Historic England

Flooding and Historic Buildings

Summary

We know that the risk of flooding is likely to increase as a result of a changing climate and the effects of increased urban development. Estimates suggest the number of people at high risk from flooding could rise from 1.5 million to 3.5 million by 2080. Currently around 400,000 homes and 75,000 businesses in England are located in areas where there is a significant annual chance of river or coastal flooding (greater than a 1.3 per cent annual chance, or once every 75 years on average). More homes are at risk from surface water, groundwater or sewer flooding, which is much harder to predict than river or coastal flooding. Many of these buildings will have been constructed before 1919 and will therefore be of historic importance.

As well as damage to property and infrastructure, flooding results in a significant human cost. Not only do householders lose possessions and suffer damage to their properties when there is a flood, but often they are also forced to endure the disruption and stress caused by several months of evacuation.

Since the 2007 floods there have been major consultations and reviews undertaken by government and other regulatory organisations and a much greater recognition of the need for coordinated flood-risk management at a local level. This was a particular emphasis of the Pitt Review, *Learning the Lessons from the 2007 Floods* (2008) and the Department of Environment, Food and Rural Affairs' (Defra) ongoing programme *Making Space for Water*, which takes a holistic approach to the management of risk from all forms of flooding (river, coastal, groundwater, surface run-off and sewer) to help deliver sustainable development. This need for a more comprehensive management of flood risk for people, houses and businesses has been incorporated into the Flood and Water Management Act 2010.

Integrated flood-risk management is essential if the historic environment is to be protected from flood damage, and effective communication between all those involved is therefore vital in securing the appropriate response. Co-operation with national agencies such as the Environment Agency is key to managing risks at a local level. Local Flood Resilience Forums also now have a very important role in helping manage the risks as well as providing integrated emergency management.

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Cover images

top left: Environment Agency engineers erecting temporary flood barriers.
[photo © Environment Agency]
centre left: Houses flooded at Bewdley, Worcestershire after the River Severn burst its banks.
[photo © Paul Glendell]
bottom left: Houses flooded in Stratford Upon Avon, Warwickshire 2007.
[photo © PA]
top right: Fan assisted drying at a church in Gloucestershire.
bottom right: Flooding to shops in Tewkesbury 2007
[photo © Nick Kirk/PA]

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Introduction

Purpose of this advice note

Although most historic structures are inherently durable and are relatively resistant to flooding compared with much modern construction, they are still vulnerable. Many of these buildings are not only at risk from flood damage but also damage from inappropriate remedial works carried out by contractors who have little understanding of historic fabric. This can result in unnecessary removal and disposal of significant finishes and fittings as well as the use of unsuitable materials for the repairs. Too often like-for-like replacement is not carried out when repair works are put in hand.

Building conservation is concerned with retaining original fabric and cleaning or repairing it in a sensitive fashion. Most historic timberwork, panelling, floorboards and plasterwork can be retained and conserved after flooding. There have been many cases where sodden materials that appeared at first sight to be too damaged have been retained in place or re-used and repaired in a cost-effective manner. Much damage can also be caused by rapid artificial drying methods that are not correctly controlled. Well-intentioned but inappropriate techniques for drying out can be exceedingly damaging to historic building fabric.

In some cases, the building and insurance industries' standard procedures for making buildings habitable again after a flood can be damaging to the special architectural or historic interest of listed buildings. Some loss adjusters, recovery contractors and builders operating in this field have very limited knowledge and experience of dealing with historic buildings or the protection given to such buildings by legislation. Older buildings (generally those built before 1919) are constructed quite differently to modern buildings in that they are able to absorb and release moisture, rather than exclude it, and as result need a different approach for flood remedial work.

Areas of responsibility

Defra

Defra is the government department with overall policy responsibility for flood and coastal-erosion risk in England. Defra funds most of the Environment Agency flood-management activities in England and provides grant aid to local authorities and drainage boards to support investment in projects to manage flood and coastal-erosion risk.

Environment Agency

Part of this agency's job is to make people aware of flooding from rivers and the sea, provide flood-warning services and build and maintain flood defences.

- Floodline 0345 988 1188 24 hours a day
- Free Floodline Warnings Direct service

Water companies

These companies are responsible for the supply of clean water and the treatment and disposal of sewage. They are also responsible for public sewers and the maintenance and function of this infrastructure.

Local authorities

Local councils should be the first port of call for advice and guidance on flooding issues local to you.

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Image 01
Flooding at Bewdley 2007
[photo © Paul Glendell]

Image 02
Debris from the River Cocker outside homes in Cockermouth, Cumbria 2009
[photo © Anna Gowthorpe/PA]

This advisory note provides guidance for home-owners, owners of small businesses and others involved with managing historic buildings on ways to establish flood risk and prepare for possible flooding by installing protection measures. It also recommends actions to be taken during and after a flood so as to minimise damage and risks.

Sources of further information and practical help are listed at the end of the document.

Information on specific historic buildings and guidance on whether remedial treatments and repairs require consent should be sought from the conservation officer in the local planning authority.

1 Types of Flooding

Each type of flooding brings its own risks and problems and can have many variables – regularity, duration, speed and depth. There are three broad categories, as follows.

1.1 River flooding

River flooding is usually the result of high convective rainfall causing river levels to rise. Rivers vary in the way they cope with the additional water depending on their capacity and access to the flood plain. Flood plains allow the storage of excess water, which reduces water volume and slows down the flow in a river. Development on flood plains can reduce flood-storage capacity and have a significant effect, creating flooding further down river where it had not previously occurred.

When forecasts show the likelihood of flooding from rivers the Environment Agency issues flood warnings to householders and/or businesses that might be affected.

1.2 Coastal flooding

Coastal flooding is caused by a combination of high tides and waves. High tides usually occur in spring and again in autumn. A build-up of low pressure can coincide with high tides and lead to a tidal surge. The Environment Agency monitors tides around the UK coastline and issues warnings when there is a danger of flooding. The risk of coastal flooding can be made worse by high water in rivers and estuaries that drain into the sea.

Most coastal change occurs rapidly during extreme storm and flood events. Coastal barriers may be breached permanently so that sites that formerly were protected behind barrier beaches, shingle spits or dunes become tidal and subject to marine erosion.

1.3 Surface, ground water and sewer flooding

This type of flooding is usually the result of sudden torrential rain, particularly in urban areas, and can be highly unpredictable. Drainage systems are unable to cope with the excess water and overflow. Much damage can occur as a result. Where foul sewers surcharge into the flood, the floodwater will be contaminated with sewage. Water companies are responsible for the foul-water and surface-water sewerage system if it has been adopted. Contaminated silts left behind when floodwaters recede can present significant health risks.

Flash flooding can be particularly bad in summer months when there has been little rainfall and the ground is very dry and hard. The water then runs straight off the land with very little absorbed into the ground. There is similarly a problem if the ground is already saturated with groundwater when heavy rain occurs. The ever-increasing amount of impermeable hard landscaping only makes the problem worse.

Watercourses that have been culverted can in very heavy rainfall lead to flooding, as there is no increased capacity available. Culverts are also liable to overflow if there are any blockages as a result of rubbish or fly-tipping.

Highway flooding can occur when run-off from roads and paths overwhelms the highway drains. In rural areas roads usually drain into ditches that run alongside the road. Highway drains are the responsibility of the highway authorities that maintain them. Excess water build-up in urban areas is sometimes diverted away from the highway into 'soak-aways' near the drains and then gradually into the ground.

General flooding can often create drain and sewer blockages that lead to backflow of sewage into properties through drain gulleys, toilets and washing machines. This flooding can often be effectively controlled by the installation of non-return valves within the private sewer of a property. Even where properties are not connected to mains drainage, a back-up of sewage into the property can still occur. These systems would need to be checked by a qualified engineer after a flood.

Much of the guidance and many of the principles of repair in this document will also apply to water damage caused by inadequate rainwater dispersal, pipe bursts, overflowing appliances or by water used to extinguish fires.


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Images 03–06

03. The River Severn overflowing its banks at Worcester in 2007.
04. Road drains being cleared at Wescott, Devon after drainage is overwhelmed by torrential rain. [photo © Ben Birchall/PA]
05. This thatched cottage suffered considerable damage from water after a roof fire. [photo © Darrel Sykes]
06. Reculver, Kent. The partly ruinous medieval church is on the site of a Roman fort and an Anglo-Saxon monastery. The site is now heavily defended with rock-rubble armouring, without which it would erode rapidly.

2 Establishing Flood Risk

You need to be clear about the extent of flood risk to your home or business. Are you in a high-risk area? It is essential to know this before you can decide how to manage the risk and the level of flood protection you may need.

The risk assessment should take into account:

- **the local topography** – is the building near a river, stream or ditch, in a flood plain or at risk of sea floods? How high is the building above the flood-risk level? Are there flood defences already in place or are they planned for the future?
- **the history of flooding in the area** – when and how frequently have floods occurred in the past? What caused them? How high did the floodwaters rise?

Establishing the flood risk of a property from a range of sources can be complex. A good starting point is the Environment Agency flood map, which shows the risks from river and coastal floods. This mapping does not include other sources such as flash sewer flooding and groundwater flooding. There is also no indication of flood depth, speed or volume of flow.

Risk is divided into three levels for the flood mapping:

- **significant** – the chance of flooding in any year is greater than 1.3 per cent (1 in 75)
- **moderate** – the chance of flooding in any year is 1.3 per cent (1 in 75) or less but greater than 0.5 per cent (1 in 200)
- **low** – the chance of flooding in any year is 0.5 per cent (1 in 200) or less.

Flood mapping is a key part of flood-risk management and will continue to be refined as more information is added. At present it covers:

- flooding from rivers or sea without defences – the natural flood-plain area that could be affected
- extent of extreme flood 0.1 per cent chance
- flood defences – embankments, walls, etc
- areas benefiting from flood defences in the event of a river flood with a 1 per cent chance of happening each year, or a flood from the sea with a 0.5 per cent chance of happening each year.

In the past there was a good understanding of where to position buildings so as to minimise the risk of flooding and water penetration. Many old buildings next to rivers and streams, where flooding was expected, used materials that were able to withstand intermittent flooding.

Recent development pressures have resulted in land being developed that had previously provided floodwater storage. Such development can sometimes put older properties at risk by reducing storage capacity.

