appear to be low (Figure 1), given the serious flooding at Easter 1998 (Tapsell and Tunstall 2000), but that event was far more restricted geographically than in 2000, hence the value of the latter flood event as our benchmark for this research.

Claims for the 2000 floods above the threshold were audited by each organization and eligible expenditure reimbursed through the DETR/DTLR at 100 per cent of costs (as against the 85 per cent set out in the normal Bellwin procedures) owing to the severity of the event. Usefully, as far as we are concerned, there are tight rules for the eligibility of the costs within a Bellwin claim (Penning-Rowsell *et al.* 2002), designed to identify the marginal cost of the flood or other disaster event, so the data obtained from the ODPM closely matches the national economic losses/costs. One exception is that the reimbursed cost of fuel, for example, is inclusive of taxes and therefore exaggerates economic costs. Unfortunately, however, no overall breakdown of most of the Bellwin data are available to guide a more detailed analysis and therefore to allow us to exclude such transfer payments (Parker *et al.* 1987).

What is eligible under the Bellwin rules is the cost of taking immediate action (i.e. usually within two months of the incident) to safeguard life and property or prevent suffering or severe inconvenience, and the cost of emergency works such as temporary embankments or dams. What is not eligible are insured costs, whether by an authority or a third party, costs recoverable from businesses (e.g. payments for fire services to pump out basements), and any capital expenditure. Staff costs relate only to additional resource costs over and above normal salaries (e.g. overtime). Some legitimate emergency-related costs can be eliminated during the audit process if the services provided fall outside the authority's remit. This means that the Bellwin data are not a complete picture of emergency costs, but no better data are available.

In addition to the Bellwin system, supplementary payments can also be made in England and Wales by central government to local highway authorities for flood damage to roads and bridges. These 'Severe Weather Capital Grant' payments also only cover a proportion of repair costs. Normally 15 per cent of expenditure has to be met from local authority sources, but the grants can cover capital costs.

The Bellwin and severe weather capital grants scheme data for autumn 2000

The Bellwin data show that claims were made for £20.73 million in England with total thresholds of claimants equal to £7.57 million, equivalent to emergency costs of £28.3 million (Figure 2A, B). Claims

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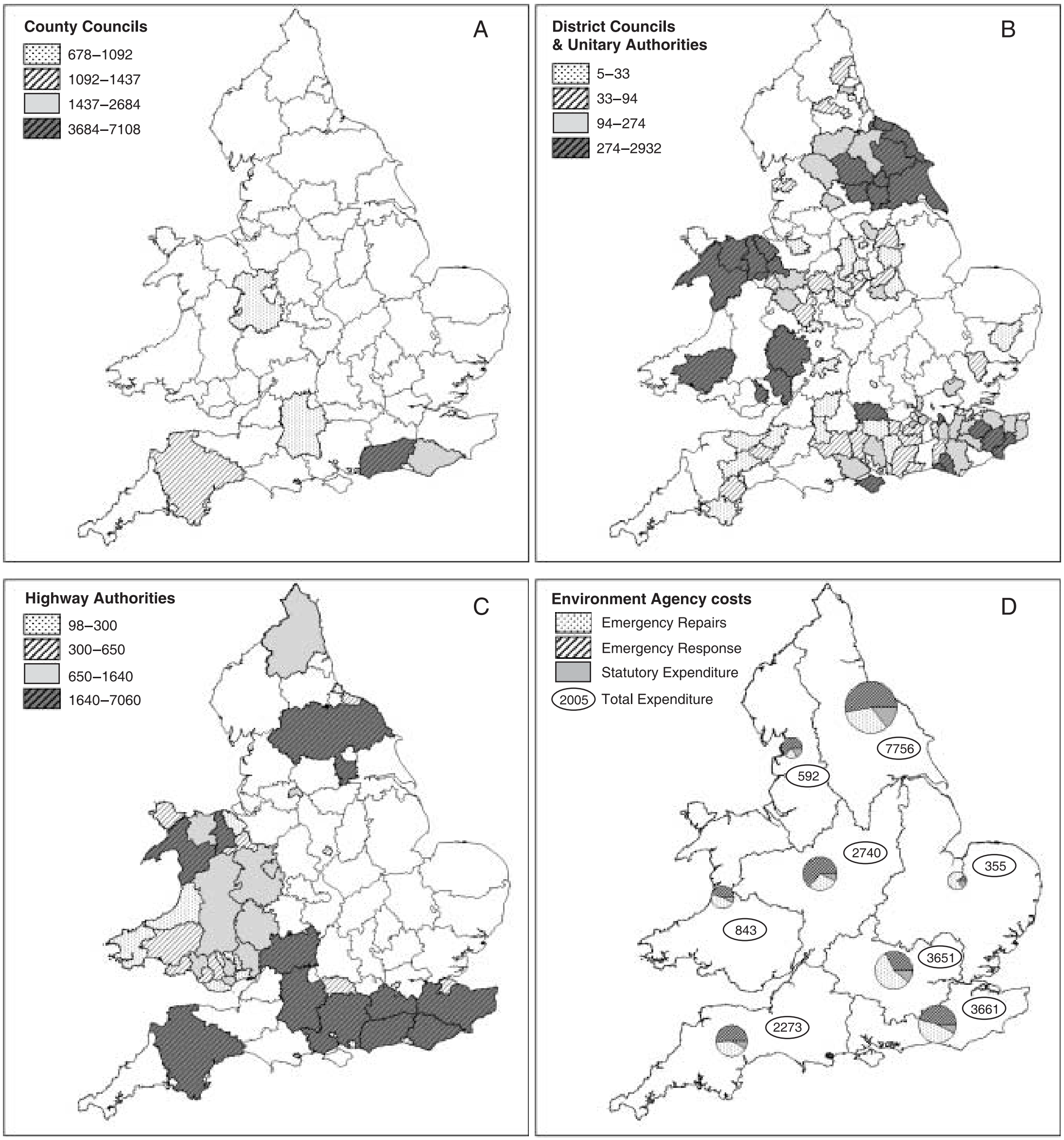

Figure 2 The distribution of emergency costs (£000s) for local authorities based on autumn 2000 Bellwin claims plus thresholds (A and B), and for highway authorities (C) and the Environmental Agency (D)

for Welsh authorities amounted to £5.5 million with total threshold values of £2.1 million. Most of the claims were from District Councils, County Councils (including, under the Bellwin regulations, their fire services) and Unitary Authorities, in addition to three claims from police authorities (North Yorkshire, South Devon and Cumbria).

