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Improving local flood protection to property

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Local flood protection comprises a range of local measures that are available to property owners and small communities in order to prevent or reduce the damage to property from flooding. These include temporary barriers adjacent to properties, moveable barriers fitted to houses and flood-resistant building materials and fittings. Effective use of local protection promises significant benefits. This paper describes the guidance drawn together and developed by the Environment Agency and its partner organisations to promote the use of local protection. The need for effective communication with property owners—as well as local authorities, insurance and building industries—is highlighted.

The autumn 2000 floods served as a reminder of the complexity of flooding and that it is impossible for operating authorities to guarantee defence against extreme and unusual events. Flooding occurred in over 700 locations and affected over 10 000 properties. The Environment Agency's assessment¹ of these flooding incidents was that

- 28% were due to overtopping, out-flanking or failure of formal defences, mainly under flood conditions that exceeded the design standard
- 40% occurred at locations where no defences existed, some with no history of flooding
- 32% were due to flooding from ordinary watercourses, inadequate local surface water drainage, sewers and third party defences, many outside the indicative floodplain.

Three points were clear from assessing the lessons learnt from the floods. First, the use of local protection significantly reduced the impact of flooding. Emergency response was strongly dependent on the use of sandbags (Fig. 1) and better understanding of other options for temporary defences and their performance

was desirable. Second, where local protection of property adequately anticipated the flood hazard (e.g. sewer or river flooding), modest investment in local protection provided major returns to property owners. Third, better public information on local protection and the repair and restoration of flooded property was needed nationally.

In the light of this, the Environment Agency, alongside its partner organisations in government and industry, has championed an improved understanding of the concept of local flood protection, together with best practice guidance on its selection and use. The Environment Agency sees this as a major action under its flood awareness campaign message

Flooding. You can't prevent it.
You can prepare for it.

Partner organisations include property insurers and mortgage lenders, and water companies and local authorities. The latter are actively looking for alternatives to sandbags.

The traditional view of flood defence taken by the public, and indeed by the civil engineering profession, is of permanent engineered structures, such as flood embankments and barrages. This is probably right, as the principal line of defence against flooding is the formal flood and coastal defence infrastructure for which operating authorities are statutorily responsible.

There has until recently been little tradition in England and Wales of property owners or communities taking a proactive approach to mitigate damage to their property in areas of flood risk. Hence, the common picture of communities and residents battling against rising floodwaters with sandbags (Fig. 1). In fact, a range of



Fig. 1. Sandbag protection to property—indicative of a reactive rather than proactive approach



local measures is available for reducing the risk of flood damage to property. It is entirely appropriate in the context of flood risk management that local protection addresses the residual risks that formal defenses do not cover. Similarly in many sustainable solutions, the ‘top down’ national or regional framework co-exists with the ‘bottom up’ local response.

Types of local protection

Methods of local protection against flooding can be categorised in terms of their relation to the route followed by the floodwater (Fig. 2) or to the property itself.

- *Temporary and demountable barriers.* These prevent floodwater from reaching the property. These will typically protect a group of properties and can be effective river bank defences (Fig. 3).
- *Moveable barriers.* These devices are designed to seal potential flood routes

into the property, i.e. doors, windows, airbricks, sewers and drainage pipes. Flood skirts are designed to ‘wrap’ around properties thus preventing floodwater from seeping through the building fabric as well as through openings.

- *Materials and techniques that minimise damage from floodwater if this gets inside the property.* Materials will either resist water penetration or will not degrade when wetted and will be capable of drying out. There are many techniques to reduce the damaging effects of floodwaters, including re-siting fittings and living areas above flood level.

Risk assessment for local flood protection

The level of investment in local protection, not only from householders but also from local authorities, water companies, insurers and mortgage lenders, will depend

on the assessment of flood risk. For existing property, this will often be influenced strongly by the local history of flooding. For new development, flood risk assessment must follow the guidance in the new planning policy guidance (PPG) on flood risk.² Whatever type of local protection is selected, it is essential to give thought to the steps to be taken after a flood warning is given in order to minimise flood risk and consequential damage.

The selection of local protection measures should take into consideration

- likelihood and type of flooding in the vicinity of property
- ways floodwater gets into property
- impact or damage that is caused by floodwater to fabric and fittings of property.

The public is now more aware of the risk of river flooding through recent media coverage of floods and the Environment Agency’s flood awareness campaigns but is usually less aware of the risk of flooding from the sewer drainage system or rising groundwater.