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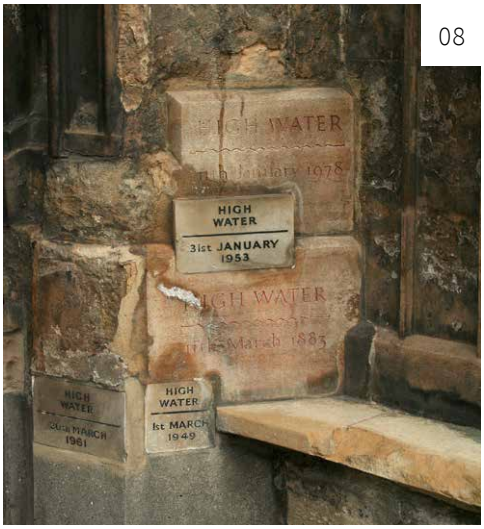

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Images 07–09

07. Tewkesbury Abbey surrounded by floodwater
There was a good understanding in the past where to build to avoid flooding.
[photo © PA]

08. St Margaret's Church Kings Lynn, showing a long history of flood events.
[photo © SPAB]

09. Flooding in the Cotswolds 2007.
[photo © Simon Cairns/Cotswold DC]

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Images 10–12

10. Temporary flood defences such as this erected around the Plough Inn at Upton, Worcestershire can prevent much damage.
[photo © David Davies/PA]

11. Investment by the Environment Agency in flood defences continues but many vulnerable buildings will remain unprotected.
[photo © Environment Agency]

12. Temporary flood barriers in place as river levels rise at Bewdley, January 2008.
[photo © Stephen Pond/PA]

3 Being Prepared for Flooding

What being prepared involves – By planning ahead and taking sensible, cost-effective precautions, it is possible to minimise and sometimes prevent the worst of flood damage and thereby reduce suffering and cut the financial cost to individuals, businesses and the public of cleaning up afterwards.

There are three stages of flooding that need to be considered:

- **preparation** – assessing, understanding and managing the risk
- **reaction** – coping with the flooding while in progress
- **recovery** – limiting damage after flooding.

3.1 Availability of insurance

In June 2013 The Association of British Insurers (ABI) and the Government agreed a Memorandum of Understanding on how to develop a not-for-profit scheme called Flood Re. This is to allow flood insurance to be available to high flood risk households at an affordable price. The scheme is due to be available in the second half of 2015.

For further details refer to the ABI website: www.abi.org.uk.

3.2 Protecting old buildings from flooding

Despite substantial investment in flood management, large numbers of properties remain at significant risk of flooding. Estimates suggest that as many as half of all properties at high risk from flooding might be in areas where large-scale public defences cannot be justified or are unlikely to receive future funding.

Property-level protection measures therefore have a significant part to play in reducing potential damage and the cost of future flood claims. It is estimated that such measures can reduce flood damage by between 50 and 80 per cent.

There are two forms of flood-protection works:

flood-resistance or proofing works – these try to reduce the amount of water actually entering a property

flood-resilient works – these reduce the amount of damage caused when water enters the property.

There is much you can do to protect your property from floods, or to mitigate the effects. However, protection works must be applied with sensitivity to a historic building so that they do not damage the special interest or integrity of the building or any associated archaeological remains. In particular, the aim must be to retain and respect the existing structure and materials. Appropriate flooding-adaptation measures, particularly for resistance, must be tailored to specific properties – no one size fits all.

Flood-protection measures can be particularly cost effective when incorporated into flood resilient repair works.

Flood-protection survey

A flood-protection survey, incorporating a flood-risk assessment to establish what are the risks and the appropriate form of protection is worth considering. An architect or surveyor should be appointed who is experienced in repairing and adapting older buildings in the area.

The survey needs to consider what parts of the building are significant and vulnerable. Does the construction differ from one part of the building to another? Will parts of the building be more resistant to flooding than other parts? What measures could be put in place that would not harm the character and performance of the building?

Flood-resistance and flood-proofing measures

Flood-resistance measures need to be considered in relation to the type of flood risk – regularity, duration, speed, cause and source. For instance, surface-water flooding can occur very rapidly with little warning, allowing no time to put temporary measures in place, whereas the likelihood of river and coastal flooding is much more predictable.

Although some types of flood protection may not hold water back for more than a few hours this might limit the damage by providing valuable time to move items to safety. These measures can also help to keep out flood debris, which itself can cause damage.

There is a growing range of flood-protection products available and a certification scheme managed by the BSI (British Standards Institution) that awards kitemarks to approved proprietary products (see the National Flood Forum Blue Pages at www.floodforum.org.uk). Alternatively purpose-made solutions can be considered (see figs 13,22-24), which can perhaps be incorporated more sensitively into older buildings.

The forces water can exert should not be underestimated particularly when properties are surrounded or partially inundated with floodwater. The general guidance is that floodwater exceeding one metre in height should not be held back as otherwise there is a likelihood that structural damage will occur. Slender walls in timber-framed or brick buildings can fail at shallower depths.

Floodwater can enter a building through:

- masonry and mortar joints
- cracks in external walls
- vents and airbricks
- around windows and doors
- door thresholds
- gaps around pipes that pass through walls and floors
- party walls of terraced or semi-detached buildings where the property next door is flooded
- sanitary appliances caused by back flow from flooded drainage systems
- manholes
- entrances to cellars and basements (coal-holes, pipe ducts)
- from under the floor or foundations.

The most common property-level products include aperture protection, such as door guards and airbrick covers suitable for short duration flooding, and building 'skirt systems' that can effectively isolate the whole property when flooding is more prolonged. These may only keep the floodwater at bay for a short period of between 20 and 60 minutes.

Products that seek to provide impervious 'skins' or sealants can be positively damaging to traditional 'breathable' materials and should be avoided.

Maintenance and recording

Good effective maintenance is a key part of flood resistance in older properties. Localised flooding can be the result of blockages in small drains, watercourses and ditches - vigilance is necessary to ensure that land drainage is not impeded and gulleys and ditches should be checked regularly, particularly after heavy rainfall. If any local drains

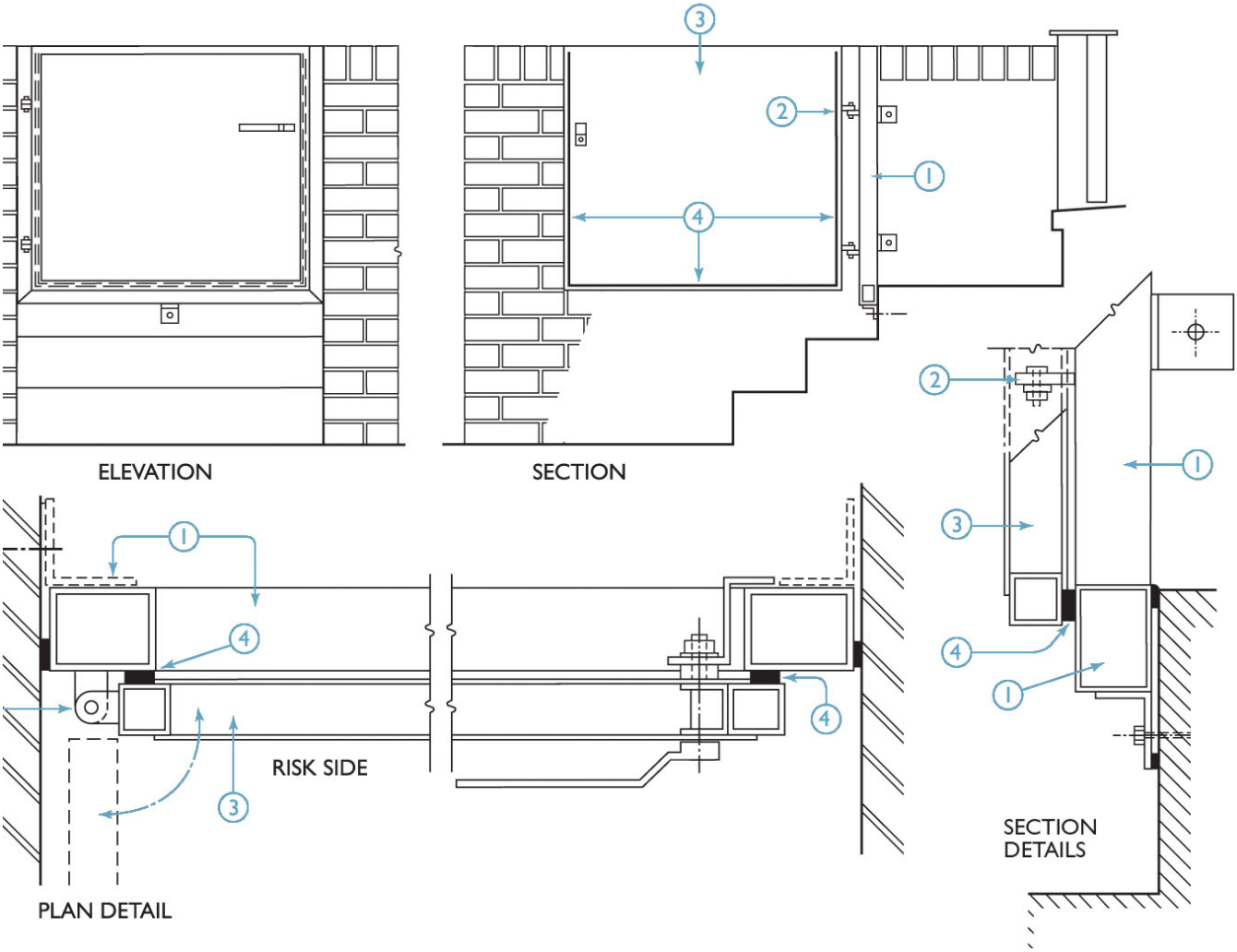

Image 13: Typical watertight door

1. Painted galvanised metal frame bedded in mastic to seal abutment with masonry, fixed to reveals and steps (alternative fixing cleats shown in pecked line).
2. Articulated hinges to ensure even contact between frame and seals all round on closing.
3. Painted galvanised sheet metal faced, metal framed door.
4. Rubber compression seals to sides and bottom of inner face of door to form watertight seal against frame when door closed.

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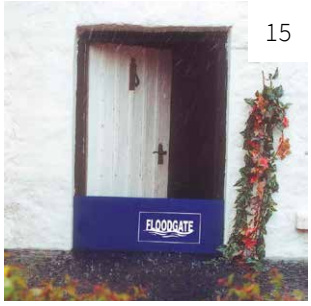

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Images 14–21

14. Sandbags can provide a limited but often effective protection against minor flooding.
[photo © Paul Glendell]
15. Proprietary temporary flood protection measures can avoid much damage and be easy to install.
[photo © Floodgate]
16. Vent and airbrick covers such as these can prevent significant amounts of water entering buildings.
[photo © Floodgate]
17+18. Sash windows fitted with slots to hold temporary flood barriers.
[photo © John Fidler]
19. These buildings close to the River Thames have permanent flood protection measures in place.
[photo © Douglas Kent/SPAB]
20 Interlocking multiple boards providing protection at the gateway to a house in Chiswick, London.
[photo © Douglas Kent /SPAB]
21. A permanent floodgate to protect a house in Kings Lynn.
[photo © SPAB]

or ditches, pipes or culverts are found to be blocked then the local authority should be contacted for advice, as the responsibility for the maintenance of drainage can often be difficult to ascertain.

Basic maintenance such as keeping masonry pointing in good order and sealing gaps around pipes that penetrate the external wall will all help. Check that drains are undamaged and working effectively. Make sure external ground levels are as low as practicable – at least 150 mm below the finished internal ground level or below any damp-proof course.