Unfortunately for our purposes, details are only provided by the ODPM on the nature of the Bellwin claims when these are below £10 000, because in those circumstances they are not audited locally but by the Department. However, in the case of the autumn 2000 floods, only seven claims were below £10 000 (out of the 114 claims received for England

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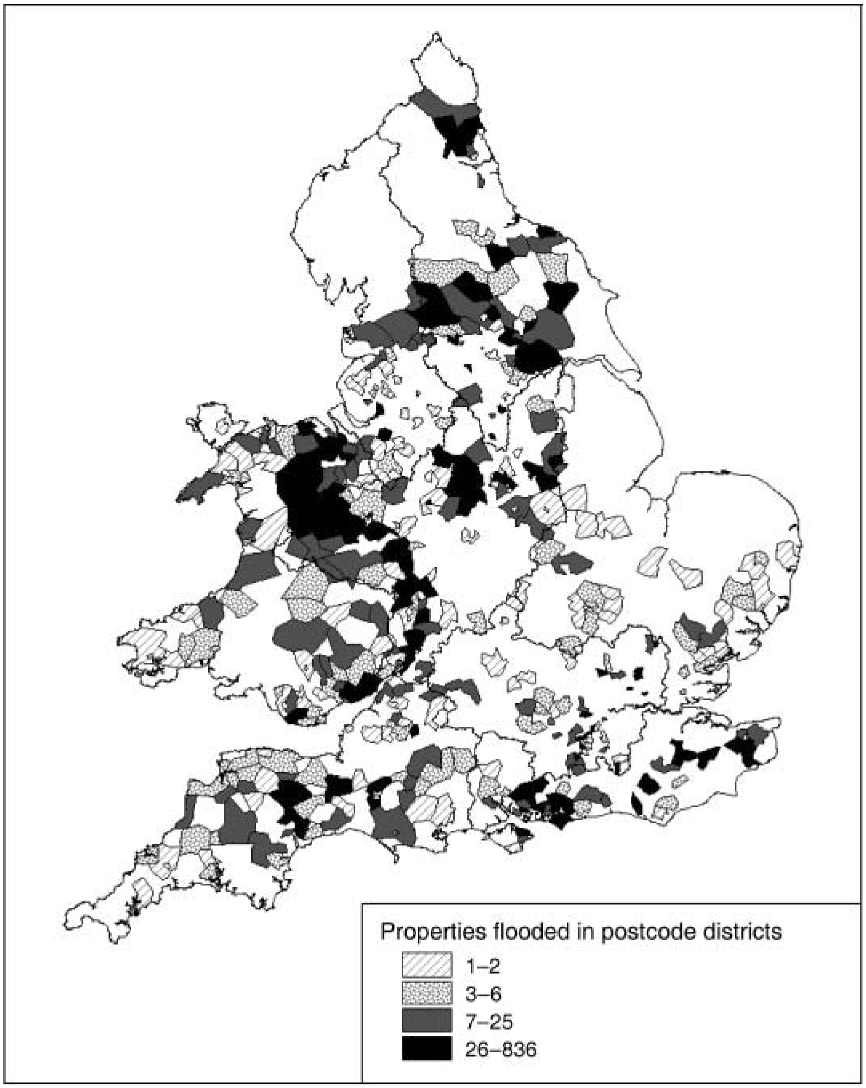

Figure 3 The incidence of property flooding by postcode district in autumn 2000
Source: Environment Agency Regional and Area data
Note: Postcode districts vary in size, so this is not a map of flood density

and Wales). Most of these small claims were for overtime for emergency services staff, including filling and distributing sandbags.

The distribution of Bellwin costs (as in Figure 2A, B) broadly follows, but does not exactly relate to, the distribution of the hazard as gauged by the location of the properties flooded (Figure 3) (Penning-Rowsell *et al.* 2002), with high cost locations in the south-east, Wales and in the north-east. Any mismatch may be partly due to inadequacy in the data, not least because the Belwin claims relate to local government areas and the flood incidence data to the much smaller postcode districts, making accurate comparison somewhat problematic. Also the Bellwin thresholds mean that the claims underestimate total impacts, irrespective of the eligibility criteria matters discussed above, because some 31 local authorities did not claim at all, because their costs were below their threshold, despite initially indicating to the DETR that they had incurred costs

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and might make a claim. To derive a more meaningful impact total, we have assumed for each of these non-claiming Councils an average emergency cost at half their threshold, totalling £3.1 million.

But there are other complications. Councils have a responsibility to cooperate in disaster situations and if this combined effort is for the benefit of just one Council's area, then it is legitimate for all Bellwin claims to go through that Council. Thus, for example, the Tandridge District Council area, some 15 km south of central London, suffered serious flood damages in October 2000, and the London Borough of Croydon (downstream of Tandridge) undertook much of the work in constructing a temporary dam. Croydon therefore charged Tandridge District Council for their costs, and Tandridge then claimed from the DETR (having deducted their threshold value). The distribution of effort and the cost claimed is geographically different, although in this case the claim and the hazard coincide.

The County Bellwin data also generally include the costs of their fire services, which have an important role in flood emergencies. The fire authorities themselves are not allowed to hold reserves for contingencies such as floods and Section 155 of the *Local Government and Housing Act* 1989 does not permit fire authorities to make direct Bellwin applications. But metropolitan fire authorities can claim from the Bellwin fund, and combined fire authorities can claim through their constituent County Councils (under the 1947 *Fire Services Act*, local authorities can combine to provide fire services). These Councils do have reserves from which to cover contingencies such as floods, and therefore they are required to compensate the fire services for their costs. However their Bellwin thresholds are high and therefore the chances of recouping these costs from central government are proportionately lower.

The Severe Weather Capital Grant payments ranged from £97 960 for Torfaen in Wales to £7.06 million for Kent, with a total of £41.9 million for England and £17.1 million for Wales and a mean payment per local highway authority of £1.9 million for England and £0.78 million for Wales (Figure 2C). Again, there is a strong correlation with the incidence of property flooding (Figure 3).

The situation in North Yorkshire: a case study

The Bellwin data lack detail, so a case study of North Yorkshire was undertaken to shed light on the breakdown of risk event tasks and their associated costs. This case study involved interviews with the officials who compiled the claim from North Yorkshire County Council (NYCC) and its seven District Councils, one Unitary Authority (York) and the police authority within the area of NYCC's jurisdiction.

