Department for Environment Food & Rural Affairs

www.gov.uk/defra

FD2682 Rapid Evidence Assessment Final Report

July 2016

Llywodraeth Cymru
Welsh Government

Cyfoeth Naturiol Cymru
Natural Resources Wales

Environment Agency

Funded by the joint Flood and Coastal Erosion Risk Management Research and Development Programme (FCERM R&D). The joint FCERM R&D programme comprises Defra, Environment Agency, Natural Resources Wales and Welsh Government. The programme conducts, manages and promotes flood and coastal erosion risk management research and development.

This is a report of research carried out by carried out by a research consortium comprising The University of the West of England, Bristol; Mary Dhonau Associates; Cunningham Lindsay; and Birmingham City University, on behalf of the Department for Environment, Food and Rural Affairs.

Research contractor: University of the West of England, Bristol

Authors: Jessica Lamond (UWE Bristol); Carly Rose (UWE Bristol, MDA)

Quality Assured by: David Proverbs (Birmingham City University)

Publishing organisation

Department for Environment, Food and Rural Affairs
Flood Risk Management Division,
Nobel House,
17 Smith Square
London SW1P 3JR

Contents

1. Executive summary 1

2. Introduction 3

2.1 Objectives 4

2.2 Primary question, secondary and supplementary questions 5

3. Description of methods used 7

3.1 Literature scoping 7

3.2 Consultations with the Project Board 10

Second consultation with Project Board 11

3.3 Fact finding interviews with professionals 11

3.4 Householder interviews 12

4. Results 14

4.1 Findings from the REA 14

4.2 New findings after the consultation 16

4.3 Findings from professional interviews 19

4.4 Findings from the householder interviews 26

5. Synthesis of results 32

5.1 What low cost approaches are there? 33

5.2 What evidence of reduced damage is there? 34

5.3 When and how to make adaptations 35

6. Conclusions and areas in need of further evidence 39

7. References and bibliography 41

Appendix 1: Evidence Review Summary Details 61

Appendix 2: Sources explored 64

Appendix 3: Categorisation of studies by sub question 66

Appendix 4: Summary of studies containing evidence of performance of measures 77

Appendix 5: Summary of studies containing evidence of how and when to implement measures 82

Appendix 6: Flipchart outputs from 1st Project Board meeting 91

Appendix 7: Comments from 2nd Project Board feedback……………..………..98

Appendix 8: Semi-Structured interview protocol - Professional interviews 100

Appendix 9: Semi-Structured interview protocol - Householder interviews......... 101

Appendix 10: List of suggested low cost measures for water entry strategy....... 102

Appendix 11: Flow diagram showing full evidence review process, with number of results at each phase.. 108

Acknowledgements

We would like to take this opportunity to thank all those who contributed to the study including: members of the research team; Defra Flood Management Division; members of the Project Advisory Board; anonymous interviewees; and interviewees from Crawford and Co, Aquobex, the National Flood Forum, Manchester Metropolitan University, National Flood School, Guardian Preservation Services, Yorkshire Dampcourse and Wallties.

Interviews carried out by Mary Dhonau (MDA) and Rotimi Joseph (Cunningham Lindsey)

We hope that communities requiring support to enhance their resilience to flooding will benefit from the results of this research.

1. Executive summary

As part of the Defra policy objective to help individuals take more ownership for management of their flood risk a Rapid Evidence Assessment (REA) around low cost resilience approaches to preventing damage once water is allowed into properties has been undertaken as follows:

- The aim of the REA was to collate the evidence of the existence and efficacy of low cost approaches and explore how they can be best implemented by property owners and occupiers.
- Using a structured protocol the review has collected academic literature, grey literature, industry and government publications and guidance to answer the primary question “How can low cost adaptation approaches be used in existing residential and small business properties to limit the damage from flood water?” Secondary and supplementary questions were also posed in order to inform the analysis of sources found.
- Academic search databases, search engines and searching of websites of organisations were used in addition to resources already known to the review team. After expert consultation further sources were identified through recommendation and highly targeted searches.
- Over 1,000 sources were scoped, 141 sources have been used at full text. These sources have been briefly scanned for evidence and information and relevant evidence has been extracted.
- 139 resilient interventions have been identified, 16 of which have accompanying costing information.
- 15 publications include scientific evidence of the likely or actual performance of these measures in a flood scenario.
- 46 publications discuss the barriers, motivations and incentives for taking up measures.
- 19 publications contain case studies and 3 alternative web based sources of case studies have been identified.
- Many of the documents built upon a core body of evidence already well known to the review team and captured by Defra research but some new ideas and evidence were gathered in the area of co-benefits, properties of insulation and wall assemblages and barriers and motivations.
- Costing information is scanty and contradictory in some cases, making it difficult to identify low cost approaches definitively. An inclusive approach is proposed to categorise measures.

- Scientific evidence for performance of measures was also found to be scarce in terms of published literature, but there was broad consistency across industry experts regarding their view of the effectiveness of many (but not all) of the approaches identified. There is a need for further research to gather improved evidence of effectiveness.
- The weight of evidence suggests that low cost approaches can be used to minimise some of the damage from floodwaters entering the home and increasing their uptake could save money for households, small businesses and their insurers.
- Low cost approaches can be taken individually or as part of a package of measures. Often they are effective on their own and so present very low financial barriers to implementation.
- Different measures are most appropriate at different stages of the property lifecycle for example at reinstatement or during planned building work or replacement of fixtures and fittings.
- Evidence also suggests that within the constraints of insurance contracts and available funding for householders and small businesses, these measures can provide a practical approach in overcoming financial barriers to implementation.
- Informational barriers are seen as critical from this review and in particular from the interviews. More information and guidance was requested by households and many professionals.
- Flood recovery and/or the availability of grants were the triggers for most of the repairable and resilient examples within the interviews.
- While literature and guidance often makes a distinction between water entry and water exclusion, interviewees saw repairability and resilience as part of a whole scheme that might also have some exclusion features. It may be helpful to reflect the concept of an ‘integrated strategy’ in communications targeted at the general public as well as in industry guidance.
- Aesthetic considerations were highlighted as important in interviews, unattractive, or abnormal looking measures will meet with opposition from building occupiers, however some of the measures were seen to be enhancements.
- Contamination considerations were also stressed by professionals as a real barrier to uptake.

2. Introduction

The rapid evidence assessment (hereafter RAE) forms part of a larger research project that aims to identify barriers and propose solutions to promote low cost flood approaches that would make properties at flood risk more resilient to damage from flood waters. The project's aim supports the long-term objective of enabling individuals and communities to take more ownership for the management of their flood risk and to recover more quickly as a result. The RAE sought to identify barriers to resilient reinstatement and means to overcome these barriers, both within the affected communities and within the professional networks engaged in the process.

The project fits within the context of extensive past research (much of it initiated by Government) on 'flood resistance' and 'flood resilience' that has led to structural interventions, community capacity building and improved planning policies. This new research will build on the earlier research, avoiding replication of previous findings by focusing on low cost approaches and innovative strategies.

The scope of interventions for the research has been clearly specified as excluding measures to keep water out of a building so that the focus becomes internal adaptation or what is often known as 'wet-proofing' or 'water entry strategy'. This is adapting a building so that when floodwater enters a building, damage to materials is minimised and building elements that are damaged can be easily repaired or replaced. Measures include use of waterproof or fast drying finishes and relocation of sensitive services above expected water levels. A flood repairable strategy is often recommended to deal with residual risk in protected properties, and in properties where protection is not practical, e.g. due to high depth of expected flooding. Some of the measures can be termed 'no regrets' or 'low regrets' options as they are cheap to install, particularly during post-flood reinstatement, or during refurbishment and/or alterations to properties. In some cases, the measures may offer other benefits, such as improved air tightness leading to lower heating costs. Low cost, 'low regret' adaptations are more widely applicable than more costly resilient approaches, extending the potential uptake to any home likely to be flooded (even those with other forms of protection) as a failsafe. The research will therefore focus on measures that fall within the low cost category, or low additional cost category when implemented at the intervention opportunities throughout the building lifecycle.

It is well recognised that, despite efforts by multiple agencies, the tendency of communities at risk to adopt measures to protect their property from flooding is generally low. It has been recognised that lack of guidance on the range and suitability of low cost flood repairable measures, and deeper understanding of their economic costs and benefits in relation to other mitigation options, is an existing and critical barrier. Although other more comprehensive and costly schemes may prevent a higher percent of damage in an individual building, the rationale for focussing on low cost approaches in this project is that low cost approaches represent the lowest financial barrier to implementation, may even be near to zero cost and could be adopted more widely thus preventing just as much damage on a community level. Therefore the project is designed to address some of the informational barriers to implementation, while also engaging with the professional networks that would support property owners and occupiers to implement the measures.

However, awareness and information alone does not result in widespread implementation of resilient measures. Appreciation of financial resources, practical, timing, emotional and behavioural barriers; and design of supporting networks, informational materials and systems that minimise those barriers, may have the potential to increase uptake. While approaches to do this have been suggested, and indeed applied in a piecemeal manner by isolated companies/individuals, evidence about the relative effectiveness of suggested approaches is lacking. This evidence gap can be partly explored through closer examination of existing research and therefore the project started with a rapid evidence assessment (REA).

2.1 Objectives

A Rapid Evidence Assessment (REA) was selected as an appropriate vehicle for synthesis of the available research and practice based information regarding low cost resilience approaches. Specifically the objectives of the assessment were:

- To collate the newest evidence regarding technical, opportunities to increase uptake of low cost adaptations to existing buildings that limit future flood damage.
- To collate the evidence regarding social and behavioural opportunities to increase uptake of low cost adaptations to existing buildings that limit future flood damage.
- To identify sources suitable for expansion into illustrative case study material.
- To gather performance data for improved cost benefit assessment of measures.

The rapid evidence assessment approach has many advantages for this purpose over the other options. A literature review would not allow for the inclusion of the required variety of sources of evidence needed, to be up to date with the range of low cost approaches used in practice, many of which will not be captured within academic literature. A scoping review would not allow for the critical appraisal of sources and inclusion of experts opinion in evaluating evidence. The full REA includes academic and policy literature and technical material, consultation with the experts to identify additional sources and further evidence gathering and synthesis.

The time and resources available for a full systematic review or more complex systematic review were not available and also judged unnecessary given that the academic evidence base was already known to the project team and subject to methodological limitations. The review process is shown in figure 1 below.

Figure 1: The Rapid Evidence Assessment process (after Joint Water Evidence Group (JWEG) beta guidance 2014) **Collins, A., Miller, J., Coughlin, D. & Kirk, S. (2014) The production of quick scoping reviews and rapid evidence assessments: A how to guide. London: Joint Water Evidence Group.**

2.2 Primary question, secondary and supplementary questions

The primary question for the evidence assessment was one of identifying low cost technical approaches that limit future internal flood damage and loss.

> **How can low cost adaptation approaches be used in existing residential and small business properties to limit the damage from flood water?**

Further secondary research questions that were addressed by the evidence assessment are as follows:

a. What low cost adaptation approaches are there?
b. What evidence exists on the impact of adaptation approaches on future flood damage?
c. When and how can these adaptations be most effectively implemented?

In addition there were several themes that Defra wished to explore alongside the main research question relating to barriers to uptake and ways to overcome these barriers.

- Does the approach require ‘bespoke’ or innovative materials, or is it about using existing knowledge and materials in a different way?
- Is it possible to develop ‘packages’ of low-cost materials that can be used to make properties flood repairable?
- For potentially useful products, are there criteria for their existing accreditation that would also serve to indicate to users that the products are suitable for use in resilient repair following a flood.
- Are there transferable approaches and lessons from projects in other fields that can be applied to work in this area – examples include the energy, waste or water supply sectors?