Extensive hard surfaces that increase run-off and make it difficult for water to soak away should be avoided. In 2008, planning legislation was introduced to limit the use of such surfaces for domestic properties.

A comprehensive photographic record of the building - internally and externally – is also a valuable resource in the event of repairs being needed, whether from flooding or any other cause of damage.

Temporary flood barriers

Temporary barriers can be installed either round the building or fitted to the building itself.

Interlocking barriers can prevent water reaching the building, using the weight of the floodwater to anchor the barrier. However, storage needs to be found for measures such as this.

Barriers fitted to exterior doorways or window openings raise the threshold of the building against rising water. They can then be removed and stored once the risk of flooding has passed. Because they are used only during a flood these features are less intrusive than permanent flood barriers, but in order to keep their architectural impact to a minimum, any fixings must be discreet and compatible with an older property.

Designs for purpose-made door and window barriers are illustrated (see figs 22, 23 and 24). These are fixed to the building as needed and removed once the danger of flooding has passed.

Covers for airbricks – temporary snap-on covers for airbricks and vents can be purchased from suppliers of flood-protection products. Airbricks and vents should be sealed only during flood conditions and then removed to aid drainage and drying out and later to provide permanent ventilation.

Bagged barriers – sandbags can provide a limited but often effective protection against minor flooding. They need to be carefully laid and well stamped down so that the upper bags mould themselves to those below. In walls that are more than two sandbags high there should be a double line of sandbags at the bottom, followed by a second double line, then a single line on top. The disadvantage is they are heavy to use and quickly become contaminated when wet. Commercial alternatives using ultra-lightweight highly expandable bagged materials are also available.

Permanent barriers

Permanent barriers using bunding, walls, gates and additional drainage ditches to site perimeters can be used to prevent water reaching any buildings. Care should be taken to avoid damage to sensitive surroundings or archaeology.

Permanent solutions to the building perimeter itself might include a built-up front doorstep, or a partially tanked lower-ground-floor elevation. Such barriers need to be carefully designed as they can have a significant impact on the appearance, character and performance of the building. Tanking should be approached with caution as this can contain water and make drying out more problematic if water does enter the building.

Permanent protection can also be incorporated externally into the boundary wall or fence or landscape surrounding the building in the form of bunding or extra ditches for drainage.

Seal any gaps and holes around the frames of windows and doors to make them watertight.

Any additions or alterations should be constructed with flood-proofing in mind.

Flood-resilient measures

For properties vulnerable to repeated flooding it is advisable to limit the potential damage and cost and the amount of time the property is uninhabitable. Modifications can be carried out to services, interior fixtures and fittings to limit damage and enable the building to be made habitable again as soon as possible after a flood.

The following issues can be considered:

- services are particularly vulnerable to flood damage so moving services (electrics, boilers and service meters) above a likely flood level could prove cost effective
- in basements and ground-floor rooms threatened by flooding new electrical circuitry, fuse boxes and heaters can be installed at a higher level. Make sure that embedded or power cables in trunking are carried down from the ceiling and not up from floor level
- where the risk of frequent floods is high in properties with basements or cellars consider installing a sump with submersible emergency power supply to help drain these areas quickly after the flooding subsides. If possible provide through ventilation for basements and cellars
- plumbing can be fitted with backflow valves to prevent water or sewage entering the building from drains and sewers
- advice is often unnecessarily given to replace timber suspended floors with concrete floors. Timber suspended floors can survive flooding and assist with drying where the water is able to soak into the ground beneath rather being retained, which would be the case with a concrete floor. If a suspended timber floor has been damaged beyond repair by a flood, a new suspended timber floor could be put back or consideration could be given to use of lime concrete, which has a greater porosity and permeability than conventional concrete
- lime-plastered walls should be retained as these will perform relatively well compared with modern gypsum plasters and plasterboard. Give consideration to replacing gypsum plaster with lime plaster
- lime is also mildly self-disinfecting
- solid timber doors will be comparatively water resistant compared to modern hollow core doors
- kitchen units with a core of chipboard or MDF will be ruined with quite low levels of inundation
- tiled floors can be washed and cleaned easily
- safeguard important personal possessions by moving them out of any potential flood zone.

Consents for flood-resilient and resistance measures

Repair and maintenance work that does not affect the special architectural or historic interest of a building is unlikely to require a formal consent. Some flood-protection works may require Listed-Building Consent from the local planning authority.

Planning consent may be required for work to a building within a conservation area. Check with your conservation officer. Consent from the Secretary of State on the advice of Historic England is required for most works that involve alterations or additions to scheduled monuments.

The granting of consent to carry out works to protect the building from flooding will be influenced by the impact of the proposals on the architectural or historic interest of the building.

3.3 Emergency planning

Emergency flood plan

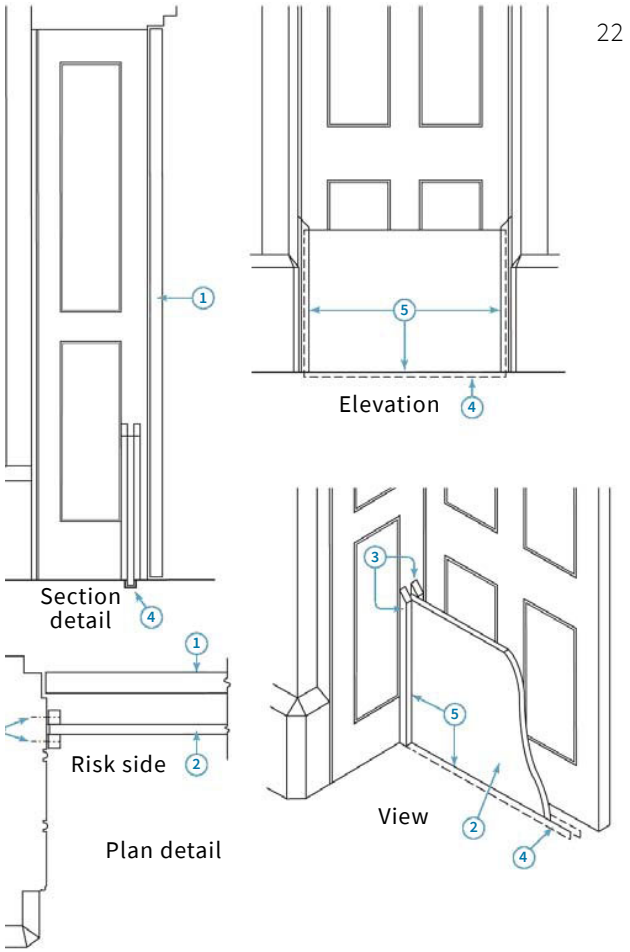
- Turn off gas, electricity and water – make sure you know how to turn off these supplies at the mains
- Contact telephone numbers: relatives, insurance company, local authority, expert professional advisers, builders, recovery experts
- Move irreplaceable valuables to safety
- Flood kit (keep it handy)
- A plan for where family members and/or pets can stay if evacuation is required – does the insurance policy cover the cost of relocation?
- Photographic record of property and special belongings.

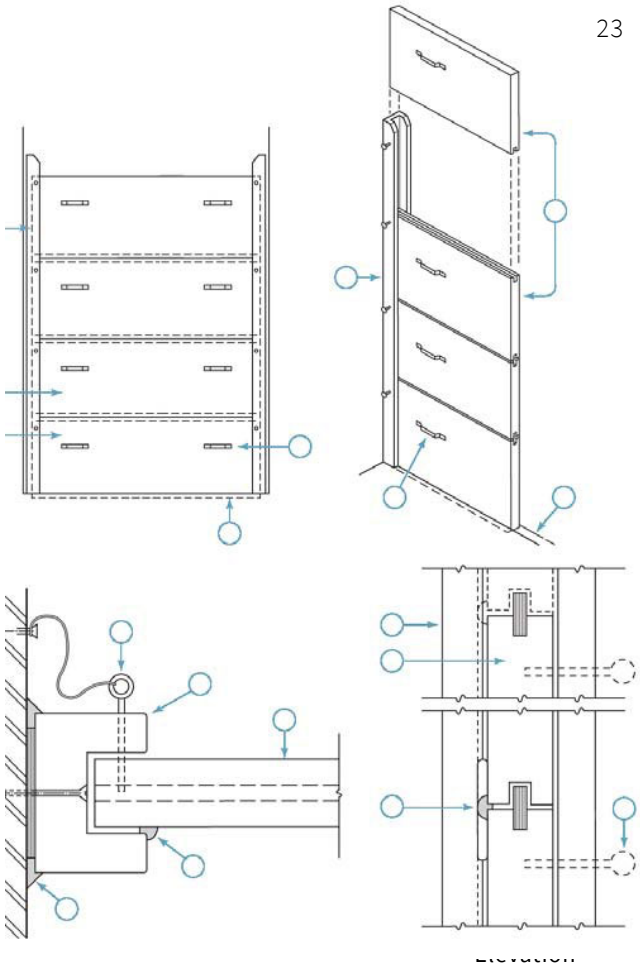
Emergency flood kit

- torch and spare batteries
- Portable, battery-operated radio and spare batteries
- First-aid kit
- Essential medicines
- Essential toiletries and anti-bacterial no-water gel
- Camera to photograph damage
- Cash and credit cards
- Warm and waterproof clothing and footwear
- Mobile phone and charger
- Insurance documents
- Camping gas stove
- Food and hot drink supplies
- Water purification tablets
- Warm clothing and blankets
- Proof of identity – passport/driving licence.

Image 22 (facing page)

22. **Door barrier** (1) Door: can be given additional protection by the fitting of proprietary weather seals (2) Barrier: painted external quality lipped plywood or similar board (3) Painted timber battens fixed to reveals each side of opening to form guide channels for board (4) Slot in paving for positive location of bottom edge of barrier (5) Efficiency of barrier can be increased by applying waterproof sealant around edges and base on risk side.

