Environmental cost of flooding

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Acknowledgements

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Cover photo:
Corporation Road, in the Rickergate area of Carlisle.

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Executive summary

This research is an attempt to understand the environmental costs of flood events at a household level, and begin to suggest how these costs might be reduced. We have looked at what happens after a flood event and what drives decisions about the initial response, strip out, drying and refurbishment. In this we are not seeking to develop or replicate technical guidance, but to understand how such guidance as is currently available is applied, what the environmental implications are of this, and how the process involved and related understandings might be improved.

It is perhaps obvious to state that the environmental costs of a flood event are huge, with this evident on every street affected in the immediate aftermath. At a household level the most significant impacts are the amount of waste created through disposal of flood damaged items and the strip out of sodden building materials, the increased fuel used to dry out properties, and the materials and energy needed to reinstate properties and make them homes again.

We have made an attempt in this report to approximately quantify this impact, finding that:

- Waste to landfill from flood affected homes is roughly equivalent to total annual residual household waste from a typical household in one year.

- Energy used for drying processes may add around 3 tonnes, or one third, to the average home's annual carbon emissions.

- Materials used in refurbishment, coupled with the replacement of items like appliances, add significantly to embodied impacts. A replacement set of kitchen appliances adds around one tonne in embodied carbon. Transport of materials and labour adds further to these impacts.

We found evidence that whilst some of these impacts may be unavoidable, there is significant scope to reduce impacts through better processes in carrying out restoration work.

- In strip out, materials and items are often be removed unnecessarily, due to a poorly developed understanding of the existing building context or the potential for retention and restoration. For example, solid wood floors are often stripped, but with careful cleaning and drying it may be possible to retain them. Walls with flood resilient renders and plasters are stripped, 'just to be sure'. Solid wood furniture is disposed of because of a lack understanding or resources for refurbishment.

- There is a limited understanding of the potential for unintended consequences of drying processes, that may result in further avoidable damage to existing materials, and therefore requiring a greater degree of strip out.

- The extent of refurbishment required is greatly affected by what has gone before, but there is often additional waste created where poor quality work has to be redone, or by not considering and integrating resilience measures at an appropriate time. This in addition to the high levels of waste prevalent in the construction industry in the disposal of unused or damaged building materials.

Whilst this is frustrating, it is also understandable. After a flood event, the key driver for all decisions for both the householders and the professionals involved in the recovery process is the desire to achieve a return to normality as quickly as possible. This means there may be reduced tolerance for processes which are perceived to add time and costs - such as taking a 'wait and see' approach to the assessment of potentially damaged building elements. With the added desire of insurers and other professionals to minimise perceived risks, this can lead to a 'one size fits all' approach that prioritises speed and simplicity over a context based and more considered understanding. One of the biggest changes that could be made that would allow the environmental impacts, and costs, to be reduced, would be to enable space for time and consideration in decision making within the recovery process.

Executive summary

The unintended consequences of a drive for speed are exacerbated by the lack of attention seemingly paid to existing published guidance on elements such as post-flood strip out and drying. Much of this guidance is not easily accessible, or is available in a format not conducive to understanding in a time pressured environment. Particularly in the areas of drying out and resilience measures, there is also a lot of contradictory and potentially confusing guidance available - and a limited consideration of the differing context of properties, especially those that are older and use more traditional building methods. The knowledge that householders have of their own property and its context and behaviour in flooding is often valuable, but can also be neglected in 'off the shelf' approaches. Householders feel they have to become experts themselves, or have to trust in the existing practices and understandings of the professionals engaged in the process, be they loss adjusters or recovery contractors.

Further technical research in areas where the guidance is currently unclear or contradictory would be helpful to improve common understandings and reduce confusion and uncertainty. However this alone is not sufficient - this knowledge will need to be widely disseminated through existing networks and community organisations, using the channels that already exist for communities to learn from each other. There is also work to do in understanding how the current procurement structures militate against a more considered flood recovery response, and a role for regulation in bringing up the laggards to ensure at least a minimal performance is met.

Reducing the environmental costs of future flood events is not simply therefore about improved technical understandings or better information and guidance. It's also not necessarily only about structural reform of the industry. Rather there is significant scope for simple improving processes to make it easier for all to do the right thing the first time round - by sharing existing knowledge more effectively, and providing support and useful, targeted guidance to householders on the process as well as the outcomes. This would help avoid unnecessary and duplicated work that seems so common in existing processes, and is something that could have a large impact on the environmental cost of flood recovery.

Introduction

The aim of this research is to develop an understanding of the drivers of current practice around clean-up and property refurbishment following flooding, and identify opportunities for the development of more environmentally sustainable and cost-effective practices.

This research is rooted in Cumbria but the findings will have relevance across the UK, for urban and rural areas and across the housing stock. As such we hope that the recommendations will be broadly applied by geography, organisation and professions.

Our aim is not to replicate guidance, or to devise new technical standards, but to understand:

- The current impact of flooding in environmental terms.
- Current practice in relation to strip out, drying out and reinstatement.
- What and who drives decisions at each stage.
- The extent to which resilience is incorporated into refurbishment work - thereby potentially reducing future environmental costs.
- The extent to which other environmental improvements are incorporated into refurbishment - such as insulation and energy efficiency works.
- How the industry response and guidance to householders might be improved.
- Where there are examples of best practice that can be shared, and whether lessons have been learned since previous flood events.

By environmental impact we mean:

- **Direct impacts** such as the amount of waste generated during strip-out, the amount of energy required in drying out homes, and the materials reinstated.
- **Indirect impacts** such as the additional journeys generated by trades travelling to flood affected areas.

The information in this report has been collated through:

- A desktop review of existing guidance and research.
- A half-day workshop with practitioners, including statutory and third sector organisations, held in Workington.
- Phone interviews with a number of people with experience of the flood response who were unable to attend the workshop.
- Phone interviews with householders directly affected by flooding (on one, two and three occasions respectively). These householders were very willing to share their experience with us and as a result we are unlikely to have captured the full range of impacts (particularly for those more vulnerable).

Recent flood events

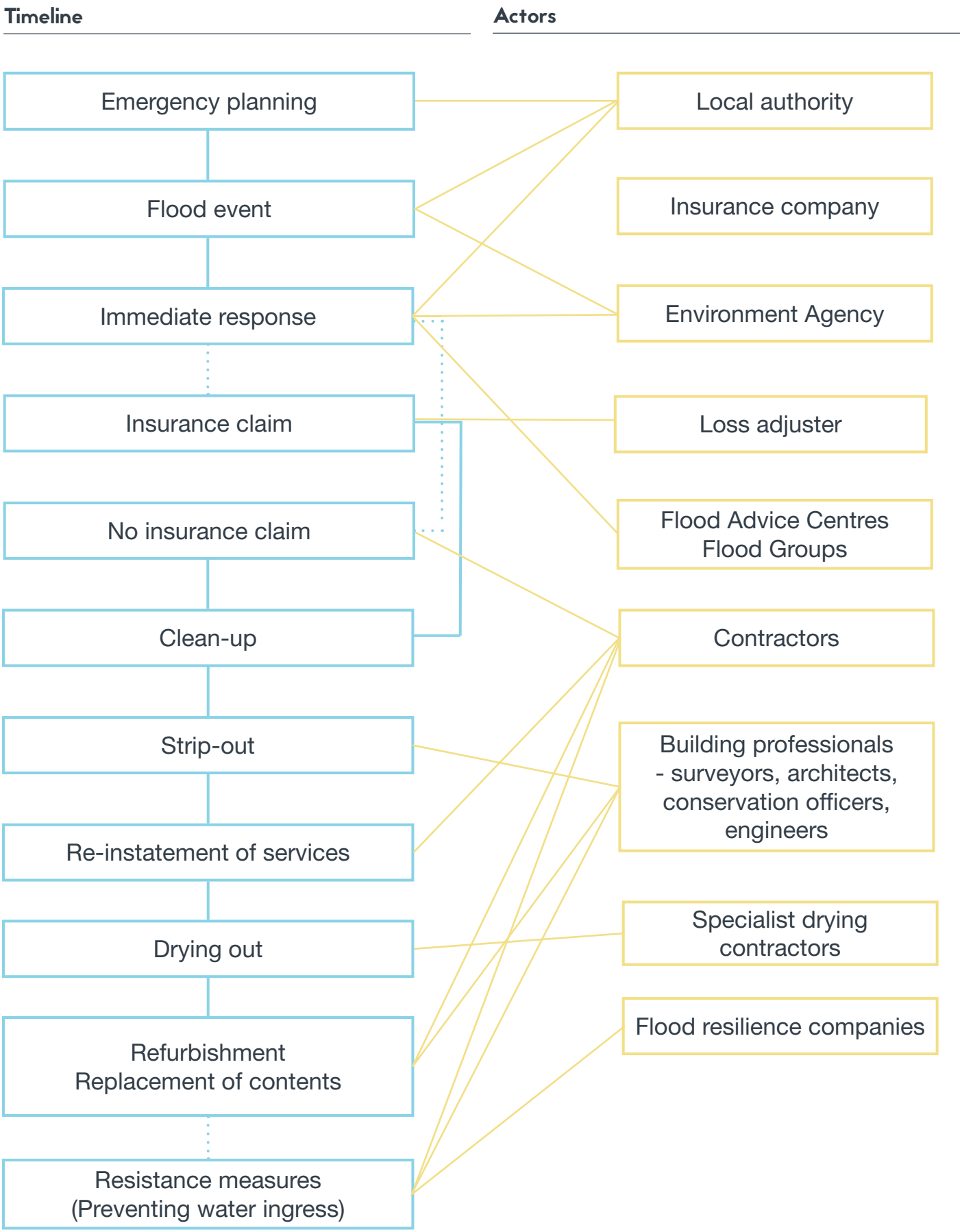
In early December 2015 many parts of Cumbria, and other parts of northern Britain, suffered from exceptionally high rainfall over a short period of time. With the ground already very wet from higher than average rainfall in the preceding month, the high rainfall caused by 'Storm Desmond' led to extensive flooding across the county. In Carlisle around 1,930 properties were directly affected by flood water with further severe flooding across the county in Keswick, Kendal, Pooley Bridge, Cockermouth, Appleby, Eamont Bridge, Braithwaite, Flimby, Maryport, Workington and Brigham. The village of Glenridding was flooded three times in a fortnight.

In addition to those whose homes were directly affected by flood water, many thousands more were impacted by loss of power (as many as 42,000 properties in Lancaster alone), evacuation and reduced mobility from roads and bridges washed away. The cost of damage to both homes and business from the 2015/2016 events alone is likely to be in excess of £1.3 billion (Association of British Insurers, 2016), a figure that doesn't account for those not insured. Of survey respondents to the Cumbria Flood Recovery Fund, as many as 19% were under-insured and 9% had voided insurance - suggesting total actual costs will be much higher than the ABI figure. The ABI estimated that the average domestic claim for the 2015 floods would be £50,000, compared with an average from the 2013/2014 winter storms of £31,000.

These claims are part of a complex recovery process, which we have represented in the diagram on the facing page and have gone on to discuss in more detail on the following pages.

Source: On the waterfront, Rickergate, Carlisle.

Introduction



1: Immediate response

Prior to a flood there are simple steps that householders and other agencies can take to reduce damage to the home and its contents. This includes practical measures such as:

- **Maintaining an up-to-date household emergency plan**
- **Rehearsing the plan (this might include familiarisation with lifting off internal doors etc.)**
- **Keeping valuable and precious items out of harms way.**

However, there are a range of other actions in the hours preceding and immediately after a flood event that can have a bearing on environmental impact and householder experience.

Understanding insurance cover

For householders, understanding the level of insurance cover is an important first step, as this may determine the approach they take to clean-up, strip-out and refurbishment. This should not be left to research until the flood event as they will have more pressing priorities. Having a good understanding of what their policy will or will not cover, and their rights and responsibilities in the process, can also avoid nasty surprises during what is already a stressful time. Understanding the relationship between the householder and any surveyors and contractors is also likely to help householder understand what is and isn't possible in the reinstatement process. Under-insurance and void insurance is a very real issue, with the survey of grant recipients from the Flood Recovery Fund showing 19% of respondents were under-insured and 9% had voided insurance. This information will also guide time dependent tasks, such as taking gas and electricity meter readings as soon as possible, in the event that these costs are covered under the policy.

Timing plays a role in reducing environmental impacts

The time it takes for flood water to naturally recede will vary by flood type, duration and extent. The time it takes for responders to arrive in affected areas may also be variable if a large number of homes are affected, as was the case during the 2015 winter floods. However, as a general rule, the longer it takes to start the drying out process, the greater the damage will be. This is because water soaks into the fabric of the building and capillary action plus evaporation spreads dampness to upper floors (CIRIA, 2005). Industry guidance (CIRIA, 2005) recommends that cleaning, decontamination and drying start within 48 hours of the incident or from flood water subsiding. This can also help to reduce the risk of mould growth.

Where householders have a sump and pump fitted (or a portable pump that can be mobilised as soon as possible), this will help to reduce damage, particularly to floors. This can be problematic if electricity is lost to the home in the immediate aftermath of the flood - as was anecdotally reported to be the case in many homes after the 2015 events. Getting the power back on is a major priority in limiting environmental damage. Those who had moved consumer units and other services above the level of any flooding previously, had a significant advantage in this, showing this to be one of the key 'flood resilience' moves.

Local authorities can and do take meaningful actions to support people, reducing potential impacts. For example, by developing simple resilience plans designed to sit below the 'blue light plan,' developing practical support services such as 'flood sack stores', helping towards the cost of items like community pumps and setting up 'drop in' information sessions. Though with stretched resources, this is becoming more difficult.

Getting 'feet on the ground' and 'faces at the door' from insurance companies and support agencies after a flood is seen as important - particularly for large scale events that attract national press attention. Whilst well intentioned, this can mean the right advice and expertise is not always present at the right time. The immediate aftermath is also when personnel are most stretched, and this is exacerbated by the reduction in the number of fully qualified loss adjusters in recent years. Coupled with the dispersed nature of some settlements, this can result in authority being delegated to other parties such as restoration contractors, who are not necessarily skilled or resourced well enough to make the considered judgements that will reduce environmental impacts and disruption - with a standardised approach more likely. Immediacy is seen as valuable in providing reassurance that something is being done. However, it may have unintended consequences such as unnecessary level of strip-out or the disposal of items that could have been saved, as companies work to budgets and take a 'one size fits all' approach. This in turn affects the type and level of refurbishment required.

The desire by all involved to return to 'normal' as quickly as possible was a frequent theme uncovered in our research. Whilst this is an understandable impulse, it can have

Useful guidance

Protecting Precious Memories (York Archaeological Trust)
This guidance is designed to supplement the household emergency plan so that people are able to better protect irreplaceable items or react quickly in the event that they are damaged.

Right: Emergency response in Carlisle, Warwick Road.

unintended costs and consequences. In the simplest case, it may lead to hasty decisions in respect of what is kept and what is thrown away. Furniture and fittings are disposed of rather than restored, as this is seen as a quicker and simpler process. In the most serious case it can lead to deeper problems such as damage to construction elements being overlooked - potentially resulting in greater environmental costs and disruption in the future, or leading to issues with persistent damp and mould that have an impact on health.

Repeat flood events create a body of knowledge that is often tacit and unrecorded, but that ultimately improves resilience.

Householders who have been flooded before are generally better prepared. For example, they may have a better idea of what to sacrifice and be more prepared to stand their ground over items they believe can be saved. These householders may also be able to re-occupy their homes sooner because they are more prepared, familiar with the insurance process and ready to mobilise once the water recedes. Others may be well linked to local trades and can secure their involvement early on, or in a position to start work on a DIY basis; this may prevent additional damage from water soaking into materials.

Preserving important belongings

Important belongings, be they documents such as birth certificates, passports and insurance policies or those with sentimental value (such as photos) can be preserved provided the correct steps are taken. In some cases emergency centres are installing extra freezers so that people can store important documents and photos in plastic bags which can then be restored at a later date. The importance of this is generally well recognised.