Vulnerability of buildings to floodwaters

There is much circumstantial evidence of the performance of different building materials and forms of construction under flood conditions. Useful source material for the UK is provided in the key Building Research Establishment *Good repair guide*³ and the Construction Industry Research and Information Association (CIRIA) review entitled *Reducing the Impacts of Flooding*.⁴ Building details and advice are summarised in *Preparing for Floods*.⁵

Walls

In the UK the use of solid walls and cavity walls with a brick/block, or a timber inner leaf is common. The external face of brick or concrete block can be permeable to water and deterioration occurs with age—cracks and voids can form within mortar joints allowing water penetration during floods. Cavity wall ties to a brick/block inner leaf can corrode after flooding unless they are stainless steel. An inner timber cavity wall is unlikely to be affected provided it is dried out promptly after flooding. Airbricks and

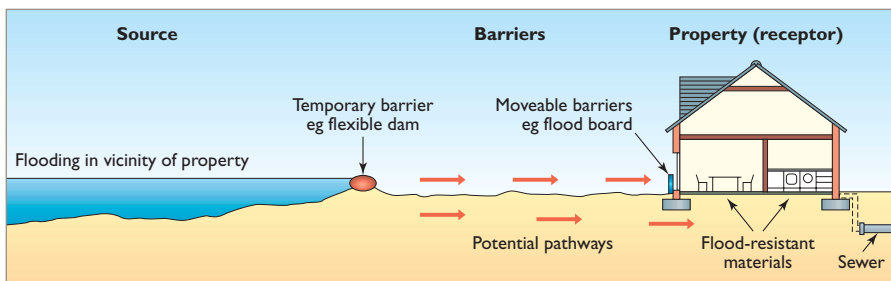


Fig. 2. Source, routes and receptor diagram for floodwater showing various methods of providing local protection



Fig. 3. Temporary/demountable barrier in operation (courtesy Pallet Barrier, Geodesign AB)

“Repairs to walls, flooring, kitchen fittings and services could all incorporate flood-resistant materials and forms of construction”

open joints in brickwork are used to improve ventilation below suspended floors but can also act as flood routes. Regular maintenance of exterior walls and the use of water-resistant coatings will reduce flood penetration.

Floodwater may cause serious damage to the internal faces of walls. Plaster or plasterboard coverings have low flood resistance and must be replaced following flooding. Water-resistant liners, renders, lime-based plaster and ceramic tiles all reduce flood damage and water penetration. There are no current options for improving the internal face of a timber-framed wall other than removing the plasterboard to allow the timber to dry (Fig. 4).

Floors

In the UK, common floors are either of solid (concrete) or suspended (timber or concrete) construction. Solid concrete floors are the most resilient to flooding but can take time to dry out. Floodwaters collect in the void beneath suspended floors. Grading the sub-layer to encourage drainage to an outlet at a low point may be an effective mitigation measure.

Timber joists and boards of suspended floors dry out after flooding but need treatment with preservative. Chipboard flooring deteriorates rapidly in a flood and usually needs replacing with treated floorboards or waterproof plywood. Modern buildings usually have mineral wool insulation between timber joists, which needs replacing after a flood.

Internal fittings and services

Kitchen fittings are almost exclusively chipboard or medium-density fibreboard with a plastic coating and invariably need replacing after a flood. Floor-standing appliances are vulnerable to water damage though opting for readily removable components should reduce this. Electrical wiring and sockets are usually located at a low level in older properties and long duration floods may penetrate insulation requiring the replacement of wiring. Water and silt can find its way into gas systems affecting their safe operation.

Reinstatement of property after flooding

The process of cleaning up property and repairing damage after a flood

requires careful planning. The recovery phase after a flood is a very stressful time for property owners. Flood victims need to deal with a lot of unfamiliar issues, such as insurance, health and safety, turning off services, security and emergency accommodation, before they can start the business of cleaning up. Three main steps to be taken before restoration or reoccupation are

- removing sediment
- cleaning and disinfecting
- drying out.

When planning repairs, consideration should be given to improving the local flood protection. For example, if flooding has resulted from backing-up within the drainage system, owners should consider getting an anti-flooding device fitted. Repairs to walls, flooring, kitchen fittings and services could all incorporate flood-resistant materials and forms of construction. For example, fittings could be removable wherever possible (e.g. cupboard doors), water-resistant materials (e.g. u-PVC or solid wood) could be used, and a solid floor with a high-quality tiling and loose fitting rugs could be installed. Fitted carpets should be avoided where possible. Without guidance, inappropriate materials are often used for reinstatement.