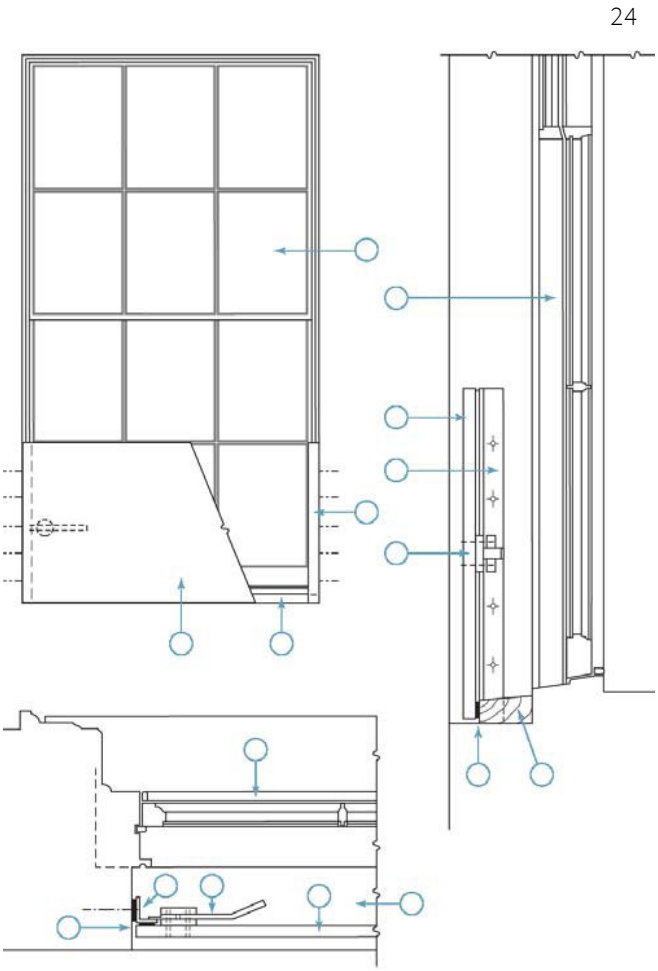




Images 23 and 24

23. **Door barrier:** example with interlocking tongued and grooved multiple boards for increased height protection (1) High channels of painted, treated timber (or metal) fixed to reveals each side of opening (2) Barrier: painted external quality lipped plywood or similar boards, the top edges fitted with hardwood tongues, the bottom edges grooved (3) Sealant to edges of side channels and channels bedded in mastic (4) Locating pin to prevent boards lifting (5) Sealant bead run along external (risk side) joints after assembly to give additional protection (6) Additional boards can be added, depending on risk level (7) Slot in paving to locate positively bottom edge of barrier (8) Optional lifting handles on rear face of boards.

24. **Typical sash window barrier:** compression type (1) Sash window: can be additionally protected by the fitting of proprietary draught and weather stripping to the sashes and parting beads (2) Barrier: painted external quality lipped plywood or similar board (3) Painted galvanised metal angles bedded in waterproof mastic and fixed to reveals each side of opening (4) Painted, treated timber packer to provide compression along bottom edge of board (5) Locking mechanism to pull board and seals tight against metal angles and timber packer (6) Self-adhesive compressible foam sealing strips stuck to rear face (bottom and sides) and along bottom edge of board.



4 Dealing With a Flood

4.1 What to do when floods are forecast

- check Environment Agency flood-warning codes: Flood watch/Flood warning/Severe flood warning/All clear
- gather essential items
- assemble flood kit and have emergency plan to hand
- have ready camping gas stove and lighter to make hot drinks
- put temporary flood-protection equipment in place when there is a flood warning eg barriers, airbrick covers, door gates
- take removable valuable and valued possessions upstairs or to a safe place
- move vulnerable belongings outside the property to higher ground.

4.2 What to do when your building is being flooded

- make safe/turn off gas/electric/water supplies when floodwater is about to enter your home if it is safe to do so
- do not touch sources of electricity when standing in floodwater
- floodwater can rise quickly – stay calm and reassure those around you. Call 999 if you are in danger
- floodwater is dangerous – keep children and vulnerable people away from it
- wash your hands thoroughly if you come into contact with floodwater. Use anti-bacterial hand gel as the water supply may be contaminated
- if floodwater rises higher than 1 metre you should allow water to enter the property to reduce the risk of structural damage
- **evacuate when told to** – listen to the advice of the emergency services.

4.3 Returning to the building

- is it safe? – there may be hidden dangers and slippery surfaces in the floodwater
- check that the electricity has been turned off at the mains before standing in any floodwater
- wear a face mask, waterproof outer wear and gloves as floodwater may be contaminated. Stay out of affected areas as much as possible
- unplug and remove any electrical appliances
- take photographs or video recordings of the damage caused
- make lists and notes of damaged items/ areas to hand to the loss adjuster or claims adviser – take copies for your own records
- open windows to reduce the humidity.

4.4 Notifying insurers

- contact your insurers as soon as possible and establish exactly the level of cover the insurer provides and what is included – such as temporary accommodation, and services inspections.
- inform the insurers that you live in an old building and try to ensure that loss adjusters, surveyors and contractors with experience of old buildings will be appointed. Agree too that you can employ an architect or surveyor experienced with old buildings to provide specialist conservation advice if this is required – and that their reasonable fees will be paid under the policy.
- once the insurance company has been informed and has approved the proposed work it is important that any standing water is removed as soon as possible and initial drying starts. The longer it takes to start the drying-out process the greater the potential damage as water soaks into the fabric of the building. This can lead to the chance of secondary damage through capillary action and evaporation or spalling.

The insurers may require the following information:

- the time the flood warning was announced
- the time the floodwaters entered the dwelling
- marking where the water level reached on the walls
- photographs or video footage.
- if you do not have insurance, contact your local council for information on possible grants. Also contact an architect or surveyor who has general historic building experience as well as experience with flood-damaged old buildings. Make sure you only use contractors who are experienced in such work. Be aware that there are often unscrupulous contractors around who take advantage of flood victims.

5 After a Flood:

Minimising Flood Damage in Old Buildings

General principles – Once floodwater has entered a building it is almost certain to cause some damage that will require cleaning, drying and repair. However, the extent and degree of damage will depend on:

- the depth that the water reaches and its speed of flow
- the course it takes
- the length of time it remains in the building
- the type of materials used in the building
- the amount of contaminants carried by the floodwater
- the length of time it takes to start the drying process.

Shallow flooding (when the water does not rise above floor level) is unlikely to cause significant damage in most properties, although there may be problems with water entering cellars, basements and voids beneath suspended ground floors.

Damage costs increase significantly once floodwater rises above floor level and comes into contact with internal finishes, electrical sockets, kitchen fittings, carpets, furniture and personal possessions. Flood depths greater than 1 metre above floor level can cause structural damage to buildings and should not be held back, particularly if the buildings are in a poor state of repair, though it is rare for the structural integrity of a historic building to be compromised.

Water damage can be divided into 'primary damage' and 'secondary damage'. Primary damage, such as expansion or shrinkage, staining, etc, is clearly evident. Secondary damage is the subsequent effects such as moisture travelling to areas that were not affected by the initial ingress. Water vapour rising through the building can cause mould growth unless it is intercepted by ventilation or dehumidification. Hygroscopic materials that absorb moisture will support mould growth because they maintain a high relative humidity at their surface. This can also occur on less-absorbent materials if they provide a cool enough surface to elevate the humidity sufficiently. Too much heat will make the situation worse if vapour production exceeds vapour removal. Preventing secondary damage is referred to as 'mitigation'.

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Beware

In some cases the flood damage responses promoted by insurance companies, loss adjusters and contractors may be highly damaging to historic fabric and may breach listed building legislation.

Typical examples of the damage caused include the unauthorised removal and disposal of wet timber panelling or floors and the indiscriminate removal of lime plaster from the walls of listed buildings.

If in doubt, consult the local planning authority's conservation officer before agreeing to any flood stripping or drying-out work and establish whether any approvals are required.

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Images 25–28

25. Muddy water being swept out of a shop following flooding in Shrewsbury.
[photo © Paul Glendell]
26. Furnishings from a flooded church have been carefully stacked and labelled and protected prior to refitting.
[photo © Phil Hadley /Continuity]
27. Historic buildings are vulnerable to damage after flooding from unnecessary removal of fittings and finishes as has happened here.
[photo © Simon Cairns / Cotswold DC]
28. Flooding at Bewdley in 2007.
[photo © Paul Gendell]

Water damage is classified into three categories:

- **Clean** – from a pipe leak
- **Grey** – an internal leak with some waste water such as that from a washing machine
- **Black** – water from an external source that will be contaminated to some degree depending on its origin.

In the case of properties that are insured, the insurer will often appoint a 'disaster-recovery contractor', who will first make a hazard and risk assessment. This assessment will cover a whole range of potential risks, which will be drawn to the owner's attention. The contractor will also carry out a 'triage' procedure: this is an evaluation of priorities to minimise primary damage, and an assessment of the potential for secondary damage.

Black-water contamination will almost certainly result in absorbent materials such as carpets and upholstery being removed, as de-contamination would not be cost effective unless the item was of particularly high value or of historic significance. The disaster-recovery contractor will make an inventory of items removed and those that are considered beyond economic repair. This will go to the loss adjuster for disposal approval.

The contractor will also carry out an initial assessment of the damage and restoration work involved together with the associated costs.

In the case of those without insurance, contractors need to be appointed directly and supervised. The British Damage Management Association (BDMA) produces checklist guidance for this purpose – *Record of Flood Recovery Activity and Personally Appointed Contractors*.

Take photographs of the damage if you have not already done so.

It is important that the restoration contractor is able to assess what is significant in an older building – what can and should be saved. A great deal of damage can be caused by contractors who have little or no experience of working with historic buildings.

The loss adjuster, and any contractors appointed, act on behalf of both insurer and the policy-holder. Any disputes that arise should initially be referred to the loss adjuster and then failing agreement to the insurers.

5.1 Waiting for the water to recede

Basements, common to many older buildings, are high-risk areas that often fill with water. Coal-holes are a particularly easy way for floodwater to enter these areas. Before deciding to pump water from a basement you first need to carry out a careful assessment of local drainage conditions outside and around the property. If the surrounding water level is high, pumping could increase the external pressure on foundation walls, which may cause fragile thin-walled structures to collapse inwards. Pumping before the floodwater has receded is pointless: as long as the groundwater table remains higher than the basement, water will continue to seep in through the walls until the groundwater level finds equilibrium.

Many older buildings have suspended floors: the under-floor voids need to be inspected for standing water and acted upon in the same way as basements. The floodwater needs to recede by itself, though this process can be helped by creating drainage holes and pumping water out where appropriate.

5.2 Initial drying, decontamination and cleaning

Safety check

A health-and-safety risk assessment needs to be carried out before decontamination and cleaning can start.

Decontamination and cleaning

Before decontamination and cleaning can take

place, there needs to be a selective removal of items or fittings that are considered to be beyond economic repair. In the case of insured buildings disposal of items will need to be approved by the loss adjusters.

Significant damage can be caused to older buildings at this stage if unnecessary stripping out takes place and important architectural features are destroyed. No matter how good modern craftsmanship may be, it is not possible to replicate the special historic, archaeological and artistic interest embodied in historic building materials, components and finishes.

Repairing old buildings by the replacement or restoration of damaged elements might be justifiable in cases of extreme decay and loss, but much of the material found after floods in builders' skips, though perhaps dirty and damaged, can be revived, retained and re-used, thus preserving the special interest of the property.

If in doubt consult the local planning authority's conservation officer or seek specialist guidance from an architect, surveyor, engineer or conservator with experience of building conservation.

Make sure all electricity is turned off before cleaning with water. Avoid using high-pressure water, as it might not only damage historic materials, but also create an aerosol spray of harmful micro-organisms. Low-pressure clean water, applied by operatives wearing personal protective equipment, is safer. Extreme care should be exercised when washing decorative features and damaged or loosened elements so as not to break them.