How hazardous is the clean up process?

Fears around contamination and hazardous materials may be driving the use of unnecessary cleaning processes. This has potential environment and health impacts. Representatives from flood advice centres cited scaremongering and misinformation on what was perceived as contamination, with little in the way of clear, concise definitions offered to householders, and no clear understanding of the processes followed by restoration contractors.

Householders often rely on contractors and professionals to advise on clean up. They may not have the confidence or the knowledge to challenge existing practices, or the ability to access published guidance. For example, an information sheet developed for householders states - 'has a satisfactory method [of decontamination] been described to me?' (BDMA, Record of flood recovery activity and personally appointed contractors). In such instances, particularly in the case of those householders with less experience of flooding, they may take what is seen as a cautious approach, preferring to clean as deeply as possible, or else simply throw things away, rather than take what may be seen as a 'risk'. Whilst understandable, this may be significantly increasing the use of potentially toxic cleaning agents and waste creation.

Guidance from Public Health England (2014) suggests that infections caused by flooding are rare. This is because although sewage systems may become inundated, any harmful materials are usually highly diluted. They state that regular hand washing with warm, clean water and soap, covering cuts and wearing waterproof footwear and gloves will often be more than sufficient. If cleaning agents are required, diluted solutions and those based on natural ingredients are acceptable. This contrasts with the tone taken in some of the guidance which calls for rinsing down masonry walls with detergents (CIRIA, 2005). It is clear that even among well respected professional bodies, there is some contradiction that may lead to confusion as to the best course of action.

Loss adjuster: work for the insurance company in assessing claims and organising repairs.

Loss assessor (or claims management): offer to take on insurance claims and liaise with the insurer on the householder's behalf.

Flood event - time-line and opportunities

1. **Preparation**: regularly updating the household flood plan can minimise damage and losses. Knowing where newly fitted resistance features (e.g. air brick covers) are located and how they should be used, and how to close the gas and water valve on a newly fitted boiler.

2. **Flood warning and mobilisation:** locating key contents to higher floors, arranging for collection and storage of key items for those in vulnerable properties (e.g. bungalows).

3. **Evacuation**: the priority is the safe evacuation of occupants.

4. **Return to property**: planned approach to disposal which categorises contents by material type and level of damage.

5. **Clean-up**: taking a measured approach to clean-up and the avoidance of toxic cleaning products that may have immediate and longer term health and environmental impacts.

Case study A:
First Time Flooded in Allerdale

Flood stats

House type: 2 storey Victorian mid-terrace
Tenure: Owner occupied
When: December 2015
Type: River flooding
Duration of water in house: 2-3 days
Depth: 1200mm

Insurance status: Insured

Procurement: Strip out - DIY, Drying - Insurance Contractor, Refurbishment - own contractor, Resilience – scheme contractor

Accommodation:
Lived with relatives while work was done.

Time-scale:
Work complete and back in the house in May 2016

Initial Response

This was the first time this householder had experienced a flood event, though they were aware of the risk due to previous events in the same area. The house had been fitted with flood gates (to front and back doors) by the previous owner, but little other work had been undertaken to their knowledge.

Above: flood doors fitted by previous owner

They didn't receive a formal flood warning, but saw updates on social media about what was happening up river and realised a flood was likely, so took action. They put the flood gates in place and moved what they could upstairs (including the TV and all mobile electrical goods) and stacked other items onto the kitchen counter-tops. Both their bathroom and kitchen are on the ground floor of the property, and so were badly affected. Kitchen appliances were fitted, so could not be moved. Due to limited time and storage space, sofas had to stay downstairs, but were stacked in a effort to reduce damage.

In the event, the flood gates offered little protection, as water found its way through cracks in the wall and other routes and eventually over-topped them. One of the flood gates (to the most critical rear elevation) appeared to fail as it had been badly fitted. The house has solid floors, so water coming up through the floor was not a factor.

Having not been flooded before, this householder wasn't always sure what to do. They spoke to their insurers in the first instance to check what information was needed, and took photographs to record the extent of the damage. The insurer took a fairly relaxed attitude, and was happy for them to just get on with the clear out as soon as possible. The insurer's loss adjuster did not actually visit the house until weeks after the flood when a lot of the drying and stripping out work had been done by a combination of the householder and a restoration contractor. It seemed like they were overwhelmed with the demand, and being based in Glasgow they had a long way to travel. However, they were supportive and very reasonable to deal with. They became the main source of information and advice for the householder, keeping in touch by phone and email.

Neighbours who lived in the same street and had been flooded before were another useful source of information, although sometimes it felt like everyone but them knew what they were doing. Other than that, and the odd conversation with the insurer, it very much felt like they'd been left to get on with it. There were no visits or information shots from advice agencies in those first few days and weeks.

The main support the district local authority provided was in prompt waste disposal, with a regular collection service from the street. However there was no suggestion that waste should be separated. The emphasis was on getting rid of anything that might be 'contaminated' but where to draw the line on this was not explained. There was also some conflict in this between the need to put waste out of the house onto the street, and the drive to re-open the road (one of the key access routes into town). This caused some practical problems, making the task of waste disposal, and even just keeping water out of the house, more difficult.

Strip Out

The strip out process started almost immediately, and was mostly done by the householder. They took advice from neighbours and the insurer, but were also reliant on their own sense of what was sensible.

Carpets and floor coverings were removed in full and put outside for collection by the council to help get rid of dampness and sediment. Having solid concrete floors throughout meant the level of assessment and work for this element was limited.

Plaster was removed on all the downstairs walls to about 2 or 3 feet above the level of the flood – and in some areas more plaster came off the walls as a consequence. The waste was taken to the local household waste collection centre (HWRC) by the householder.

Despite being fully tiled, the householder felt the walls in the bathroom had to be stripped as they were sodden and unable to dry otherwise. The bath, WC and hand-basin were all stripped out. Although the insurer argued the hand-basin might have been saved, the householder was able to argue for its replacement, and took these out themselves. The fitted kitchen was completely removed (chipboard based), and again taken to the HWRC by the householder.

Above: the stripped out bathroom

Drying out

Drying out was undertaken by a contractor engaged by the insurer who seemed to do quite a number of the houses in the area. This is the area over which the householder felt they had the least understanding and control, and were reliant on the contractor signing off the property as 'dry' before refurbishment work could start.

Drying out was undertaken with electric heaters and electrically powered dehumidifiers, supplied by the contractor. The process took around a month and used a lot of electricity. The householder hadn't been aware until a neighbour mentioned it in passing that they were also able to claim for these costs on their insurance.

There were some issues as the contractor was based in Lancashire, and a few weeks after the floods in Cumbria, Lancaster suffered severe flooding. This meant there was increased demand for their services and they took a while to respond to queries and requests.

Refurbishment

The insurer agreed to the householder using their own contractor and simply submitting quotes for approval. The insurer seemed grateful for this as there was such a high demand for construction contractors in the area.

They were confident in the contractor because they were a friend and based locally. The contractor had their own staff and managed a small team of subcontractors. Whilst the householder did some elements themselves, the bulk of the building work, plastering, electrical, bathroom and kitchen fitting work was done by the same contractor. They got the job done in a reasonable time-frame, and there was very little snagging needed afterwards.

In re-instating their home, they opted for 'like for like', not taking the opportunity to get a kitchen upgrade, but also not really thinking about energy efficiency upgrades in lighting and appliances. The priority was always to get back in the house, and so 'standard' fittings were chosen.

Resistance and Resilience

The householder did access the property level flood resilience grant available through the local authority – though was a little frustrated that this came along quite late in the process, after a lot of the key decisions had been made. In the initial aftermath, resistance and resilience measures were not something they had much awareness of. The priority was to get the house dry and in a fit state to be lived in again.

There are things that they might have done differently if they had been aware of them at the time. For example, moving the electricity consumer unit to a new higher position, altering wiring and raising plug sockets, or using different plaster on the walls that would allow for easier drying out without having to be stripped in future. However, they were also unclear, since they didn't ask at the time and simply re-instated things on a 'like for like' basis, whether the insurer would have paid for this. The flood resilience grant might have paid for this work, but as this scheme wasn't up and running until several months after the flood, it would potentially have delayed the work or caused complications in payments.

Case study A: First Time Flooded in Allerdale

A Flood Resilience Survey was done, and the associated grant money accessed, opting to do this through a single contractor. They found the survey report quite generic, and didn't opt for any of the suggested measures. The house already having solid floors meant that one obvious resilience measure had already been done. Instead they asked that a flood defence wall be built at the back of the house. This was their own suggestion, based on their knowledge of how flooding had occurred, and was agreed to by the contractor.

Key lessons

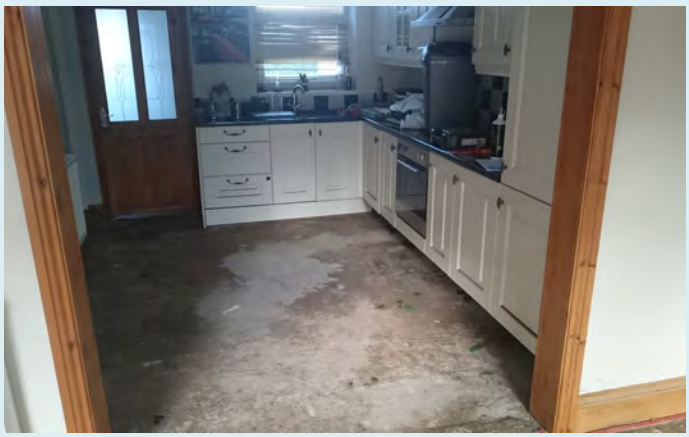
1. Householders, especially those who have not been through the process before, are very **reliant on the professionals they come into contact with for advice.** Not being experts themselves, they have to trust this. They also look to **informal networks of neighbours and friends**, but this can sometimes result in confusion and **contradictory advice**.

2. **Being able to work with contractors that the householder knows and trust is of great reassurance** and appears to result in better experience and outcomes. However, mass flood events put **huge strains on local and even regional supply chains**, with flood events in other areas, often miles away, affecting resourcing.

3. **Energy efficiency is not always high on the list of priorities** for householders who are dealing with the chaotic aftermath of a disaster event. In this case improvements in energy efficiency may still come about. For example, because in the time since appliances and lights were originally purchased, regulations have moved on, and the default position will be better.

4. **Advice and funding for resilience measures needs to come at the right time**, when they can have the biggest impact for minimal input. Issues around 'betterment' vs. 'like for like' refurbishment still cause confusion. Though having some flexibility under what was allowed as 'resilience' measures mitigated this to some degree.

Flooding badly affected the kitchen and bathroom. The householder tried to move items like sofas above the flood water.



Tiles in the kitchen floor were stripped out and replaced.

Drying out was by electric heaters and dehumidifiers.

Re-plastering in the living room.

Bathroom tiles were also removed and replaced.

2: Strip out

One of the most obvious environmental impacts of a flood event is the waste created by strip out. Kitchen appliances, furniture, fixtures, fittings and building materials damaged by flood waters are stacked outside homes awaiting disposal. Whilst to some degree this may be unavoidable, it is also true that there is significant room for improvement in current practices. It may be helpful to consider the home as a series of layers - from unfixed furniture and belongings, to fixed appliances and fittings, building services and the fabric of the building itself. Each of these layers is affected differently by the flood waters, and therefore needs to be tackled differently.

Residual Waste

With the exception of appliances and white goods, which must be disposed of separately, flood waste is considered contaminated. It is not generally sorted for recycling or reuse, and so large quantities of furniture, carpets, food waste and personal belongings are sent to landfill. Approximate figures are available from Cumbria County Council's draft flood impact assessment (see Table 1). Whilst the figures here should be treated with some caution - there is not a perfect audit trail for flood waste - this gives some idea of the order of magnitude of waste created. For comparison, the UK and regional average for total annual residual waste per household is just over 0.5 tonnes per year. This suggests that a flood event has the potential to approximately double the annual amount of residual waste created per household or more. Since not all homes in an area are affected, the absolute numbers may remain manageable by local authorities, though this additional waste will impact on costs and resources, and is a cause of significant environmental damage. There is potential to take positive action through better guidance and by providing support for clean up and restoration in preference to disposal. This would both reduce environmental impacts, but also the costs to local authorities, and potentially also the distress to householders, as familiar items are saved.

At a household and neighbourhood level, the priority in the aftermath is often to get things 'back to normal' as soon as possible. There is an understandable desire to clear affected streets, for practical reasons of access, removal of traffic hazards and cleanliness, but also in an attempt to remove the signs of a traumatic event. Local authorities have developed 'Clean Up Plans', which include either quick liaison with providers to deploy large skips or the diversion of waste collection trucks from their normal rounds. In Allerdale for example, collections were made of anything left on the pavement by refuse collection teams every few hours. Councils may also issue fines if they deem building materials from strip out, such as skirting boards and flood boards, to cause a health and safety risk. Whilst the intention is to reduce risks to the public, it may also have the effect of rushing the householder into disposing of belongings before fully assessing whether they could be restored, and adds to the quantities of residual waste identified above. There will be additional energy, financial and pollution costs from clean-up work undertaken by the council at night (where portable lighting and generators are used). As well as increased waste going to landfill (this includes sandbags that have come into contact with flood water), anecdotally it is reported that affected areas also experience a dip in recycling rates as collections are suspended to allow extra resources (people and vehicles) to cover flood clean-up instead - though it has not been possible to quantify this.

Local Authority	Approx number of homes flooded	Flood waste received to end of March 2016 (tonnes)	Tonnes per flooded household (approx)
Allerdale	1700	651	0.38
Carlisle	2100	2662	1.27
Eden	600	523	0.87
South Lakeland	1900	914	0.48

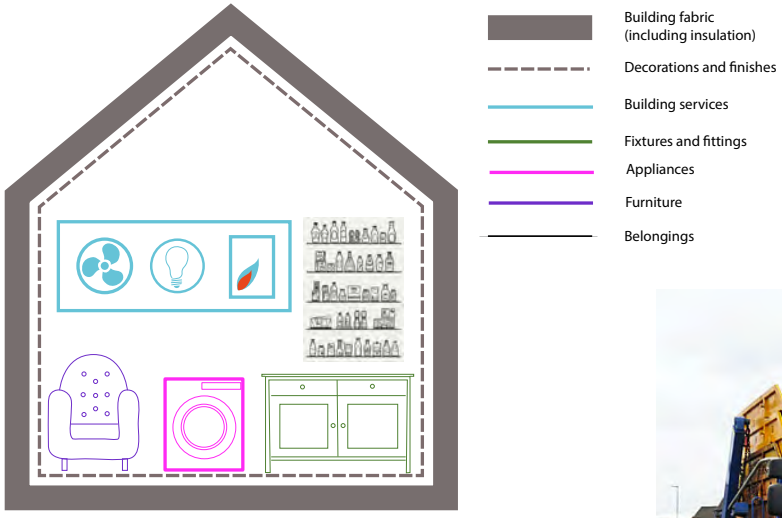
Table 1 : Figures provided by Cumbria County Council. Note figures are approximate, and should be treated with some caution.

The Strip Out Process

The vast majority of waste is created by the strip out process at a household level. The approach to this process varies significantly by household: from minimal and partial strip out, removing only what is deemed absolutely necessary; to a blanket approach removing everything touched by flood water including all timber, plaster wall coverings and furniture.

This not only affects the amount of waste created and its associated environmental impact, but also goes on to affect each step of the recovery process - with a greater degree of strip out resulting in a greater level of reinstatement work and extended time-scales. Whilst some level of removal of damaged items may always be necessary, the huge variation in approaches found, and the limited references made to published guidance, suggests that there may be room to learn from best practice to reduce environmental impacts. For example CIRIA (2005) suggest that a moisture survey should be undertaken before embarking on strip out, so that the level of damage is understood. We are not clear from our research how often this actually happens

Householder's interactions with insurance companies have a large impact on the level of strip out. Insured householders are often dependent on surveyors for advice, and loss adjusters for sign-off of agreed costs. Insurance companies add to the pressure for a more extensive strip out through their processes. For example, the strip out and drying out process is often led by renovation contractors,



Above: Any home contains layers or construction and materials, all of which behave differently and need to be treated differently in any flood recovery process.