Guidance on local protection and self help

Four new guidance documents on local protection have been produced since January 2001 for distinct user groups of practitioners and property owners. Each has been supported by a project in the



Fig. 4. Drying out a timber frame wall and floor structure after flooding (Courtesy of BRE)

UK government's Department for Environment, Food and Rural Affairs and the Environment Agency's research and development programme. Provision of this best practice guidance has been developed through research contracts and a significant amount of the basic information has been collected from outside the UK, notably from the Federal Emergency Management Agency in the US.

The four areas of guidance are as follows.

- The CIRIA website *Repair and Restoration of Buildings Following Floods*⁶ (Fig. 5) (compiled in collaboration with the Environment Agency and the Association of British Insurers, using technical information from CIRIA and the Building Research Establishment) and the Environment Agency/CIRIA guide entitled *After a Flood—How to Restore your Home*.⁷ These are aimed at helping flood victims to clean their property and to repair the damage caused by flooding. Experience following the autumn 2000 floods indicated that mistakes and delays were taking place because first-time flood victims have little knowledge of what to do. Many were unaware of the potential to reinstate with water-resistant materials. Others needed help to communicate with professionals and tradespeople, and to understand the technical literature. The CIRIA-run website was opened in February 2001 and has averaged 2000 hits per month.
- The Environment Agency/CIRIA guide entitled *Damage Limitation—How to Make your Home Flood*



Fig. 5. CIRIA website on how to repair and restore buildings following floods

Resistant (Fig. 6).⁸ This is a partner publication to *After a Flood*⁷ and provides practical advice to property owners on simple measures to make their houses more likely to withstand the effects of flooding. The measures cover the use of sandbags, flood boards and plastic sheeting as barriers to exclude floodwater, as well as basic internal measures to improve the resistance of the interior fabric to flood damage. 30 000 copies of each guide have been distributed to households in flood risk areas during the Environment Agency's 2001 flood awareness campaign. They are available on the *Floodline* pages of the Environment Agency website at www.environment-agency.gov.uk/flood.

- *Preparing for Floods—Improving the Flood Resistance of Domestic and Small Business Properties*.⁵ This publication will become the UK's principal guide to property owners on ways to



Fig. 6. Environment Agency/CIRIA guide on damage limitation



Fig. 7. Moveable barrier in front of a doorway (Floodgate flood board)

improve the flood resistance of their properties. The guide is also intended for use by developers, local planning authorities and others involved in the construction of new buildings and in the renovation of existing buildings at risk of flooding. The latter involves the so-called 'retrofitting' of flood resistant measures. The guide was published in February 2002 as interim guidance and is to be reviewed in 2003. *Preparing for Floods* supports the requirements of the new PPG 25, *Development and Flood Risk*,² for developers to consider measures to deal with flood risk in specified flood zones. It forms the 'supplementary design guidance on flood-resistant construction techniques' referred to in the PPG. This formal recognition of 'flood-resistant' construction results from pressure from stakeholders during the consultation stage that the new PPG should endorse and promote more appropriate forms of construction.

- The Environment Agency guide entitled *Temporary and Demountable Flood Protection Systems*.⁹ This technical guide is intended for use by professionals in operating authorities and the emergency services involved in developing flood emergency plans or more permanent flood defence. It also provides advice to communities in which conventional flood defences cannot be justified economically. The guide was published in April 2002, also as interim guidance.

Strong messages of 'being prepared for flooding' and 'people helping themselves' underlie the various guidance documents. Care has been taken not to give the impression that the planning and use of local protection is simply a form of 'do it yourself'. Property owners are reminded of the role of professionals and of the need to take advice and not to attempt work that is beyond their capabilities. Explaining the concepts of

- performance of products and materials under flood conditions
- assessment and management of flood risk

has been problematic. Key issues covered by the guidance and ongoing research are considered in the remainder of this paper.

Application of local protection Moveable barrier protection

The principal moveable barriers used on buildings are flood boards in doorways (Fig. 7) and airbrick covers, but moveable barriers can also be used for windows, patio doors and garages. They are generally designed for quick installation on receipt of a flood warning. For the majority of properties, the external walls have sufficient strength to retain flood depths of up to 0.9 m.