Yorkshire was badly affected by the floods in 2000 (Figure 3), especially towards the end of the long period of national-scale flooding. Major emergency efforts were necessary to prevent flood embankments from breaching and properties from being flooded, particularly around Selby. The NYCC, the Fire Service and the Police Authority had also been affected recently by a number of other disasters (the 1999 Norton and Malton floods; the autumn 2000 fuel cost 'crisis'; the foot and mouth epidemic covering the whole of England and Wales, and the Great Heck train accident). As a result, the subject of emergency services and the costs of these emergencies were very familiar to our interviewees, and the response was excellent.

Also useful for this research was the precedent from the 1999 Malton/Norton floods of the DETR allowing the majority of County expenditure to be claimed via Districts, on the grounds that the County's efforts were to give assistance to these District authorities and their local communities. This procedure also allowed a larger claim, because the County's Bellwin threshold was £881 000 whereas the combined threshold of all the Districts was only £129 000. It also means, for this research, that we have local detail as to the composition and distribution of the claim (Table IV) which otherwise would not have been available.

A summary of costs in the North Yorkshire County Council area are given in Tables II and III and Figure 4A. The £119 000 declared ineligible by the auditor relate to expenditure by NYCC departments on functions for which the District Councils have no responsibility and for which they therefore could not claim (e.g. Social Services; Education).

Table II The principal autumn 2000 flood emergency costs for North Yorkshire County Council

A	Gross revenue costs of the emergency	£1 845 000
B	Costs disqualified costs by the auditor	£6 000
C	Bellwin threshold for all Districts combined	£129 000
D	Revenue costs incurred but not eligible through Bellwin	£119 000
E	Bellwin payment (i.e. A–B–C–D)	£1 591 000

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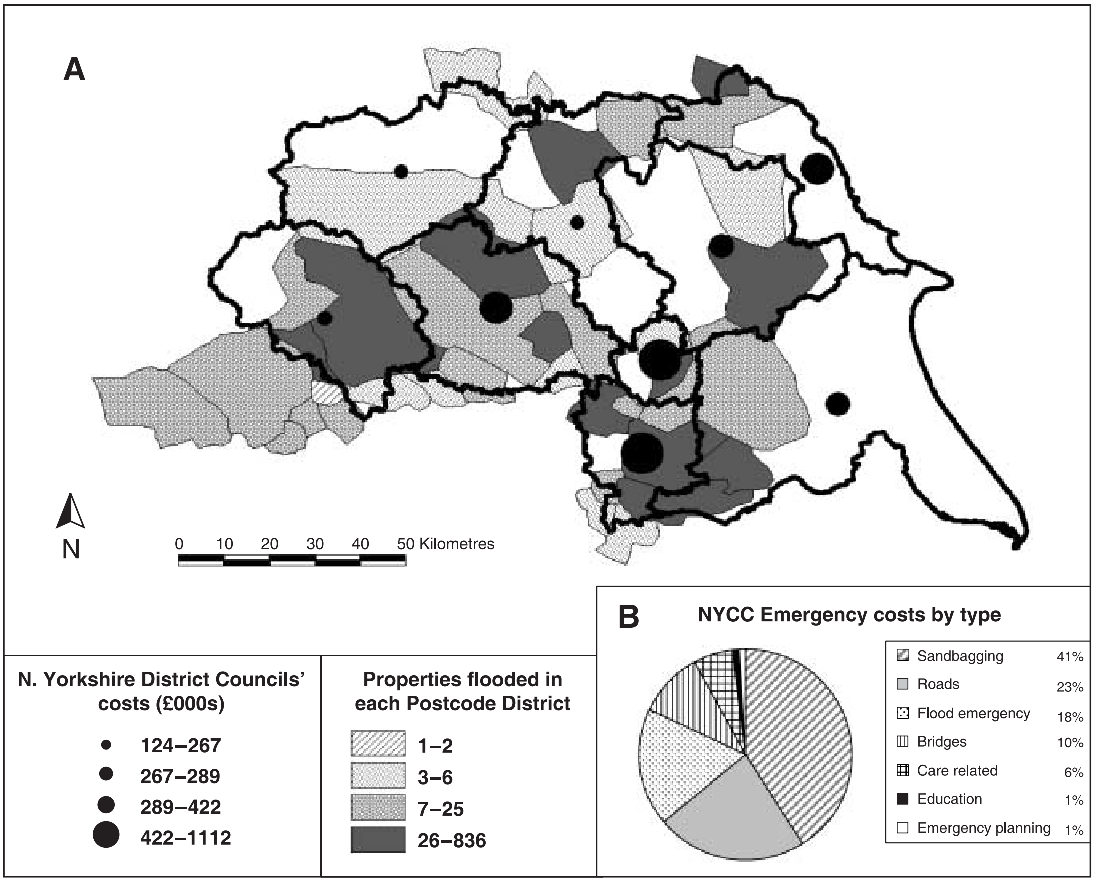

Figure 4 North Yorkshire County Council emergency costs as claimed through its Districts, their breakdown by type and the overall context in terms of properties flooded (the last taken from Figure 3)

Table III A summary of NYCC, police and fire service emergency costs

Authority	*Cost (£ million)*	*% of total*
North Yorkshire County Council	1.845	39.3
Fire Service	0.414	8.8
North Yorkshire Police Authority	0.681	14.5
District Councils[a]	0.750	16.0
York City Unitary Authority[a]	1.000	21.3
Total	4.690	100.0

[a]District Council and York City costs remain estimated, but with Selby accounting for half the District Council costs. Most of District Council costs relate to staff overtime, particularly filling sandbags.

Thus the extra costs for the Social Service's home carers as a result of delayed journeys because of flooding were excluded from the claim, as were sandbagging and pumping out floodwater from schools. Other Counties' claims through Districts (Figure 2B) were probably similarly affected. However, two of the County's schools in Selby were used as evacuation centres, and these costs were eligible because the schools were being used for a community-wide service. Bellwin claim data, therefore, again underestimate full emergency costs, but not by a wide margin. It also does not include the District claims, on top of the County claims through the Districts, but these were generally less than £50 000 each (some did not even reach their Bellwin threshold until NYCC added to their claims). Most of those costs relate to overtime for individuals staffing emergency centres and providing general assistance.