Right: skip wagon in Greystone Road, Carlisle

engaged by the insurance company on a standard rate or a fixed cost contract. These contractors are then motivated to keep costs down by minimising the amount of time spent on site. The rates paid to these contractors make few allowances for geography, and they are often national franchising operating on a regional basis. As such, in more remote and dispersed communities, the incentive to speed up the process is increased.

Both insurers and contractors are also highly risk averse. They are often not willing or able to 'wait and see' with potentially damaged items, and are not willing to sign off on reused items that may be deemed safe, but whose functionality may not be guaranteed in the longer term. This tends to drive a 'blanket' approach, with minimal consideration of what may be salvageable and an increased level of strip out and disposal, all driven by a need for speed, simplicity and risk aversion. This can have the unintended consequence of prolonging the recovery process by resulting in a greater degree of required reinstatement work afterwards. For example whole walls of plaster are sometimes stripped, rather than just affected areas. Similarly, solid timber floors are removed and replaced, because of fears around damp, contamination and longer term condition - where much of the published guidance suggests that these could simply be cleaned and dried.

Those householders who are not insured, or who rejected the insurer's approach in full or part, often undergo a more limited strip out. In older properties and with householders who have experienced previous flood events, as many of these occupants know what the property has withstood in past events, and are possibly more confident in the ability of their home to dry out without extensive stripping or more willing to take the on the perceived 'risks' to minimise disruption and time-scales. Those who have a better understanding of their right for 'reinstatement' and general control of the process may also have a better experience.

Furniture and Belongings

Loose belongings are some of the easiest things to move in the event of a flood, and are often a consideration in the household emergency plan. As flood events have become more frequent, and some homes have been flooded on multiple occasions, provided someone is home to move things, many belongings can be saved.

There is a consensus that soft furnishings or chipboard furniture should be discarded, as they will have absorbed water and the glues that hold them together are likely to be compromised. It is better to avoid these items getting wet in the first place by stacking sofas on top of other furniture, or choosing to have removable rugs in place of fitted carpets. However, not all householders are able to do this - either because they don't have the space or the physical strength, or because they need to prioritise other actions in a fast-moving situation. New support services being developed by flood action groups may address this - such as the 'flood removals' van owned by Cockermouth Flood Action Group that can move items to a safe place for vulnerable residents or those living in bungalows.

When it comes to solid wood furniture there are two clear approaches:

- To discard items, adding to the household waste sent to landfill
- To clean, dry and restore them.

Whilst it may be technically possible to save items, it is often down to the householder to take the initiative and find someone or do it themselves. Householders gave examples of furniture being sent out of the county, or taking years to be restored. This takes patience and dedication, and is in direct opposition to the desire for speed and simplicity, so it is perhaps not surprising that it is a relatively rare occurrence.

2: Strip out

Another impact of the speed imperative is that in the haste to throw away items details are not properly recorded - so items may be listed by removal companies simply as 'chair' or 'carpet'. Furniture companies will often only keep purchasing records for 6 years so householders have little to fall back on if the item is thrown out quickly. With insurers looking to replace items cost effectively, this may mean an inferior quality or less durable item replaces that which was lost - leading to further environmental impacts in future years as these items break and need to be replaced. Householders are encouraged to take photographs to mitigate this - but again this requires time and dedication on their part and may not always be sufficient.

Appliances and Electrical Goods

It is often not possible to move larger electrical and mechanical appliances, especially washing machines or dishwashers which are plumbed into water systems. As most kitchens and some bathrooms are on the ground floor of houses, this means that thousands of appliances were affected by flooding in 2015.

The draft County Council flood impact assessment reports that an additional 370 tonnes of electrical goods were received at Household Waste Recycling Centres (HWRCs) across the county in 2015/16 in comparison with 2014/15. This is in addition to the waste to landfill (see above). This is not an exact figure, as it was arrived at simply by comparing against the previous year, though it gives some idea of the scale of the issue.

Included were an estimated 2,900 fridges and freezers. The nature of these products leads to an increased need to dispose of potentially dangerous elements such as refrigerants with high Global Warming Potential (GWP), in addition to the energy intensive aluminium, steel and plastic that most appliances are manufactured from, and the potentially toxic waste in heavy metals associated with electronic items and circuit boards. Whilst some of these elements can be recovered and recycled, it is an energy intensive process that without the flood would not be necessary - or at least, not on the same time-scale, with some appliances otherwise having the potential to last many more years.

Assuming that the vast majority of items will be replaced with similar or possibly even larger items, the embodied carbon and energy content is significant. The average embodied carbon of a washing machine has been estimated at 270 kgCO_2e for a 70kg machine. A rough calculation suggests that for a household disposing of and replacing a washing machine, fridge freezer, dishwasher and cooker, the embodied carbon content would approach 1 tonne CO_2e - or approximately 10% of the annual carbon footprint of a resident of the UK.

Whilst there may be some benefit in emissions from energy in use by replacing older appliances with more efficient ones, this is only really of benefit if new appliances are in place for long enough to pay back the energy and carbon debt incurred in their manufacture. As more of the items disposed of are A and A+ rated, the gains may be marginal by upgrading to an A++ appliance. Dependent on the model, it could easily take a decade to pay off the embodied carbon through 'in use' savings (Braithwaite *et al.,* 2015). If another flood event occurs within this time-frame, this potential benefit is negated, even assuming the appliance is durable enough to last this long.

Some householders decide to keep appliances, provided they are still in good working order, tested for electrical safety, and have no apparent damage to seals and other parts. This is often in opposition to the advice of insurers and surveyors - who are concerned that they may then be liable if the item fails in the future - or where no insurance cover exists. Cleaning and repair is thought to take more time and effort, though it can cost less money. If a householder does not have a trusted electrician, it can also be difficult to have appliances signed off as safe. Concerns about contamination are also prevalent, though as noted above, given that most of the flooding in Cumbria has pollutants in a highly dilute form, official guidance suggests that simply washing down with soap and water should be sufficient.

Fixtures and Fittings

The standard assumption for fitted kitchens is that they will need to be fully replaced as storage units will warp or fail over time. Whilst this might be sensible where units are made from chipboard or fibreboard that is badly affected by moisture, it is not always the case for solid timber or other more robust materials, such as steel. However, it is also not quite as simple as leaving these other materials in place. The units themselves may at least need to be removed to drain water, clean silt and allow the walls and floor behind them to dry fully.

Once this is done, with units cleaned, dried and assessed for damage, it is technically possible to refit them. However, it seems this rarely happens. This is perhaps again a product of the drive for speed, simplicity and risk aversion - with both insurers and householders unwilling to 'wait and see', having limited storage room and wanting to make progress with clear up, and being uncertain about potential long-term undiagnosed defects. This results in significant additional waste to landfill and new resource use in the replacement kitchen.

Bathrooms and WCs located on the ground floor often having fittings replaced, potentially unnecessarily. Whilst it may be necessary to remove bath panels and covering plinths to ensure that the areas behind are properly cleaned and dried, the sanitary ware itself is generally unaffected by flood damage, provided it is well supported (BRE 1997: Part 4). Insurers do suggest that units be kept - though this is not consistent.

Another motivating factor may be consumer culture, and the assumption on the part of surveyors, contractors and householders that having a new kitchen or bathroom is inherently better than refurbishing an existing one - despite the fact the build quality of a new kitchen may be lower. Some householders object to this, and fight to retain their old cupboards and fittings. However this can take effort and energy that is in short supply and it is often seen as easier to simply allow things to be fully stripped and replaced.

Building Services

This is an area where safety is of paramount concern. Where consumer units, fuse-boards and sockets have been submerged, they often require replacement. Similarly, gas supplies can be affected by a build up of silt and mud. The guidance on how to deal with this is limited. Though advice on the Gas Safe Register website suggests that water can be drained and gas meters made suitable for operation, the assumption is that more often than not things are replaced.

A knock-on effect of disruption to services is the ability of households to carry out the clean up and drying process. The sooner services are back up and running, the sooner and more effectively drying out can be done. The key means of limiting damage to services is by ensuring they are fitted above the likely level of any flood. The householder or their surveyors needs to have foresight in this, and it needs to be something that can be financed - either by the householder, the insurer or through grant programmes.

Building Fabric and Finishes

This is by far the most disruptive element of strip out, and where practice is most varied. Whilst there is published guidance on the level of stripping out likely to be necessary in which the need to carefully monitor actual flood damage and pay attention to context is highlighted (CIRIA 2005) it seems this is seldom referred to in practice, and rarely followed in full.

From discussions with both professionals and householders it is clear that a 'one size fits all' approach is often taken in the name of speed and simplicity. Despite this the level of strip out advocated seems to also vary by insurance company and surveyor. There are also sometimes inconsistencies - for example with affected timber in one area being stripped, but left in another where it is less accessible or is more disruptive to remove. This approach often has little regard for the age of the property or the ability of different materials - such as lime or cement based plasters and renders and solid walls common in older buildings - to dry more effectively than 'standard' modern materials such as gypsum plaster and insulation-filled cavity walls.

There are even cases of previous flood resilience work being removed, supporting evidence for poor 'flood memory'. In some cases cement renders installed after floods in 2005 or 2009 were stripped instead of being left to dry out. Where householders were aware of these works, the risk averse and time-saving attitude of some surveyors resulted in householders having to argue for flood resistant renders to be retained even where the guarantees from the original installers were still valid. Similarly, solid timber elements such as skirtings, architraves and doors are often removed and disposed of unnecessarily. Where there is uncertainty, there is a tendency to opt to strip out more to be sure.

Both environmental damage and the disruption and distress to householders could be reduced simply by paying greater attention to existing published information, such as that from CIRIA and the BRE. Training is also available from bodies such as the British Damage Management Association (BDMA, online). However, even in published guidance from bodies such as BRE and CIRIA there are conflicts, and the understandings about the behaviour of more traditional building materials is limited. Further research is required in this area - coupled with a programme of dissemination and training for all involved.

Transport Impacts

Another factor in environmental impact at all stages, is the transport related energy use and carbon emissions created by contractors. In Cumbria this appears to have been exacerbated by the fact that so many of the contractors involved came from outside the county. Existing local construction supply chains were simply overwhelmed with the scale of demand. It was not unheard of for contractors to travel to West Cumbria from Lancaster, to Carlisle from Dundee, and to Eden from North Yorkshire. Though these journeys were not made every day, with contractors also seeking local accommodation, it will have added to total impacts - and increased the pressure on provision of temporary accommodation. With the average transit van emitting in the region of 200g/CO_2 per kilometre, travelling the additional 120km from Workington to Lancaster, for example, will result in an addition 24kg of CO_2 emissions. Whilst this will not have occurred in all cases, it shows that there may be benefits to supporting local supply chains to carry out recovery work - in addition to the likely local economic benefits and issues with trust noted in the case studies.

Strip out - key environmental impacts

- Additional residual waste to landfill created by removal of furnishings and materials from homes, and transport costs of the same.
- Risk of additional global warming impacts from refrigerants in household appliances.
- Embodied energy and carbon in new appliances installed to replace flood-damaged items.
- Transport impacts associated with journeys by contractors.

3: Drying

Once visible flood water has been removed, either due to naturally receding water levels or using pumps, sediment cleared and rooms washed down, the next stage is to dry out the building fabric. This is an essential step before repairs can take place and belongings can be reinstated.

Nearly all the practitioners we spoke to believed that this stage of flood recovery has the highest environmental impact. This assumption seems to be based on the high energy requirements of operating drying equipment over long periods.

There is a lack of clarity over the different processes used. From the direct experience of those we spoke to it often proves to be a very elongated and sometimes uncertain process. There was also concern that 'indiscriminate' drying is occurring, without due concern for different construction types and the rates of drying needed to prevent further damage, with the potential for unintended consequences.

Drying out objectives

The ultimate objective of drying out is to return the moisture content of materials within the home to pre-flood levels or better. Coupled with the reinstatement and suitable operation of heating and ventilation systems, this should contribute to an internal environment that is healthy for occupants and will not compromise material integrity or contribute to mould growth. For a healthy home, relative humidity levels should be between 40 and 60% - though in warmer months, when the moisture content of external air is also higher (especially in the North-West) these figures may also be higher.

Knowing when a home is sufficiently dried out is not straightforward, and simply basing this on the amount of time elapsed, touch, or a visual inspection is not adequate (BRE Digest 163, 1974) meaning that monitoring is required. CIRIA guidance (2005) notes that regular adjustments of moisture removal and air movement is required as drying progresses - though we found limited evidence of this guidance being followed, and householders largely dependent on the contractors and surveyors to confirm when drying is complete. Applying more permeable paint finishes may allow reoccupation whilst also allowing the walls to continue drying - though how often this was considered after the flood events in Cumbria is unclear.

Methods of drying out

The Department for Communities and Local Government (DCLG 2010) review of guidance and standards for drying flood damaged buildings outlines three main methods of drying. In reality, often some combination of these techniques is used:

1. **Natural ventilation** (sometimes fan assisted). This is generally the slowest method of drying a building, with time-scales very variable as it is more reliant on ambient conditions (i.e. external temperature and humidity vary throughout the year).
2. **Convection drying using heating and ventilation:** This can range from using the existing heating system, additional fan heaters or high temperature 'speed drying' techniques. Ventilation might include running mechanical extractor fans and/or opening windows and doors.
3. **Dehumidification:** Dehumidifiers work by cooling the air to the point of condensation, or by chemical desiccants. The speed of drying is largely dependent on the capacity of the equipment relative to the space. Windows and doors must be closed for dehumidifiers to work effectively.

CIRIA guidance (2005) notes that for optimum drying conditions, the air will have a relative humidity range of 40-50%. Heating alone will not dry out materials unless moisture can escape, so ventilation is also crucial. CIRIA guidance notes that the thermostat should be set to 22°c and heating will normally be in use 24 hours a day. Under normal conditions most householders would set it to between 18 and 21°c for the periods in which the home is occupied, so using heating as part of a drying out regime will incur higher fuel usage.

Speed drying systems are typically mobile trailer units designed to heat multiple rooms to over 60°c. As independent units they are not reliant on the existing heating or electrical system of the home. Whilst this may reduce electricity costs to the householder, and may also mean the process can start more quickly - saving subsequent damage from prolonged dampness - they use diesel or petrol generators for power. These emit particulates and carbon monoxide which contribute to poor local air quality and create noise. The main unit usually pumps heat to smaller heat exchangers throughout the home; which usually have a power rating of 10, 30 or 60kW (ISS Restoration, online). The power used by such systems is therefore considerable.

Above: speed drying trailer

We have compared three typical drying scenarios in Table 2, in an attempt to understand the approximate comparative energy and carbon emissions implications. This shows that energy used in drying may effectively add around 3 tonnes to a household's annual carbon emissions - approximately one third of the UK average of household emissions (see Oxford City Council *et al,* 2012).

Interestingly, the calculations suggest that there may be very little difference in total carbon emissions between methods given the current carbon intensity of mains electricity - though as the grid decarbonises in coming years, this will change. It is therefore important to consider other factors, such as local air pollution and impact on the building fabric. In particular whether the drying process risks causing further damage to the building fabric, increasing the requirement for strip out and refurbishment, and so increasing the environmental impacts.

Table 2:
Estimated comparative environmental impacts of different drying methods for an average 100 sq m terraced house

	Description
Scenario 1: Electric Heat	In cases where the home does not have access to a gas-fired central heating system, either during the drying process or at all, so uses electric heat aided by fans and dehumidifiers, with windows open. Assumed to use 5 no. 2kW electric heaters, 4 no. 1.5 kW dehumidifiers, and 2 no. 0.5kW fans - all operating continuously and using grid electricity.
Scenario 2: Gas Central Heating	In cases where the primary source of heat used to dry the home is a gas central heating system with a relatively new condensing boiler supplying 10kW of heat, aided by 4 no. 1.5 kW dehumidifiers, and 2 no. 0.5 kW fans - all operating continuously and using grid electricity.
Scenario 3: Speed Drying	A stand alone unit designed to provide intense heat to dry the house quickly, with the windows and doors of the property sealed. Assumes a single diesel generator providing 60kW of heat, split between all rooms of the house.