Mud, dirt and flood debris should be removed from all surfaces with fresh water as soon as possible after the floodwater has receded. Do not wait until the deposits have dried; it is safer and easier to remove the mud while it is still wet. Plastic shovels will cause less damage than metal ones.

Silt and mud will accumulate not only on the floor and furnishings but also in interior wall and floor cavities. Open electrical outlets, ducts and chases and rinse them thoroughly. Let these areas dry completely before closing them up again. Clean out any services ducts as well as drains, gullies and inspection chambers.

5.3 Assessing and recording the damage – post-flood survey

Once the property has been cleaned and decontaminated and some initial drying has taken place then a more detailed assessment can be made of the damage and what repair work is required. A health-and-safety risk assessment should be undertaken to establish that it is safe to make a survey. For insured property the insurers are likely to appoint a chartered surveyor to carry out a post-flood survey, though this might not always be the case. You may wish to consider obtaining advice from specialists in historic-building repair work for an independent assessment of what work is required as this is a stage when a lot of unnecessary stripping out can be specified.

Further photographs can be taken at this stage to record areas that may have been previously covered by floodwater. This record will be invaluable to insurers and any surveyors, architects or other professionals involved in the repairs, informing them about the extent of historic fabric that has been affected and might need specialist attention.

The survey needs to cover all areas of the building that have been affected by flooding from potential structural or settlement damage to surface-material damage externally and internally. The degree of moisture content of the various elements of the buildings will also need to be assessed. Most old buildings comprise a mixture of materials that will have differing degrees of porosity.

Typically, the survey would cover the condition of the following areas:

- external walls
- internal walls
- floor elements
- basements and cellars, and floor cavities
- building services
- appliances and fittings.

Structural issues

Flooding is unlikely to lead to serious structural instability in buildings unless there has been significant washing-away of the supporting ground, or the property has been battered by heavy storm seas or fast-travelling heavy flotsam. Damage is more likely to occur in areas suffering fast-flowing water on hillsides, where landslips may occur, or close to where sea walls have been breached.

Signs of structural damage include bulging or dislodged sections of masonry caused by heavy impacts, excessive pressure or undermined foundations, especially at corners. Cracks greater than 6mm above doors and windows and at the ends of facades, and any major leaning, tilting and subsidence of the structure that was not evident, or was not as pronounced, before the flood would need specialist investigation. Floods can also exploit existing structural weaknesses, for instance in timbers which may have been subject to rot and have been largely concealed.

In these situations consult the emergency services during flood inundation and thereafter the local authority Building Control Department for advice, guidance and local knowledge. Special assistance and advice may be necessary for listed buildings and the local planning authority's conservation officer should be contacted.

Architects, building surveyors and structural engineers with experience in the conservation and repair of structurally damaged historic buildings can be appointed to help. They may be able to offer remedial solutions to avert the need for dismantling and rebuilding.

Reconnecting services

Consult the local utility companies before turning on power and gas supplies. To prevent residual moisture or contaminants from causing short circuits when the power is switched back on, electrical systems need to be opened up, cleaned, and either dried or replaced depending on the severity of the problem. Systems should be inspected and certified by an appropriately qualified electrician before use.

Gas supplies, pipe-work and meters are normally resistant to water. During floods, however, mud and moisture can enter the burners, jets and electrical components of fires and boilers and damage them. These elements all need to be inspected, cleaned, dried and tested before re-use to make sure they are safe.

In coastal areas it is worth noting that the salt in seawater can corrode metal fittings, including metal conduit and switch boxes. Simply ensuring that the metal components of an electricity or gas system are dry may not be sufficient; they should still be checked as described above.

Chimneys can also present difficulties: because the moisture absorbed within the chimney's brickwork changes to steam, lighting a fire too soon after a flood could cause structural damage to the structure.

Drains and sewers

Mud and silt can block waste and foul-water drainage systems after a flood. Until the local authority can unblock mains drainage, the impact of continuing rainfall and waste drainage from the property will need to be carefully monitored and managed to avert additional flooding. The responsibility for cleaning private drains remains with the drain owners.

If water rises through the trap (U-bend) of the lowest appliance (eg sink, bath or toilet) report this immediately to the local water authority.

Flush sinks and toilets regularly to help rinse the system.

Salvaging detached and damaged items

Do not throw away materials but salvage and retain as much as possible - even items thought to be badly damaged. Cleaning and steady drying out, together with conservation and repair, may save them. If not, they may be used as models for new replica fixtures and fittings.

Security

You may need to secure the building to keep out people who are not supposed to be there. This should be the responsibility of the contractor carrying out works. Opening doors and windows to help a building dry out creates many opportunities for thieves to enter, particularly when many different people are coming and going.

Perforated plywood sheets or wire grilles can be temporarily screwed to existing frames to secure openings at night without inhibiting through ventilation in the building. An alternative way to secure sash windows without inhibiting ventilation is to open the sashes a little way and screw them to the frame, leaving a gap of no more than 100mm at the top and bottom.

The provision of secure salvage stores and temporary alarm systems may also be worth considering.

5.4 Drying out

Once decontamination and cleaning works have been completed then a planned programme of drying out can start. It is essential not to attempt to dry old buildings out too quickly by turning the central heating on full blast, as this could cause a great deal of damage. Thin timber elements, including floors, doors and panelling, may warp, twist or split; salts may migrate through old stone and plasterwork, causing blistering, powdering and exfoliation; many painted surfaces will peel and flake. The remedial work can become more damaging than the flood itself.

Temperatures above 18°C may also encourage mould growth. Conversely temperatures below 4°C allow the formation of ice crystals in moisture-laden materials, leading to spalling and de-lamination.

'Forced' drying can also produce a temporary and superficial result as the surface is dried quickly while the bulk of the wall remains wet. This can lead to secondary damage, often manifesting itself just as repair works appear to be finished.

Despite pressures to re-occupy flooded buildings as quickly as possible, the best general advice is to dry the building out gently and slowly, first through natural ventilation (possibly aided by mechanical fans). Cross-ventilation is greatly aided by air movement, which can be natural air movement or controlled with the use of fans. Research has shown that drying is a two-stage process: the first stage is drying by liquid transfer to the surface, and the second drying by vapour transfer. The first stage is fast and effective and governed by ambient conditions of evaporation, the second stage is much slower and almost independent of the ambient conditions.

It is essential that the relative humidity is monitored and recorded both in and outside the building so that the rate of evaporation can be assessed and thus the speed of water removal estimated. Slow and gentle drying can take several months, but it is better than destroying irreplaceable historic fabric by acting in haste.

If the flooding has been significant then professional help and equipment will be needed.

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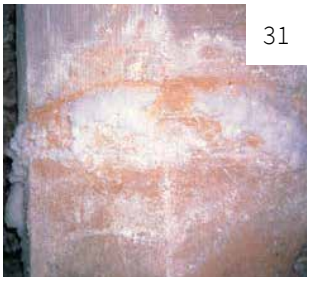

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Images 29–37

29. An endoscope being used to investigate beneath floorboards.
30. Church floor being dried under polythene following removal of pews.
[photo © Phil Hadley/Continuity]
31. Masonry suffering the effects of damp: a 'cushion' of efflorescing salts has developed around a joint in this sandstone pier as the saturated masonry has dried out
32. Humidity probes (shown behind polythene) with data logging is good way of checking that drying is happening.
33. An estate cottage drying out naturally.
[photo © National Trust]
34. A three speed air-mover fitted with a 'hydrovent' for injecting air into voids
[photo © Darrel Sykes]
35. Floorboards that have been tightly re-fixed without sufficient drying have bowed.
36. The drying-out process must be carefully controlled and monitored in order to protect historic decorations. Paintings on plaster, such as these early seventeenth-century examples in a Grade II*-listed house in Bewdley are especially vulnerable to flood damage.
37. A dessicant dehumidifier being used with polythene sheeting to isolate a particular area.

Floorboards carefully stacked at Wickhamford Manor during post flooding repair work.
[photo © Peter Rhodes/Ward and Dale Smith]

Wickhamford Manor, Worcestershire

Wickhamford Manor is a Grade II listed building in Worcestershire that was flooded for the first time in living memory in July 2007. The water reached depths of around 500mm in the principal rooms.

The initial remedial measures included early recording of moisture levels, and inspecting concealed areas such as behind the oak panelling (using a boroscope) and below the suspended timber ground floors. A scheme of gentle and targeted drying and ventilation was introduced with regular monitoring. Once the affected parts of the building had dried back to acceptable levels (after allowing for the likelihood of above-normal moisture levels in places before the flooding), a scheme of conservation repairs and replacements was carried out based on a schedule of works prepared, agreed and costed during the 'drying-out period'.

Despite the owners wishing to preserve as much of the historic fabric as possible, there was considerable pressure from the contractor immediately after the floodwaters had receded to remove all of the timber panelling from one of the principal rooms, because of fears that if left *in situ* the timber would be subject to decay. This was avoided, and by using a combination of regular moisture testing (part at depth) and boroscope inspections, it was eventually proved that taking out the panelling would have been completely unnecessary and could have resulted in extensive damage to important historic fabric.

Investigative work and opening-up

It may be necessary to open up the structure of the building to check for sources of moisture, to check on the condition of the fabric, and to allow trapped moisture to evaporate from masonry and timber, from voids under floors or behind panelling or from behind decorative finishes. The process must be carefully targeted, planned and supervised to avoid the needless removal of perfectly viable original fabric.

Opening-up should not be allowed to develop into 'stripping out' – the wholesale removal of internal finishes (for which, in the case of a listed building, Listed Building Consent would be required before work could begin).

More often than not, stripping-out work is unnecessary and opening-up can be limited by non-destructive and keyhole surgery techniques as well as by using infrared cameras, boroscopes and moisture meters with deep wall probes.

Before removing or dismantling any part of the structure make a visual record of it by means of a sketch, photograph or video. Make sure that items such as floorboards or pieces of joinery are numbered (in soft pencil on the reverse side) so that, if lifted temporarily, they can be put back in the same place, thus preserving the archaeological integrity of the building.

Plan for drying out

The drying needs to be planned for maximum effectiveness and minimum loss of historic fabric and finishes. The objective should be to create a balanced drying system, ie one where the rate of evaporation is equal to the rate of water vapour removal by either ventilation or dehumidification. If drying is unbalanced, for example if fans are used to speed evaporation but with inadequate removal of water vapour, then two problems can arise:

- The rate of drying will progress more slowly as the relative humidity rises
- High concentrations of water vapour will move from where the drying is taking place to other rooms where the concentration is lower. This can result in humidity damage such as mould growth in rooms that were previously undamaged.

Wickhamford Manor

Schedule of preliminary works & monitoring record (at week 9) - note: part record only

Notes

Refer to drawings for positions of monitoring points.