3. Description of methods used

3.1 Literature scoping

To structure the questions and search terms, the elements defined within the project specification for the research were considered first, followed by search terms derived from them. Evidence is required to answer a question that relates to a specific population of interest. The question usually relates to an intervention or treatment to achieve a desired outcome. Ideally this is compared to an alternative treatment or intervention or to the existing no intervention condition.

The project specification defined both the at-risk population that would require low cost approaches (single households and small to micro sized businesses) and the other required elements (see table 1 below). As noted above the project focussed upon households and small businesses, and comparing the low cost intervention approach against no intervention rather than against an 'optimum' intervention.

Table 1: 'PICO' elements for the REA

Population	The Population of interest is residential and small business properties at risk from fluvial and pluvial flooding.
Intervention	The Intervention of interest is low cost adaptations to prevent internal damage from flood water.
Comparison	The Comparison is with properties without such low cost adaptations
Outcome	The Outcome is reduced damages from flooding

Consequent upon this, lists of subject terms relating to existing residential and small business properties were developed, likewise intervention terms relating to low cost adaptation approaches; and outcome terms relating to reduced loss and damage and rapid reoccupation. For example, a 'subject' term was 'residential property'; an 'intervention' term was 'resilient reinstatement'; and an 'outcome' term was 'damage'. The full resultant lists are shown in Appendices 1,2,3,4 and 5.

Search strategy detailed in full

One of the objectives of using a systematic search protocol for evidence is to ensure that the conclusions are based on the best available evidence, no matter what subject area the research derives from. In a multidisciplinary field such as flood risk management a challenge for reviewers is to ensure adequate coverage of all the potential sources of evidence. The study search strategy was chosen to maximise coverage of all relevant disciplines.

Databases of academic and industry sources were scoped during this study; generic search websites were also used. As this review concerned building practice there was anticipated to be a large contribution from grey literature sources. The websites of specialised organisations likely to contain relevant information were accessed. The search term was framed as: Flood to be included as main search term AND any subject AND any intervention AND any outcome.

For the search databases an advanced search query was developed working with the ISI-WebofScience. Query development entailed trialling variations of the search query, recording the associated number of hits obtained and screening the first 20 titles returned for relevance to the primary question (using the inclusion criteria). The purpose of this process was to identify any search terms that returned a large number of irrelevant sources and to remove or replace these terms with alternatives.

The query arrived at by the above process is shown below; as this still yielded 936 hits, however, the ISI-WebofScience offers the facility to exclude subject areas judged to be irrelevant (such as computer science, and cell biology); having employed this, the outcome was reduced to a more modest 576 records.

> *TS = (Flood AND (hous* or domestic or home or basement or wall or insur* or fixtures or fittings or boiler or electric or services or meter or cladding or plaster or ventilation or Sealant or Particle board or concrete or lining or foundation or membrane or Floor* or Insulation or Building or Brick* or Cellar or Commercial property or Residential or Business or sacrificial) AND (reinstatement or adaptation or proof or water entry or resistant or drying or repair* or reduce vulnerability or retrofit or flood-aware or betterment or sacrificial) AND (damage or loss or recovery or disruption or cost or destruction or claim or reoccup* or displace*) NOT “fuel cell")*

This stage also indicated the scale of resources likely to be returned, as well as informing the time constraints that needed to be applied, in order to render the full search process manageable.

The same (or equivalent) query was then applied to the other search databases and titles hits collected. Duplication was avoided and a record of all hits was kept. It was noted, however, that many database sites offered severely limited search facilities, being incapable of accepting a complex Boolean logic query such as that above. Where this was the case, attempts were made to retrieve relevant records via the site's own 'Advanced Search' option, where available. If the most sophisticated query possible within the limitations of a given site yielded copious quantities of predominantly irrelevant material, the search was abandoned; likewise, where developing a useable query formulation took more than 15 minutes. The latter issues reduced the total number of databases searched by six, all of them relating to relatively small niche areas with results likely to be replicated by the more comprehensive databases successfully interrogated. Titles were then screened for relevance and the irrelevant titles abandoned.

Study inclusion criteria

All sources retrieved were assessed for relevance at title and then abstract level.

- **Relevant subject(s):** Studies which concentrated on approaches at a building, building component or building material level that can be applied as retrofit.
- **Types of intervention**: Studies relating to adaptations that can be applied as retrofit at a low cost or at a low additional cost during reinstatement.
- **Types of outcome**: prefer studies that contained evidence of performance.
- **Types of study**: Empirical studies, technical studies and statistical analyses. Guidelines and policy documents.
- **Geographical scope of studies**: worldwide.
- **Language scope**: English language only.

For the ISI-WebofScience search results, the relevance filter was applied separately by two researchers and the results combined. This process revealed slight differences between researchers and resulted in a slightly higher presumption in favour of inclusion at title stage to accommodate these differences.

Filtering by abstract was performed after the title filter with sources without abstracts or summary being kept for full text scanning.

Websites were sampled after the search databases, using a limited set of key words due to the restricted search capabilities of most websites. Websites furnishing PDF resources were prioritised, together with international sources not previously interrogated by project staff. Titles were scanned online, then abstracts or executive summaries were accessed.

Although numerous local government websites included relevant search terms, the material was found to be derivative in nature (much of it relying on sources already accessed); such results were therefore discarded. Whilst Google Scholar was used at this stage, a wider Google search was not employed until after the Project Board had reviewed the materials already amassed, such that specifically targeted queries could be formulated.

Finally a rapid full text screening rejected those with clearly no relevance – usually where the abstract did not accurately reflect the paper's contents, and those that were obviously derived from other studies containing no unique information. The remaining sources were categorised in terms of supplying evidence or addressing one or more of the three sub-questions as detailed in the following three sections. At this stage it was observed that 53 of the full text sources contained no unique information with respect to the questions (see references section).

To complete the process for the interim report the titles were subject to the following analyses:

1. The publications were categorised on the basis of relevance to the three sub questions.
2. A table of interventions identified by the literature was derived.
3. The level of cost information and preliminary categorisation of cost category was identified.
4. The presence or absence of evidence supporting the effectiveness of the measure was noted.
5. Studies containing evidence of effectiveness of measures were summarised.
6. Presence or absence of advice on how and when to carry out interventions was noted.

3.2 Consultations with the Project Board

The interim report summarising the outcomes of the above process was circulated for critical appraisal by the Project Board. A workshop structured around key questions arising out of the REA was held, the feedback from this process being used to inform the subsequent stages of the project. The questions put to the group were as follows:

1 – What is missing from the draft report?

- Methods/materials/ Intervention opportunities
- Documents/ reports/ guidance
- Evidence sources/case studies

2 – How does this report relate to building standards and British Standards?

- Building standards that relate to the measure
- British Standards that relate to the measure
- Material properties that could indicate resilience to floodwater

- Any conflicts that arise between standards and resilience

3 – Which elements of the new materials are worth investigating and why?

- Is it likely to be low cost at reinstatement?
- Is it likely to be low cost at other times?
- For less well evidenced measures, is it worth pursuing more evidence about the performance of the measure?
- For newly suggested measures – is this worth investigating?

4 – What are the unanswered questions?

- Technical questions
- Resource questions, what is low cost?
- What is the role for proprietary products/kits?
- Ideas for increasing uptake?

The resulting responses, in the form of 'post-it' notes added to flipcharts, were subsequently typed up into a matrix format. Project team members then examined all the information garnered, noting specific items requiring follow-up and adding appropriate responses for feedback purposes. The completed matrix is included as Appendix 6.

The list of potential publications arising from responses to the first question were initially cross-checked against the REA to ensure they were not already covered, under variants of title, author or publishing organisation. Where specific documents/references not already forming part of the REA had been recommended, these were obtained, reviewed and, where appropriate, added to the database. In some cases, these gave rise to a need for further research: for example, to fully understand the properties of the wide variety of plasterboard types referred to by the respondents, eight additional sources were accessed. The resulting list of additional material sources is included in the References and Bibliography (section 7).

Second consultation with Project Board

The draft final report was circulated to the Project Board for feedback and several recurring themes were identified as listed and discussed in Appendix 7.

3.3 Fact finding interviews with professionals

A series of fact finding semi-structured telephone interviews, one face to face interview and three written responses to the interview questions with individuals from the professional and practitioner community were also undertaken, resulting in a total of eighteen responses. The purpose of these interviews was to capture additional evidence about emerging approaches not represented in published sources, as well as examples of leading practice in relation to measures and materials and reflection on the effectiveness of approaches. Interviewees were identified through several sources, including members of two key professional associations the BDMA and the PCA, recommendations by the project board, surveyors and contractors known to the project team, and leading national organisations. This purposive strategy was appropriate given the need to identify expert individuals that had used or recommended resilient measures and were aware of emerging approaches, rather than to take a representative sample of the profession who may be less well informed. Interviews were recorded to ensure accuracy and then notes taken from the recordings. Interviews were initially piloted with three individuals who gave feedback on the questions; as the interview questions were found to be appropriate and no changes needed, these pilot interviews were included within the findings. The interview questions are included in Appendix 8.

The interviews resulted in qualitative data and testimonial evidence on current practice and effectiveness of measures (summarised below). Extra measures were also identified and added to the list of measures. Potential literature identified by the respondents was located where possible and considered for inclusion in the interim report.

3.4 Householder interviews

Thirteen semi-structured face-to-face interviews with householders/small business owners who had already adapted their properties were also conducted. The purpose of these interviews was to capture the experience of individuals during the process of deciding to adapt, adapting and living in their adapted property. Homeowners, tenants and business owners were represented.

The interviews included discussion around the nature of the adaptations specifically undertaken, together with the drivers for this approach to flood adaptation, as well as any barriers these individuals had encountered in pursuing these methods and experience of performance of resilient features during flooding.

Interviewees were identified through several sources, including personal recommendation, individuals known to the research team and case studies previously documented. This purposive strategy was appropriate, given the difficulty in identifying individuals with substantially resilient measures through any other means within the constraints of the project. Interviews were recorded to ensure accuracy and then notes taken from the recordings. Interviews were initially piloted with one individual who gave feedback on the questions; as the interview questions were found to be appropriate and no changes needed, this pilot interview was included within the findings. The interview questions are included in Appendix 9.

The interviews resulted in qualitative data and testimonial evidence on motivations and experience of householders and small businesses and effectiveness of measures (summarised below). A number of innovative measures were also identified and added to the list of measures.

4. Results

4.1 Findings from the REA

The REA sits in the context of the development, over decades, of evidence to inform policy, guidance and government investment in making individual buildings less susceptible to flood damage using a variety of strategies. In understanding the material, it is important to note that the majority of studies and evidence has been designed to keep water away from (avoidance) and out of (dry-proofing) buildings. Water entry strategy is far less represented in the literature and it is often included as a small part in wider advice on flood risk management. Two major threads of evidence are represented by work in the US and UK. Perkes (2011) presents a flow chart of US standards and regulations up to 2009 (see Figure 2 below).