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Figure 4B shows that 92 per cent of total NYCC costs relate to emergency repair of highways, bridges, staff time associated with the flood 'fighting' and sandbagging (this last being 41 per cent of all NYCC costs, with a focus on the major effort at Selby, including for military helicopters and personnel). Table IV also shows that evacuation, where it occurs to a large extent, can account for substantial sums and be a large component of emergency costs.

Under Section 25 of the 1996 *Police Act*, police authorities can opt for a direct Bellwin claim or claim through their Counties. Usefully for this research, the North Yorkshire Police Authority did not want to delay reimbursement by making a claim combined with the local authority, having already incurred substantial costs associated with the foot and mouth and Great Heck events. The Authority therefore made a separate claim, for £681 398 (Table IV), with two-thirds of their costs being incurred managing the event in just Selby and York. Excluding York, for which the data are incomplete, these costs are approximately one-sixth of local authority costs, and are again dominated by staff overtime, costs repaid to other forces who lent staff, and the cost of the 'Gold Command' unit overseeing the flood. Most of the staff time involves setting up roadblocks, assisting local authorities, the Environment Agency and the military, facilitating evacuations and attending flood-related road traffic accidents. The overtime costs here do not include 'consequential' overtime (i.e. overtime worked on non-flood duties because officers have been called out for flood duties).

Table IV also gives details of the Bellwin claim for fire services made within the NYCC claim as allowed by the Bellwin rules. Fire services in North Yorkshire are funded 77 per cent by NYCC and 23 per cent by York Unitary Authority; fire service claims were therefore made by NYCC and York separately. Overtime again represents nearly three-quarters of the fire service costs, with supplies and transport comprising the bulk of the remainder (the latter including fuel tax, as discussed above). Fire services costs are only some two-thirds of the police costs, and range from 7.8 per cent to 33.3 per cent of total costs in the different Districts, with a mean of 14.6 per cent, whereas police costs are more variable (the mean is 24.1 per cent, but the range is from 0.3 per cent to 46 per cent, again excluding the city of York for which the data are incomplete).

This case study reinforces the point that the emergency costs of flooding are not related in a simple way to the hazard gauged as properties flooded and their damage, because much of the effort is designed to prevent this from happening. Most of the costs themselves are therefore for a great deal of sandbagging, and for post-flood repair of damaged infrastructure. This shows the 'low-technology' and labour intensive nature of flood event management, which still focuses on efforts to lessen the exposure of vulnerable communities to many millions of tons of flood water. The associated 'high technology' weather radar warning systems and helicopter rescue operations facilitate this, but their costs are low in relation to total emergency expenditure. The implication is that there is unlikely to be a breakthrough in overall response efficiency, driven by technological change, and that emergency response costs in future flood events are therefore unlikely to be lower in real terms than today, and indeed could well be higher.

The Environment Agency's emergency costs

The Environment Agency is the prime mover in managing flood risks in England and Wales, and hence is central to any flood emergency response. It alone has the skills necessary to understand and forecast the evolution of the flood itself, to assess the safety of flood defences and to prioritize efforts to prevent property being flooded. Its role in the recovery phase is a lesser one (Table I), but its repair and renovation tasks are still important.

Given that the Environment Agency, like the fire services, has a clear role in emergencies, a key issue in assessing its flood response costs is the test of 'additionality': what are the additional resource costs in a major event versus what is annually spent as a normal provision for emergencies, not least in employing its 1600-strong Incident and Flood Risk Management workforce. In practice, the Agency is expected to meet costs arising from flooding incidents out of existing budgets, re-prioritizing expenditure as necessary. In exceptional circumstances, however, as with the Bellwin process, the Agency can seek further funding from central government and this happened in 2000/01 (Table V), regarding emergency costs in excess of 1 per cent of the Agency's regional budgets. Claims were only allowable if the costs were above normal operating costs and therefore, in principle, their magnitude should usefully

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Table IV North Yorkshire County Council, Police Authority and Fire Service expenditure (Bellwin claim) associated with the autumn 2000 floods in each District Council area and in York

	Selby		*Ryedale*		*Harrogate*		*Hambleton*		*Craven*		*Richmondshire*		*Scarborough*		*York*		*Total*	
North Yorkshire County Council	£	No.	£	No.	£	No.	£	No.	£	No.	£	No.	£	No.	£	No.	£	No.
1. Care-related services																		
Nursing home evacuation	101 790	5					2 657	2								not available	104 447	7
2. Flood alleviation																		
Sandbagging	471 379		15 917		53 508		48 715		58 537		35 045		30 465			not available	713 566	
Emergency costs	28 072		21 604		174 000		50 617		5 866		20 344		19 140			not available	319 643	
3. Highways and bridges																		
Emergency repairs – roads	1 877	1	58 959	19	111 381	9	37 922	18	45 626	12	18 434	12	126 891	17		not available	401 090	88
Emergency repairs – bridges	5 809	2	2 287	1	62 761	7	20 268	4	57 849	3	21 157	6	940	1		not available	171 071	24
4. Emergency planning																		
Evacuation	12 700	1															12 700	1
5. Education-related																		
Evacuation – Sherburn school	10 015	1															10 015	1
North Yorkshire CC total	631 642	10	98 767	20	401 650		160 179	24	167 878	15	94 980	18	177 436	18	0	0	1 732 532	121
North Yorkshire Police	£	%	£	%	£	%	£	%	£	%	£	%	£	%	£	%	£	%
Police overtime	263 844	80.4	100 648	90.0	1 224	68.5	15 317	91.9	500	92.3	892	91.2	4 713	91.8	179 723	83.1	566 861	83.2
Overtime support	2 077	0.6	1 193	1.1		0.0		0.0		0.0		0.0		0.0	5 059	2.3	8 329	1.2
Mutual aid (other forces)	34 073	10.4		0.0		0.0		0.0		0.0		0.0		0.0	631	0.3	34 704	5.1
Travel, subsistence, etc.	0	0.0	271	0.2		0.0		0.0		0.0	10	1.0		0.0	1 039	0.5	1 320	0.2
Vehicle costs	750	0.2	7	0.0	400	22.4	46	0.3		0.0		0.0	20	0.4	1 576	0.7	2 799	0.4
Other costs	1 835	0.6	979	0.9	25	1.4		0.0		0.0		0.0		0.0	11 541	5.3	14 380	2.1
Command/Authority-wide	25 523	7.8	8 696	7.8	139	7.8	1 296	7.8	42	7.7	76	7.8	399	7.8	16 834	7.8	53 005	7.8
Police Authority total	328 102	48.2	111 794	16.4	1 788	0.3	16 659	2.4	542	0.1	978	0.1	5 132	0.8	216 403	31.8	681 398	100.0
Fire Services	£	%	£	%	£	%	£	%	£	%	£	%	£	%	£	%	£	%
Overtime/additional staff	102 479		23 164		24 355		27 808		13 512		11 169		16 457		77 510		296 454	71.5
Travel/subsistence	1 194		270		284		324		157		130		192		903		3 454	0.8
Supplies	15 818		3 580		3 764		4 298		2 088		1 726		2 544		11 980		45 798	11.1
Premises/telecommunications	1 310		296		311		356		173		143		211		990		3 790	0.9
Transport	22 324		5 046		5 305		6 057		2 943		2 433		3 585		16 885		64 578	15.6
Fire Service total	143 125	34.6	32 356	7.8	34 019	8.2	38 843	9.4	18 873	4.6	15 601	3.8	22 989	5.6	108 268	26.1	414 074	100.0
Overall total	1 102 869	39.0	242 917	8.6	437 457	15.5	215 681	7.6	187 293	6.6	111 559	3.9	205 557	7.3	324 671	11.5	2 828 004	100.0