Moveable barriers, such as flood boards, can be ineffective where the property's walls are permeable or cracked. It is essential to consider how the groundwater below the barrier or the property will respond to local flooding and the differential head caused by the barrier. The response of local groundwater levels and the consequent seepage through the floor may lag behind the floodwater. Often, the weakest link is the junction between the barrier and the wall or adjacent high ground. Flood boards are used extensively in Venice to exclude high tidal water from properties.

Flood boards are typically made of a metal, synthetic cellular or wooden construction and normally slide into a frame attached to the doorframe to provide a watertight seal. The pressure of floodwater helps to seal the barrier but this can be enhanced by seals or a purpose-applied sealant. A beneficial feature on some flood boards is a positive locking action that compresses the seal. More heavily reinforced and supported construction is used for wider openings. Airbrick covers are usually plastic and are clipped onto a frame fixed around the airbrick or vent opening. It is essential to remove airbrick covers after use to restore ventilation.

Flood skirts are flexible lengths of water-resistant material designed to be stored flush with the ground when not in use and attached with fastenings to surround a building before a flood to prevent water seepage.

Anti-flooding devices are fitted in the drainage system close to the property to prevent flooding through backflow in sewers. Types of closure device include flap gates, gate valves and ball valves, some of which are electrically powered and alarmed.¹⁰ Clearly there is loss of use of the normal drainage of the foul water when these are closed.

In the new Environment Agency guide, *Temporary and Demountable Flood Protection Systems*, 27 currently available systems are reviewed

Temporary barriers

Temporary defences cover a range of different functions. They can enhance formal flood defences, for example, to add height to a flood embankment during an extreme flood event or be used by a small, otherwise undefended, community (Fig. 8). In the new Environment Agency guide, *Temporary and Demountable Flood Protection Systems*,⁹ 27 currently available systems are reviewed. Most of these have some service or testing history. Many are not of UK origin, being mainly from elsewhere in northern Europe or the US where there is most experience of their use. These systems are categorised in the guide as

- filled container, with permeable or impermeable liner (Fig. 9)
- air or water filled tube
- flood barrier—free standing (Fig. 10)
- flood barrier—with frame (Fig. 11)
- panel barrier, comprising interconnecting rigid lengths.

It is the different structure and functional components of these different systems that makes the new guide desirable. The guide sets out a procedure for system selection and design based on these generic types. Access is given to current suppliers and manufacturers through the Environment Agency’s *Floodline* web pages. The first issue to be addressed in considering the use



Fig. 8. Temporary barriers can be used to protect a small, otherwise undefended, community

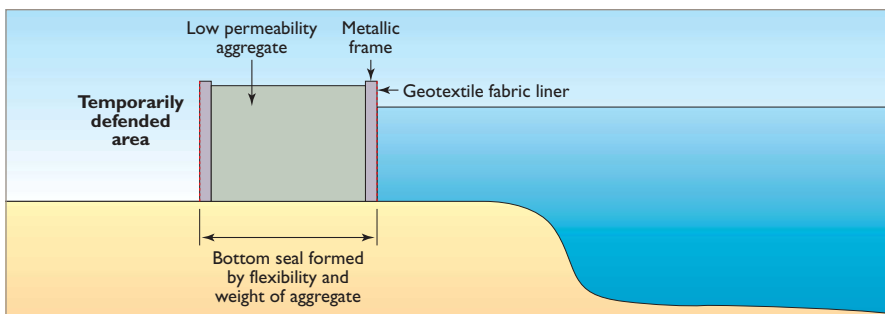


Fig. 9. Filled container type of temporary barrier (courtesy Hesco Bastion Ltd)

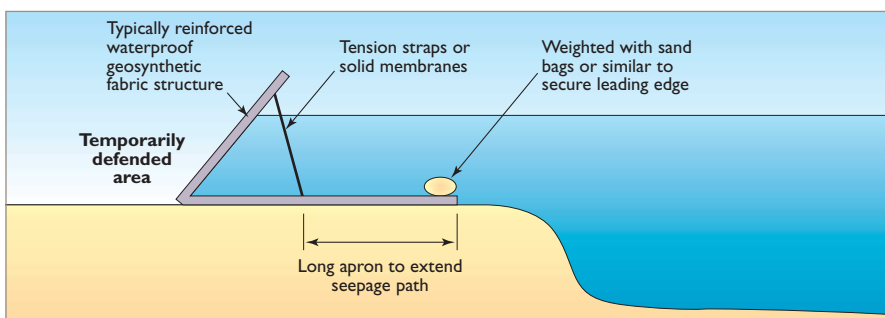


Fig. 10. Free-standing type of temporary barrier (courtesy Hydrscience Ltd)