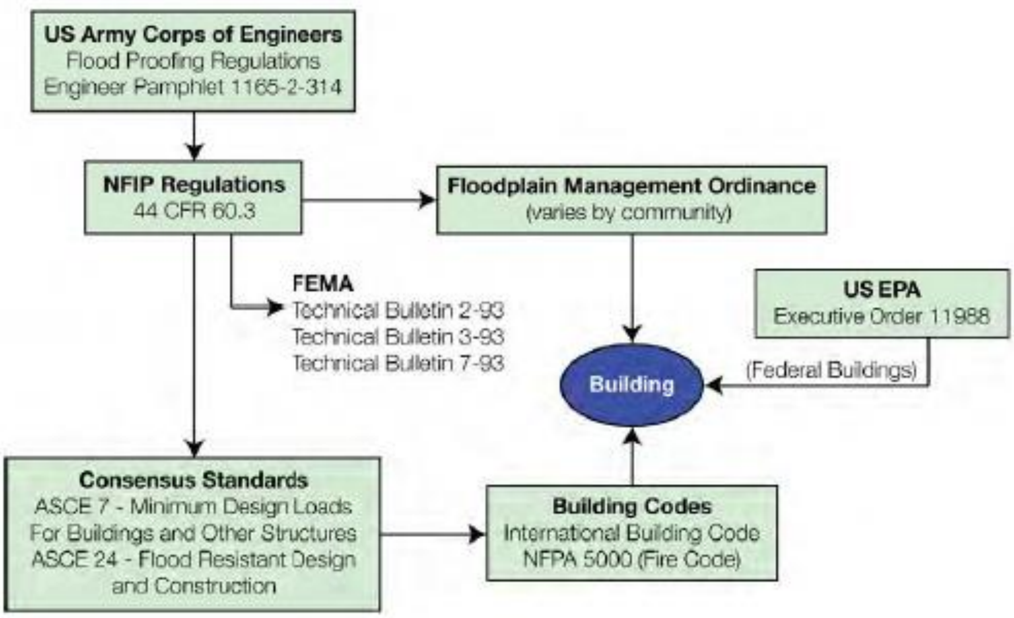

Figure 2: Knowledge map of Key US publications (Source: Perkes 2011)

In a similar vein, it proved useful to consider the evidence trail leading to the latest Defra research and guidance; an initial mapping exercise was undertaken, showing the overlap and interactions between UK studies and reflecting the influence of US work on the UK. Where additional publications were identified subsequently, these were incorporated into the map and the final result is shown in Figure 3. It will be noted that many international evidence trails lead back to the same US and UK examples (for instance, much of the New Zealand and European guidance cites FEMA and BRE sources).

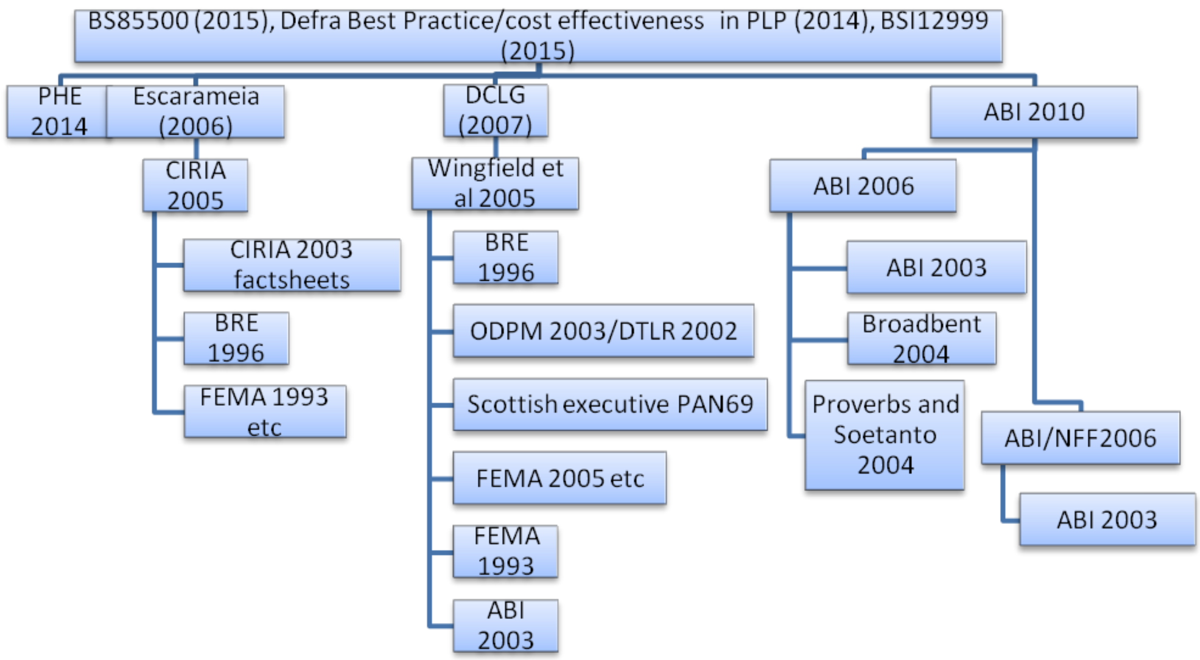

Figure 3: Knowledge map of key UK publications

Over 1,000 sources were scoped initially, of which 141 sources were used at full text. They contained suggestions for 86 resilient interventions at this stage (forming part of the final list included as Appendix 10). Costing information was found to be scanty, potentially out of date and costing assumptions were sometimes unclear, the results are also contradictory in some cases, making it difficult to identify low cost approaches definitively from the available evidence contained in the literature.

Evidence on the performance of these initial interventions was contained in 15 publications. 46 publications discuss the barriers, motivations and incentives for taking up measures from a variety of perspectives (as summarised in the table included as Appendix 3). The scoping therefore suggested that further highly targeted searches and case study enquiry was likely to be necessary to generate evidence of the performance of measures. This was undertaken after the Project Board had advised on the most promising low cost measures to take forward.

Anecdotal and testimonial accounts provided some of the strongest and most convincing evidence of whether resilience measures work in practice: 19 publications contain case studies and 3 alternative web based sources of case studies were identified, which were followed up where appropriate to the chosen suite of low-cost approaches. The weight of evidence and expert opinion suggested that low cost approaches can be used to prevent some of the damage from floodwaters entering the home and increasing their uptake could save money for households, small businesses and their insurers. Low cost approaches can be taken individually or as part of a package of measures. Often they are effective on their own and so present very low financial barriers to implementation. Different measures are most appropriate at different stages of the property lifecycle, for example at reinstatement or during planned building work or replacement of fixtures and fittings.

The process outlined above has been captured in the form of a flow diagram; following the consultation process discussed in the next section, the original figure was then modified to reflect the additional sources recommended and the associated research undertaken to underpin development of the subsequent stages of the project (see Appendix 11).

Evidence also suggested that, although low cost resilient approaches may not be the most cost beneficial way to limit damage, within the constraints of insurance contracts and available funding for householders and small businesses, they can be the most practical approach in overcoming financial barriers to implementation. Other barriers to implementation are identified – for example informational and ownership of risk.

4.2 New findings after the consultation

All the comments received were reviewed and highlighted issues were investigated by the appropriate members of the project team (where these were judged to be within the project's scope) or noted for future reference. Where further resources, documents or other information had been signposted, these were first cross-checked against the listings amassed during the REA compilation. This revealed that some reports suggested by the Project Board members had been reviewed at an earlier stage, but had been found to contain no new or unique information (eg – a specific issue of the RICS Journal); others were of tangential interest only (such as the Dublin Resilient City project). A final recurrent theme was how best to capture the potential cost-effectiveness of some measures over the longer-term.

Particular issues arising from the consultation included, for example, the need for precision regarding terminology. For example, the uses of different types of plasterboard (dry-lining): a leading UK manufacturer lists 7 different categories (British Gypsum, 2015), each with subdivisions, whilst the US/Canadian trade body lists 15 (USG, no date). The appropriate usage of different types of plaster, and the issue of 'breathability' relating to specific construction techniques, particularly in historic properties, was also investigated in detail. An array of problems may arise from insulation materials in a post-flood situation (including disintegration, or difficulty/failure to dry out) and this issue again highlighted the importance of precision of terminology.

The findings from the additional research on the three above mentioned issues are discussed below; additional sources accessed are listed in the References and Bibliography (Section 7).

4.2.1 Plasterboard terminology

There are many alternative boards that can be applied to internal walls and on internal surfaces of external walls: the terminology can be confusing, however, with products variously described as 'moisture resistant', 'water resistant' and 'waterproof' all being available. The properties, recommended usage and comparative costs of the different types was, therefore, explored in detail.

The components of a typical 'moisture resistant' plasterboard comprise a' *gypsum core with water repellent additives and firmly bonded strong paper liners'*. However, the use of paper-faced gypsum boards has been deemed unacceptable for walls and ceilings in flood hazard areas by the US agency responsible for specifying flood damage-resistant materials (FEMA, 2008). Non-paper-faced gypsum products that comply with the FEMA requirements incorporate fibreglass mats instead of paper facings (for example, Georgia Pacific Gypsum, 2013), and these materials are typically described as 'water resistant'. Some manufacturers of the latter type recommend these products for use as tile-backing boards in locations such as the walls and ceilings of 'kitchens, bathrooms, shower cubicles and wet rooms'; however, other manufacturers add that they should *not* be used in '*areas subject to prolonged exposure to standing water (… showers, saunas and hot tub decks)*' (United States Gypsum Company (USG), 2012). This could imply that such materials would be inappropriate for use in many flood situations, although there could be a potential use for these where shallow surface water flooding of brief duration is anticipated. The 'waterproof' types are, as might be expected, the most robust, with the manufacturer of one such product claiming that *'even when completely immersed for a month, (it) takes up only half a per cent of water'.* These materials are the most expensive: nevertheless, not only are they recommended for use in tiled areas, including floors, but some have additional properties such as providing thermal and/or noise insulation, as well as a waterproof barrier (British Gypsum, 2015). It is possible these may be cost-effective in flood situations where such multiple functions are appropriate.

4.2.2 Plaster issues

Where the construction of a particular property dictates that 'breathability' must be maintained, the issue of permeability of various plaster/render types arises. Research by Straube (2000, 2002, 2003) includes data on a variety of different types, with cement/sand mixes reported as being virtually impermeable to water vapour, while lime-based types are the most permeable. This issue is of particular importance in older/historic properties, as discussed by Historic England (2015):

" … the building and insurance industries' standard procedures for making buildings habitable again after a flood can be damaging .... 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."(Historic England (formerly Eng Heritage)/Pickles et al., 2015)

The final, decorative, coating to wall surfaces can also pose a barrier to the passage of water vapour, for example, vinyl wall coverings as noted by Lstiburek (2002). Where a vapour permeable material, such as lime plaster, has been used for its flood-repairable qualities, the subsequent application of inappropriate finishes can prevent the plaster from drying out as intended by trapping moisture within the wall (as occurred in Case Study H#10).

4.2.3 Insulation issues

Closed cell insulation is commonly recommended in guidance, and this was corroborated by some of the professional interviewees. However, further investigation revealed there are multiple closed cell types (including rigid expanded polystyrene; fibreglass board; blown-in polyurethane foam; and polystyrene beads). There is a lack of detailed evidence about the performance of these different closed cell options during flooding, or their thermal integrity post flood. Some specialised waterproof insulation materials have been tested in laboratory assemblages and found not to absorb water: for example, blown-in closed cell insulation (*Technitherm*) (Gabalda *et al.*, 2012). Similarly, caution needs to be exercised as regards 'closed cell' floor insulation materials, as not all of these are suitable for use in a permanently wet environment (such as below the membrane layer in a groundwater flood-risk location). The manufacturers' specifications and/or certification must be examined carefully to ascertain the suitability of the material under consideration: one interviewee suggested insulation materials *'with certification from the BBA'* were appropriate, but investigation revealed the tests conducted on such products merely certify they are resistant to water in normal use (British Board of Agrément, 2013) rather than being resilient to total inundation by floodwater. (Please refer to discussion of 'breathability' issues, raised by PB members, in section 3.2 in this context).

The performance of mineral wool insulation 'batts' has been examined (Sanders, 2014) and the conclusion drawn was that under laboratory conditions, this material kept its integrity and did not retain significant quantities of water after a clean water 'flood' had drained out of a simulated cavity. In a real cavity (simulation) however, the bottom of the insulation was found to remain wet for over 12 months. The author acknowledges that, in actual flood conditions, contaminants such as sewage, agricultural chemicals or seawater are likely to be present, which casts doubt upon the suitability of such an absorbent material in a resilience context.

4.3 Findings from professional interviews

As previously detailed (in section 3.3) a series of semi-structured interviews were conducted with individuals from the professional and practitioner community. The purpose of these interviews was to capture additional evidence about emerging approaches not represented in published sources, as well as examples of leading practice.