Notes: Where the number of cases is cited (i.e. No.), these are the most significant separately identified incidents/applications. York is a Unitary Authority and North Yorkshire County Council's costs do not here apply. All the North Yorkshire CC costs reflect the local assistance to the District Councils. District Council costs are not included

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Table V Central government contributions to the Environment Agency's autumn 2000 emergency flood costs (£000s)

Financial year	*2000–2001*	*2001–2002*
Emergency response and repairs	9000	7300
Special funding of feasibility and design for accelerated projects	3000	7700

Source: Defra personal communication (E. Brophy, 28 January 2005)

reflect the true marginal costs of the emergency response.

The nature of these costs is detailed in the Agency's Regional and Area 'Lessons Learned' reports (Environment Agency, 2001): they total £18.734 million for England and £780 000 for Wales (Table VI). In addition, Table VII details the costs of additional data archiving, flood reporting and the costs of the 'Floodline' telephone information service (both internal and external to the Agency) for both England and Wales: a total of £2.368 million. Total Environment Agency costs directly associated with the autumn 2000 floods are therefore £21 882 800 (including emergency repair and response costs in Wales, for which less detail is available).

The geographical pattern of these costs (Figure 2D) generally again follows the incidence of flooding, which first affected the south-east of England (e.g. Lewes and Uckfield) and then moved north (e.g. the Ouse at York) (Centre for Ecology and Hydrology 2001). The Agency's Kent and Yorkshire Areas, with the Midlands Region, therefore represent over half of total costs (54.4%). The exception is the disproportionately high emergency response costs in relation to the parallel emergency repair costs in the Environment Agency's Thames and Anglian Regions. This difference reflects the cross-regional response assistance provided by those Regions – which were not affected so severely by the flooding – to the others who were.

As in the local authority sector, the Agency's emergency repair costs exceeded emergency response costs (48.7% compared to 40.0%), probably because of the cost of the materials involved in the former component. Preparing post-event reports, collecting event data, flood defence infrastructure condition surveys and flood mapping (Table VII) represent a significant 11.2 per cent of total Agency costs, incurred to inform policy and investment planning in the post-recovery period. An argument could be made that these are not true emergency response costs, but are related to post-flood tasks. Indeed the Defra 'special funding' of £10.7 million (Table V) covered costs related to 'Feasibility and design for

Table VI Environment Agency emergency repair and response costs (£000s)

Flood Defence Committee/ Region or Area	*Original budget 2000/01*	*1% ceiling*	*Total emergency repairs*[a]	*Total emergency response*[a]
North West	26 576	266	380	110
Northumbria	4 158	42	195	131
Yorkshire	25 248	252	3 942	2 432
Midlands	30 658	307	1 750	786
Hants & Isle of Wight	3 472	35	159	106
Kent	13 096	131	1 106	741
Sussex	11 214	112	401	838
South West	8 612	86	374	134
Avon & Dorset	5 043	50	276	187
Bristol Avon	3 323	33	163	55
Somerset	5 700	57	340	552
Thames	70 300	703	1 167	2 095
Essex	10 590	106	2	60
Great Ouse	11 232	112	25	75
Lincoln	13 588	136	–	90
Norfolk/Suffolk	16 063	161	–	10
Welland and Nene	7 479	75	12	30
Head Office	0	0	–	10
TOTAL England	266 352	2 664	10 292	8 442
TOTAL Wales			780	

[a]Includes emergency repair and response costs for 2000/01 and 2001/02, but excludes 'Floodline' marginal costs (see text)

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Table VII Environment Agency: additional 'non-statutory' costs (£000s)

	Externally purchased[a]								
EA region	*A*	*B*	*C*	*D*	*E*	*F*	*Subtotal*	*Internal*	*Total costs*
North East	0	444	148	138	23	36.3	789.3	267	1056.3
Midlands	0	33	45	5	0	40.8	123.8	80	203.8
Southern	0	24	56	0	129	28.2	237.2	73	310.2
Anglian	0	0	5	0	0	46.5	51.5	0	51.5
Thames	0	79	37	40	57	74.4	287.4	102	389.4
South West	39	95	10	0	0	24.3	168.3	24	192.3
North West	0	3	0	2	9	33.6	47.6	55	102.6
Wales					46.8	15.9	62.7		62.7
Total	39	678	301	185	264.8	300.0	1767.8	601	2368.8

[a]Categories: A = photogrammetry and LIDAR remote sensing costs; B = ground surveys; C = aerial photographs; D = condition surveys of flood defences; E = 'Lessons learnt' Flood Report (Environment Agency 2001); F = extra 'Floodline' call costs (memo dated 23 November 2000 from Manoch Kerman). All the above attract extra statutory contribution of 100 per cent subject to a ceiling of £2.5m

accelerated projects'. However, on balance, we treat the costs in Table VII as emergency costs, because without the emergency they would not have been incurred, but do not count the balance of £8.33 million in this way (i.e. £10.7 million less £2.368 million) because this was the 'accelerated' component that would have been spent anyway but simply later.