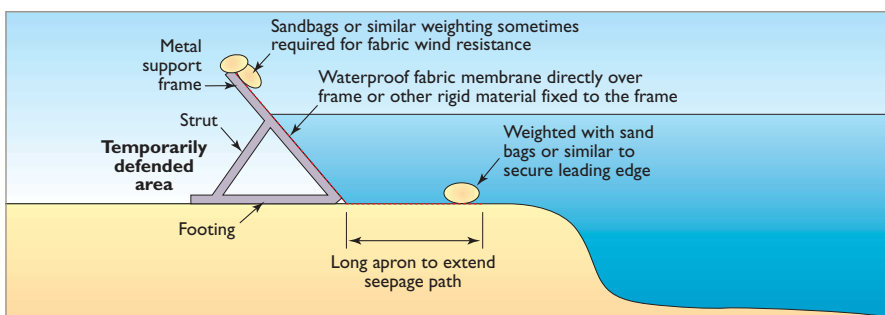


Fig. 11. Framed type of temporary flood barrier (courtesy Pallet Barrier, Geodesign AB)



of any temporary system is the operational conditions under which it would be used and the risks that will be encountered in deploying it. Experience in the use of temporary barriers in the Netherlands highlights failure to mobilise as an important risk. Having decided to proceed, the issues to be addressed in selecting the most appropriate system include

- functional issues, such as retained water depth, location, terrain, dimensional constraints, formation and details at junctions
- operational issues, such as flood warning time, access, resources, storage, transportation, pumping, site preparation, operation of system, ease and experience of use
- structural/system issues, such as structural resistance, bearing pressures, damage resistance including vandalism and failure mechanisms, formation characteristics and local groundwater regime—the barrier, formation and subsoil must be regarded as a system
- costs, including capital cost, maintenance, storage, transportation, training, installation and removal—related issues include durability, reuse and service life
- other considerations such as environmental attributes, appearance, ease of future alteration and versatility.

The Environment Agency is currently evaluating

- welded mesh aggregate-filled containers with semi-permeable geotextile
- free-standing flood barriers with PVC-coated fabric membrane
- pallet flood barriers with frame and polypropylene membrane.

This evaluation includes operational assessment by its in-house work force. The Environment Agency recognises the need for clear operational protocols for any systems that are introduced into emergency plans. The current view is that these systems will increase flexibility of emergency response.

Demountable barriers

These form the heavy end of the spectrum of moveable defences. They are cur-

rently being used by the Environment Agency in new formal flood defence schemes for Bewdley and Shrewsbury (Fig. 12). However, it is quite possible for demountable systems to be used as local protection, for example, to provide a high level of protection to a strategic building or installation within the floodplain. In all cases, they must be purpose-designed for a specific location.

Demountable systems can only be used where there is likely to be sufficient flood warning time (for example 8–10 h warning at Bewdley). These systems typically comprise lightweight metal profiles supported by posts—both of which are erected following the flood warning. Their principal attribute as flood defence infrastructure is their environmental acceptability. All that is visible when not deployed is a permanent steel base plate and ground beam. The substructure design will depend on local conditions but must be capable of withstanding the water pressure on the free-standing wall (2.7 m high at Bewdley).

Current development, testing and marketing issues

A wide range of different manufacturers, ranging from small enterprises to large businesses, has developed temporary and moveable barriers that are currently available. All are purpose made for flood prevention but have different degrees of formal product development, performance testing or documented performance in service. Potential users of these products currently have difficulty in assessing objectively the reliability of the product in service.

Suppliers are able to advertise their products on the Environment Agency's *Floodline*

website. It is currently the responsibility of the user to assess the suitability of the product, based on the supplier's literature and the generic guidance given in the new guidance documents. Research currently underway at HR Wallingford under Department of Trade and Industry (DTI) led sponsorship will develop a suite of standard specifications, test equipment and generic performance tests for the evaluation of the performance of barrier products. This is intended to lead to an accreditation procedure whereby manufacturers will be able to have their products tested under standard, near natural, flood conditions. This should become available during 2002.

Parallel research will investigate the water-resistant qualities of commonly used building materials and forms of construction. This is intended to lead to improved guidance on the choice of materials for use in flood-resistant construction.