There may be measures applicable to different approaches but it is not possible to identify a single approach that will be best for all circumstances. The choice of approach will remain a matter of judgement based on factors such as the type, depth and expected frequency of flooding and the nature of the building type and construction.

The age of a flooded property, the nature of its construction, and the needs of the occupants are also (or should be) fundamental to deciding on the most appropriate course of action for an individual property (eg P#16). The unnecessary removal of materials that are already resilient in nature (an example being 'oak ripped out of an Elizabethan manor house' p#16) is not as prevalent as it once was. Professionals acknowledged that there was still room for improvement, as the busy period after a flood lends itself to adoption of a 'one-size-fits all' approach (in the interests of rapid reoccupation) rather than viewing each case as individually as possible. There were also differences in approaches that may be related to specialists from related disciplines who undertake flood reinstatement using their own tried and tested approaches and materials, rather than seeking to understand other valid alternatives.

In the context of insurer-funded reinstatement, avoidance of 'betterment' does not preclude restoration with different materials, provided these are consistent with the cost and time constraints applying (P#16). In some cases, there could be an appreciable time-saving in using different materials, thereby hastening re-occupancy, with a concomitant reduction in the costs of alternative accommodation (P#14) and/or drying equipment (P#16). Similarly, several interviewees commented that some approaches, such as flooring replacement, may only be appropriate (and cost-effective) if the existing material needs to be removed for reasons other than the inundation event.

Some professionals acknowledge that they would welcome more specialised education and training. Indeed this was reflected within the interviews through evidence of different interpretations of terminology around material properties (such as the critical differences between 'water resilient', 'water-repellent' and 'flood-proof' material types) and the subtler details of current Building Regulations (eg – Part L1b, which governs the insulation of buildings, does in fact include specific exemptions for both Listed buildings and *'Buildings of traditional construction with permeable fabric that both absorbs and readily allows evaporation of moisture.'*) A further example relates to the confusion surrounding the raising of electrical sockets: for repair and reinstatement works in existing domestic buildings, alteration to an accessible height is not currently mandatory (Part M section 8), although it may have additional advantages over and above flood resilience, particularly for older householders.

4.3.1 Details by Building components*: Plaster*

If plaster needs replacement, then a lime or cementitious alternative to gypsum will be more resilient (P#4); these can incorporate additives to inhibit the impact of salt transport (proprietary 'renovating plasters' fulfil this requirement)(P#8, P#16). The practice of finishing with a 'skimming layer' is controversial, as the latter is not resilient and will be degraded by any future flood event; similarly, the type of paint finish adopted requires careful consideration.

In some cases, it may be more appropriate to line the internal surface with a waterproof membranes and use sacrificial plasterboard as a finish, together with a sump-and-pump assembly (P#2; P#16). The underlying masonry can continue to dry out behind the membrane via the external surface after the building is reoccupied (providing the external face has not been waterproofed as part of a preceding water exclusion strategy) (P#14). Whilst this approach is particularly suitable for relatively shallow surface water flooding situations, these membranes are *not* designed to withstand any long-lasting or significant hydrostatic pressure (P#16).

4.3.2 Details by Building components: *Plasterboard/other wall-board types*

Reinstatement professionals expressed the view that plasterboard (and other non waterproof boards) would often need to be removed, even if it dried intact, due to contamination (for example P#4). Cement based boards are recommended as alternatives by some practitioners (eg P#6) and the use of Magnesium Oxide/silicon-based boards by others (eg P#16). Although more expensive than gypsum plasterboard, they can be used in limited quantities, for example, as the bottom-most section of walls (P#6).

4.3.3 Details by Building components: Timber framing

Timber framing (in modern buildings) requires specialist treatment (P#10) and panels will usually need to be removed for restoration. (Issues affecting historic timber in buildings are covered within the 'Floors' section below).

4.3.4 Details by Building components: Insulation materials

Degradation of insulation within cavities or beneath floor surfaces is a considerable problem: removal of the damaged materials may entail some destruction of wall or floor finishes, even if they are not themselves affected (P#2). Insulation materials most susceptible to 'slumping' are loose fill types such as fibreglass (P#1, 5) and mineral fibre (variously known as mineral wool/ rockwool/ stonewool) (P#1 after prolonged flooding, P#9). Some professionals recommended materials proven through use in basement waterproofing (P#2,14); another cited tests that have been conducted on one material (polyurethane closed-cell insulation) for use in flood-specific situations (P#16). Others suggested using materials *'with certification from the British Board of Agrément (BBA)*, however the certification in question indicated enhanced water *repellent* properties, and the use of such materials has not been tested under hydrostatic pressure, although they may offer some advantages.

Some practitioners suggested that, for the purposes of flood resilience, it might be preferable to remove and not replace insulation; others pointed out that there are some constraints on this owing to current building regulations regarding thermal efficiency (Part L, 1b)(for example P#2, P#14). When replacing insulation, or when large sections of un-insulated wall need to be disturbed, an upgrade to conform with the current standard is usually required (P#1, 8). The current building regulations do, however, provide exemptions for listed buildings and properties in conservation areas (in some circumstances) and for '*Buildings of traditional construction with permeable fabric that both absorbs and readily allows evaporation of moisture*.' Therefore, if a building in one of these categories has had an *inappropriate* insulation type installed previously, then removing it may not necessarily be contrary to the intention of the regulations.

Application of closed cell spray insulation within a timber frame structure is not appropriate, as an open-cell type is required (to avoid timber decay) (P#9). (Please refer to discussion of 'breathability' issues, raised by PB members, in section 3.2 in this context).

4.3.5 Details by Building components: *Floor structure*

Solid timber can be highly resilient to flooding, and many professionals questioned the recommendation to routinely replace suspended timber floors with concrete (P#1, 2, 8, 14, 16) unless there are additional damage/deterioration issues that need to be addressed (P#16). Concerns were also raised as this practice carries the additional risks of decreasing breathability in older properties, as well as incorporating a (potentially) slow drying material (P#1, 4, 8, 11, 14). The latter issue can, however, be overcome by using two membranes, one beneath the slab (to exclude groundwater ingress) and a second one above (to prevent saturation in subsequent flood events) (P#16). Retention of existing timber flooring, where possible, would avoid such additional costs.

The nature of the (historic) timber components in older properties also differs from that use in modern construction (P#16): slow-grown timber having greater structural density was used in the past, in contrast to modern lumber products (the former being *'... superior in hardness and durability to faster grown material'* Coed Cymru, 2011) and may, therefore, have already survived a considerable number of floods.

Replacement of extant concrete floors with a concrete alternative was seen as appropriate in some circumstances (for example, in areas prone to a high water table) (P#8, 9, 12). If replaced, the slab should be thicker than normal (P#6); if floor insulation has been damaged, the whole floor would need replacement (P#10). A note of caution was raised regarding 'closed cell' floor insulation materials, as not all of these are suitable for use in a permanently wet environment (such as below the membrane layer in a groundwater flood-risk location); manufacturers' specifications must be examined carefully to ascertain the suitability of the material under consideration (P#16).

4.3.6 Details by Building components: Floor coverings/finishes

Floor coverings that are resilient include tiling (ceramic or stone) and resins, in each case applied with suitable waterproof adhesives/grout and with workmanship of a high standard. Vinyl flooring may also survive inundation, if suitable adhesives have been used (P#16). However, the performance of even waterproof adhesive may be variable in prolonged floods (P#4).

Any recommendation to adopt removable carpets/rugs will only be appropriate where both sufficient warning time is likely to be available, and occupants have the physical capability of carrying out the procedure (P#16). Non-engineered floor coverings (eg laminate styles) are prone to swelling during floods and should be avoided (P#14, 16). Sealed Bamboo flooring, although currently in fashion for use in bathrooms, is 'splash-proof' but it is not suitable for use in flood situations (P#16).

There can be difficulties regarding the floors in listed buildings, but there are cases where Conservation Officers have accepted the use of resilient tiles (resembling quarry tiles) as a replacement for stone-flag floors (P#16).

4.3.7 Details by Building components: Services

Raising water sensitive services above the likely flood level is a commonly recommended approach (eg P#4 and others) which most householders find acceptable when applied to meters, control panels and boilers (P#1). Larger boilers can be raised on plinths, whilst smaller units may be wall-mounted (P#16) or, relocated to an upper floor if available. Modern cabling and piping within walls and floors is usually well protected and, by following current regulations during reinstatement, old properties may become more resilient (P#1); isolation of vulnerable circuits, rather than relocation, was suggested by one respondent (P#14).

The raising of electrical sockets is more complex: a minimum height of 450mm above floor level is part of Building Regulations (Part M) but the regulations only applies to new-build dwellings, public spaces and work on non-dwellings (H M Government, 2013a, H M Government, 2013b). As this height may be sufficient to protect many systems subject to shallow flooding (P#1), many householders accepted this measure (P#1); however, others had found some reluctance based on aesthetic issues, or fear of signalling the existence of flood risk)(P#6,7) when not presented as part of a regulatory requirement.

One alternative (potentially lower cost) approach was suggested, this being to remove switch-plates/covers from affected sections, allowing them to dry, and to drain any remaining water from conduits, followed by inspection by an independent electrical inspector; if corrosion of steel back-boxes has occurred, these can be replaced with plastic equivalents (P#16). Similarly, gas and water service piping can be retained, unless any physical damage has occurred that poses a safety risk

Similarly, central heating radiators only need to be replaced if prolonged flood exposure has affected their structural integrity (by exacerbating pre-existing corrosion); superficial rust patches can be rubbed down, treated and repainted, provided the unit is otherwise sound (P#16).

4.3.8 Details by Building components: *Doors and windows*

Modern PVC doors have been seen to stand up well to flooding (for example P#1). Solid timber and good-quality joinery can also be highly resilient to flooding, provided the components have been appropriately maintained (regular inspection/ painting/ oiling) (P#16). Oak doors have been found to survive quite prolonged flooding (P#1,7); where new timber components are used as part of repair, these should be primed on all surfaces prior to installation (not merely on the faces to be painted) in order to inhibit mould /rot during the drying phase after subsequent flooding (p#16). Window joints are usually glued, but if fixings are required these should be stainless steel (rather than ferric) as most timbers are acidic (oak in particular) and corrosion will result (P#16).

4.3.9 Details by Building components: *Kitchens*

Replacing fitted kitchen units with free standing furniture is only occasionally acceptable to householders (eg P#1); raising furniture, ovens and appliances above the flood line is one alternative (P#5), another is to retain extant worktops, doors and drawer fronts (where possible) coupled with low-cost sacrificial carcasses (P#16). Removable kickboards have the advantage of permitting air circulation, which can facilitate drying; the use of ‘wrap-around’ ends to unit runs was also recommended, rather than standard end panels made of chipboard, in contact with the floor and therefore at risk of absorbing water (P#1). Solid wood kitchens may, however, require replacement as the joints open up, and also due to contamination concerns (P#7). Although both plastic and stainless steel kitchens are available, they have rarely been found to be acceptable to householders, due to aesthetic issues: according to one practitioner the ‘country kitchen’ is still widely in vogue (P#7).

4.3.10 Details by Building components: *Other*

Varnishing timber (using marine grade yacht varnish) and new breathable varnishes (P#6), painting and other treatments can be used to improve resilience (although these need to be renewed regularly to remain effective, and re-treated after a flood event).

Timber staircases can best be dried out and retained, unless in the context of a frequently flooded basement, where concrete replacement steps may be justified (P#16).

A low-cost free-standing pump can be used in conjunction with a sump to drain below-floor voids, rather than a permanently fixed pump (p#16).

4.3.11 Barriers, challenges and opportunities

Many of the professionals pointed out that they had little evidence about performance of installed measures because they would have no reason to go back to households for that information unless they flooded again. Even in that case the same professionals would be unlikely to be involved. The lack of complaints, however, was seen by some as an indication that things had worked in general (P#2, 4, 13). Most respondents could cite one or two successes. Two of the respondents were involved in advising on arbitration around flood claims and observed that poor workmanship is often to blame for failures of systems (P#3, 16) and that badly installed systems can increase reinstatement costs. There was also concern that in very long, deep or contaminated flooding most measures would eventually prove inadequate.