An important part of the Agency's flood defence 'armoury' is the Automated Voice Messaging system (AVM) and the freephone 'Floodline' telephone information service (Table VI). Both are designed to assist the flood-prone public in mitigating their personal injury/stress and promoting a reduction in property damage. The Agency allocates a significant budget to facilitate this process, but this allocation is given irrespective of actual flood events. The additional costs of AVM/Floodline for the autumn 2000 events (i.e. over the planned annual level) were estimated at £300 000 for the 467 200 Floodline calls that were made (e.g. Environment Agency 2001). However, some of these costs are 'wasted', in that Floodline calls were made where there was little or no flooding (e.g. in the Anglian Region). However, we judge that they are still costs legitimately attributable to the emergency, just as sandbagging costs are incurred but 'wasted' when the floodwaters do not quite reach the property concerned.

Emergency costs vis-à-vis direct flood damage and other flood losses

The full economic cost of the autumn 2000 floods in England and Wales has been difficult to establish, but was somewhat over £0.75 billion (Penning-Rowsell *et al.* 2002).

This figure is corroborated by data from the Association of British Insurers (ABI) (2001), who reported claims in excess of £1.2 billion, although these are financial rather than economic costs, especially since 'new-for-old' insurance policies now generally prevail (ABI 2001). Figure 5 shows the patterns of these claims through time, yielding a net figure for the event of £773 million if the claim levels for the pre-flood period (July to September 2000) are deducted from the claims for the next three quarters, after which total claims had nearly returned to the pre-flood 'base'.

But actual losses must have been higher, since we know that some 25 per cent of households are uninsured (ABI 2001), and adjusting the domestic claims accordingly gives a total financial loss of £631 million for that component. The combined commercial and domestic financial loss then totals £931 million. This closely corresponds to the modelled financial losses of £946 million (Penning-Rowsell *et al.* 2002). The similarly modelled economic losses totalled £570 million. Adding to this the assessed economic losses for agriculture (£35 million), road transport (£13 million), and the rail network (£51 million), gives total economic damage and disruption costs for the event of some £669 million (Penning-Rowsell *et al.* 2002). The £118.3 million emergency costs for the organizations researched for this paper brings the total event economic loss to £787 million.

The emergency costs as analysed here therefore amount to over 15 per cent of total losses, falling

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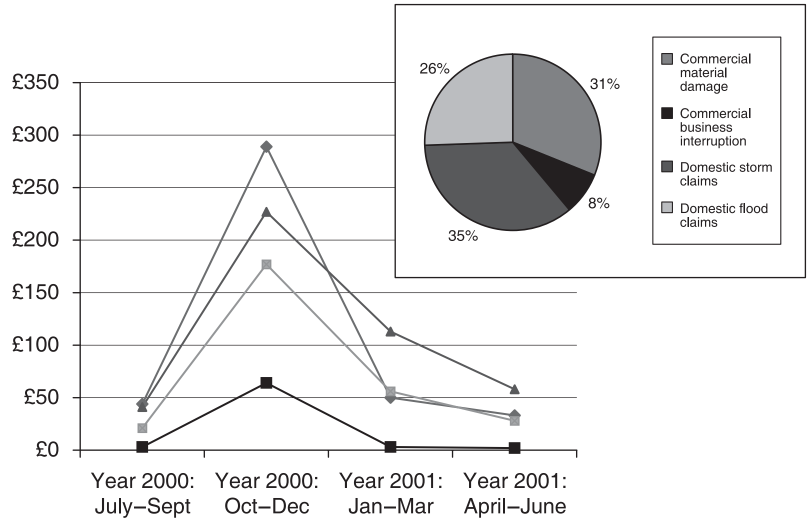

Figure 5 Losses reported by the Association of British Insurers (£000s) for autumn 2000
Source: For source, see Association of British Insurers (2001)

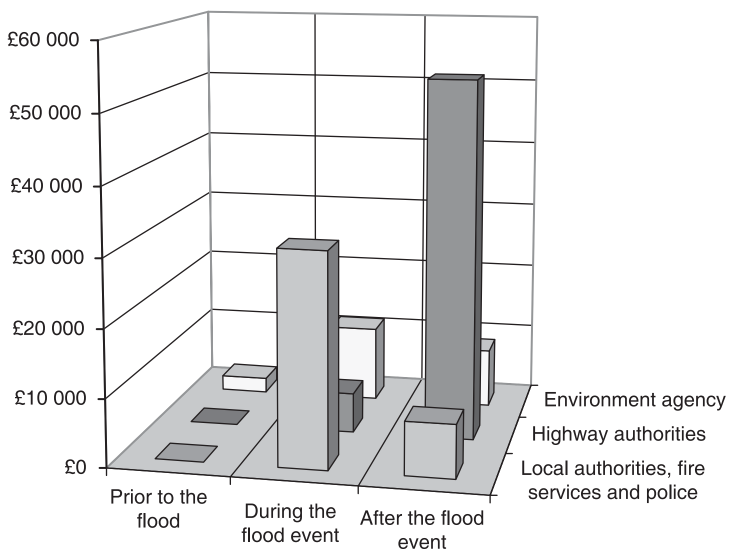

Figure 6 The breakdown of emergency costs incurred in the autumn 2000 floods, by flood phase and by organization (£000s)

predominantly in the aftermath of the event, since repair costs generally exceed immediate response costs (Figure 6). Whilst it can be misleading to quote emergency costs per property flooded (because much emergency effort is spent avoiding this), the data here yield a sum for emergency costs of some £10 750 per property affected, given approximately 11 000 properties flooded in autumn 2000. Unfortunately we cannot calculate the equivalent sum for the larger number of properties threatened by flooding, as this number is not known. However, in real terms this emergency cost, at £10 750, is more than ten times the figures suggested from the previous research (Parker *et al.* 1987) and quoted above.

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Counting emergency costs in flood risk reduction investment appraisals

Most flood risk management options – structural or non-structural – will reduce the impact of floods, and this in turn will reduce the emergency response costs. These cost reductions therefore form one of the benefits of implementing those options.

But, being very conservative, not all the emergency costs as analysed here are always allowable by HM Treasury as contributing to the benefits of flood risk reduction. An example here is sandbagging; often its effect in reducing damage is not allowed for in project appraisal flood modelling of flood damages and benefits (Penning-Rowsell and Green 2000; MAFF 1999). Therefore to count a reduction of its cost in reduced flood fighting effort as a benefit of flood alleviation without analysing its effect in reducing damages is illogical. Also, secondly, some of the emergency repairs following floods can result in betterment, such that a bridge or road is in a better condition after its repair than previously. In effect, part of the cost is for maintenance brought forward to the time just after the flood, rather than for damage caused by the flood alone.