Suppliers were invited to display their flood protection products at the first public flood trade fair held in Bewdley in June

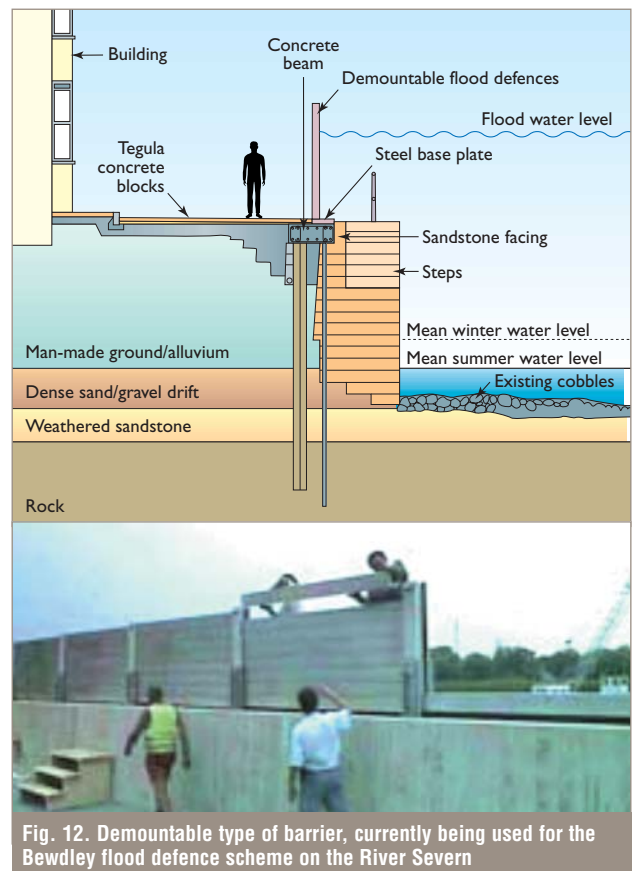


Fig. 12. Demountable type of barrier, currently being used for the Bewdley flood defence scheme on the River Severn

“The single most important measure that can be taken to reduce the impact of flooding is to raise the minimum floor level of the property or development above expected flood levels”

2001. There have been many similar fairs held throughout England and Wales since then. These have both raised public awareness of the products and also brought the industry closer together. In January 2002, the Flood Protection Association was formed by the manufacturers with the prime objective of promoting best practice within the industry.

Measures in new property development

As noted, *Preparing for Floods*⁵ also provides guidance on flood-resistant construction techniques for new properties. The single most important measure that can be taken to reduce the impact of flooding is to raise the minimum floor level of the property or development above expected flood levels. The local planning authority also has the power to impose a condition on the planning permission by specifying a minimum ground floor level. There are practical limits, however, to which ground floor raising can be employed but it is essential that this measure be fully considered in the planning and design process.

Innovative designs where residential living areas are raised to first floor level may be appropriate in some cases, with the ground floor used as garages or storage and designed appropriately with local protection measures. Solid concrete floors are preferable to suspended floor construction as they can provide an effective seal against floodwater pathways through the floor. They are generally less expensive and quicker to restore following exposure to floodwater than timber floors. For walls, the choice of all materials, including bricks, mortars and renders, should be considered carefully to limit water penetration during flooding. Electrical wiring should be raised above flood level and removable water-resistant fittings should be encouraged.

Incentives to use

The autumn 2000 floods caused unprecedented insurance losses. Members of the Association of British Insurers have agreed to continue to provide household insurance cover to properties at risk until the end of 2002. In general, insurers have continued to reinstate flood-damaged properties with similar replacements rather than with flood-resistant alterna-

tives. The Association of British Insurers is actively involved in all government flood initiatives but discussions are continuing to determine policy after the two-year deadline (end 2002). Discussions are also underway regarding the provision of grants or other incentives for the use of properly designed local protection.

Conclusions

The range of options and materials available for the local protection of buildings against flooding is wide. They form an important suite of measures that are available to the local community, authorities and to the engineer in order to reduce significantly the damage and distress that flooding can bring to people. Irrespective of their apparent simplicity, their use in any situation should be supported by a flood management plan and by appropriate technical planning and advice.

Ongoing research will help to provide a better understanding of the performance

and flood resistance of products and materials.

The Environment Agency has championed a series of guidance documents aimed at different users. Effective communication of the complex issues that can be involved in selecting the best option for local protection is essential. At a time of increasing risk of flooding, effective use of local protection provides a logical way of increasing overall protection of people and property from the impact of flooding by helping people to help themselves.

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