		Estimated Total Power Demand (kW)	Duration (hours)	Estimated System Efficiency	Total Energy Use (kWh)	Carbon Emissions (kgCO2)*	Impact on Building Fabric
Scenario 1: Electric Heat	Grid electricity	18	504	100%	9,072	3,456	Where undertaken carefully over a period of several weeks, and where guidelines are followed on monitoring moisture content and adjusting temperature and ventilation rates accordingly, this should have a limited impact on the building fabric.
Scenario 2: Gas Central Heating	Mains gas	10	504	65%	7,754	1,721	
	Grid electricity	7	504	100%	3,528	1,344	
	Total				11,282	3,066	
Scenario 3: Speed Drying	Electricity from diesel generator	60	48	100%	2,880	2,880	This fast drying process aims to remove moisture from a property very quickly - in the space of a day or two. Conservation specialists have raised concerns about the consequential damage this could do to building materials such as timber and plaster - with this in turn leading to a greater need for strip out and replacement of materials.

Notes:
1. Duration taken from reports from householders, recommendations and manufacturer's literature.
2. All electrical systems assumed to be 100% efficient. Gas central heating system efficiency includes allowance for boiler efficiency, system losses and heat emitter efficiency.
3. Grid electricity = 0.381 kgCO2/kWh (SAP 3 year average), Mains Gas = 0.222 kgCO2/kWh (from SAP), Local Diesel Generator - 1.0kgCO2/kWh (estimated figure - from EPA data)

3: Drying

Drying methods are not necessarily tailored to building type

Research participants were aware of at least four different approaches to drying out by the main insurers, with some employing speed drying techniques (also described as 'kiln drying') over as little as 24 hours, with others preferring dehumidifiers. Speed drying appears to be increasingly popular as it helps to reduce related costs such as temporary accommodation. It should be acknowledged that such accommodation in itself will also have an environmental cost - potentially effectively doubling the heating and power needs of any given household, so minimising time spent is beneficial - and is likely to be welcomed by householders keen to return to normal.

However, within the industry there seems to be little coherence or agreement about the best methods for drying out - both in terms of effectiveness and minimising unintended damage to the building fabric. The suitability of different techniques for different types of construction are not well established, at least not in publicly available materials. A DCLG review highlighted research, that in some cases dates back to the early 1990s, that warns of damage from intensive heating methods, particularly in relation to older buildings. It is not clear that current practice follows such advice. There is also a risk that water that has soaked deeper into the fabric will take longer to dry out; as this occurs it can cause damage to reinstated finishes. This would be a particular issue if a gypsum type plaster was reinstated, which is badly affected by heightened moisture content - a practice that still appears to be widespread even after repeat flood events.

Competency and availability of drying contractors

During extensive flooding both contractors and equipment are in high demand. Even relatively recent guidance (such as the Flood Recovery Guide by Know Your Flood Risk) lists just three specialist drying companies, and two of these appear to no longer be in business.

Workshop attendees raised concern that there is often an assumption by householders that drying out contractors are competent. However, they point to a dominant business model of franchises with one area manager overseeing multiple jobs, and operatives on the ground often not trained. Examples were given of drying contractors using dehumidifiers that drained into open buckets within the property.

PAS64: 2013 is the British Standards Institute (BSI) code of practice for the mitigation and recovery of water damaged buildings. This document outlines processes for selecting drying techniques and equipment. Householders are advised to look for companies that operate within this code of practice. However, they have very little means of interrogating the data without paying around £80 to access the document. The impartiality of the document itself is also perhaps questionable given that it was sponsored by a number of private companies that have a significant market share in speed drying and loss adjustment surveying. The code of practice gives an example of an environmental impact assessment (considering issues such as the power usage of equipment and CO^2 emissions) but we have not found any evidence to suggest that these are routinely applied. Further independent research, that also considered the behaviour of traditional constructions, would be of benefit here in producing trusted guidance.

The main qualifications available in this area are certified by the IICRC (Institute of Inspection Cleaning and Restoration Certification) in:

- Applied Structural Drying
- Water Damage Restoration Technician

Both are 3 day courses with an exam. The availability of operatives with such qualifications, who are also able to carry out the necessary moisture load calculations, is extremely limited during extensive flood events. As such, their ability to guide appropriate techniques is limited by proprietary tools and software such as the National Flood School Moisture Wizard and other hand held digital calculator devices. This finding is reinforced by the DCLG 2010 review which found that during a major emergency the guidance is less widely adhered to, particularly by companies not usually engaged in this type of activity.

The energy used in drying, and its potential to affect both strip out and refurbishment works when done badly, means that this is an area with potential for significant reductions in environmental impacts - but this requires further research and better industry-wide understandings.

Drying out - key environmental impacts

- **Additional heating** (gas, oil, electricity) with associated energy resources and CO_2 emissions.
- **Electricity** for dehumidification and mechanical ventilation with associated energy resources and CO_2 emissions.
- **Diesel and petrol** for trailer drying systems. In addition to fossil fuel reliance and CO_2 emissions is the issue of air pollution.
- **Materials and labour costs** associated with removing and reinstating parts of the building fabric to enable thorough drying.
- **Transport impacts** associated with journeys by drying contractors.
- **Mould growth and damage** to materials caused by delays in starting the drying process, or materials not being adequately dry before finishes are reinstated.

Case study B: Twice Flooded In Carlisle

Flood stats

House type: 3 storey Victorian mid-terrace
Tenure: Owner occupied
When: December 2015 and January 2005
Type: River flooding
Duration of water in house: 2-3 days in total on both occasions, with water in under-croft for longer.
Depth:
2005:1850mm at rear, 1500mm in kitchen, 1000mm at front
2015:1300mm at rear, 900mm at kitchen, 400mm at front

Insurance status: Insured

Procurement: Strip out, drying and (most of) refurbishment by Insurance Contractor, Kitchen fit out and minor refurbishment items/ defects rectification - own contractor, Resilience – scheme contractor.

Accommodation:
2005: Placed in temporary accommodation in nearby village, as 'keyworker'.
2015: Lived upstairs while work was done.

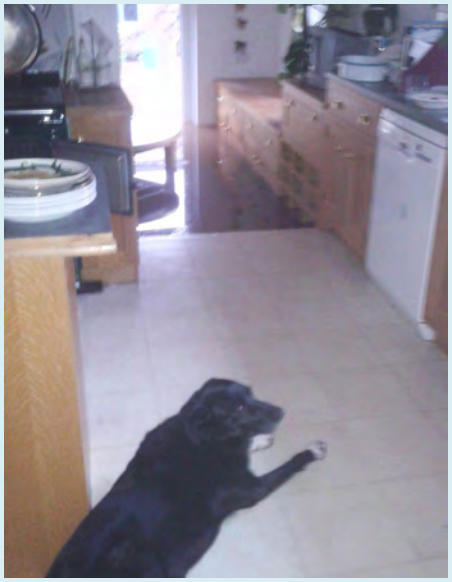
Time-scale:
2005: Moved out for 18 months, work took almost 2 years to complete.
2015: Strip Out, Drying and main Refurbishment Work complete: Summer 2016. Other work: Summer 2017.

Initial Response

Being flooded before really helped with this householder's understanding of what to do when the warning was issued in December 2015. More thought was given to what to move where and what to prioritise. Things that weren't replaceable or potentially repairable were moved first – though as the householder lives on their own, heavier items were inevitably left.

As the ground floor is on three levels, and the flood water rose relatively slowly, they could move things quickly and simply to the next 'step' up whilst planning their strategy. Unfortunately all kitchen appliances had to be left in place. The householder simply didn't have the time or the strength to move them. This included an AGA which had been replaced after the 2005 floods.

The householder stayed as the waters rose and simply moved upstairs. After the 2005 flood, most vulnerable elements of the gas and central heating had been moved to the first floor. This meant that the heating could remain on for longer, and come on again sooner after the water had receded. This made a big difference to the liveability of the property and the drying process.



Left:
The ground floor is on three levels which spared some items from damage.

Strip Out

There was a marked difference in the approach to strip out between 2005 and 2015, with a generally reduced level of strip out undertaken after the later flood. This was partly to do with shallower flooding, and so most of the house was under water for less time. It also seemed that the attitude of the insurer had changed and they were perhaps more willing to accept a reduced level of strip out – possibly because of the sheer scale of flooding. The householder was also more confident dealing with insurers, surveyors and contractors. Despite being flooded twice, they still have no clear idea of what defines something that is 'contaminated' and needs to be removed - though are possibly more relaxed about this now.

An example of this is the suspended timber floor. After the 2005 floods, the householder wanted to keep the original oak floorboards to the suspended timber floor in the front of the house, which had been under water for the least time. The householder understood that they could be cleaned, dried and saved – though this process would take time and care. The insurer, their surveyor and the contractor were unwilling to do this. They considered the risk of future defects too great, and in the householder's view, didn't seem to have the expertise or be willing to take the time. Not only did this result in additional environmental impacts through the disposal and replacement of the floor, it also meant that refurbishment took longer, meaning the householder had to remain in temporary accommodation for longer.

After the 2015 flood, the householder was determined to keep the floorboards in the front part of the house. This time they won the argument, but not without a lot of effort, as again the feeling was the contractor wanted to do what was most straightforward.

Some areas of plaster, skirting and joinery had to be removed, and the kitchen floor (which had been replaced after the last flood with chipboard) had to be completely removed. However, the householder found it hard to understand the logic behind which areas were stripped and which were left. For example, some skirting was stripped where it was accessible, but in other areas that had been flooded to the same degree, skirting that was behind radiators or connected to other joinery was left in place. uPVC patio doors at the rear of the house had to be removed, and a blown glazing unit replaced in the lowest window. Otherwise, all existing doors and windows (both solid timber and older-type uPVC with cold-edge spacers) remained in place.

In 2015 some items of furniture, such as sofas, had to be dumped. The fact that the ground floor didn't have fitted carpets reduced the amount of waste generated – rugs had been removed in advance of the flood. The AGA started to rust and had to be removed. After the flood in 2005 the householder had asked whether this could simply be refurbished. However, the insurer was unwilling to take the risk on this. As an AGA is primarily a large lump of cast iron, this has a significant environmental impact.

Right:
The flood water reached 1.3m at the rear of the house.

Drying out

As the householder was able to live upstairs, the impetus to get the house dry quickly was perhaps reduced compared to those who had moved out. They were also conscious of the porous nature of older building materials, and the need to dry the house slowly so that the timber floor and other elements were not adversely affected. The fact that the central heating was back up and running promptly after the flood helped in this.

Drying out was done by running the gas central heating system continuously at a low level, with support from dehumidifiers and opening windows for natural ventilation. The drying contractor provided one dehumidifier and one fan. This caused a significant increase in the amount of energy used in the house. Although the bills were covered by the insurer, the associated carbon emissions are significant.

Refurbishment

Refurbishment was mostly carried out by a contractor engaged by the insurance company in both flood events. In 2015 this contractor travelled from near Dundee. The householder would have preferred to engage their own contractor both times, but found it impossible to find someone reasonably local and willing to undertake the work, and didn't have any close friends or family they could call on. This was a common theme among neighbours too.

This contributed to issues with trust and control. Whilst the insurer described the surveyor and contractor as working for the householder, this is often not what it felt like. The surveyor and contractor had a pre-existing relationship and agreed things without fully explaining them or seeking sign-off. This increased environmental impacts as elements had to be redone later. For example, the replacement dining room doors had to be replaced a second time by a local contractor. There were also concerns that the contractor didn't have the skills to be able to carry out a sensitive refurbishment of an older property. For example, internal solid timber doors were not removed for drying and storage (as per industry guidance) but were instead left in place. They had 'dropped' as joints between the stile and the top rail had loosened due to the flooding and the increased weight of the door from moisture. The contractor originally intended to simply plane the doors until they closed again – rather than fixing the joint – until the householder insisted the root cause of the ill-fitting doors was addressed.

In the end the relationship broke down, and it was agreed with the insurer (who was very supportive), that the contractor would complete enough work to allow the householder to take control of the ground floor again. By this time the householder was able to find contractors to complete the work – which was mostly kitchen fitting and minor joinery items. They were much happier with the quality of work, and were able to use these contractors to address defects left by the original contractors with the support of the insurer. In contracting work now the householder considers whether they like and trust the person quoting to be of much higher importance than the sum quoted – and distrusts very low quotes.

Improving energy efficiency was a consideration, though this was constrained due to limited resources. The householder paid an 'extra/over' cost to improve the

Case study B: Twice flooded in Carlisle

replacement kitchen floor above the minimum U-value required. The requirement to insulate this was one of the few times Building Regulations were mentioned. In agreeing the specification they had support from a member of their family who works in construction. However, there was a lot of debate about what type of insulation to use, thinking about what might happen in another flood. In the end a high performance rigid board was chosen in the hope this would be easy to remove. The family member was able to advise on what the correct insulation should look like so when the wrong type was delivered, the householder felt able to challenge it. However it was quite badly installed by the contractor, and the householder is now looking to do rectification works to improve fit and air-tightness.

In purchasing new appliances, energy efficiency was a concern but A+ rated appliances were standard as part of the kitchen fit-out. Six items of solid wood furniture were saved. This took a lot of effort on the part of the householder, spending a lot of time researching and then persuading a specialist to carry out the work. The company they found was based near Newcastle, and took almost a year to complete the work, but the householder is happy that items of sentimental value were saved and the amount of waste reduced. If the householder had not been willing or able to do this work, these would have simply been dumped and the insurer would have paid for new furniture.

Resilience

After 2005 the householder had implemented some resilience measures. By moving services so that the central heating was less affected this time round, and relying on their existing open fires in the first few days after the flood, they were able to make the house warm and dry much more quickly.

After 2005 they also paid for part of the wall in the lowest area of the house to be re-plastered with a special damp-proofing treatment. However, in 2015 this caused further complications. This had been done so that this area of wall would not need to be stripped and re-plastered after a flood. It took research and effort on the part of the householder, with support from the original installer and conflicting advice, to prevent the contractor from just stripping this wall. The contractor saw this as a risk for future failure, and sought to avoid it.

Some resilience works were undertaken as part of the refurbishment after 2015 – with the householder willing to pay for these 'out of pocket' and in advance of the grant scheme being announced and finalised. As before, the insurance company were only willing to consider 'like for like' costs. Moving the kitchen upstairs was dismissed partly due to personal preference, but also because they simply would not have been able to afford it if the insurance company were unwilling to pay.

Having been flooded for a second time, the householder wanted to implement measures they had been unable to do last time round – such as altering the wiring in the kitchen so that cable runs and plug sockets were higher. They also insisted that the replacement kitchen floor was solid timber, so that next time round it may not need to be replaced.

Once the PLR grant scheme was available, they commissioned an independent survey and obtained a PLR report. They found this to be quite generic, and it also suggested things they had considered but previously dismissed. For example, the original report suggested replacing the kitchen floor with a solid floor. In the past they had sought professional advice from structural engineers, who suggested that the risk of the pressure on the external walls causing problems were significant as the floor level is almost a meter above the external ground level, and the house does not have very deep foundations.

In the end they chose a limited set of measures from the report, and felt confident in this based on their own understanding of their property and their needs. They bought a pump to keep upstairs, as one of the biggest issues after a flood is removing the water from below the house, and after a flood pumps tend to be in short supply. They had a 'no-return' valve fitted to their drainage system, reducing the risk of future flooding by this means. They engaged a contractor to fill some cracks in the external cement render around the perimeter of the house below the level of the flood, to help prevent water penetrating the walls.

Key lessons

1. Being flooded as a householder feels like a full-time job. **It requires time and energy to make sure you get what you want out of the process** – and things that may reduce environmental impact, such as a reduced level of strip out, or refurbishment of furniture, are often in conflict with the insurer's desire to minimise risk, time and effort, and the contractor's desire to keep things simple.