Apart from normal certification (eg thermal compliance and Kitemarks) there were no special certificates or guarantees offered by most companies regarding the resilience of measures installed. Some companies offered installation certificates for households to use as evidence for insurers. Although respondents were aware that some in the industry did offer ‘guarantees’, concerns were expressed regarding the validity of such practices.

Practitioners appealed for a common sense approach. Resilience of PVC, tiles and good quality hardwood can be observed from general reinstatement experience (P#1). Within a building reinstatement scheme, however, resilient materials may be removed and discarded through ignorance or to assist drying of other elements (P#7). The issue of secondary damage of materials and breathability were again raised.

Education is perceived as a major challenge at all levels, for both the public and tradespeople involved (P#5, 11). Professional interviewees cited lack of awareness in general but also lack of specific detailed information and guidance (P#10) such that sometimes inappropriate measures are recommended by partially informed advisers. Cost and lack of resources (P#7, 9) and the difficulty of accessing grant funding (P#11) were mentioned and it was pointed out that low cost is not always a viable option, or may not be the first choice, depending on the situation. The complications this adds to the claims process (either through grant application, or negotiating and pricing time) can deter loss adjusting companies from initiating discussions (P#7, 9). One respondent pointed out the current trend for cash settlement meant that insurers were settling claims more quickly and cheaply and expert advice might be lacking. Households will also prefer insurers or the government to pay: there is confusion about the ownership of risk and the new Flood Re scheme is not expected to help, as many affected people may just “breathe a sigh of relief” (P#3).

A lack of specialised contractors was felt to be a barrier by some (P#2, 3, 6, 10) but others had found no difficulty in briefing contractors (P#1, 7, 9). However another expressed concerns that standards must be checked when contracting out (P#7) and tanking in particular was seen as problematic (P#4). More specialist training was called for by some, regarding standards and Kitemarks for resilience to boost confidence in the approaches. There is also a lack of market pressure, as no major companies or critical mass of SME’s are involved in this market (P#6).

Lack of belief in the measures is seen as an issue (p#7); the public would benefit from seeing successful examples (P#10) and they also need to know how to get advice. The advice needs to be consistent, as far as possible, as, where experts are seen to disagree, then credibility suffers (P#3). There are important emotional factors for householders, such as not wanting to talk about the possibility of flooding again (P#7). Dislike of the measures, on aesthetic grounds was also highlighted (P#1, 4, 8), likewise the impacts on the use of the building, and the wish to feel ‘normal’ (P#3), as well as lifestyle needs all have to be considered.

Opportunities to increase uptake identified include: the recent growth in specialist contractors that could potentially incorporate resilience along with the protection products (P#15); the planning process and building control procedures could also pose an opportunity to flag up the need to install measures. Some felt that the decision could be removed from householders in some circumstances (usually those with very low or neutral cost, for example, re-siting of sockets or different plaster boards) to save the stress of decision making. Others suggested that some of the approaches could be recommended to households as home improvements, if more effort was invested in making them attractive (thereby addressing the aesthetics barrier). The structural drying and restoration industry has a role to play in trying to encourage builders not to rip out resilient finishes after a flood (P#8) and insurers could offer premium discounts, or tie people in to new long term insurance products, as a condition of supporting measures (P#3). Grants should be focussed on low cost approaches to benefit the maximum number of people (P#2)

Good examples are needed to encourage faith in the methods and also more research to prove these approaches work (P#6). Encouragement of low cost 'do it yourself' methods (such as buying bricks to raise furniture above flood levels) was suggested as a first step accessible to most people. Experience may then lead people to adopt more extensive measures when next they flood. A professional said *"We have a lot more experience than we think we do – not always 'labelled'"* and another pointed out that the creativity of individual householders had often come up with the best low cost measures. Experience is a key component of the process, as properties near rivers frequently have the measures because of a long iterative process (P#7): a means of empowering those at lower risk would, therefore, be welcomed.

4.4 Findings from the householder interviews

As previously detailed (in section 3.4) a series of semi-structured face-to-face interviews were conducted with householders/small business owners who had already adapted their properties were also conducted. The purpose of these interviews was to capture the experience of individuals during the process of deciding to adapt, adapting and living in their adapted property. Homeowners, tenants and business owners were represented.

4.4.1 What kinds of properties, people and flooding?

All but one of the householders live in older property (the oldest was built in 1750, the newest in the 1970's) and some are listed, often close to a river but not exclusively. The properties ranged from detached through attached and terraced; most were owned, two were tenanted (one via a housing association, one privately). Most of the property owners had been flooded more than once, up to 14 times, but for some a single flood or knowledge of flood risk was sufficient for them to decide to install measures. In that respect these individuals appear to be atypical and more proactive than the average population at risk. The properties were variously at risk from high depth river flooding, groundwater flooding, drain flooding and surface water flooding. The depth of flooding varied from just the basement to more than 1 metre above ground. Awareness of flood risk on moving in varied, with some unaware, others vaguely aware and one fully aware of risk before occupying the property (the latter having made changes before moving in during necessary renovation work). There was a sense of community engagement from many of the respondents: both tenants talked about being there to help out the neighbours and one had already become a flood warden (H#7), the other mentioned a family member was training to become one (H#10); many were flood group members; another bought a boat that they used to access supplies and to assist neighbours; others were very keen to share their experience because now: "*Being flooded is a … nuisance but it's not a disaster*" (H#5).

4.4.2 Why have they taken the approach?

Recognition that flooding was likely to recur and that it is impossible to keep water out was a universal theme. Not being prepared to suffer again they have taken the only alternative approach. Respondents used phrases such as "*sandbags are worse than useless*" (H#5) and "*Realistically, we know we will never be able to stop flooding … so we have done everything we can to make this house more resilient*." (H#9). The most expressed motivation was to prevent upheaval and 'getting back to normal as soon as possible' (H#3). Having peace of mind and being able to stay in a property or location that they loved, (H#7) with many households staying put and moving upstairs rather than relocating in the immediate aftermath. Pet ownership was a factor for some and also security issues. They felt it was worth investing time and money to save money in the long run or to keep their insurance. Along with that, some felt flooding was becoming worse and one respondent recognised that there was residual risk despite benefitting from community defences. The majority of the changes were made in the aftermath of flooding, during reinstatement. One of the two tenanted properties is a special case, as it had previously been adapted as part of a research project, rather than at the behest of the occupant (H#10); the second has been adapted as a joint project between the owner and tenant (H#7).

4.4.3 What measures did they take?

Internal walls were treated with a variety of different plasters: gypsum, lime plaster (with salt resistant additives) and cementitious treatment but with porous paint finishes. Some had 'tanking' or bitumen coatings behind, others had air gaps. Dado rails or (removable) panels were used to limit the need for future redecoration (eg H#10). Skirting boards were dealt with in a variety of ways, popular methods including: easily removable skirtings; resilient wood, or heavily painted or yacht varnished skirtings; H#13 was the only example of stone skirting, whilst others have tiled skirtings in some rooms. Most reported satisfaction with the finishes and their performance if they had been re-flooded. However, existing damp conditions had made lime plaster problematic for one household (H#4), another had observed minor salt accretion (H#6). In the case of H#10 the most recent flood was far more severe than those experienced in the past, and as a result some measures proved unsuitable, either for the additional depth of water, or the rapidity of onset when the local telemetry system failed to activate a warning. One respondent reported that because of the highly porous nature of the existing masonry, drying was very slow and an internal membrane system was used to allow reoccupation while the walls remained wet (H#9). This demonstrates the importance of salt inhibitors and a thorough understanding of the existing conditions of a building. The external walls had also been treated in some cases to limit ingress and air bricks had been re-positioned. Due to the age of the properties, there were few with cavity insulation but one reported a problem with insulation material in their modern extension, as the oblong 'batts' acted as sponges and took a long time to dry (H#3), another household had successfully used closed cell insulation in an extension (H#13).

Most had concrete floors, some of these having been replacements for previous timber floors; one interviewee had also raised the floor level (H#9). Most chose to attempt to limit ingress through the floor from below, or into the floor from above, with tanking, thick membranes and waterproof additives. Some had seen such approaches fail (eg a DIY Sika layer H#11), and had subsequently replaced, or planned to replace, the tanking system. Only two considered their floor as accepting water, ie designed to get thoroughly wet and then be cleaned and dried out; one of these had previously seen tiles pushed out by hydrostatic pressure from groundwater flooding (H#5). Tiling was the most popular surface treatment for floors – a variety of slate, porcelain, marble, limestone, and encaustic were noted. Inadequate adhesives was the most common reported issue with tiling in re-flooded properties and the use of swimming pool standard adhesives, waterproof cement and additives was recommended. Other treatments included stone flags, varnished solid wood, engineered wood, removable rugs, cheap sacrificial carpets, and removable carpets – particularly for lower treads on stairs and, in one case, the replacement of the bottom-most stair by an uncarpeted concrete block

Some households had relocated their kitchens, bathrooms and downstairs cloakrooms from flooded areas – mostly basements. For those that were not relocated, a combination of approaches was usually used by each household. Free standing (and thus removable) items, for example: lightweight tables and removable kitchen units; non-integral electrical items; free standing 'Belfast' sinks, removable kick boards; raised cookers and stacked tumble driers, with other electrical items on plinths; increased use of wall rather than floor cupboards; and kitchens made of flood resilient materials. Resilient materials included steel, acrylic, marine ply, oiled oak, old oak, solid oak, plastic. Respondents reported that the majority of these kitchens had survived flooding, needing only cleaning, disinfecting and some retouching – eg re-varnishing. The one that had not was a steel kitchen that had begun to show signs of damage prior to a major flood, suggesting some pre-existing problems had compromised the units (H#10). Removable kitchen cabinet doors were rare but one respondent mentioned removing doors with ordinary hinges. One householder had successfully used an internal barrier system to protect a cooker that could not be moved (H#4).

Every household had raised electrical sockets, and these were dropped down from the ceiling in most cases or housed in easy drain conduits. Meters, controls and boilers, service entry points were raised or moved upstairs. Many reported isolating electrical and heating circuits to enable them to live upstairs and maintain their heating and electrics while the downstairs was flooded and then reinstated. This include sump pumps, where present H#8. Unplugging electrical items in advance of the flood was recommended to prevent short circuiting. An alternative heating source was also recommended in case the electrics and gas fail (H#12, 13). Removable or enamelled radiators were also recommended. A majority had also installed non-return valves (NRVs) on sewage pipes and other plumbing items; in one case where this had not been done (H#10), a rapid onset flood had triggered raw sewage outflow from a downstairs toilet before the occupants were able to deploy their toilet 'bung', thereby reinforcing the merits of the 'passive' NRV approach.

Good quality wooden doors and staircases, treated, oiled or painted had survived flooding and were retained. Others had installed higher quality wooden items on replacement, as MDF and other cheaper wooden items had not survived. They expressed the view that these paid for themselves and looked good. Removable doors were reported in three cases (eg H#13), but in one case the occupants had been unable to remove theirs due to the rapid onset of the flood (H#10). Another said that they used ordinary hinges rather than rising hinges (H#13). External doors and windows were replaced by UPVC alternatives in some cases, and these changes were seen to have the added benefit of improved thermal efficiency (H#12).

Avoidance was the most popular approach for contents. Some items were raised, such as wall mounted TV and speakers (H#1, 9) and wall mounted cupboards (H#8). Others chose items with resilient lower features such as plastic legs and sofas with legs, others noted that precious or sentimental items had been re-located permanently upstairs H#7, H#8. Avoidance of fitted units (H#8) and contents that are lightweight and removable to upper floors or alternative locations (including tables, bookcases, sofas) was another avoidance strategy. Other items were raised permanently, or just temporarily during the flood and there were several different ways to do this: plastic trestles, supporting doors, hinged wainscoting, chair-raiser 'pots' (marketed for raising seat heights for elderly people), carpenters' telescopic metal trestles, bricks (wrapped in plastic to prevent water wicking up to the protected items), nylon bricks, sturdy work surfaces in the kitchen. Wrapping in plastic was chosen by one household (H#4) and they recommended polytunnel grade plastic. One household had chosen not to have irreplaceable items on display – for example glassware – that would take too long to move and had disposed of most of their traditional books and now used e-books instead (H#13).