Monitoring readings taken with Protimeter SM generally in 'search mode' for solid floors & walls. These readings are relative (abbreviated to 'rel') and are intended for comparison purposes in order to assess the drying out process. Readings taken into timber are actual percentage values. Where readings have been taken into other materials in the 'measure mode' then these have been given as a 'wood moisture equivalent (abbreviated to 'wme').

Element	Construction/Preliminary Work	Mon Ref
Dining Room		external RH/temp
		internal RH/temp
Floor	Oak boards on joists with mostly earth sub-floor/infill; conc sub-floor with embedded joists to S bay. Boards lifted & stacked; earth removed from between joists; sub-floor conc/completely decayed joists removed to bay. Replacement or remedial work considered/ discussed with CO. Latter agreed to provision of limecrete floor with boards refixed. LBC applic to be made concurrent with this work	FA1 (Top of joist)
		FA2 (Top of joist)
		FA3 (Top of joist)
		FA4 (Top of joist)
E wall	Panelling - monitor drying out incl investig behind	WA1 sktg
		0.3m
		0.5m
		0.8m
		depth@0.5m
		endoscope
N wall	Panelling - monitor drying out incl investig behind	WA4sktg
		0.3m
		0.5m
		0.8m
		depth@0.5m
		endoscope
W wall	Panelling - monitor drying out incl investig behind	WA6 sktg
		0.3m
		0.5m
		0.8m
		depth@0.5m
		endoscope
S wall	Panelling - monitor drying out incl investig behind	WA11 sktg
		0.3m
		0.5m
		0.8m
		depth@0.5m
		endoscope

With relative values the following guidance would be provided : below 17% rel = safe zone; between approx 17 - 19% = borderline zone; over 20% = damp zone. Values in timber (or WME) below say 15% are 'safe'; 18-20% borderline; any over 20% are 'at risk'.

Where 'colour blocks' have been added these are for indicative purposes only. The colours have the following representations: green=safe, orange=borderline; red=damp/at risk.

Despite the fact that some values are shown as 'damp' or 'at risk', a number of these were probably in this condition previous to the flood. Ongoing monitoring will eventually reveal these.

Chart

It is important to monitor the drying process and record the results.

	Initial	After 3 Weeks	After 4 Weeks	After 6 Weeks	After 9 Weeks
	67%RH/20°C	71%RH/17°C	66%RH/17°C	61%RH/15°C	76%RH/5°C
	76%RH/18°C	70%RH/18°C	68%RH/19°C	49%RH/21°C	53%RH/18°C
	82%		No further monitoring required as replacement of floor construction agreed		
	27%				
	19%				
	19%				
	20%	20%	20%	17%	13%
	17%	18%	18%	15%	13%
	15%	18%	17%	15%	13%
	15%	17%	17%	15%	12%
		12%WME			
		clear			
	20%	20%	19%	15%	13%
	16%	17%	17%	13%	12%
	17%	17%	17%	13%	12%
	16%	16%	17%	14%	13%
		15%WME			
		clear			
	20%	23%	22%	13%	14%
	19%	20%	21%	17%	15%
	16%	17%	17%	14%	13%
	15%	16%	17%	14%	14%
		9%WME			
		clear			
	20%	22%	19%	18%	15%
	18%	19%	18%	16%	14%
	17%	18%	17%	16%	14%
	15%	17%	17%	16%	13%
		13%WME			
		clear			

Drying time and the regime depends on a number of factors:

- time of year (outside weather conditions)
- building-fabric components and coverings
- porosity and permeability of the materials
- flood duration
- type of flooring
- water table
- ambient relative humidity.

Rushing into remedial work before the building is thoroughly dry could mean you have to re-do the work later on, doubling the disruption and expense. This is especially true of redecoration – most paints do not adhere well to damp substrates and many of the relatively impermeable modern paints will slow down the drying process if they are applied before the substrate is completely dry. The result is that paint will blister and underlying materials will decompose. However, with older buildings some areas may not have been dry before the flood occurred.

Base readings should be taken for the monitoring of the drying-out process. This allows the rate of drying out to be established as accurately as possible. Moisture levels can then be checked on a regular basis against these benchmark figures to establish the progress of drying and help highlight where problem areas may exist.

Natural ventilation

Begin the drying process by using only natural ventilation. Some or all of the following measures may be necessary to help ventilate the building. Even with standing water at low level, it is possible to start drying the rest of the building. However, it is preferable to remove mud and silt from floors by thorough washing at an early stage to avoid the potential hazard of inhaling dust as it dries.

- clear the mud and silt away from the bases of external walls, which should be at least 150mm below the level of internal floors, and return the surrounding ground to its original level.
- remove covers and flood detritus from airbricks around the base of the walls. The free passage of air is essential to enable suspended timber floors to dry out from both sides.
- open all doors (including those to cupboards), windows and roof-lights to allow the maximum amount of air circulation. It may be necessary to provide some temporary framing to maintain their correct shape.
- remove carpets and underlay, vinyl, linoleum and other impermeable surface coverings. Also remove any timber sheet coverings, such as hardboard or MDF sheets, which can absorb considerable quantities of moisture and are of no historic importance.
- move furniture and pictures away from walls so that they do not hinder drying.
- lift floorboards to ventilate the under-floor spaces. Even if the floorboards themselves are dry, lifting every sixth board will help to create vents for the damp area below. The easiest floorboards to lift will be those that are butt jointed or that have already been altered to accommodate radiator pipes. Lifting tongue-and-grooved or very old and tightly fitting floorboards without damaging them is difficult and should be left to a carpenter.
- sodden floorboards may be swollen and softened and can easily be damaged by rough handling. They should be lifted and left on edge, wedged apart, to dry. If they are laid flat they should be turned frequently to aid drying.

- remove saturated insulation. Most types of insulation, especially loose-fill varieties (cellulose, vermiculite, rock wool, blown fibre-glass), have air pockets that collapse under the weight of the sodden material, rendering the insulation permanently ineffective. They must be removed and discarded to allow the structure to 'breathe'. Insulation that does not absorb water may have to be removed temporarily if it is preventing water from evaporating, but it can be returned when the structure has dried out after cleaning.

- specialist advice should be obtained if asbestos-based insulation materials are found.

- old houses are likely to have hidden voids where air cannot circulate. Investigate awkward spaces behind panelling, box shutters and linings to door and window reveals. Check under stairs and inside cupboards and open them up if necessary to ensure the free flow of air. This work may necessitate the employment of a skilled joiner if damage to historic fittings is to be avoided.

- wallpapers that have no historic significance can be removed to aid the drying of plaster finishes.

Assisted drying

Natural ventilation alone may not be sufficient to produce balanced drying conditions and it may be necessary to assist the drying process with the use of fans. Conditions might be such that natural drying will be too slow, possibly giving rise to excessive mould growth and potential timber decay. Accelerated drying requires much management time if it is to be effective and non-damaging.

Mechanical ventilation - using fans

Controlled air movement with fans can speed up the natural drying process. Four times the air speed across a surface results in twice the rate of drying. To speed up the drying it helps to focus the air movement in strategic positions on the wetted areas: for example, if only the floor has been affected, erecting a polythene tent over this area concentrates the drying.

Background heating

Modest slow background heat (preferably around 18-20°C) can be introduced in the final stage of drying. If temperatures are low the air cannot hold much water, so a little background heat (controlled by a humidistat) can be beneficial at this stage. This must be accompanied by plenty of ventilation.

If heaters are used without adequate ventilation the absolute humidity may actually increase, potentially creating high-humidity conditions in other previously unaffected rooms.

Dehumidification

Aggressive dehumidification is best avoided for old buildings. The surface of the walls can appear dry but sub-surface water can migrate to the surface after a fairly short period of time. Dehumidification can dry lime plasters too quickly, resulting in cracking and deterioration.

Both refrigerant and desiccant dehumidifiers can be controlled by a humidistat. If these controls are used properly they can provide gentle drying conditions. The desiccant dehumidifiers are more effective, and potentially more efficient. They are smaller than refrigerant dehumidifiers, quieter in operation and can be used via hoses to send the drier air into voids and cavities. They can also be used to work on areas that have been isolated with polythene. However, they output at lower absolute humidity levels and therefore need to be carefully monitored by correctly placed humidistat controls.

Burford Church, Oxfordshire

This Grade I listed church was flooded to a depth of about 450mm in the summer of 2007, when the adjacent River Windrush broke its banks after torrential rainfall.

The floodwater deposited a layer of sandy silt over the floors and lower part of the walls. This water affected many of the floor-mounted contents, such as antique furniture, pews, kneelers, altar cloths and bookcases.

The first exercise was to remove all the contents that were at risk to a safe, secure and dry area of the church and to compile an inventory. Fabric items were dry cleaned and furniture was allowed to dry naturally.

Once the floodwater had receded vacuum cleaners and soft-bristled brushes were used to gently remove the silty deposits. A neutral detergent-and-water solution was used to gently clean the floor and walls. The same areas were then rinsed with clean water, dried with cloths and then allowed to air dry before being sprayed with a sanitising mist to kill any remaining bacteria.

Natural ventilation was maximised by the use of large fans strategically positioned within the church. The fans were set up so that they drew dry air into the building while at the same time blowing wet air out. Relative humidity measurements were taken at regular intervals.

The choir stalls, which were built on oak plinths with voids beneath, were opened up to allow air circulation and to allow access to the void for cleaning. The boards were numbered to ease identification for replacement. High-velocity fans were then used to dry the void and stone flooring.

No dehumidification or heating was used to dry the building and the church was certified dry less than seven weeks after the floodwaters had receded.

Large fans strategically placed to aid drying at Burford Church, Oxfordshire.
[photo © Phil Hadley/Continuity]

Monitor the drying process

It is important to monitor and check the drying process, taking regular moisture measurement readings. It is essential that the relative humidity and temperature are monitored and recorded both in and outside the building in order to know and assess the rate of evaporation and therefore the speed of water removal.

Base readings for the monitoring of the drying-out process should be taken as soon as possible. This allows the rate of drying to be established as accurately as possible – it sets a benchmark.

The key factors for the monitoring and control of a balanced drying process are:

- air movement – ie there must be sufficient ventilation to remove moist air
- air temperature needs to be maintained at preferably below 20°C
- air-moisture content - the relative humidity should be monitored and maintained at 40-50 per cent
- the physical properties of the materials to be dried.

The list below gives the various types of equipment for monitoring both air conditions and the moisture content of materials. An understanding of the use and limitations of each should inform their appropriate application.

- digital hygrometers
- resistance or conductance meters
- capacitance meters
- drilling equipment
- Karsten tube
- boroscopes or endoscopes

When has adequate drying been achieved?

The 'drying-out certificate' is what loss adjusters and contractors strive for; however, many old buildings might not have been particularly dry in the first place and it may not always be clear what the previous pre-flood condition of the building really was. Often a subjective judgment needs to be made, backed up with drying-monitoring data to establish when it is safe to commence with reinstatement and repair works.