2. **Trust in contractors is a big issue.** Finding contractors is an issue – existing supply chains, especially in areas like Cumbria, simply can't cope.

3. **Property Level Resilience survey suggestions were generic** and not always suitable. Householders tend to 'pick and choose' measures, in accordance with their needs and their knowledge of their own home.

Some areas of skirtings, such as behind radiators, were not removed.

Belongings stacked outside.

Drying out was by the gas central heating and dehumidifiers.

Some items of sentimental value were restored, but only after a lot of time and effort on the part of the householder.

The AGA had to be replaced again after showing signs of rust.

4: Refurbishment and reinstatement

Once a property has been stripped and declared dry, the reinstatement of finishes, fixtures and fittings can commence. This work is much more akin to standard building work, and perhaps less specialist, than the strip out and drying out processes before it. It also appears to share many of the issues apparent in other household-level building work; concerns about the quality of the work and trust in contractors are common.

The amount and type of work required is determined by what has been agreed and done in the proceeding stages. One of the key ways to reduce the impact of refurbishment would be to follow the guidance that suggests minimal strip-out and appropriate drying. If this is done, refurbishment work can be minimised, speeding the process and reducing disruption for householders. Another way to limit the environmental impact of such works is to minimise defects and amount of work that needs to be redone - something that our research suggests is a significant issue. 'In-use' impacts can then also be reduced by considering energy efficiency in refurbishment, for example by including new insulation or more efficient services.

Process and Procurement

In most cases this is simply the work required to make the home habitable again, by reinstating plaster finishes, timber and other fixtures, building services and decorations. There may be opportunities to improve on what went before, either in terms of flood resilience, the quality of the finish or energy efficiency.

The biggest issues at this stage for householders appear to be:

- How decisions are made about what reinstatement work is done.
- Who they can rely on for advice.
- Who carries out the work.
- How the quality of the work done is monitored and assessed.

For those who have been flooded for the first time, or who do not have the time or confidence to take a fuller part in the process, refurbishment will often be led by their insurance loss adjuster and surveyor. Householders are reliant on these professionals knowing what to do and when. This does not always have a satisfactory outcome - with 28% of affected homes surveyed by the Cumbria Community Foundation (CCF) following the 2015 floods reporting a poor service from their loss adjuster or assessor. Whilst some householders report an improvement since the flood events in 2005, there is still a sense that householders feel they have to become reluctant 'experts' and challenge surveyors and contractors on what is right for their home (see also Wittle *et al.,* 2010).

Depending on preference, insurance status and available time and funds, there are a number of routes open to householders. Those who are able to use their own contractor for at least some of the works generally report better outcomes and higher satisfaction and control. However, there are barriers to this. Firstly it can be hard to find a contractor willing to carry out the work. Given the relatively sparse population of Cumbria in comparison with other parts of the country, there is a limit on the number of local building companies who can be called on, and those who are able to use local contractors often have a personal connection. Secondly, dependent on the contractor chosen, the householder themselves may be required to do a lot of work of project management - purchasing materials or finding specialists. Thirdly, if a householder uses their own contractor and wants to make an insurance claim, they may need to be able to provide acceptable guarantees, with different insurance companies having differing policies on this. Some insurers will dispute electrical work and many don't recognise bodies such as the NICEIC.

Assigned contractors are therefore commonplace, with insurers using contractors they have often worked with before - or may even have a formal business relationship with - whose work they are happy to guarantee. Despite this, complaints from householders about the standard of refurbishment works and the level of defects are commonplace. 26% of flooded households in the CCF survey cited poor workmanship, and 28% reported issues with the management of repairs. Some householders also report negative attitudes about the quality that can be expected in 'insurance work' (Wittle *et al.,* 2010).

Whilst action is being taken by some local authorities to address quality concerns - by providing lists of suggested contractors and other support to householders - it remains an issue. The registration and certification of contractors appears to be a poorly understood area, and one that local authorities and community groups are not well resourced enough to take on. The British Damage Management Association (BDMA) is the only UK based certifying authority for practitioners in flood recovery and restoration (according to CIRIA, 2005) - however awareness of this body among those we spoke to is limited.

In almost all cases householders take a keen interest in what is being done and to what standard. This can lead to stress and disappointment when expectations are not met about quality or time-scales (see also Wittle *et al.,* 2010). However, poor quality work and delays also lead to greater environmental costs, caused by the need to re-do work, with all the associated costs in resources used for tools, transport and materials and also extended periods of time spent in temporary accommodation.

Transport impacts appear to be exacerbated by the supply chain restrictions identified above - and one that was commented on by householders and professionals alike. Insurance companies' nominated contractors often travel long distances to reach affected properties. As 'out of area'

contractors they may also not have the same incentives to maintain a good local reputation among householders, with consequent loss of quality and knock-on environmental impacts. Finding ways to support more local supply chains may be of benefit.

The idea of reducing environmental costs through the use of lower impact materials was not something that was mentioned by any of the research participants. However, several householders mentioned how wasteful they felt contractors were, with lots of new materials being thrown away, not just materials that became waste through strip out. Construction waste generally is a huge issue in the UK - with waste from construction making up almost 24% of the national total of waste to landfill (UKGBC, online). While significant action has been taken on larger sites to tackle this, with often sophisticated re-use and recycling schemes, at the domestic scale flood repairs come under, there has not been the same degree of action. It may be possible to reduce this through better management of materials ordering, and through better training and oversight for site operatives - requiring investment in systems and training by contractors.

'Like for Like' vs. 'Betterment' or Reinstatement

Whilst the refurbishment itself is to some degree an unavoidable environmental cost once the strip out and drying processes have been completed, it does also present opportunities to reduce the environmental impact of future floods through design for resilience. With the increasing frequency of flooding, this is something that more householders and professionals are considering, especially where they have experienced flooding more than once. This need not mean specialist materials or equipment, and can be achieved through the more considered use of 'traditional' building materials and approaches.

The cost of 'resilient refurbishment' and more environmentally sustainable approaches can be higher, but there is variation between building elements and often there is minimal 'extra over' cost. For example, there is little variation in the cost of different wet-applied plasters, so little justification for not using the most flood resilient options (CIRIA ,2005). However, we have found that even in cases where the risk of future flooding is high - in properties that have been flooded repeatedly in the last decade - there are barriers to attempting more resilient refurbishment:

- Awareness: In frequently flooded properties, householder's awareness of the possibilities and potential for resilience tends to be greater, but it is not exhaustive. They may need support, at the right time, to understand what is possible. This may enable simple and relatively cost-neutral measures to be carried out, such as moving electrical services to a higher location.

- Financial: Insurers can be unwilling to pay for anything other than 'like for like' refurbishment, and householders expected to pay for any perceived 'betterment' (see discussion below on resilience measures). Householders often don't have large additional funds they can tap into given all the other costs associated with a flood event. Grant funding may be available - but after the 2015 floods, this came along too late for some to use it to pay for integrated measures.

- Programme: The pressure to get things back to normal

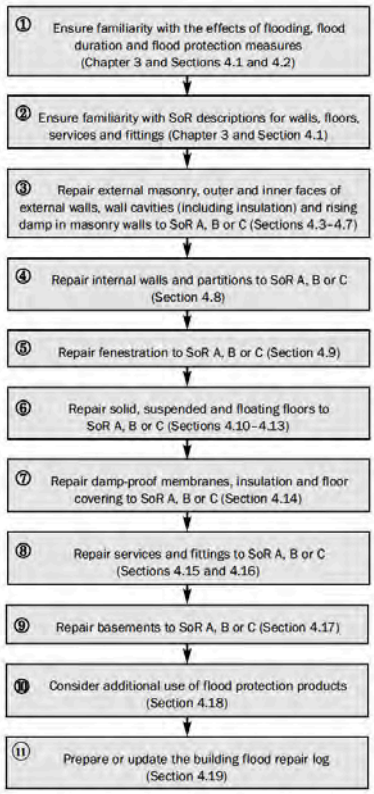


Figure 4.1 *Specification for the standard of repair (SoR) for building elements of flooded buildings (following thorough decontamination and drying)*

CIRIA three standards of repair

A: Where a risk assessment shows little or no risk of a future flood it is recommended to repair the building to the original specification, although some minor upgrades may be incorporated to improve resilience.

B: Where the risk of future flooding is low to medium, it is considered sufficiently high to recommend repairs to increase resilience and/or resistance of the property above the original specification.

C: Where the risk of a future flood is high it is recommended that repairs increase the resilience and resistance of the property significantly. These include dry-proofing and/or wet-proofing the building.

4: Refurbishment and reinstatement

as soon as possible can also prevent due consideration of resilience measures which may take time to design and develop - with householders and surveyors needing to better understand context and potentially seek specialist advice.

Advice on resilience measures was provided to many householders in the flood surveys that were done as part of the Property Level Resilience Grants. However, as well as coming too late in the process, householders also often felt that the reports were overly generic. They tended therefore to pick and choose from the recommendations, and suggested measures of their own based on their knowledge of their home and how it flooded.

Further waste was generated in Cumbria by conflicting time-scales and agendas. For example, in some properties doors were put back after the flood in an initial refurbishment contract, only to be stripped out and replaced with flood resistant doors funded by resilience grants at a later date - so the environmental costs of the work in materials and labour was effectively doubled.

Several people spoke about the potential to avoid damage to appliances by rethinking where they where placed. Either by entirely re-locating the kitchen to an upper floor, or by moving appliances above 'counter-top' level. However, this appeared to have been dismissed by many for practical reasons, such as having to lift washing down and dishwashers not designed for side-loading - or the concern and need for level access to rooms as they get older - as well as t financial constraints.

In considering resilience in refurbishment, there appear to be three definable approaches in practice and outlines in the available literature:

- Ignore resilience concerns, and simply reinstate 'like for like'.
- Consider resilience by installing materials that will be able to withstand future floods without damage and allow drying out without removal - for example by using cement or lime plasters, or installing solid floors.
- Consider resilience by installing materials that will be 'sacrificial' in the event of a future flood, for example by replacing wet plaster with plasterboard that can be more easily stripped and replaced (as suggested in BS85500:2015).

To start to understand the differing potential environmental impacts of this, we have carried out an approximate calculation of the embodied carbon in four different approaches (table 3). This does not consider the associated impacts of labour and transport, and as such under-estimates the total environmental impact, but is a useful initial comparison.

This suggests that whilst the use of cement based renders has a higher impact in refurbishment, this may pay off in the longer term - as well as having the advantage of minimising disruption. The use of 'sacrificial' elements seems to produce a higher environmental impact, and as such should perhaps be avoided. It also shows the importance of minimising unnecessary strip out - with plaster remaining in-situ having the lowest impact, as well as the lowest level of disruption for the householder. Though in all areas, more research is required to establish effects with more certainty than is possible in these rough calculations.

Table 3:
Embodied carbon within different refurbishment materials and approaches.

	gCO_2 for 25 sq.m strip-out	
	gCO_2/ m^2 - First Flood Event	gCO_2/ m^2 - Third Flood Event
Scenario 1: Existing Cement or Lime Render left in situ	0	0
Scenario 2: Existing gypsum plaster stripped after flooding, replaced with cement render - thereafter not stripped	230	230
Scenario 3: Existing Gypsum plaster stripped and replaced with gypsum plaster (like for like) after each flood event.	67	202
Scenario 4: Existing Gypsum plaster stripped and replaced with sacrificial plasterboard and skim - thereafter plasterboard replaced after each flood	170	509

Opportunities for Energy Efficiency and Environmental Improvements

Stripping out a home and refurbishing it following a flood would seem to be the perfect time to carry out energy efficiency upgrades and retrofit the building fabric. There is also significant potential for co-benefits with resilience measures. For example, rewiring to take electrical items above the likely flood level is also the perfect time to upgrade to better controls and LED lighting. Replacing a suspended floor with a solid floor to make it more flood resilient is also the perfect time to upgrade floor insulation and is likely to also help reduce draughts. Despite this, such upgrades seem to happen relatively rarely, and only in limited circumstances. We found there were several possible reasons for this:

- Lack of Awareness: Householders and support workers are often simply not aware of what it may be possible to do, or may become aware too late in the process, once key refurbishment decisions have been made.
- Uncertainty: Where householders are aware and keen, they are often uncertain. What is the best insulation to use in a room likely to be flooded? Should they insulate the floor at all? Should insulation be upgraded elsewhere instead? Is uPVC a more environmentally sound material to use than timber in areas subject to flooding? How do different materials behave, and should 'heritage' properties be treated differently? Householders need support in making decisions, and there is not a consensus as to the right answers among professionals or published information and further research is required.
- Finance: Whilst some elements, such as replacement floors to meet Building Regulations and new windows, may be covered by insurance claims, going beyond what is required by the regulations may not be, so householders may be required to self-fund or look to other sources. This may be difficult to do when resources are already stretched.
- Unwillingness: Householders and others involved in the recovery process report that contractors are there to do an 'good enough' job and get off site as soon as possible. They are unlikely to be willing to carry out something that is above and beyond that required by insurers or Building Regulations, particularly where it may require additional time on site.

The role of the Building Regulations and Building Control to improve current practice in refurbishment for both resilience and energy efficiency should be considered. Regulations may help to drive improvements and act as a backstop against the worst practices - and so future improvements to the regulations may have an impact. However, householders reported having limited contact with building control officers, and with the current stretched resources in local authorities, and a seemingly limited appetite from central government to use or improve regulation, it seems unlikely that this will change in the immediate future.

Despite this, one of the few areas of 'betterment' that seems to occur on a semi-regular basis is the upgrading of insulation levels to ground floors at the insistence of building control officers.

Finishes and toxicity

The environmental cost of internal finishes can be high, but looking to more environmentally sound solutions may cost time and money that householders don't have. Environmental and health motivations are also a relatively small consideration for most householders when choosing internal finishes, although there is some suggestion that this is growing (for example, paint companies such as Lakeland Paints and Earthborn that specialise in this sector). Some materials, such as gloss paints, have higher environmental impacts in terms of toxicity, although lower VOC (Volatile Organic Compounds) are now much more commonplace as the default option in DIY stores.

Record Keeping

As was discussed in the strip out section, it is important after a flood event to understand the prior condition of the building to avoid any unnecessary strip-out, and especially where resilience measures and more flood resilient materials may already by in place. CIRIA guidance suggests a flood repair log should be created:

"All the information relating to a building, from the flood event to the completion of any repairs, should be filed in one place. Such information may include photographs, receipts, notes on advice given, formal surveys and risk assessment reports, and all should be dated.
Where flood-resilient repairs have been carried out, their nature and maintenance requirements should be recorded. Where repairs are concerned, the flood repair log should serve to:

- *record accurately the design for future owners and occupants, thereby assisting new owners should conditions change and the design no longer meet requirements*
- *ensure a proper understanding of maintenance requirements, including the frequency of maintenance, and that maintenance activities are logged*
- *provide guidance to enable appropriate remedial action in the event of a flood".*

We found little evidence of this happening in practice in a regular way, though some householders kept good records. Supporting householders and offering guidance in this has the potential to significantly reduce the environmental impact of future flood events by reducing unnecessary strip out and refurbishment work, with the added benefit that this may also reduce disruption, timescale and costs in future recovery programmes.

5: Resistance and resilience

There are two main approaches to what is described as Property Level Protection (PLP) or Property Level Resilience (PLR). These have the potential to reduce environmental costs from flooding by reducing the level of damage and allowing quicker re-occupation.

1. **Keeping the water out (resistance)**: also referred to as dry-proofing, this involves the use of flood protection barriers (flood doors, air brick covers, water proofing treatments to walls) to prevent water from entering the building.

2. **Letting the water in (resilience):** also referred to as wet-proofing, this involves an acceptance that water will enter the property, and uses design features and materials to reduce the level of damage and allow quicker re-instatement and re-occupation.