4.4.4 How did they go about it?

Experience with insurers was variable with some households praising the generosity of insurers in being willing to replace items repeatedly. However, one respondent mentioned that some policies allow insurers to replace items that don't match, for example as part of a three piece suite, therefore policy wording should be checked. Insurance issues with 'betterment' led to the reluctance on the part of some insurers to install resilient features and insisting that resilient features were removed, perhaps to speed up the drying process. Householders "learned to deal with insurers" or accepted lump sum settlements in order to have more control over their reinstatement work. The households had often undertaken their own extensive research in order to select appropriate measures, (for example referring to research undertaken by the National Trust) and taken advice from experienced builders, neighbours and members of their local flood group. As mentioned above, one of the tenanted properties had been adapted as part of a research project (H#10); the second had negotiated some physical changes funded by the property owner, but also made lifestyle changes entailing no financial outlay (H#7).

Miscellaneous advice included: buying a sack truck to help with moving items H#1; raising outside items including oil tanks and hen houses; ensuring a woodburner is completely cold before water enters, to avoid cracking; using protective sheets on upstairs carpets when moving items from downstairs pre-flood; using pumps to control water depth; also portable 'puddle-sucker' pumps for use during a flood and subsequent clean up stage; creating a 'grab bag' to include important documents, supply of medication and similar items.

Most of the households interviewed had used a combination of resilient approaches but had some exclusion measures as well as resilient features. Although the schemes were not all low cost, many individual items within the schemes were not more expensive than like for like replacement and some households had skilfully offset expenditure in one area against savings in another (eg H#1, #2). Their strategies were designed to fit in with their own lifestyles, resources and capabilities. As a result many of the households are now in the position where they do not need to move out of their homes and could reoccupy the downstairs quite quickly after a flood. The ability to get on with cleaning and drying independently of insurers was mentioned – one had bought their own dehumidifiers for the purpose (H#13). As one put it, the concrete floors simply need washing and drying out, and the sacrificial dry-lining replacing, " … *and then we can crack on as normal*" (H#9), another said *"…*

last time it flooded we just washed everything down and moved back in" (H#5), and another had been flooded fourteen times in twelve years but only needed to put in 2 insurance claims during that time (H#3). Several of the households were flooded in the 2015 event (H#6, 11, 12) and were back in residence within days. In only one instance (H#10) had some of the previously installed resilience measures been compromised to the extent that they were not retained, but many of these decisions were made by the housing association that owned the property and which was funding the reinstatement works.

5. Synthesis of results

Water entry strategy is sometimes also known as resilient reinstatement, resilient repair or wet proofing. Water entry strategy is defined in the 2007 CLG guidance as: "Allow water through property to avoid risk of structural damage." (notwithstanding that, for low depths, this strategy can always include "*Attempt to keep water out for low depths of flooding").* This is reiterated by the recent 'FloodProbe' project (Escarameia *et al*., 2012/2013) noting that the strategy entails:

- Flood-resilient material and designs up to 1m in depth.
- Access to all spaces to allow drying and decontamination.
- Design to drain water away after flooding.

Thurston *et al.,* (2008) also describe a water entry strategy listing a number of different measures for building elements and fixtures and fittings.

The recent EU SMARTEST project also covers techniques and strategies for water entry or wetproofing. On their main wetproofing page there is reference to building materials and sacrificial approaches (ie cheap and easily replaced materials) but they also mention some important structural considerations:

- Targeted improvement and reinforcement of structures, especially of ceilings to possess higher loads due to saturation;
- Reinforcement and expansion of foundations to prevent scouring due to dynamic flood impacts;
- Consideration of special loading conditions because of floods (hydrostatic pressure, impact loads) in the dimensioning of components, reinforcement / improvement of flood-endangered components of structural relevance.

These structural considerations have been considered outside the scope of the REA as they are likely to involve substantial work and be very costly to implement. However, it is important to recognise that they represent limitations to the scope for non-specialists to undertake resilience measures without expert assessment of risk. It is also important to consider how the water will be allowed to enter a property, means of escape for the building occupants and security of building contents during and after a flood. Equally the assessment of these aspects of secondary damage, security and safety could be considered to be part of the normal professional reinstatement process as outlined in the publically available standard (PAS64 - BSi, 2013).

The interface between water exclusion and water entry is also a crucial matter for debate:

First there is the physical interface, particularly the internal surfaces and cavities of external walls and the treatment of floors. The limitations on the height of internal finishes and the presence or absence of resistant cavity or void insulation are highly relevant. Therefore, knowledge of the structural and drying properties of such materials and the impact they have on wall assemblages has been considered within the scope of this review.

Second there is the question of suitable circumstances for implementation of the water entry strategy. In the literature, water entry strategy is usually associated with recommendations about structural stability but it can also be recommended: as a failsafe – recognising that in long duration flooding many resistant methods may fail; for flash floods where there may be inadequate warnings to implement resistance; in historic properties where resistance is unsuitable. The reason for adopting the strategy and the associated depth of flooding and duration that is expected will impact on the suitability of some of the recommended measures.

Flood resilience within a building can be achieved in different ways. Vulnerable elements (such as electrics) can be raised above the expected flood level or removed (avoidance) either permanently (passive) or temporarily on receipt of a warning (active). Exposed elements can be made of, wrapped or coated in flood resistant materials (for example use of plastics), permanently or temporarily, or exposed elements can be made of resilient materials that can accept water without deformation or disintegration and dry quickly afterwards with potential for decontamination (for example cementitious materials). In all cases the need to evacuate the water quickly is important. For resistant and resilient materials the adequate circulation of air around the exposed elements for reasonably rapid drying must be assured. It follows that there are likely to be multiple possible water entry strategies for any given building and this was reflected in the results found by the structured search.

5.1 What low cost approaches are there?

The combination of literature, consultation and interviews combined to produce a list of 139 proposed measures in all (86 from the initial REA and 53 additional items from subsequent inputs) associated with the water entry strategy. The list is included at Appendix 10. Measures covered the full range of building elements, categorised as follows:

- Water compatible internal walls
- Water compatible flooring
- Water compatible kitchen fittings
- Water compatible bathroom fittings (for ground floor/ basement locations)
- Services

- Fixtures and fittings

Suggestions for contents protection, measures to facilitate rapid reoccupation and miscellaneous suggestions are also included.

Cost information is rarely presented in studies, nor are there existing catalogues of solely low cost measures; consequently, an initial documenting of proposed wet proofing approaches was followed by an examination of available cost information. However, it became clear that some contradictory views of cost categories existed in the literature. In addition costs differ depending on whether an intervention is applied at reinstatement or planned building work, as opposed to a stand-alone intervention specifically to reduce risk. The contradictions may be in part to do with underlying assumptions about the timing of interventions – ie during or after reinstatement or about the labour requirements. In the longer term further refinement is needed in the thinking of what represents ’low cost’ or perhaps it might be useful to think about using the term ‘affordable’. However the term is taken within this report to be as inclusive of measures as possible. Measures are flagged as low cost in Appendix 10 if they have the potential to be installed at low cost (under £750 per measure) either at replacement or at reinstatement or at any time. It must be borne in mind that a suite of measures would then be much more expensive – 6 or so being achievable within the constraints of a £5,000 grant.

Each of these measures may be applicable for inclusion in the water entry strategy depending on the depth of flooding expected. Therefore Appendix 10 also indicates whether the measure is suitable for low, medium or high flood levels. Other factors such as speed of onset, velocity of floodwater, type and age of property, and capacity and preferences of building occupiers also need to be taken into account.

5.2 What evidence of reduced damage is there?

Studies documenting actual performance of measures are very rare. In the evidence assessment there were 15 studies that included actual performance data.

The studies involving performance data were mainly experimental studies that reported the results of experiments of building assemblies or building components subject to simulated flooding. The findings provide robust evidence for resistance and resilience properties of a small range of building materials, mainly related to wall assemblies. The results of these studies are reflected in current guidance materials for example BS85500. However, the results of these studies demonstrate that considerations of material properties alone are not sufficient to predict resilience within a building setting. Quality of construction, state of maintenance, the interfaces between materials and the drying spaces around materials are equally important to consider.

There are also a number of studies that explore water resistance properties of materials subject to other forms of wetting, or report material characteristics related to the capacity of materials to absorb water such as porosity. These studies provide an indication of the types of materials that may prove resistant or resilient in flooded buildings but they do not provide robust evidence of the likely performance of such materials in a flood situation.

Anecdotal and testimonial evidence suggest that a number of resilient interventions will be successful in preventing damage. However, in assessing anecdotal and testimonial evidence within the literature it is likely that a bias towards the reporting of positive results will be present and failures are unlikely to be reported. The review found 19 publications containing case studies and 3 web based sources of case studies. The table included as Appendix 4 summarises the evidence available on performance of measures within the literature.

From the professional interviews evidence of positive performance of some materials (for example hardwood) was offered. There were also some examples of material failure in a flood situation (mineral wool insulation). This testimonial evidence is not considered to be subject to positive bias. The evidence from the professionals on the performance of materials concurs largely with current recommendations. The resilience of hardwood, tiling and sand and cement plaster was highlighted by these respondents. However, the professionals pointed out the importance of considering building assemblies, joints and interfaces, and questioned the necessity of replacing timber floor with concrete for most properties. They also reported instances where normally resilient materials had deteriorated, usually after very prolonged flooding.

From the households and small business interviews further testimonial evidence of material performance was gained that was mostly positive. Marine ply and plastic kitchens had been seen to be resilient. Lime plaster and sand and cement had worked for some. Hardwood, varnished and painted wood had survived flooding. Tile finishes were successful in most cases. Households also reported on the success of other measures, such as the raising of sockets, services and other items, non-return valves, moving contents, wrapping in plastic, and isolating circuits. Some issues were also reported and these included contamination issues, higher than expected flood depth, failure to execute plans and failure under hydrostatic pressure. Other issues such as minor salt accretion, breathability and a rusting steel kitchen appear to have some relation to existing building conditions rather than flood damage.

5.3 When and how to make adaptations

Two elements underlie the question of when and how to make adaptations. There are more studies that explore the barriers to adaptation than there are studies that look for positive opportunities and behaviours. The REA identified 46 studies that looked at drivers, motivation and barriers for implementation of measures from a variety of perspectives, as summarised in the table included as Appendix 3.

It is well recognised that, despite efforts by multiple agencies, the tendency of communities at risk to adopt measures to protect their property from flooding is generally low. Studies in the UK have been carried out to explore the barriers to climate adaptation generally (Bichard and Kazmierczak, 2009) and to flood adaption (Thurston *et al.*, 2008). The recent work of Joseph, Lamond and Proverbs (eg Wassell, Joseph *et al.,* 2009) has related specifically to 'resilient' or 'flood repairable' adaptation. All these studies have identified a complex set of constraints that need to be addressed in order for change to occur within a variety of 'theory of change' models. For example, Lamond and Proverbs (2009) consider resilience under four barrier types (informational, financial, emotional and timing) that impacted variously on the necessary awareness and perception of risk, ownership of the risk, knowledge of solutions, resources to implement solutions and belief that the measures would work. Other models include Spence *et al.* (2011), Bubeck *et al.* (2012) and work summarised by Fell *et al.* (2014).