Another problem is how to 'scale' the figures for a particular project appraisal feasibility study from the data reported above. The temptation is to relate emergency costs to the numbers of properties flooded (as is done for some other indirect flood costs (Parker *et al.* 1987)), but this has limitations, as discussed above. An alternative approach, indicated in Table VIII, has met with Defra economists' approval. This takes the total emergency costs under Bellwin (and below Bellwin thresholds), the severe weather payments and the Environment Agency costs for England and Wales, and allows only those costs unambiguously appropriate to project appraisals. This means deducting 50 per cent of the severe weather payments, in lieu of betterment, and factoring the total Bellwin claims by 42.5 per cent, being the sum of those items deemed allowable from our North Yorkshire case study (i.e. excluding sandbagging and 50 per cent of road and bridge repair costs (see Figure 4B)).

The result is a figure of £60.8 million as total emergency costs applicable to project appraisals (Table VIII) – compared with the less conservative £118.3 million – or 7.7 per cent of total economic event losses and 10.7 per cent of property damage. This, therefore, in the absence of better information than reported herein, represents a multiplier on top of property damages to allow for emergency response costs in future flood events.

Assessment and conclusions

As far as we are aware, the research reported here is internationally unique: no other data have been found that gauge the economic cost and the spatial patterns of the emergency response to major flood events. This is despite the worldwide policy interest in non-structural approaches to flood risk management, amongst which emergency response and the recovery it facilitates is a vital part.

Yet many methodological and technical research problems remain (Handmer 2002). First, we have no way of knowing how representative the UK's autumn 2000 event is internationally, only that it was a large event by national standards. Secondly, we recognize that the research reported here is not a complete analysis of emergency costs, nor can the information be fully accurate. For example, individuals' emergency response costs are not included, since they are counted within property damages, and the severe weather payment data, as the largest component analysed here (Figure 6), suffer from including some element of betterment. Unquantifiable flood impacts cannot be included (see Tapsell *et al.* 2002), and organizations' insured costs are not allowable in Bellwin claims, so we have no knowledge of these. Voluntary organizations have an important role in emergency response, but their costs are not included, although they are likely to be low. The same applies to costs incurred centrally by Defra or the ODPM, although the low Environment Agency Headquarters costs (Table V) perhaps indicates that the national emergency effort is small in comparison with regional and local flood response.

We have also not tackled here the efficiency with which the emergency services operate – their costs versus their benefits – or the contribution of the responses that we have quantified to effective recovery, as part of the bigger risk management picture (Mitchell 2004; Norman 2004). Indeed, even within the narrower field that we have investigated, we still know very little about the effectiveness of emergency services at reducing flood damage and other flood impacts (RPA/FHRC 2004), and therefore have little understanding of their cost-effectiveness. Gauging this would require much more information on the damage saving in relation to the costs that we have quantified here, and this is perhaps part of an agenda for future research.

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Table VIII Overall emergency costs as applicable to project appraisals

A. Autumn 2000 total losses[a]

	Financial (£ millions)	*Economic (£ millions)*
Property losses	946	570
Professional partners (PP)	39	39
Capital grants to the EA's PP	58	58
Environment Agency	21	21
Road traffic disruption	73	13
Railway network	51	51
Agriculture	195	35
Total	1383	787

B. North Yorkshire CC emergency cost (Bellwin) breakdown

Cost item	*% of total*	*Allowed*[b] *amount (%)*	*% of total allowed*
Sandbagging	41	0	0
Roads/bridges	33	50	16.5
Education	1	100	1
Emergency planning	1	100	1
Care related	6	100	6
Other staff costs in the flood emergency	18	100	18
Total	100		42.5

C. Emergency costs applicable to project appraisals

Cost item	*Amount (£ million)*	*Allowed*[b] *amount (%)*	*Allowed amount (£ million)*
Total Bellwin:			
England	28.3	42.5	12.0
Wales	7.6	42.5	3.2
Costs below thresholds[d]	3.1	42.5	1.3
Severe weather payments:			
England	41.9	50.0	21.0
Wales	17.1	50.0	8.6
Environment Agency costs[e]:			
Emergency repairs[c]	11.1	50.0	5.5
Emergency response	9.2	100.0	9.2
Total	118.3		60.8
As % of economic property losses of £570m =			10.7%

[a]From Penning-Rowsell *et al.* (2002); [b]judged to be costs not counted elsewhere in benefit-cost analyses. The figure for roads recognizes some betterment after repair (hence the 50% taken); [c]as for roads, above, some element of betterment here, hence 50% taken; [d]taken as 50% of thresholds; [e]England and Wales

Nevertheless the data analysed here do begin to fill a significant gap in our knowledge of the impact of disasters, albeit just for one flood event and just for one country. This analysis shows that these costs are widely distributed, both geographically and institutionally. Spatially, they broadly match the incidence of property flooding, but with some notable and significant exceptions where costs were incurred in areas of sparse flooding when assistance was given by the organizations there to those more severely afflicted elsewhere. This in turn reflects the fact that the geography of flooding here is highly localized, focused on the UK's narrow and small floodplains, whereas the spatial remit of the emergency services covers County and District Council areas and the Environment Agency's regions, and thus localities well beyond the floodplain. The spatial mismatches that occur between hazard and response are therefore not unintended. They should be seen in the context of the institutional structure of the emergency services and the fact that these services are dealing with many different

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hazards – fire, pollution, crime, floods, etc. – which inherently have many different spatial 'footprints'.

Our results also show that total emergency costs are much larger than we had hitherto appreciated, at approximately 15 per cent of total economic flood losses. This in turn indicates that previous techniques (Parker *et al.* 1987) for assessing emergency response costs during and following a flood event have significantly underestimated these costs. The implication is that we should take this topic more seriously in the future than in the past, within a 'portfolio' approach to countering increased flood risk (Evans *et al.* 2004). We should also not see emergency response to floods and other disasters as a low-cost or even a cost-free option, but continue to enhance the performance of response activities to ensure that this effort is as effective as possible in facilitating post-event recovery.

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Note

1 Previously (to May 2002), the Department of Transport, Local Government and the Regions (DTLR), and prior to that (May 1997 to June 2001), the Department of Environment and Transport (DETR).