It is important to note that industry guidance (e.g. CIRIA, 2005) stresses that resistance/dry-proofing measures should only be used where expected flood levels are less than 1m in depth. This is because of the structural risk to walls when holding back greater depths of water. For homes where there is a particularly high flood risk, it may be appropriate to use a combination of resistance and resilience measures. However, this should only be done where there is knowledge of the extent of previous flood events and/or a flood risk assessment predicts that flood water depths will be under 1m.

The insurance industry approach to resilience is variable

The over-riding approach taken by insurers is of 'like to like' replacement and a policy of only paying for items damaged. This places the onus firmly on householders to determine the benefits (in cost, disruption and health terms) of incorporating additional resilience (and/or resistance) measures, and overseeing this process. This somewhat mirrors the experience of householders wanting to incorporate energy efficiency improvements into reinstatement works.

Property resilience surveys

Much of the guidance highlights a need to take a holistic approach to resilience; 'it is important to check the suitability of products for a particular building. Often one product on its own is not sufficient, as a holistic approach to protection is required' (CIRIA, 2005). Our research suggests that a holistic approach is lacking at present.

Furthermore there is currently no single profession qualified to complete these surveys, and they range from surveyors, accredited or otherwise, to engineers and those with very little background in the building or flood risk industry. Workshop attendees suggested that local authority building surveyors would be well placed to conduct these surveys, and would provide a degree of independence, but are currently restricted to commenting on surveys completed by others, though even then, they do not feel able to be particularly critical. Organisations like BRE have recently launched online training courses that give an 'Introduction to Flood Protection and Flood Prevention'. However, these are very much introductory with only around 3 hours learning.

There are concerns among support organisations, householders and other professionals that many of the recommendations for resistance measures are unsuitable, or are poorly installed. For example:

- Suggesting a flood door to the front of the home, when all previous flood events have seen water enter from the rear.
- Flood doors recommended in areas where flood events have exceeded such levels, and flood doors fitted at different levels along a street - and in some instances above 1m in height.
- Sump pumps recommended at 100l/min, where experience suggests that most properties actually require much higher rated pumps, and sometimes more than one.

A further issue which does not seem to be captured in current resilience surveys and associated suggestions is sensitivity to the characteristics of the household in specifying resistance measures. For example, householders with limited mobility or manual dexterity, such as older people or those with conditions like arthritis, may struggle to fit a flood door, or reach air brick locations when a flood warning is received. Similarly they may struggle to move resilience items such as removable baskets from kitchen units. Resilience measures may also be unsuitable if they create issues with access, for example where raised consumer units can then not be reached to carry out everyday operation and maintenance tasks.

If the likely depth of flooding is such that any items up to ceiling level are at risk, standard resilience measures may also not be sufficient. This is particularly relevant to bungalows where the ability to move belongings out of harms way is severely restricted. The suitability of measures to property and personal circumstances is therefore key, and installing unsuitable measures may unnecessarily increase environmental impacts.

Use and maintenance

Some householders are unaware of how to use items once a warning is received, and do recall where they are stored. Householders are often also unaware that products need to be checked annually, or may require maintenance in order to work effectively.

For householders that decide to only take up a small number of recommendations or relatively minor works (for example, fixing cracks on external walls), it can also be difficult to find contractors under the PLP schemes as it is more cost effective for them to do this work while installing larger items such as flood doors. Householders are primarily signposted to the Blue Pages Directory (www.bluepages.org.uk) and although this encourages suppliers and contractors to advertise the standards their products meet, and associated accreditations, there is no vetting process.

The role of regulation and standards

Some of the practitioners we spoke to felt that until insurers are compelled to consider resistance and resilience measures, we will continue to see high levels of strip-out and repeated mistakes in refurbishment. Some suggested that a key driver for this should be the local authority and Building Regulations. However, others pointed out that local authorities are severely restricted in what they can ask for 'over and above' national regulations, and that the agenda for this is set at a national level. If this was to happen they would also need more resource to provide proper oversight - in a similar situation to the insulation issues mentioned above. This point is echoed by the Property Level Resilience Action Plan (part of the Bonfield Review), which recognised a need to explore whether Building Regulations can be better used to encourage flood resistant and resilient construction in a way that is tailored to meet the needs of properties in areas at risk of flooding, with a focus on methods that speed their recovery from flooding.

The un-regulated nature of many products and methods used by the flood resistance and resilience industry is another issue. CIRIA guidance, as far back as 2005, noted that although water repellent treatments are commonly available, there is no current British Standard for their use meaning that risks may be neglected. For example, many tanking treatments mean that moisture loss by evaporation is reduced, causing water to accumulate within the brick and leaving it susceptible to frost damage. It can also cause stone-built properties to deteriorate and so is often discouraged by heritage bodies (CIRIA, 2005).

For some measures that can help to provide greater resilience to wall finishes (such as external wall insulation systems), there are already established codes of practice, British Standards and heritage guidance. An area for future research would be to understand the extent to which this guidance and standards incorporates flood events, and how it might be improved to ensure that a holistic approach is taken. For example, by considering the interaction between the use of moisture resistant insulations and the need to manage moisture movement in the wall build-up.

Property level resilience grants

Many resistance and resilience measures have been funded by grant schemes. These typically offer around £5,000, with the Cumbria Community Foundation also offering top-up grants after the 2015 floods. Of those householders than responded to CCF's survey, around 53% agreed that the grant helped them to protect their home against future flooding, and as has been seen above, there was a degree of flexibility in what they could be spent on, which was helpful. However, 26% had issues with getting information and advice on resistance and resilience measures. Survey costs were eligible as part of the grant. However, it was felt by some that when these costs and VAT was factored in, it left little money to fund actual works. There are also reported instances of householders being encouraged to sign so that grant funding is released directly to the company; it was felt that this gave householders little recourse when they were not happy with the quality of the work. As with the drying, strip out and refurbishment elements discussed above, the need for quality control that householders can have confidence in is evident. With unnecessary or badly done work having the potential to further increase the environmental impact of flood events - and the distress of householders.

Flood Re & resilience measures

Flood Re is a not-for-profit scheme set up by the Government in conjunction with insurers. It is designed to provide more affordable insurance premiums to those affected or at high risk of flooding.

The scheme is underwritten by a central fund, with each insurer passing the flood risk part of the policy on to Flood Re. The insurer is then reimbursed in the event of a qualifying claim.

Many householders are under the impression that fitting resistance and resilience measures will help to reduce their insurance premiums. However, because the scheme is underwritten centrally it provides little incentive to insurers to value this type of work. As such, the 'business as usual' approach to reinstatement work with 'like for like' measures appears to be continuing. This has been reinforced in our research by examples of homes continuing to have the same materials (such as gypsum plaster) reinstated and stripped out after each flood event.

The Flood Re scheme is carrying out research into the '*relative value and effectiveness of resilience measures and will report separately on its findings in due course. In the meanwhile, in accordance with the terms of the Treaty, Flood Re will not indemnify insurers for resilient repair...It will not follow the fortunes of underlying policies even if they allow for betterment as a standard term.'*

www.floodre.co.uk/homeowner/faq

5: Resistance and Resilience

Useful guidance

Six steps to property level flood resilience: guidance for property owners.
Developed as an output from the SMARTeST project (funded by the EC's 7th Framework) it provides well balanced information on understanding risk, property level surveys, product supply, installation and operation and maintenance with simple check lists. (White *et al.,* 2013)

Six steps to flood resilience: guidance for local authorities and professionals.
A partner guide, it provides more detail and could also be suitable reading for some householders. (White *et al,* 2013)

Resources in development

Putting Flood Resilience into Practice:
Funded principally by private businesses and with support from the NW Regional Flood & Coastal Committee and the Environment Agency, the project's aim is to make three property showcases for flood resilience in Carlisle and Keswick (including a residential property, restaurant and community centre). Updates on the project will be promoted via the Know Your Flood Risk website (www.knowyourfloodrisk.co.uk) and the @flooduk and @floodmary Twitter feeds.

Examples of 'resilient homes' - videos

Cockermouth Flood Resilience Grants:
http://bit.ly/Cockermouthkitchen

Householder near Oxford (shallow flooding):
http://bit.ly/OxfordFloodHome

BRE Flood Resilient Home:
http://bit.ly/BREFloodHouse

Key standards (resistance and resilience)

CIRIA C623: 2005 Standards for the repair of buildings following flooding.
Only free excerpt available from CIRIA website (full standard behind pay-wall).

PAS 1188: 2014 Flood Protection Products
Covers the following products: building apertures, temporary flood protection, buildings and building skirt systems, demountable flood protection (behind pay-wall).

BS 85500:2015 Flood resistant and resilient construction
Free version with core elements is available to download from the BSI website (full standard behind pay-wall).

BS 8102: 2009 Protection of Below Ground Structures Against Water from the Ground
Free summary of what this covers is available from the Property Care Association (full standard behind pay-wall).

BS 12999: 2015 Damage management: code of practice for the organisation and management of the stabilisation, mitigation and restoration of properties, contents, facilities and assets following incident damage
Includes a method of establishing whether activities have been completed to a satisfactory standard, and a guide for communication between parties (behind pay-wall).

BS EN 13564: 2003 Anti flooding devices for buildings
Covers requirements, test methods and quality assurance (behind pay-wall).

See: www.centre4resilience.org/flood-guidance/standards

Case study C: Three-times flooded in Eden

Flood stats

House type: 18th Century 2 storey stone cottage
Tenure: Owner occupied
When: December 2015, November 2009 and January 2005
Type: River flooding
Duration of water in house: 2-3 days
Depth:
2005: 500mm
2009: 900mm
2015: 1500mm

Insurance status: Insured

Procurement: 2005 - insurance contractor, 2009 - DIY, 2015 - insurance contractor

Accommodation: Temporary accommodation

Timescale:
6 months in 2009, 17 months in 2015

Initial Response and Drying Out

As a veteran of repeated flooding, this householder had a good understanding of what was needed in 2015. They describe flood events as being 'stressful in advance, but once it's happened, you just get on with it'. They prioritise moving precious and irreplaceable items such as photographs upstairs. Despite this, it wasn't possible to save some fabric furniture and electrical items. These had been stacked on higher surfaces, but the depth of the flood in 2015 was greater than before, and so some items were lost unexpectedly.

Each time drying out of the property has been undertaken by simple methods, which have taken some time – weeks and months rather than days - but have been shown to not produce any unintended consequences or create damp issues upstairs. The central heating system has been run continuously, with the windows opened and some dehumidifiers and electric desk fans used in support.

Strip Out, Refurbishment and Resilience

This householder felt that their repeated experience of flooding and their ability to call on friends and family in building trades for advice, meant they were better able to argue for what they wanted than others. The level of strip out undertaken after each flood has varied – affected by both the depth of the flood and the method of procurement of the works, and the householder's wishes. In this they have mostly found the insurers, loss adjusters and surveyors to be reasonably supportive of their needs - though they have had to make a case.

Their experience after the 2015 flood with professionals was a good one – they felt the insurance surveyor listened to them, and was willing to be flexible. They got the impression that this was because they surveyor felt the householder knew what they wanted and gave the impression that they knew what they were talking about. Though they are acutely aware of the fact that they have access to knowledge through friends and family that others may not have. They have not accessed the support of the local authority or building control officers – and are not aware of any interactions with them during the works.

In 2005 they opted to use the contractors provided by the insurance company, citing issues with high demand and limited local supply chains. In 2009 they opted to carry out most of the work themselves, with help from friends – this gave them a greater sense of control over the quality of the work and the time-scales. They were able to complete the work within 6 months, and suggest it cost less than £20,000, against a quote from the insurer's preferred contractor of over £45,000, which included what the householder considered to be an unnecessary level of strip-out. In 2015 they did not feel they had the time or the energy to carry out the work themselves – being older and having other caring responsibilities – so they opted to use the insurer's chosen contractors. They did access the flood resilience grant – though they already knew what they needed, so felt the survey was a little superfluous.

They are generally sceptical about the level of strip out often required by insurers and surveyors. They also have a preference for repair and reuse over throwing things away. They believe that older houses, made from solid materials that can dry out (and that will have been through multiple floods), do not need to be stripped in the same way as more modern homes might. In support of this, they cite their neighbour who has been flooded the same number of times but never carried out an extensive strip out, and instead just washed out their home, without any apparent issues.

Floors and timber:

As in other houses, the suspended timber floor has been an area of some debate. After 2005, the householder was able to argue that the existing solid timber floor should be retained, despite the advice of the surveyor at the time. The householder was confident in their understanding of the behaviour of timber and its quality. The existing floorboards were already reclaimed from another property, and laid by family – they knew that after getting wet, the floorboards would 'cup' and then return to being flat once dried

Case study 3: Three-times flooded in Eden

properly. They checked the joists and noggins and a few were replaced – though it was suspected this was as much to do with the age of the timber as any recent flooding.

After 2009 they chose to replace the suspended floor with a solid concrete floor, to make the house more flood resilient. They also choose to upgrade the thermal performance of the floor by adding 100mm of rigid insulation between the main slab and screed so it was protected from flooding. They also fitted under-floor heating within the screed, which helped improve comfort. In 2015, the floor structure proved sound and appears to have dried without problems. However, the waste created in 2009 when carrying out the work was considerable, requiring nine trips to the local waste centre. The timber floorboards were saved by the householder – and are now being used as a ready supply of wood for carrying out other repairs around the house.

Other timber items, such as doors and architraves, have been retained and reinstated, with the need for only minor repairs. Most of the timber in the house is oiled, and does not seem to take much harm.

After the 2015 flood the only debate was in relation to an area of tiles on the solid floor and the fireplace. The contractors suggested that this had cracked and would need to be replaced. This was only avoided when the householder showed the contractors an original space tile, demonstrating that the 'cracking' was actually part of the pattern of the tile, and as such, the tiles could safely be left in place.

Walls:

The plaster finish to internal walls was the other major area of strip out required. In 2005 this work was needed as the original lime render had been replaced with a gypsum-based plaster. Work was undertaken by the insurer's chosen contractor, and was meant to have used a cement render with water proofing additives that should not have needed to be stripped after subsequent floods. However, after 2009 there were obvious damp patches across the walls that took longer than they should to dry out. It became apparent that whilst the right render had been used on most of the wall, some areas of levelling work had been carried out with a gypsum plaster – meaning these areas needed to be stripped. In 2015 the householder agreed to the whole area being re-done, as they were not confident in the quality of work done previously, and so creating a significant additional amount of disruption and waste that would not have been necessary if the installation had been right the first time. Again there were problems, with the quality of finish not meeting the householder's expectations. They were able to insist that a particular plasterer was used, whose work they trusted. However this has resulted in a thicker than ideal layer of render, which the householder is now concerned will affect its performance in the event of another flood – so again potentially leading to unnecessary financial and environmental costs.

Windows and doors:

The householder had already replaced older windows and doors with uPVC double glazed units prior to any flooding. After all three flood events, they have only had to replace two blown panes. The higher quality windows in particular seem to have taken no harm, with no water ingress into the units or frames. After 2015 they replaced three external doors on the property with uPVC flood resistant ones, using the flood resilience grant. This has had the added benefit of cutting down on draughts – with the seals on the doors also proving to be effective draught-stripping. However, they also have some concerns about potential unintended consequences – with the doors also acting as good barriers to prevent silt and mud from escaping the property once it has been flooded, and so potentially creating more damage.

Services:

Each time a flood has occurred, the mechanical and electrical services that have been underwater have been stripped. The householder is in agreement with this – especially given safety concerns around elements like gas fires. However, they do have some queries around items such as wood-burners, which have few moving parts and which can be easily inspected. They managed to retain their wood-burner after the 2005 and 2009 floods, asking a trusted friend and heating engineer to check and sign it off as safe and cleaning it out themselves – despite the insurer's surveyor encouraging them to replace it. As wood-burners are made from energy intensive materials, such as iron and steel, this has significantly reduced the environmental cost. After the 2015 floods, they took the opportunity to upgrade the wood-burner to a more efficient model – not quite trusting it to survive being flooded 3 times, but also realising the opportunity to improve energy efficiency and performance.