The following criteria will determine whether sufficient drying has been achieved. Ideally a building or its contents should be returned to the same condition that existed prior to the flood.

- Internal conditions are normal for that particular property. Old buildings are damper than new buildings so the criteria has to be 'dry for the purpose' – ie equilibrium in moisture content has been achieved.
- The remaining moisture will not support the active growth of fungal spores, mould, mildew or insect infestation.
- The building materials and contents will finish returning to equilibrium under normal room conditions by themselves without further damage. Acceptable levels of moisture content will differ depending on the materials involved.

Image 38
Flooded cottages at Tewkesbury.
[photo © Nick Kirk/PA]

5.5 How flooding affects historic building materials

Although relatively resistant to flood damage, historic-building materials can all suffer some degradation and may need appropriate treatment. These materials include stone, solid brick-and-mortar walls, timber frames, wattle-and-daub panels, timber boarding and panelling, earthen walls and floors, lime-plaster walls and ceilings and many decorative finishes.

Organic materials such as timbers swell and distort when wet and suffer fungal and insect infestations if left damp for too long. If dried too quickly and at temperatures that are too high, organic materials can shrink and split, or twist if they are restrained in panels. Inorganic porous materials do not generally suffer directly from biological attack.

Significant damage can occur when inherent salt and water (frost) crystals carried through the substrate are released through inappropriate drying or very cold conditions (see next column).

Masonry

As they recover from flood saturation, masonry walls can be damaged by inherent soluble salts and by salts absorbed in rising damp from groundwater. When masonry is saturated, the salts dissolve but when the water evaporates, the salts are carried nearer to the surface, where they crystallise and can appear as a powdery white residue called 'efflorescence'. Although unsightly, this is not usually harmful and can be brushed, vacuumed or washed away. Problems arise if the salts are trapped behind a relatively impermeable coating, such as a water-repellent sealant, or an oil-based or acrylic paint.

The salts crystallise within the substrate and expand, pushing off the surface of the brick or stone in processes known as 'spalling' or 'exfoliation'. It is therefore important to allow historic masonry to breathe effectively after flooding.

The removal of historic lime plaster from its surface is rarely justified, as this should not inhibit drying – its relative porosity should actually assist substrate drying. Permeable coatings such as lime-wash can be used to decorate damp surfaces while allowing them to go on drying without damage.

The spalling of soft brick or stonework usually occurs on building exteriors when the temperature drops below freezing while moisture is still trapped within walls. Water expands below 4°C as it turns to ice crystals, causing spalling on wall faces. Lime-mortar joints can also become weakened by these processes and by the long-term seepage of contaminated water through masonry. Impermeable, heavily cement-based mortar will exacerbate deterioration during a flood because it holds the moisture in the masonry for longer and causes salts to crystallise within the historic materials. Its wholesale removal and replacement with weaker porous lime-based mortar will help the walls to dry out.

After winter floods, very soft saturated bricks on the outside of the property should be protected from frosts and rain by inert (ie water-resistant) insulation and by putting up a ventilated shelter – a temporary lean-to, screen or tarpaulin – and allowed to dry out slowly.

Masonry flooded by sea water should be rinsed down several times with clean salt-free water as soon as possible after the flood has subsided and then allowed to dry out slowly so as to minimise the effects of chloride-salt damage to soft masonry.Where stone, terracotta or tile paving laid on to bare earth appears to be suffering from rising damp and salt migration following flooding, rake out the mortar joints and leave them open. These can be filled with clean dry sand to increase the surface area for drying and thus provide sites for crystallisation to take place. Later, re-point the joints with sacrificial, highly porous, lime-based mortars to help wick the salts away from the historic paving and into the mortar. Periodically, the mortar may become saturated with salts and have to be replaced. However, this will be far less damaging and more cost effective than having to deal with damaged paving.

Do not seal the paving with wax, oil or polyurethane varnish as sealants will encourage

salt sub-florescence and the breakdown, powdering or exfoliation of the paving slabs themselves, as well as the wicking of moisture into any surrounding porous walls.

Concrete

Concrete floors and screeds, once saturated, can take a long time to dry. Remove and do not re-lay impermeable or low-permeability coverings that restrict drying. Where timber boards on battens or parquet-block floors have been laid over concrete, the coverings may have to be lifted out of the way to permit the concrete to dry effectively. In some cases this may be avoided by the use of injection-drying methods.

Earth construction

Cob clay-lump and other forms of unbaked earth-wall construction can be particularly vulnerable to water damage. Earth buildings are nearly always constructed on a masonry plinth to protect them from water damage. If floodwater rises above the plinth for any prolonged period the cob will begin to disintegrate. It is important to keep the external plaster finish well maintained and to repair it with appropriate materials.

Structural timber

When saturated (ie when the moisture content goes above 25 per cent), timber is vulnerable to rot as a result of fungal and insect attack. Like other living things the organisms that cause rot need food (wood and water) in order to grow. In most building environments the missing element is water. As long as it is kept dry structural timber can last for centuries. The wood used in many historic buildings has a high resistance to decay.

Moreover, decay mechanisms must exist for a long period of time in order to become destructive. A one-off event such as a flood should not cause serious damage as long as the wood is allowed to dry afterwards.

Problems occur when moisture is trapped in the wood and cannot escape. This can happen in wall cavities, in sill plates under floors, behind panelling and under impermeable finishes such as oil-based gloss paint. If the moisture content exceeds 28 per cent then dry rot spores could germinate.

Ventilate hidden voids (as previously described) and take the advice of a conservation professional before you consider stripping historic paint finishes or surface decoration. Such work may require Listed Building Consent.

Key-hole injection-drying techniques may assist in these situations.

Flaking paint does not necessarily signify that the underlying timberwork is rotten, merely that it is temporarily wet. In most cases timber can be dried and returned to a fair state ready for repainting.

Timber panelling and other woodwork

Water trapped behind panelling can be allowed to drain out by drilling tiny holes. It may be possible then to dry behind the panelling with injection drying. Where this is not possible the panelling should be photographed and the individual pieces should be numbered before being gently dismantled by specialist joiners (for listed buildings such work may require Listed-Building Consent). Dry the panelling out in a dry, well-ventilated space. The pieces should be stacked with spacers, turned over periodically and loaded with uniformly distributed weights to counteract warping.

Floorboards can buckle if they become saturated as a result of prolonged immersion in water. Removing a number of intermediate boards can help to allow some expansion without causing permanent damage to the boards. If boards are buckled they will need to be taken up and carefully stacked and allowed to dry slowly. If the buckling has been considerable they may never regain their previous profile and may need to be replaced.Skirting boards, door frames and other items of internal joinery are likely to survive a flood intact. After drying they should return to their original size and form and can be retained. It may be necessary to remove skirting boards and the linings of door and window reveals to help the wall dry out. All such items should be carefully numbered, stacked as for panelling and returned to their original locations.

Panelled doors usually survive flooding surprisingly well. They should be allowed to dry in place, but left open to help air circulation. They may need

stabilising frames during drying or repair to correct warping, or to strengthen joints if their original glue was not waterproof. Repairs should not be attempted until the doors are completely dry.

Timber staircases can suffer swelling and shrinkage in their many components during and after flooding, and this can lead to the loosening and weakening of structural joints. If necessary, stabilise loose treads with additional underside blocks and fixings once the staircase is dry. Ensure that natural ventilation reaches both the upper and lower side of the stair so that the timber dries evenly; this will reduce distortion.

Independent experts can be hired for advice on drying and treating woodwork to prevent decay. They can carry out surveys to assess the potential risks of fungal and other infestations and have the tools to monitor the welfare of concealed or remote historic timbers over time.

Render and plaster

The term 'plaster' covers a wide range of wall and ceiling coating materials, each with its own chemical and physical responses to water saturation. Older lime-based plasters may soften and swell when wet, usually without collapse, and harden again once dry. De-bonding of lime plaster can occur as the underlying laths swell and shrink when wet, causing breakage of plaster nibs. De-bonded plaster can be re-anchored using resins and screws. Lime is very porous and helps underlying fabric to 'breathe'.

Modern gypsum-based plasters are water sensitive and hygroscopic. The calcium sulphate in the plaster is partially soluble in cold water, so they deteriorate and may need remedial treatment or replacement.

Modern plasterboards, which incorporate paper linings that deteriorate when wet, are fixed to the walls by plaster dabs and may come unstuck and need replacing.

If in doubt about the authenticity or importance of the plaster material, consult your local planning authority's conservation officer.

Do not assume that unsound plaster will sound hollow when tapped and must therefore be removed or repaired. Traditional plasterboard is often based on timber laths attached to battens and always sounds hollow even when it is in good condition.

Check for obvious cracks and areas where plaster has bulged on walls or sagged on ceilings. Some of this deterioration could be historic deformation unrelated to flooding. Localised damage to the substrate in rotted timber lathing, for example, may need key-hole-type repairs. New plasterwork should be in lime to maintain the 'breathability' of the building.

Take the opportunity to use lime-based renders in reinstatement works, which will afford greater resistance in any future flooding.

Metalwork

Aluminium, bronze, copper and brass objects, components and fixtures will not be damaged by immersion in water as long as they are allowed to dry quickly. Iron and steel will oxidise and rust and expand when exposed to water, though they should not be harmed by a single immersion as long as they are dried quickly.

Rusting, particularly in maritime environments, can lead to serious structural problems where metal components such as steel sections or reinforcements in concrete lintels are embedded within saturated walls that do not dry quickly. Here, the exfoliation of oxidising metal sections or the expansion of the metal causing spalling of the concrete can reduce the bearing capacity of the beam or lintel and result in cracking, if not collapse. Check the lintels: cracks, deformation or oxide-staining (rust-staining) are signs of distress and should be inspected by a structural engineer.

Similarly, ties, cramps, pipes and conduits in masonry walls or floors can continue to oxidise and expand once rusting has commenced, leading ultimately to cracking and spalling of surfaces and possibly to localised de-bonding and structural failure.

Simple surface staining can be cleaned, primed and redecorated.

Buscot and Coleshill Estates, Oxfordshire

The Buscot and Coleshill estates lie predominantly on the western border of Oxfordshire and are almost entirely owned by the National Trust. More than 50 properties were flooded to differing degrees in July 2007 although none were identified as being in areas of high flood-risk. Some properties had a few millimetres of rainwater for about an hour while others were inundated with river and field water to a depth of about one metre for up to a week after the rivers Cole and Thames broke their banks.

The drying process was much the same for all the properties affected. Wherever possible natural drying and ventilation was used and supplemented with low-level dehumidification, gentle heating and the use of fans.

Removal of fixtures and fittings was restricted to the carcasses of modern kitchens. All historic features remained *in situ*, including one property that had oak panelling to one room. This was dried slowly without warping or cracking. Lime plasters dried out well, but where these had been replaced with gypsum plaster this was removed to allow the building fabric to dry and was then later replaced with a lime plaster. For buildings with suspended timber floors water was first pumped out and then a small number of boards were lifted to allow for cross ventilation. Regular inspections were then carried out. Those properties with stone floor-slabs were just left to dry and then cleaned. Any pointing that was missing or damaged was replaced several weeks later with lime mortar.