References

Association of British Insurers 2001 Letter from Jane Milne of the Association of British Insurers to the Middlesex University Flood Hazard Research Centre 10 July 2001 (Reproduced in Penning-Rowsell *et al.* 2002)

Beck R J and Franke D I 1996 Rehabilitation of victims of natural disasters *Journal of Rehabilitation* 62 28–32

Cabinet Office 2003 *Dealing with disaster* Brodie Publishing, Liverpool

Centre for Ecology and Hydrology 2001 *Hydrological yearbook, 2000* CEH, Wallingford

Defra 2003 *Revisions to economic appraisal procedures arising from the new HM Treasury 'Green Book'* Department for Environment, Food and Rural Affairs, London

Defra 2004 *Making space for water: developing a new government strategy for flood and coastal erosion risk management in England* Department for Environment, Food and Rural Affairs, London

Defra 2005 *Making space for water: taking forward a new government strategy for flood and coastal erosion risk management in England: government first response* Department for Environment, Food and Rural Affairs, London

Environment Agency 2001 *Lessons learned: autumn 2000 floods* Environment Agency, Bristol

Environment Agency 2003 *Strategy for flood risk management (2003/4 to 2007/8)* Environment Agency, Bristol

Evans E P, Ashley R, Hall J, Penning-Rowsell E C, Saul A, Sayers P, Thorne C and Watkinson A 2004 *Future flooding: scientific summary* 2 vols Office of Science and Technology, London

Few R 2003 Flooding, vulnerability and coping strategies: local responses to a global threat *Progress in Development Studies* 3 43–58

Green C H 2003 *A handbook of water economics* John Wiley, Chichester

Green C H 2004 The evaluation of vulnerability to flooding *Disaster Prevention and Management* 13 323–9

Hall J W, Evans E P, Penning-Rowsell E C, Sayers P B, Thorne C and Saul A J 2003 Quantified scenarios analysis of drivers and impacts of changing flood risk in England and Wales: 2030–2100 *Environmental Hazards* 5 51–65

Handmer J 2002 The chimera of precision: inherent uncertainties in disaster loss assessment *International Journal of Mass Emergencies and Disasters* 20 325–46

Hewitt K 1997 *Regions of risk: a geographical introduction to disasters* Longman, London

Howe J and White I 2001 Flooding: are we ignoring the real problem and solution? *Regional Studies* 35 368–70

Howe J and White I 2002 The geography of the autumn 2000 floods in England and Wales: causes and solutions *Geography* 87 116–24

Institution of Civil Engineers 2001 *Learning to live with rivers* ICE, London

Johnson C, Tunstall S and Penning-Rowsell E 2005 Floods as catalysts for policy change: historical lessons from England and Wales *International Journal of Water Resources Development* 21 561–75

Kelman I 2001 The autumn 2000 floods in England and flood management *Weather* 56 346–60

MAFF 1999 *Flood and coastal defence project appraisal guidance (3): Economic appraisal* Ministry of Agriculture, Fisheries and Food, London

Marsh T J 2001 The 2000/01 floods in the UK – a brief overview *Weather* 56 343–5

Mitchell J K 2004 Reconceiving recovery in **Norman S** ed *New Zealand recovery symposium proceedings* Ministry of Civil Defence and Emergency Management, Wellington, NZ 47–68

Mustafa D 2003 Reinforcing vulnerability? Disaster relief, recovery, and response to the 2001 flood in Rawalpindi, Pakistan *Environmental Hazards* 5 71–82

ISSN 0020-2754

Norman S 2004 Focus on recovery: a holistic framework for recovery in **Norman S** ed *New Zealand recovery symposium proceedings* Ministry of Civil Defence and Emergency Management, Wellington, NZ 31–46

ODPM 2002 *Preparing for floods* Office of the Deputy Prime Minister, London

ODPM 2005 *Consultation on Planning Policy Statement 25: development and flood risk* Office of the Deputy Prime Minister, London

Parker D J 2004 Designing flood forecasting, warning and response systems from a societal perspective *Meteorologische Zeitschrift* 13 5–11

Parker D J, Green C H and Thompson P M 1987 *Urban flood protection benefits: a project appraisal guide* Gower Technical Press, Aldershot

Penning-Rowsell E C and Green C H 2000 New insights into the appraisal of flood alleviation schemes *JCIWEM* 14 347–62

Penning-Rowsell E C, Chatterton J, Wilson T and Potter E 2002 *Autumn 2000 floods in England and Wales: assessment of national economic and financial losses* Middlesex University Flood Hazard Research Centre, London

Penning-Rowsell E, Tapsell S and Wilson T 2005 Key policy implications of the health effects of floods in **Kirch W, Menne B and Bertollini R** eds *Extreme weather and climate events: risks to human health and public health responses* Springer, Heidelberg 207–23

Penning-Rowsell E C, Johnson C and Tunstall S M in press 'Signals' from pre-crisis discourse: lessons from UK flooding for global environmental policy change? *Global Environmental Change*

Pottier N, Penning-Rowsell E C, Tunstall S M and Hubert G 2005 Land use and flood protection: contrasting approaches and outcomes in France and in England and Wales *Applied Geography* 25 1–27

Red Cross/Red Crescent 2004 *World disasters report: focus on community resilience* International Federation of Red Cross and Red Crescent Societies, Geneva

Rosenthal U and Bezuyen M J 2000 Flood emergency management in developed countries in **Parker D J** ed *Floods* Routledge, London 340–50

Rosenthal U and 't Hart P eds 1998 *Flood response and crisis management in Western Europe: a comparative analysis* Springer, Heidelberg

RPA/FHRC 2004 *The appraisal of the human-related intangible impacts of flooding* R&D Project FD2005/TR Defra/ Environment Agency, London

Salthouse R 2002 Lessons to be learned from the autumn 2000 flood disaster in the UK *Insurance Research and Practice* 17 64–7

Tapsell S M and Tunstall S M 2000 The health effects of floods: the Easter 1998 floods in England in **Parker D J** ed *Floods* Routledge, London 172–87

Tapsell S M, Tunstall S M and Wilson T L 2002 Vulnerability to flooding: health and social dimensions *Philosophical Transactions of the Royal Society of London* 360 1511–25

UN/ISDR 2004 *Living with risk: a global review of disaster reduction initiatives* United Nations Inter-Agency Secretariat of the International Strategy for Disaster Reduction, Geneva

ISSN 0020-2754