Successful adaption of buildings is most likely when stakeholders have the desire and ability (financial, practical) to make changes. The most commonly reported factor that contributes to the desire to adapt property to flooding is flood experience, usually direct experience of flood damage to the home or business. Householder interviews confirmed that the motivation for adaptation was almost universally triggered through not wanting to experience another flood, with its attendant distress and displacement. It is also commonly recognised that this desire is strongest in the period immediately following a flood (Steinführer *et al.*, 2009); some professionals, however, noted some reluctance to slow down the reinstatement process. These are also potentially occasions where cost of installing resilience measures may be at its lowest. Within the property lifecycle, it has been suggested that adaptation can take place naturally and most cost effectively at reinstatement (Joseph *et. al.,* 2014) or at pre-planned maintenance or renewal of fixtures and fittings (Soetanto et al 2008). The disruption associated with installing resilience will also be lower at this point, and both professional and householder interviews confirmed this was a very common experience for measures relating to building fabric.

However, this is not the only point at which measures can be taken. Some evidence exists that during insurance renewal businesses in particular may be driven to install measures (Lamond *et. al.,* 2009). At property transfer there is the potential for the vendor to take measures in order to present a lower risk to the buyer, during negotiations. However, the greater opportunity may be the tendency for new owners to invest in their new property if they are properly advised: an example of this was seen in household interviews and one professional mentioned it also. Finally, there is the chance that property owners will install measures as a result of some other external influence such as an awareness campaign or grant opportunity: in the interviews with professionals, grants were highlighted as a new and important trigger for thinking about resilience. General awareness campaigns were not mentioned as a factor by any interviewees; which underscores the importance of thinking about innovative awareness raising activities targeted at the windows of opportunity.

At the intervention points, guidance and advice may be delivered to property owners and occupiers by a variety of professionals and these might include:

- damage management professionals such as loss adjusters, building surveyors and reinstatement contractors, local authority
- general builders and building/DIY suppliers, property care advisers
- surveyors, valuers, estate agents, estate managers
- Insurance brokers, product providers, underwriters.

In thinking about how measures are selected, professionals interviewed used a combination of their own professional training and experience, together with the limited guidance available, to make their recommendations. The interviews suggested that many of these network members could benefit from professional development and training to better support households and small businesses.

However, individuals are also increasingly seeking out information from less formal networks such as flood action groups, the National Flood Forum (NFF) and web based sources of guidance and advice such as the Blue pages, Defra website and NFF website. Ideally the guidance available from these sources should be consistent and designed to assist and promote uptake rather than confuse and prompt inaction. The utility of such sources was confirmed by householder interviews, some individuals having invested a great deal of time in researching optimal interventions for their particular property. Householders also proved to be a source of several novel measures, as well as improvements on some existing methods, mainly around non building fabric measures. Several interviewees mentioned they had successfully negotiated lump sum payments from insurers, effectively removing advisers from the process. Ideally the guidance should also signpost sources of further advice, particularly in respect of those measures where building expertise may be essential to avoid unintended consequences (for example, where older properties need to maintain their breathability). There is an acknowledged risk that inappropriate products and services may be adopted, unless impartial advice and guidance can be accessed. Ideally, a reinstatement plan should be made in advance of a flood event occurring, so that the necessary information is to hand when the time comes to negotiate with insurance company representatives.

Further, it is clear that people also rely on informal networks of friends and family for guidance and support. Importantly there was a general sense from both professionals and households that, given the current lack of evidence for performance, there has to be an acceptance that these approaches are about damage limitation. Most stressed that water exclusion – seen as ‘protection’ - was still the preferred option. Most of the households interviewed, and many of the professional examples described, had a combination of measures to limit water entry as well as repairable internal features. This suggests that repairable approaches could be reappraised: instead of being seen as the last resort, adoption might be encouraged if they were promoted as useful within any property level scheme, rather than as an alternative. Stressing co-benefits could also be helpful; for example, one householder had purchased stylish Italianate furniture, which enhanced her interior décor, as well as being lightweight and resilient. Similarly, raised sockets can be convenient in the longer term, as they are more easily accessed by older people, or those with mobility issues, whilst both waterproof insulation and UPVC door and window frames can offer improved thermal efficiency and thus lower energy bills, (provided the nature of the building’s construction does not preclude the use of these approaches).

6. Conclusions and areas in need of further evidence

Much of the literature and guidance builds upon a core body of evidence already well known to the review team and captured by Defra research but some new ideas and evidence were gathered in the area of co-benefits, plaster and plaster boards, properties of insulation and wall assemblages, and barriers and motivations, current practice and successful case study examples.

- Costing information was found to be scanty and contradictory in some cases, making it difficult to identify low cost approaches definitively. Too many variables are involved in the complex internal environment to provide scenarios covering every eventuality. Further research is required to examine the concepts of low cost and affordable. However a pragmatic interim approach is to define low cost as having the potential to be low cost and to provide a limited number of illustrative costed examples of common measures.
- The evidence scoping identified several areas where scientific evidence of performance is lacking but industry experts have consistently recommended approaches. More research is needed to gather improved evidence of effectiveness. Given the complexity of building assemblies this will need to combine laboratory testing, testimonial and documentary evidence and post flood damage assessments.
- The weight of evidence suggests that low cost approaches can be used to prevent some of the damage from floodwaters entering the home and increasing their uptake could save money for households, small businesses and their insurers.
- Low cost approaches can be taken individually or as part of a package of measures. Often they are effective on their own and so represent very low financial barriers to implementation. However it is important to understand the strategies employed in order avoid combining measures that are incompatible and trap moisture.
- Different measures are most appropriate at different stages of the property lifecycle: for example, at reinstatement, or during planned building work or replacement of fixtures and fittings. However the opportunity of reinstatement was highlighted as particularly important for flood repairable measures and the pivotal role of insurers, loss adjusters and restoration professionals was confirmed within this study. Exploration of the other windows of opportunity is recommended.
- Evidence also suggests that low cost resilient approaches may not be the most cost beneficial way to limit damage but, within the constraints

of insurance contracts and available funding for householders and small businesses, they can be the most practical approach especially where resistance is not practical or as a fail-safe.

- Existing standards for materials and building regulations cut across the reinstatement or refurbishment process. However, it is noted that in some instances standards may only be indicators of improved water repellent properties and not applicable under hydrostatic pressures.
- Changes to the building fabric, insulation, windows, drainage, electrics and services will almost invariably need the input of suitably qualified professionals. Other modifications to fixtures and fittings may not require such support.
- Some proprietary products, such as insulation and plasterboards, are suitable for use in repairable approaches. Households and professionals will need to take care to consult technical specifications as the descriptive terms used, such as waterproof, can cause confusion.

7. References and bibliography

Studies accessed and accepted at full text

1. AF KLINTBERG, T. & BJORK, F. 2012. Air Gap Method: Dependence of water removal on RH in room and height of floor air gap. *Building and Environment,* 56**,** 1-7.
2. AGLAN, H., LUDWICK, A., KITCHENS, S., AMBURGEY, T., DIEHL, S. & BORAZJANI, H. 2014. Effect of long-term exposure and delayed drying time on moisture and mechanical integrity of flooded homes. *Journal of Flood Risk Management,* 7**,** 280-288.
3. ANAND, K. B., VASUDEVAN, V. & RAMAMURTHY, K. 2003. Water permeability assessment of alternative masonry systems. *Building and Environment,* 38**,** 947-957.
4. ASCE 2015. Flood Resistant Design and Construction (ASCE/SEI 24-14), American Society of Civil Engineers.
5. ASSOCIATION OF BRITISH INSURERS 2003. Assessment of the cost and effect on future claims of installing flood damage resistant measures. London: Association of British Insurers.
6. ASSOCIATION OF BRITISH INSURERS 2006. Flood resilient homes **-** what homeowners can do to reduce flood damage. London: Association of British Insurers.
7. ASTM 2014. Special Technical Publication. Symposium on Building Walls Subject to Water Intrusion and Accumulation: Lessons from the Past and Recommendations for the Future, April 14, 2013 **-** April 15, 2013, STP 1549**,** ASTM International Committee E06 on Performance of Buildings; Subcommittee E06.55 on Performance of Building Enclosures. AVIVA. 2005. *AVIVA - Flood Resilient Project* [Online].
8. AVIVA. Available: http://www.aviva.co.uk/home/home-advice/video/flooding-information/#FloodResilientProject 2015].
9. AVIVA. no date. *AVIVA - Guidance for Businesses - Managing your Flood Risk [Hardfacts]* [Online]. Available: http://www.aviva.co.uk/risksolutions/help/faq/answer/1773/ 2015].
10. BEDDOES, D. W. & BOOTH, C. 2011. Property level flood adaptation measures: A novel approach. *International Journal of Safety and Security Engineering, ,* 1**,** 162-181.
11. BEDDOES, D. W. & BOOTH, C. A. Property level flood protection: the need for an effective and affordable solution. 2nd International Conference in Flood Recovery Innovation and Response (FRIAR), 26th-28th May 2010 Milan. WIT press.

12. BIA 2005*. Technical notes on Brick Construction*
13. BICHARD, E. & KAZMIERCZAK, A. 2009. Resilient Homes; reward-based methods to motivate householders to address dangerous climate change. Salford: University of Salford.
14. BINDA, L., CARDANI, G. & ZANZI, L. 2010. Nondestructive Testing Evaluation of Drying Process in Flooded Full-Scale Masonry Walls. *Journal of Performance of Constructed Facilities,* 24**,** 473-483.
15. BIRKHOLTZ, S. & JEFFREY, P. 2014. Flood risk perceptions in CORFU case studies (Hamburg & Dhaka): determining protection motivation for the social dimension (D3.6). CORFU Project.
16. BLONG, R. 2004. Residential building damage and natural perils: Australian examples and issues. *Building Research and Information,* 32**,** 379-390.
17. BLUE PAGES (NFF). 2014. *The Blue Pages* [Online]. National Flood Forum. Available: http://www.nationalfloodforum.org.uk/bluepages/listing-category/floodresilience/].
18. BMG RESEARCH 2011. Cumbria Business Survey 2010. Cumbria intelligence observatory,
19. BOWKER, P. 2007. Flood resistance and resilience solutions an R&D scoping study. R&D technical report. Department for Food and Rural Affairs/Environment Agency.]
20. BRADLEY, A., CHANG, W.-S. & HARRIS, R. 2014.The effect of drying condition on post flooding mechanical properties of timber shear walls. World Conference on Timber Engineering(WCTE) 2014, 2014. University of Bath.
21. BRANZ/IAN PAGE 2011. Tool 4.4: Individual house flood mitigation measures – Costs and benefits. *Impacts of Climate Change on Urban Infrastructure & the Built Environment - aA Toolbox.* BRANZ.
22. BRANZ/PATRICIA SHAW-MATERIALS SCIENTIST 2015. Flood It! New Zealand: BRANZ.
23. BRE/KATY HUNTER 2015. Future–proofing New and Existing Buildings Flood Resilient Design and Construction Techniques (PowerPoint presentation).
24. BRISLEY, R., WELSTEAD, J., HINDLE, R. & PAAVOLA, J. 2012. Socially Just Adaptation to Climate Change. York: Joseph Rowntree Foundation.
25. BROADBENT, C. 2004. Improving the flood resistance of domestic property. *structural Survey,* 22**,** 79-83.
26. BSi 2015. Consultation - Draft BS 85500 - Guide to improving the flood performance of buildings - Flood resistant and resilient construction.
27. CARLISLE HOUSING ASSOCIATION (2007) After the floods. Housing corporation open magazine, vol Features.
28. CASSAR, M. & HAWKINGS, C. 2007. Engineering historic futures: stakeholders dissemination and scientific research report. UCL centre for sustainable heritage.