Many of the buildings had a mixture of materials. The traditional materials performed well but the more modern materials had to be removed completely.

Flooding on the Buscot and Coleshill Estate.
[photo © National Trust]

Ironmongery

Once they have dried out locks and hinges can be dusted with powdered graphite to prevent squeaking and seizing. Historic metalwork can be temporarily lacquered or waxed by conservators to limit future damage by flooding

Wall-coverings

When wet, paper and paste can provide food for mould growth. Non-historic wall-coverings should be carefully removed and discarded. Consult a specialist conservator (see Institute of Conservation, ICON Section 6, Further Information) about moving, cleaning and disinfecting historic wall-coverings, whether of paper, textile, pressed metal, leather or other material.

Paint finishes

Water can cause the staining, flaking, blooming and dissolution of binders in historic varnishes and paints. Permeable traditional paint finishes such as lime-wash and distemper, which allow moisture to evaporate through their surfaces from the substrate, can be cleaned, disinfected and left to air dry or repainted to match. Do not paint any previously painted interior surface with relatively impermeable modern paints such as alkyd oil-based paints or acrylic emulsions until it is completely dry.

Relatively impermeable modern finishes may have to be stripped off completely to allow the substrate to dry out effectively. Historic paintwork should be treated by a specialist conservator.

Old paint may contain white lead carbonate. Special precautions (such as the use of face masks and gloves) must be observed when handling lead-based paint and it is best left to qualified painters and decorators.

Wall paintings

Do not use dehumidifiers or heaters in interiors that have historic wall paintings on plaster or timber. Specialist advice should be sought from conservators. Slow substrate micro-drying assisted by cold-air fans, supervised by a conservator, should avoid salt crystallisation, paint flaking and mould growth.

Re-servicing

Modern services are especially vulnerable to flooding and can represent a significant proportion of any refurbishment cost. All retained services should be tested and re-commissioned by an appropriate engineer. Insensitively applied re-servicing, especially to meet current standards, can be both intrusive and damaging to historic buildings.

Personal possessions

Specialist conservators can return many badly damaged items (papers, photographs, certain fabrics,) to their previous condition.

Cost and programme implications

There are no standardised costs - costs for two similarly flooded buildings may vary according to both their historic importance and any statutory requirements for reinstatement required by the conservation officer.

Insurance cover should provide fair and reasonable economic settlement to restore the building to its pre-flood state without any long-term adverse effects. Costs should include any necessary specialist advice and procedures, and given the potential complexity of any specialist repairs, be agreed without a fixed settlement period.

Programmes for slow and careful drying and sympathetic repair will inevitably appear prolonged compared with the stripping-out and replacement works for flooded new buildings, and will vary according to the extent of flood damage.

5.6 Monitoring the long-term effects

As the building and surrounding land dry out, monitor the stability of the walls and floors and the integrity of the mortar joints. Any cracks that appear in foundation walls or around openings should be investigated. If they are the result of temporary hydration and expansion of the underlying clay soil around the foundations, the cracks should shrink or at least cease to expand when the water content of the soil returns to normal.

Cracks from foundation erosion, however, can be expected to worsen over time as the building settles. Cracks that widen or move are signs of structural instability that warrants careful examination by a structural engineer.

Under-floor timbers should be inspected six months after flooding and then annually, for evidence of fungal infestation and rot. Fibre-optic boroscopes of diameters as small as 6mm are useful for investigation within the fabric via small boreholes or where skirting boards have been temporarily removed. Experience and skill are required to interpret such observations accurately.

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Images 39–41

39. St Michaels and All Angels Church at Tirley, Gloucestershire.
[photo © PA]

40. Flooding at Lancaster Quay.
[photo © Environment Agency]

41. Flooded brick cottage at Tewkesbury.
[photo © PA]

6 Where to Get Advice

6.1 Grants and loans

Historic England

Grants for emergency works may be available for the conservation and repair of Grade I and Grade II* listed buildings and scheduled monuments following floods where insurance does not cover specialist work. For further information contact the relevant regional office (see inside back cover).

Local authority

Grants may be available from the local authority for properties at high risk that are unlikely to benefit from community flood defence schemes.

6.2 Principal sources of flood advice

Association of British Insurers (ABI)

The ABI represents the collective interests of the UK's insurance industry. www.abi.org.uk

British Damage Management Association (BDMA)

The BDMA is the certifying authority for recovery, restoration and damage-management practitioners. www.bdma.org.uk

Department for Communities and Local Government (CLG)

This department leads the government's response on recovery following major flooding. The department provides support and grants to local authorities. www.communities.gov.uk

Department for Environment Food and Rural Affairs (DEFRA)

Defra is the government department which has overall policy responsibility for flood and coastal-erosion risk in England. Defra funds most of the Environment Agency's flood-management activities in England and provides grant aid to local authorities and drainage boards to support investment in projects to manage flood and coastal-erosion risk. www.defra.gov.uk

Environment Agency

Their job is to make people aware of flooding from rivers and the sea, provide flood-warning services and build and maintain flood defences.

- Floodline 0345 988 1188 24hrs a day
- Free Floodline Warnings Direct service

www.environment-agency.gov.uk

Flood Protection Association

The Association was founded in 2002 as the trade body for the flood-protection industry. www.thefpa.org.uk

National Flood Forum (NFF)

The NFF is a registered charity that offers advice and information on all types of flooding, from main rivers, local watercourses, sewers, storm water and highway drains, tidal and coastal flooding, and groundwater to run-off from urban areas or agricultural land.

They offer free advice to individuals or groups on flood-protection products and specialist help and advice on insurance issues. www.floodforum.org.uk

Register of Architects Accredited In Building Conservation (AABC)
The AABC holds a register of architects who have been assessed as to their individual knowledge and experience of conservation work. www.aabc-register.co.uk

Royal Institute of British Architects (RIBA)
The RIBA is the UK body for architects and the architectural profession. www.architecture.com

Royal Institution of Chartered Surveyors (RICS)
The RICS is an independent organisation that sets and regulates standards for chartered surveyors. The RICS has a database of surveyors who have experience and knowledge of working with old buildings. www.rics.org.uk

Society for the Protection of Ancient Buildings (SPAB)
The society provides much useful guidance and advice on appropriate repairs to traditional buildings. www.spab.org.uk

6.3 Other sources of advice and information

Association of Building Engineers (ABE)
www.abe.org.uk

BRE (Buildings Research Establishment)
www.bre.co.uk

British Hydrological Society
www.hydrology.org.uk

BSI (British Standards Institution)
www.bsi-global.com

Chartered Institute of Loss Adjusters (CILA)
www.cila.co.uk

Chartered Institution of Water and Environmental Management (CIWEM)
www.ciwem.org

CIRIA (Construction Industry Research and Information Association
www.ciria.org

Electrical Safety Council (ESC)
www.esc.org.uk

Institute of Conservation (Icon)
www.icon.org.uk

Institute of Historic Building Conservation (IHBC)
www.ihbc.org.uk

Institution of Civil Engineers (ICE)
www.ice.org.uk

Institution of Structural Engineers
www.istructe.org

The UK Climate Impacts Programme (UKCIP)
www.ukcip.org.uk

UK Resilience
www.ukresilience.gov.uk

7 Publications

Association of British Insurers (no date). *Repairing your Home or Business after a Flood: how to limit damage and disruption in the future* (joint publication with the National Flood Forum)

Association of British Insurers (no date). *Responding to Major Floods: what to expect from your home insurer*

British Damage Management Association. Publishes three flood-advice leaflets:

- *Understanding Basic Flood Recovery Procedures*
- *Self Help for Victims of Flooding Record of Flood Recovery Activity and Personally Appointed Contractors*
- British Standards Institute 2013. PAS 64 *Mitigation and recovery of water damaged buildings-code of practice.* London, BSI.

Cabinet Office 2008. *The Pitt Review: Learning Lessons from the 2007 Summer Floods.* London: Cabinet Office

Cassar, M and Hawkings C (eds) 2007. *Engineering Historic Futures Research. Stakeholders Dissemination and Scientific Research Report.* London: UCL Centre for Sustainable Heritage

DCLG 2009. *Planning Policy Statement 25: Development and Flood Risk - Practice Guide.* ***London:*** Department of Communities and Local Government

DCLG 2010. *Guidance and standards for drying flood damaged buildings* London: Department of Communities and Local Government

Defra 2005. *Making Space for Water: Taking Forward a New Government Strategy for Flood and Coastal Erosion Risk Management in England.* First Government response to the *Making space for water* consultation exercise. London: Defra

English Heritage 2003. *Coastal Defence and the Historic Environment. English Heritage Guidance.* London: English Heritage (product code 50756)

English Heritage 2006. *Shoreline Management Plan Review and the Historic Environment. English Heritage Guidance.* London: English Heritage (product code 5I238)

English Heritage 2008. *Climate Change and the Historic Environment.* London: English Heritage (product code 5I392)

Environment Agency. Publishes three flood-advice guides:

- *Preparing for a Flood: Practical Advice on What to Do to Stay Safe in a Flood Property*
- *During a Flood: Practical Advice on What to Do to Stay Safe in a Flood*
- *After a Flood: Practical Advice on Recovering from a Flood* (available to download from publications.environment-agency.gov.uk)

Flood Repairs Forum 2006. *Repairing flooded buildings: an Insurance Industry Guide to Investigation and Repair of Flood Damage to Housing and Small Businesses.* Watford: BRE Press (available from www.brebookshop.com)

Foresight. *Future Flooding* 2004, Flood and Coastal Defence Project.

Garvin, S, Reid J and Scott, M 2005. *Standards for the Repair of Buildings Following Flooding.* London: CIRIA

Historic Scotland 2014. *Flood Damage to Traditional Buildings.* Edinburgh: Historic Scotland

National Flood Forum. Publishes a series of 'Beginner's Guide to Flooding' fact sheets:

- Fact Sheet 1 – *How Do I Find Out if I'm at Risk of Flooding and What Should I Do if I Am?*
- Fact Sheet 2 – *What Preparations Can I Make to Protect Myself from Flooding?*
- Fact Sheet 3 – *I'm Just About to Flood, Help!*
- Fact Sheet 4 – *What You Can Do to Protect Your Home in the Future* (available to download from www.floodforum.org.uk)

National Flood Forum. Blue Pages Directory. An independent directory of flood-protection products and services to improve your home's flood resilience. (www.bluepages.org.uk)

Ridout, B 2000. *Timber Decay in Buildings: The Conservation Approach to Treatment.* London: E and F N Spon in association with English Heritage and Historic Scotland

White, I. O'Hare, P. Lawson, N. Garvin, S. and Connelly, A. 2013. *Six steps to flood resilience-guidance for local authorities and professionals.* Manchester.

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