They have taken the opportunity to improve the resilience of services after flooding – moving the consumer unit and wiring after the 2005 flood, so that it was not flooded in 2009. However, this proved to not be high enough in the 2015 flood – so the board was submerged and needed to be replaced. After 2015 they installed a separate circuit at a higher level in the kitchen in the hope that this will not be affected by future floods, and can be used to power equipment to help get the house warm and dry as soon as possible.

After 2005 they replaced and moved the gas boiler to a higher position, so that in 2009 it did not flood. In 2015, the flood reached the electrical control panel, so this had to be replaced. They would also like to move the gas meter to a higher position. However, this has not been possible

because of the costs involved and the bureaucracy – which while understandable to ensure safety, is frustrating. They also used some of the flood resilience grant to install a new non-return valve on the drainage system and buy some better pumps.

Appliances:

Where possible, the householder has opted to retain and clean appliances like fridges and freezers. They did not claim for these items after the 2009 flood, rather asking a friend to check them for electrical safety, and using a thermometer to check they were still working effectively. After the most recent floods they were replaced, as they had been fully submerged and were found floating around inside the house.

Furniture:

Each time a flood has occurred, they have thrown away any damaged soft furnishings, but have rescued, cleaned and restored any solid timber furniture. Again, despite the insurers often encouraging their replacement. They have either done this work themselves, or used a specialist they know locally – again showing the importance of local contacts to facilitate this work being done.

Key lessons

1. **Householders feel they have to question and monitor the work** being proposed by surveyors and carried out by contractors – and to do this requires a degree of knowledge and confidence that may not be possible for all householders, especially if they have no one they can turn to for independent and trusted advice.

2. **Accessing local and trusted contractors is difficult** – in small communities particularly, there are only so many tradespeople to go round, and demand after a flood is simply too high. The energy and time that householders have to tackle this by doing some or all of the work themselves is limited. However, there may be the potential to build and support existing networks. For example, this householder suggested the idea of a 'shed club/repair club' to help tackle some of the issues above, but also issues of social isolation and loneliness, especially among older men.

3. **Concerns about poor quality work are common**, with work having to be re-done on multiple occasions, including work that was meant to be resilient to future floods. This in turn leads to additional environmental costs.

Conclusions & recommendations

The environmental impacts of flooding are huge, most directly related to waste, energy and transport, but with wider impacts that are harder to quantify in terms of landscape and contamination.

With a focus on the residential sector, this study focuses on the environmental cost of flooding from key stages defined as:

- **Immediate response and emergency planning.**
- **Strip-out.**
- **Drying out.**
- **Refurbishment.**
- **Resistance and resilience measures.**

Our key findings are summarised below.

1. Technical understanding exists but is not readily used

Technical guidance exists that, if followed, could reduce environmental costs, or bring additional benefits - for example, by minimising unnecessary strip out or driving the inclusion of energy efficiency improvements. However, feedback from practitioners and householders suggests that this guidance is rarely followed, particularly during the cleaning and strip out phase - leading to increased waste generation and materials use, and so increasing environmental impacts.

The key drivers for this seem to be a desire for speed and simplicity, with many actors within the chain taking a 'worst case scenario/risk minimisation' approach. For householders, there is an understandably strong desire to get 'back to normal' as soon as possible. Contractors are keen to keep costs down and minimise time on site, and insurers are driven by getting homes to a habitable state as quickly as possible so as to minimise costs.

Where processes and decisions are insurance led there is a need to educate householders to question and understand these different approaches - whilst understanding that they may have limited time and energy having been through a traumatic experience. This is compounded by the lack of incentives for insurers to 'get it right'.

2. Guidance is not accessible, or is generic or unclear, creating uncertainty

The issue of technical guidance not being followed is compounded by a lack of access, with many key standards and guides behind pay-walls. This is especially difficult for householders to access, but may also hinder small contractors. This is particularly frustrating for householders that are environmentally and cost aware and want to do something, but are not sure what. Furthermore, there are few places where this information is pooled or referenced centrally, resulting in a scatter gun approach to research. Much of the technical guidance is also unwieldy and difficult to digest in a time pressured environment.

In addition to this, the guidance can sometimes be contradictory. For example in the conflicting advice given on decontamination requirements from CIRIA and from Public Health England. This may need to be addressed through review in any programme to better disseminate knowledge. Equally importantly, technical guidance can also be too generic to be useful - not taking account issues such as the properties of traditionally constructed properties, or the physical abilities of householders to use resistance measures. This leads to further uncertainty, which slows down or prevents positive action.

There is a need for real world examples to show householders what is possible and engage them in more diverse and interesting ways. These real homes, accessible to the public, should be relevant to the local housing stock and showcase refurbishment, resistance and resilience features that are in line with the likely flood depths in that particular area and that show how environmental and energy efficiency could be considered alongside these works.

In some cases specialist and independent advice will be needed. There is scope to define and raise awareness of the role that can be played by engineers, architects, accredited surveyors and conservation experts - which can also better take account of the particular context of a given property.

There is also scope to broaden the remit and deepen the involvement of other professionals and support organisations. For example, local authority building surveyors are potentially much better suited to carrying out resilience surveys or advise on refurbishment measures, as they are removed from product and company interests and more likely to be familiar with the local context and building stock. Likewise, conservation officers should be able to play a proactive role rather than be reactive to applications.

Existing community networks, such as flood action groups, may be best placed to share improved understandings - and to make sure that this information is shared at an appropriate time that allows it to be considered ahead of key decisions being made in the recovery process,

and sharing knowledge from those who have previous experience of flooding.

We recognise in all of this that there are challenges to resourcing this adequately within local authority departments and community organisations - though the investment is likely to pay dividends in reduced environmental impacts, distress to householders and costs to local authorities in waste disposal. Opportunities to call on mutual aid from neighbouring local authorities or community groups may be a way round this in the immediate aftermath of a flood event

3. Householders lack control and trust in the process

Many householders feel they have limited control over the recovery process, although there is scope for negotiation, not all householders are confident enough or have the knowledge to be able to do this. Concerns about quality control in construction work are common, with environmental impacts being significantly increased in many cases as defective work has to be redone. Local supply-chain limitations mean that contractors often travel long distances to carry out work - and so increase environmental impacts from transport, as well as being outside local networks of trust and personnel recommendation. Providing support to trusted contractors, many of whom may be locally based, to enable them to carry out more work will have benefits in both reducing environmental impacts and supporting local economies. Advice and support that emphasised good decision making over speed would also be beneficial.

Where householders know what they want to do and how, they can be restricted by procurement processes and finances. For example, many insurers won't pay for what they consider 'betterment' - despite the right householders have to insist on reinstatement, this is often a poorly understood area. Grant schemes may arrive too late and householders often have limited funds themselves to incorporate resilient refurbishment or energy efficiency improvements. Indicative costs for resilience measures range from £6,200 to £9,500 for 'standard' work (defined as plaster, removable doors, internal wall rendering, resilient kitchen, raised electrics and appliances) to between £9,500 and £14,100 where concrete floors are fitted in addition to the above (based on 2008 costs from DEFRA report, 2015).

Cross departmental working needs to be strengthened to iron out potential conflicts between grant programmes and other agendas (such as conservation), and there needs to be greater clarity about who can and should access grants in the case of private rented and shared ownership properties. There is a key role here for support services and front-line workers, especially in relation to more vulnerable householders. These play an important role in linking to other agendas, such as making referrals for energy efficiency, heating and accessibility improvements. Ideally this work will be joined up more so that interventions happen at the right time. These services and workers may also have a role in ensuring that resistance measures fitted are appropriate and can be operated by the householder - though ideally the whole Property Level Protection sector should be subject to greater scrutiny.

4. Environmentally sustainable options should become the default approach

This is about moving beyond sharing information and improving understanding to making 'doing the right thing' the norm. This could help to move the burden from householders, in terms of research and regardless of motivation, at what is already an incredibly stressful time.

Avoidance:
Thorough flood planning, especially for those who have experienced repeat flood events, and for who the risk of future flooding is medium to high. An emergency plan, tailored to their home, can help to prioritise items to move away from flood water (assuming there is sufficient time from flood warning). Some resistance measures may be appropriate where part of a holistic review of the property where the context is fully understood, and where fitted and maintained properly. Otherwise such measures may actually serve to cause greater harm and thus incur higher environmental costs.

Refurbishment:
Repairs that are more resilient to future flood events may reduce the need to strip out materials (reducing waste), reduce drying times (reducing the energy input required for heating, reducing humidity levels and ventilation) and allow the householders to reoccupy their home sooner (reducing the costs associated with temporary accommodation and increased travel). There is already a good alignment with resilience measures and better environmental sustainability, For example, the use of lime wall finishes and a move away from composite wood kitchen units. In some cases this will involve the need for a trade-off or cost-benefit analysis. For example, specifying materials that are more resilient to flood water, but that have higher environmental impacts in manufacture and end of life disposal, may be preferable to having to repeatedly strip out and replace. Improved energy efficiency, through floor and wall insulation, is one area where this may be applicable in considering both resilience and energy efficiency improvements. Further research is required to improve understandings of the behaviour different materials and their application in particular contexts.

Regulation:
The Building Regulations could be a tool to support changes here, by better considering resistance and resilience measures, and improving understandings and enforcement around the application of environmental improvements in refurbishment. This would require a national level review and for local authority Building Control teams to be adequately resourced to provide oversight. This is a challenge, but something that could be campaigned for as part of wider reviews of regulation in the construction industry.

Incorporation of such considerations in planning may also be a possibility, through mechanisms such as the local plan. There is also a role for other standards, for example, those relating to energy efficiency and retrofit, to incorporate and reference flooding concerns. Such a 'double pronged' approach may result in greater progress and added benefits to other agendas, such as reducing fuel poverty (see National Energy Foundation, 2017).

Further research

This study highlights a number of areas where it would be valuable to have further research. This may help to improve understanding so that the environmental impact of future flood events can be reduced. However, there are likely to be multiple benefits in also improving support services for householders, and strengthening the supply chains involved in refurbishment. Some of the poorest areas of understanding we have identified are:

Drying process in different materials

This is not a new finding, and one reinforced by the previously published DCLG review into guidance and standards in 2010. The impact and appropriateness of speed drying techniques needs further research, particularly in older properties. This study undertook some initial analysis of the CO_2 intensity of different drying methods, but this needs to be further understood, especially in relation to different types of buildings and materials - and wider impacts such as the levels of noise and air pollution produced.

Insulation behaviour in flood

The way that different insulants respond to flood water needs to be better understood. This may help to reduce unnecessary strip-out, but also promote the energy efficiency agenda, making improvements a default part of refurbishment work - particularly in the insulation of floors and walls - and reducing uncertainty. This work needs to be sensitive to the nuances of building typology and building physics. This should include an understanding of the impact of flooding on newer-build properties, as we know from previous flood events that these developments are not necessarily immune from the effects.

Embodied impacts, cost-benefit and 'payback'

In the application of resilience measures and energy efficiency measures has unavoidable embodied impacts. A better understanding is required of the whole life financial and environmental costs of flood resilience measures will help in decision making, and whether a fully resilient or a 'sacrificial' approach is more beneficial. There are questions here about wall and floor build ups, appliances, furniture and the environmental sustainability of uPVC as against timber windows in the context of regular floods.

Tenure Impacts

In this research we have focused on the owner occupied sector - partly as a result of the availability of information and the response to our requests for input. We are very conscious that the impacts and processed in the social housing and private rental sectors may differ significantly. The impact on small businesses was also outside the scope of this research. All of these areas would benefit from further research.

Effectiveness of flood resistance and resilience measures

Nearly everyone we spoke to in the course of this research expressed concern about the effectiveness of flood resistance measures in particular. There are fears that measures designed to stop the ingress of water are being fitted which do not work, are inappropriate for the building or type of flooding experienced, or which the householder is unable to operate and maintain effectively. This is potentially damaging to the flood resilience industry in a broader sense, can give householders a false sense of reassurance and is an inappropriate use of public funding. Further research is needed to improve understandings about what works, and what doesn't. This needs to clearly distinguish between resistance and resilience measures, the latter of which should become the default in flood recovery. Some published research in this area is useful (for example, DEFRA, 2015) but is based on already outdated cost estimates.

Wider environmental impacts

Flood events cause a number of wider impacts and we have come across little research that captures the environmental costs of these. For example:

- The mapping of supply chains used in drying, refurbishment, resistance and resilience work (in terms of contractors, sub-contractors and materials).
- The distance travelled by trades.
- Number and location of households indirectly affected by flooding - through electricity outage or water supply issues or 'near misses'.
- Public transport infrastructure affected (e.g. the flooding of the west coast main line may have forced more journeys by car).
- Ground and river contamination, and the subsequent impact on areas such as allotments and agricultural output.

Appendix

Element matrix:
Summary of guidance, like-for-like and resilient replacement in relation to the different elements of the home.

References

Element matrix

Building element		What does the guidance say?	More resilient options
Fabric	Walls	**Dry-lining** Cut a few holes about 100 mm square in plastered lath linings to examine the lathing, wall and cavity. If the lining is in good condition, redecoration can start once the surface is dry. If the lining is unstable, showing signs of rot or there is bridging that can transfer water from the wall, replace the lining with plasterboard on treated timber supports fixed to the masonry with corrosion resistant fixings. The opportunity can be taken to improve thermal performance by fitting thermal insulation between the supports, or a lining laminated to insulation if practicable. **Cavity wall insulation** Wet or damaged cavity insulation can extend drying times, lead to rain penetration and increase heat loss. Insulation materials in the cavities can form voids or crush when they float, and compact or slump as they dry. Partial cavity fill may be displaced but is more robust than blown fill. Built-in full cavity fill will store water but should drain and recover within a few months. Remove insulation that is fissured, very wet or has shrunk back to the sides of the cavity. Replace cavity insulation using specialist contractors. *BRE Good Repair Guide 11: Part 3 (1997) Repairing flood damage: foundations and walls.* **Structural problems** Structural work is rarely required, a notable exception being with heavily saturated earth based construction. *SPAB Technical Q&A 31: Floods and Old Buildings*	**Insulation** The difficulty of replacing means of protecting the plaster on masonry inner Water resistant insulation insulation). Applying external waterp mortar mix and the benef *CIRIA (2005) C623: Stand* **Waterproof membranes** Membrane in the wall me channelled away to preve affected. *BRE Flood Resilient Repai* **Where walls are re-built** Low-permeability bricks,
	Floor	**Insulation** Mineral wool insulation between joists may compact, retain water and not regain its thickness or insulation value. Rigid insulation boards should not deteriorate but may take several weeks to dry. Aluminium foil insulation may sag and hold water. *BRE Good Repair Guide 11: Part 2 (1997) Repairing flood damage: ground floors and basements.* **Floor joists** Inspect joists and other timber for rot. Replace timber showing signs of rot and treat adjacent timber to reduce the risk of further spread. Cut off rotting joist ends embedded in walls, repairing them with treated timber extensions, supported on joist hangers if practicable. Treat wet but sound joist ends with preservative plugs. Stiffen joists with strutting or battens, where needed, to reduce distortion. Form hatches in the flooring of refurbished floors so that the moisture content of the joists and other timber in the ventilated underfloor area can be measured until it is 24% or less. *BRE Good Repair Guide 11: Part 2 (1997) Repairing flood damage: ground floors and basements.* Inspect under-floor timbers six months afterwards and then again after 12 months. *CIRIA (2005) C623: Standards for the repair of buildings following flooding. London: CIRIA.* **Finishes** Chipboard flooring may be weak - if unsure, test it (manufacturer, BRE, local colleges or test houses) *BRE Good Repair Guide 11: Part 2 (1997) Repairing flood damage: ground floors and basements.*	**Sump and pump** Membranes installed und the perimeter of the room remove the water, pumpi *BRE Flood Resilient Repai* **Replacement floors** Suspended floors that are **Finishes** Ceramic tiled floor and lo Chipboard should be rep tiles. Avoid carpets, parquet ar Solid floors: ceramic tiles hook and eye. Suspended floors: less ex eye). *CIRIA (2003) Improving the* **Floor joists** Preservative treated timb
	Windows & doors	**Windows** Remove units from drained and ventilated window frames and clean debris from frame before reinstatement. Ensure moisture content of timber frames is below 20%. Good quality sealants that are well adhered to the masonry or window frames restrict the passage of water in the short term. *CIRIA (2005) C623: Standards for the repair of buildings following flooding. London: CIRIA.* **Internal doors** Hollow core doors are common, especially in buildings constructed since 1945. Water that penetrates these doors can destroy them.	**Seals and locks** Enhanced seals and locks *BRE Flood Resilient Repai* The material your doors a water. For example, a uni water than one made fron *CIRIA (2003) Improving the* **Internal doors** Replace with resistant typ undercoat and topcoat]. F hung on hinges that allow *CIRIA (2005) C623: Stand*

	What else should householders consider?
existing full cavity fill without removing masonry or internal surface finishes means that other cavity are preferred. For the inner wall [this may include] the use of hard,moisture resistant leaf, and sealing the wall-to-floor junction and the skirting boards. in the walls and under the floor (such as spray applied PUR foam or injected foamed cavity roofing, such as a render coating or a rendered external insulation system. Consider the fits of increased lime content. *ards for the repair of buildings following flooding. London: CIRIA.* ans that if the adjoining property floods, water that seeps through the wall from next door is ent damage on your side. This allows repairs to start even if the neighbouring property is still *r Home.* such as engineering bricks, will reduce the speed of water penetration (CIRIA, 2005).	**Risk: trapping moisture within the construction** Note that use of water resistant treatments both internally and externally may result in moisture being trapped and building up inside the wall, and might cause dampness, particularly in solid masonry walls. These walls perform best when they have no water resistant coatings and water vapour can escape from the inside and outside faces. This makes them particularly prone to flood water penetration, but enables more rapid drying thereafter. *CIRIA (2003) Improving the flood resistance of your home. Advice Sheet 4: Flood resilient walls.*
er the floor and in the walls* to divert water towards drain channels beneath the floor around , directing water into a sump in the corner of the home fitted with automatic pumps to ng it outside, before it can reach up to the floor. *r Home.* e regularly flooded can be replaced with solid concrete floors. ose rugs in place of fitted carpets. laced with more resistant materials such as treated floorboards, WBP plywood, screed or nd laminate. with suitable water resistant grout or tile resin, loose fitting rugs, removable carpets - velcro/ xpensive synthetic options, removable floor boarding, removable carpets (velcro/hook and *e flood resistance of your home. Advice Sheet 6: Flood resilient floors.* er. Replace timber wall plates with corrosion resistant steel alternatives.	Grout finishes to be maintained otherwise water may find routes underneath.
s to the doors and windows to make them flood-proof. *r Home.* and windows and their associated frames are made from can affect the seal against flood t made from UPVC is more likely to have a better seal and will be more impermeable to flood m timber. *e flood resistance of your home. Advice Sheet 5: Flood resilient windows and doors.* oes such as solid timber doors. Finish the door properly with a high-build paint system [primer, Paint the doors before hanging so that the sides and bottom are fully covered. Doors can be w their easy removal. *ards for the repair of buildings following flooding. London: CIRIA.*	Removable internal doors will only be practical if the householder is physically able to lift them off before the flood.

Element matrix

Building element		What does the guidance say?	More resilient options
Decoration & finishes	Internal walls	**Decoration** Remove low-permeability internal finishes such as vinyl paper, ceramic tiles and gloss paint to speed drying and reduce the risk of corrosion of embedded metal. *BRE Good Repair Guide 11: Part 3 (1997) Repairing flood damage: foundations and walls.* **Plaster** Repair detached, friable or damaged plaster with material of a similar specification. *BRE Good Repair Guide 11: Part 3 (1997) Repairing flood damage: foundations and walls.* Lime plaster tends to dry out on walls intact, whereas daub, gypsum plaster and plasterboard are more vulnerable to water damage. *SPAB Technical Q&A 31: Floods and Old Buildings* Where whole plasterboards are damaged they should be replaced with whole new boards. For smaller areas of damage, support should be provided around the area of repairs and the new pieces fixed securely to the new supports. Plasterboard can be mounted horizontally as opposed to vertically. *CIRIA (2005) C623: Standards for the repair of buildings following flooding. London: CIRIA.*	**Waterproof wall boards** Waterproof magnesium o **Permeable finishes** Inner leaf: Redecorate su any stains. *BRE Good Repair Guide 1* **Alternatives to gypsum** Instead of using gypsum, • water resistant render • lime plaster finish • hydrated lime coating • ceramic tiles These finishes should be applied over layers of gyp **Fitting of plasterboard h** If plasterboard is used, th *BRE Flood Resilient Repai* **Timber frame walls** The internal lining of timb frame to dry out. Conside lime based finishing layer *CIRIA (2003) Improving the*
	Skirtings etc.	**Laminate** Laminate flooring - it is unlikely that they can be re-laid, even when dried out, but a flooring specialist can advise you on this. *Know Your Flood Risk (2013) Flood Recovery Guide.* **Skirting boards** Remove skirting and cut or drill holes through plasterboard or dry-lining. *CIRIA (2005) C623: Standards for the repair of buildings following flooding. London: CIRIA.*	**Skirting** Plastic skirting. Glued as opposed to nail Paint wood skirting on all Box out from wall to enab *CIRIA (2003) Improving the*

	What else should householders consider?
xide wall boards instead of plasterboard, or, *BRE Flood Resilient Repair Home.* rface dry plaster that is in good condition with permeable finishes, after cleaning off or sealing *1: Part 3 (1997) Repairing flood damage: foundations and walls.* consider using internal finishing materials that are more flood resistant: s applied to a height of at least 500mm above the expected flood level. Tiles should not be osum plaster. **horizontally** his fitted horizontally so that in future only the lower boards need replacement if damaged. *r Home.* ber-framed walls - difficult to make more resistant because of need to remove to allow timber er using water resistant boards (e.g. marine ply) with demountable fittings, sacrificial joints and . *e flood resistance of your home. Advice Sheet 4: Flood resilient walls.*	The need to consider plaster and decoration holistically so as to avoid one compromising the other. E.g. where it is desirable to allow some moisture movement through wall finishes, porous or vapour permeable materials can be used. Where vapour permeable building products are used, these should not be compromised by inappropriate decoration. *Property Care Association (2013) Code of Practice for the Recovery of Flood Damaged Buildings.*
ed so can be easily removed. sides. ble easy drying out. *e flood resistance of your home. Advice Sheet 4: Flood resilient walls.*	

Element matrix

Building element		What does the guidance say?	More resilient options
Building services	Gas, oil and other flued appliances	**Pipework** Check copper pipes. Copper is generally considered to be durable and corrosion-resistant and is unlikely to be affected by short-term contact with flood water. **Use in drying out** Flue-less appliances should not be used (for drying out) and flued appliances should be monitored. All gas appliances affected by flood waters should be inspected by an installer registered with CORGI (now Gas Safe). **Meters** Gas meters may be affected and may need to be replaced. Flood water can sometimes infiltrate gas pipes. *CIRIA (2005) C623: Standards for the repair of buildings following flooding. London: CIRIA.*	**Raise meters above exp** As gas meters can be aff during refurbishment wor appropriate drain points. **Raise appliances above** Gas and oil fired boilers a expected flood level. Mount boilers on the wall *CIRIA (2005) C623: Stand* **Access and insulation o** Pipe insulation below the is being installed, pipewo down following flooding. **Oil tanks** Ensure that oil storage ta from the tank incorporate moves and the pipe breal *CIRIA (2003) Improving the*
	Electric	**Wiring** Modern wiring is not usually affected by flooding, but long immersion may result in the need to replace wiring. *CIRIA (2003) Improving the flood resistance of your home. Advice Sheet 7: Flood resilient services.* Replace rubber sheathed wires whether obviously damaged or not. It is essential that a qualified electrician checks all affected circuits and appliances before they are reused. In many cases extensive repair and replacement will be required. *CIRIA (2005) C623: Standards for the repair of buildings following flooding. London: CIRIA.*	**Re-wiring to provide cir** Sockets and switches pla *BRE Flood Resilient Repai* Moving the ground floor r sockets. Sockets should If there is sufficient space level could be considered Have the house wired so available. **Raise other incoming se** Where possible, incoming *CIRIA (2003) Improving the* **Electrical services withi** Electrical services should and fully dried in the even sealed to the wall and flo *CIRIA (2005) C623: Stand*
	Water	**Septic tanks** It is advisable to have a professional inspect an affected septic tank. Sewage tanks should not be used until water in the drainage field is lower than the water level around the house, otherwise further contamination may result. *CIRIA (2005) C623: Standards for the repair of buildings following flooding. London: CIRIA.*	**Fit non-return valves** One-way valves in the ma *BRE Flood Resilient Repai* **Insulation of pipework** Water pipework insulation *CIRIA (2003) Improving the* **Improve access and sea** Wrap water services in po floors or walls to make th *CIRIA (2005) C623: Stand*
	Ventilation	**Vents** Ventilation systems must be thoroughly checked; if they are blocked the carbon monoxide build-up can kill. *CIRIA (2005) C623: Standards for the repair of buildings following flooding. London: CIRIA.*	**Fit air brick covers** Air brick covers. *BRE Flood Resilient Repai* **Fit temporary vapour ba** Excessive evaporation of Install temporary vapour

	What else should householders consider?
pected flood level ected by flood water it is worth considering raising meters above the expected flood levels ks. Provision should be made for purging gas supply pipes through the installation of **expected flood level** nd associated pumps and controls should preferably be installed above the maximum 1m above floor level or on a plinth above the level of a flood. *ards for the repair of buildings following flooding. London: CIRIA.* **f pipework** expected flood level should preferably be replaced with closed cell insulation. If new heating rk routes should be made easily accessible to allow pipes to be maintained and washed nks are anchored down so they do not float away. You should make sure that the oil feed s a stop valve at the end nearest the tank so that the tank contents will not be lost if the tank ks. *e flood resistance of your home. Advice Sheet 7: Flood resilient services.*	Familiarity with the location and operation of the Emergency Gas Shut Off Valve will mean that the gas supply can be safely shut off before flood water enters. Keep contact details for Gas Safe, Oftec and qualified electricians alongside the Household Emergency Plan as they are likely to be very busy after the flood event.
cuits higher up walls aced higher up the wall, and the wiring to them all coming from the ceiling. *r Home.* ring main cables to first floor level could be considered with drop down cables to ground floor also be raised to an appropriate height above flood levels. e, raising the meter and consumer unit (fuse box) to a higher level above the expected flood d subject to approval by the local electricity supply company which owns your meter. that the ground floor ring main can be switched off, leaving the supply to the upper floors still **ervices (e.g. phone/broadband) above expected flood level** g telephone lines and internal control boxes should be raised above the expected flood levels. *e flood resistance of your home. Advice Sheet 7: Flood resilient services.* **n conduits** be placed within easily accessible conduits and voids so that they can be drained, checked nt of a future flood. Conduits could include replacement skirting boards in PVC-U that are ors. *ards for the repair of buildings following flooding. London: CIRIA.*	Moving sockets higher up the wall should only be done if the householder is able to access them comfortably. If there is a history of deep flooding it may be better to direct resource elsewhere.
ain drains to prevent water coming up into the home via the sewers. *r Home.* n can be replaced with flood resistant closed cell material below the expected flooding level. *e flood resistance of your home. Advice Sheet 7: Flood resilient services.* **al pipework** olyethylene sheeting to seal them fully. Place water service pipes in conduits or voids through em easily accessible for inspection. Protect taps using non-return valves. *ards for the repair of buildings following flooding. London: CIRIA.*	
r Home. **arriers to prevent damage to unaffected rooms** flooded water from the ground floor may produce condensation problems in upstairs rooms. barriers to prevent condensation reaching unaffected rooms during this process (CIRIA, 2005).	Householders must remember to remove these once the flood risk/event has passed, otherwise there is a risk of damage to the building fabric.

Element matrix

Building element		What does the guidance say?	More resilient options
Fixtures & fittings	Kitchen units	Anything made from wood-chip or 'particle board' will be damaged beyond repair and need replacing - which, sadly, means most modern fitted kitchens have to be taken out entirely. *Know Your Flood Risk (2013) Flood Recovery Guide.*	**Kitchen units made fron** Kitchen units and doors r *BRE Flood Resilient Repai* Pressed steel kitchen uni *CIRIA, 2005*. **Re-locate kitchen** Consider moving kitchens *CIRIA (2005) C623: Stand*
	Appliances	**Drying out white goods/appliances** Domestic appliances contain insulation materials that can be contaminated and wetted by the flood. If possible, remove covers for cleaning and drying. *CIRIA (2005) C623: Standards for the repair of buildings following flooding. London: CIRIA.*	**Re-locate items above e** Appliances in the kitchen *BRE Flood Resilient Repai*
Furniture	Soft furnishings	Rinse with clean water and soft cloth or sponge. Absorb any excess water using clean towels and soft cloths. Dry shaped objects with padding for support, change the padding when wet. Objects can be air dried indoors with the air circulating. Monitor for mould growth. *York Archaeological Trust (2017) Protecting Precious Memories.*	
	Other furniture	As above. Open all the doors and drawers. *York Archaeological Trust (2017) Protecting Precious Memories.*	Measures to make bathro that will allow removal of *CIRIA (2005) C623: Stand*
Belongings	Personal items & valuables	Clothing, bedding and other soft fabrics (including children's toys) should be washed at 60c or the highest temperature shown on the manufacturer's instructions. *Know Your Flood Risk (2013) Flood Recovery Guide.* Electric blankets should be dried on a clothesline and gently stretched to their original size and shape. They should NOT be used until safety tested by a qualified electrician. *Know Your Flood Risk (2013) Flood Recovery Guide.* For items of particular personal or sentimental value, antiques, fine art etc it advises that they can often be restored by specialist restorers and conservators. *British Damage Management Association (BDMA) Understanding basic flood recovery procedures.*	
	Food	Food from freezers and fridges - everything will need throwing away, whether it was ruined because flood water got in, or because the power went off. *Know Your Flood Risk (2013) Flood Recovery Guide.* Any canned foods that have been damaged or dented should be thrown away, but undamaged ones can be saved. (When there is time, fill in a sticky label with the details of the can contents, then take off and discard any paper labels, as they could harbour mould, or germs. Wash and disinfect each can then stick on the new label). *Know Your Flood Risk (2013) Flood Recovery Guide.*	**Ways to quickly evacua** The lower kitchen cupboa flooding is imminent. *BRE Flood Resilient Repai*

	What else should householders consider?
n waterproof materials. made from resin bonded board, and fitted with all ceramic worktops. *r Home.* ts are available and will resist flood water. s to first-floor level. *ards for the repair of buildings following flooding. London: CIRIA.*	Solid wood or plywood units may also be more resilient to flood water, although will need to dry out. These might be a closer match aesthetically to most traditional kitchens, and easier to source.
expected flood level (fridge, oven, washing machine etc) mounted at worktop height. *r Home.*	If white good such as fridges have to be disposed of, remove contents first. This makes the items easier to lift (for householders and council waste disposal teams). It also means it may be possible to recycle as WEEE (Waste Electrical and Electronic Equipment).
	Dry outside or on clothes lines if possible to avoid adding further moisture into the home. A tumble dryer may enable smaller items to be quickly dried, but check the care label first - the energy cost associated with tumble drying should also be considered.
ooms easier to clean and dry after a flood include readily removable frames and fascia covers flood water from under baths. *ards for the repair of buildings following flooding. London: CIRIA.*	If the flooding is expected to be shallow, consider placing plastic tubs under the feet of solid wood furniture. However, this will only be feasible if the householder is physically able to lift the items.
	Timing is key, particular for salvaging sentimental items. Make a list of key contacts (restorers etc) and keep these with the household flood plan so that they can be quickly contacted after the flood event.
te cupboards and reduce food waste ards fitted with slide out baskets so that they can be taken out and placed on the worktop if *r Home.*	This will only be realistic if there is sufficient flood warning. Higher value and precious items should be moved first.

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