29. CIRIA. 2003. Improving the flood resistance of your home - Advice sheets 3,4,5,6,7 and 8 [Online]. London: CIRIA. Available: http://www.ciria.com/flooding/advice_sheets.html 2015].
30. DAVIES, R. 2008. The Red Store, Lerryn, Cornwall Its Adaptation Including Flood Mitigation Measures. *Journal of Architectural Conservation,* 14**,** 7-22.
31. DAVIS LANGDON 2011. Research to identify potential low-regrets adaptation options to climate change in the residential buildings sector. London: Adaptation sub-committee, Commission for Climate Change.
32. DEFRA & JBA 2014. Best Practice in Property Level Protection Systems Advice for Local Authorities. London: Defra.
33. DEFRA/ENVIRONMENT AGENCY 2011. Understanding the risks, empowering communities, building resilience – the national flood and coastal erosion risk management strategy for England.
34. DHONAU, M. & LAMOND, J. E. 2011. Property-level flood protection - Case studies of successful schemes. *In:* LAMOND, J. E., PROVERBS, D. G., BOOTH, C. A. & HAMMOND, F. N. (eds.) *Flood hazards, impacts and responses for the built environment.* New York: Taylor CRC press.
35. DHONAU, M. & ROSE, C. B. 2014. *Homeowners' guide to flood resilience (3rd edition 2014)* [Online]. Know Your Flood Risk Campaign. Available: http://www.knowyourfloodrisk.co.uk/sites/default/files/FloodGuide_ForHomeowners.pdf 2014].
36. DIEKMANN, A. & PREISENDÖRFER, P. 2003. The behavioral effects of environmental attitudes in low-cost and high-cost situations. *Rationality and Society,* 15**,** 441-472.
37. DOMONE, P. L. J. & ILLSTON, J. M. 2010. *Construction materials: their nature and behaviour,* London, Spon.
38. DRDÁCKÝ, M. 2010. Flood Damage to Historic Buildings and Structures. *Journal of Performance of Constructed Facilities,* 24**,** 439-445.
39. DUFTY, N. 2014. A review of the value of social media in countrywide disaster risk reduction public awareness strategies. *INPUT PAPER Prepared for the Global Assessment Report on Disaster Risk Reduction 2015.*
40. DUŽÍ, B., VIKHROV, D., STOJANOV, R., JAKUBÍNSKÝ, J. & KELMAN, I. 2013. Results from a Survey on Household Flood Risk Reduction in the Czech Republic. *Mitigation and Adaptation Strategies for Global Change,* 18**,** 1-8.
41. ELLIOTT, C. R. N. & LEGGETT, D. J. 2002. Reducing the impacts of flooding - extemporary measures (FR/IP/45). London: CIRIA.
42. ENVIRONMENT AGENCY 2009. Prepare your property for flooding - a guide for householders and small businesses. Bristol: Environment Agency.
43. ESCARAMEIA, M., GRAAF, R. D., LINDEMANS, W., WALLIMAN, N., ANVARIFAR, F., ZEVENBERGEN, C., SZYMANSKA-RZEZNIK, K., PONETA, P. & TAGG, A. 2012. Building flood resilience measures: outline design guidance including roadmap for accelerated acceptance. H R Wallingford/FloodProBE.

44. ESCARAMEIA, M., KARANXHA, A. & TAGG, A. 2006. Improving the flood resilience of buildings through improved materials, methods and details work package 5 – Laboratory tests WP5C Final report. London: Department of Communities and Local Government.
45. ESCARAMEIA, M., KARANXHA, A. & TAGG, A. 2007. Quantifying the flood resilience properties of walls in typical UK dwellings. *Building Services Engineering Research and Technology,* 28**,** 249-263.
46. ESCARAMEIA, M. & STONE, K. 2013. Technologies for Flood Protection of the Built Environment - Guidance based on findings from the EU-funded project FloodProBE. Floodprobe Project.
47. ESCARAMEIA, M., TAGG, A. F., WALLIMAN, N., ZEVENBERGEN, C. & ANVARIFAR, F. 2012. The role of building materials in improved flood resilience and routes for implementation. *2nd European Conference on Flood Risk Management - FLOODrisk2012.* Rotterdam, The Netherlands.
48. EVANS, R. Flood Risk Management and Community Resilience: Coldbrook Flood Risk Management Scheme.
49. EVERETT, G. & LAMOND, J. Household behaviour in installing property-level flood adaptations: a literature review. Sustainable Cities, 2013 Kuala Lumpur. WIT Press.
50. EXTENSION. 2014. *Selecting Building Materials to Help Reduce Future Flood Damage* [Online]. eXtension. Available: http://www.extension.org/pages/13862/selecting-building-materials-to-help-reduce-future-flood-damage#.VQvky46sUs4 [Accessed 20/03/15.
51. FELL, D., BAIN, J. & WILLIAMS, G. 2014. Synthesis of flood social science evidence for policy decision and delivery improvement. Brook Lyndhurst. Defra, London
52. FELTMATE, B. & THISTLETHWAITE, J. 2014. Partners for action - priorities for advancing flood resiliency in Canada.
53. FEMA 1999. Protecting building utilities from flood damage - principles and practices for the design and construction of flood resistant building utility systems, Washington, Federal Emergency Management Agency.
54. FEMA 2008 Mitigation best practices search [Online]. Washington: FEMA. Available: http://www.fema.gov/mitigationbp/index.jsp [Accessed April 2008].
55. FEMA 2008. Flood Damage-Resistant Materials Requirements for Buildings Located in Special Flood Hazard Areas in accordance with the National Flood Insurance Program. Washington D.C., USA: FEMA.
56. FEMA 2010. Water-Resistant Building Materials. Protecting Your Home And Property From Flood Damage - Mitigation Ideas For Reducing Flood Loss. FEMA.
57. FIDLER, J., WOOD, C. & RIDOUT, B. 2004. Flooding and Historic Buildings, technical advice note. *In:* WEDD, K. (ed.). English Heritage.

58. FLOOD MANAGER 2010. *Flood resilience measures* [Online]. Available: http://daad.wb.tu-harburg.de/?id=1328 2015].
59. FLOOD REPAIRS FORUM & PROVERBS, D. G. 2005. Repairing flooded buildings: an insurance industry guide to investigation and repair, Watford, BRE press.
60. GABALDA, V., KOPPE, B., KELLY, D., HUNTER, K., FLORENCE, C., GOLZ, S., DIEZ, J., MONNOT, J. V. & MARQUEZ, P. 2012. Tests of flood resilient products (report to the EU Commission). SMARTeST Project.
61. GARVIN, S., REID, J. & SCOTT, M. 2005. Standards for the repair of buildings following flooding (C623). London: CIRIA.
62. GOLZ, S., SCHINKE, R., NAUMANN, T., GARVIN, S. & WHITE, I. Assessing the effects of flood resilient technologies. 2013.
63. GROTHMANN, T. & REUSSWIG, F. 2006. People at risk of flooding: Why some residents take precautionary action while others do not. *Natural Hazards,* 38**,** 101-120.
64. GUPTA, T. 2014. UK floods: How one woman held back the water. Available: http://www.bbc.co.uk/news/uk-england-kent-26238532 [Accessed 19 February 2014].
65. HARRIES, T. 2008. Feeling secure or being secure? Why it can seem better not to protect yourself against a natural hazard. *Health Risk & Society,* 10**,** 479-490.
66. HARRIES, T. 2010. Household Flood Protection Grants - The householder perspective. Defra and Environment Agency Flood and Coastal Risk Management Conference 2010. 29th June 2010. Telford International Conference Centre, Telford UK.
67. HARRIES, T. 2012. The anticipated emotional consequences of adaptive behaviour - impacts on the take-up of household flood-protection measures. *Environment and Planning A,* 44**,** 649-668.
68. HARRIES, T. & PENNING-ROWSELL, E. 2011. Victim pressure, institutional inertia and climate change adaptation: The case of flood risk. *Global Environmental Change,* 21**,** 188-197.
69. HARVATT, J., PETTS, J. & CHILVERS, J. 2011. Understanding householder responses to natural hazards: flooding and sea-level rise comparisons. *Journal of Risk Research,* 14**,** 63-83.
70. HAWKESBURY-NEPEAN FLOODPLAIN MANAGEMENT STEERING COMMITTEE 2007. Reducing vulnerability of buildings to flood damage - Guidance on building in flood prone areas. Hawkesbury-Nepean Floodplain Management Steering Committee.
71. HERSHFIELD, M. 2013. Investigation of the Constructability and Water Penetration Resistance of Concrete Masonry/Polyurethane Foam Wall Systems and Other Interior Applied Materials. Northwest Concrete Masonry Association.
72. HISTORIC ENGLAND (FORMERLY ENG HERITAGE)/PICKLES ET AL 2015. Flooding and Historic Buildings. Historic England (formerly Eng Heritage).

73. HOWE, P. D. 2011. Hurricane preparedness as anticipatory adaptation: A case study of community businesses. *Global Environmental Change-Human and Policy Dimensions,* 21**,** 711-720.
74. IBREKK, A. S., KRASOVSKAIA, I., GOTTSCHALK, L. & BERG, H. 2005. Perception and communication of flood risk - preliminary results from the flows project. *International conference on innovation advances and implementation of flood forecasting technology.* Tromsø, Norway.
75. JBA CONSULTANTS 2012. Evaluation of the Defra Property-level Flood Protection Scheme: 25918.
76. JBA CONSULTING 2013. Establishing the Cost Effectiveness of Property Flood Protection: FD2657 - Final report. London: Defra.
77. JOHNSON, M. 2011. Protection and performance of flooded buildings. *In:* LAMOND, J. E., PROVERBS, D. G., BOOTH, C. A. & HAMMOND, F. N. (eds.) *Flood hazards, impacts and responses for the built environment.* New York: Taylor CRC press.
78. JONES, C. P., COULBOURNE, W. L., MARSHALL, J. & ROGERS, S. M. 2006. Evaluation of the National Flood Insurance Program's Building Standards.
79. JOSEPH, R. D. 2014. *Development of a comprehensive systematic quantification of the costs and benefits (CB) of property level flood risk adaptation measures in England.* PhD, University of the West of England.
80. JOSEPH, R., LAMOND, J., PROVERBS, D. & WASSELL, P. 2011. An analysis of the costs of resilient reinstatement of flood affected properties: a case study of the 2009 flood event in Cockermouth. *Structural Survey,* 29**,** 279 - 293.
81. KASPERSON, R. E., RENN, O., SLOVIC, P., BROWN, H. S., EMEL, J., GOBLE, R., KASPERSON, J. X. & RATICK, S. 1988. The Social Amplification of Risk: A Conceptual Framework. *Risk Analysis,* 8**,** 177-187.
82. KELMAN, I. & SPENCE, R. 2004. An overview of flood actions on buildings. *Engineering Geology,* 73**,** 297-309.
83. KOERTH, J., VAFEIDIS, A. T., CARRETERO, S., STERR, H. & HINKEL, J. 2014. A typology of household-level adaptation to coastal flooding and its spatio-temporal patterns. *SpringerPlus,* 3**,** 466-466.
84. KOERTH, J., VAFEIDIS, A. T., HINKEL, J. & STERR, H. 2013. What motivates coastal households to adapt pro-actively to sea-level rise and increasing flood risk? *Regional Environmental Change,* 13**,** 897-909.
85. KREIBICH, H. 2011. Do perceptions of climate change influence precautionary measures? *International Journal of Climate Change Strategies and Management,* 3**,** 189-199.
86. KREIBICH, H., SEIFERT, I., THIEKEN, A. H., LINDQUIST, E., WAGNER, K. & MERZ, B. 2011. Recent changes in flood preparedness of private households and businesses in Germany. *Regional Environmental Change,* 11**,** 59-71.
87. LAKS, P. E., RICHTER, D. L. & LARKIN, G. M. 2002. Fungal susceptibility of interior commercial building panels. *Forest Products Journal,* 52**,** 41-44.

88. LAMBERT, P. 2006. Research on the impacts of speed drying. EPSRC flood repair network workshop on identification and facilitation of flood damage research. Sheffield.
89. LAMOND, J., DHONAU, M., ROSE, C. & PROVERBS, D. Overcoming the Barriers to installing Property level flood protection – an overview of successful case studies. Road Map Towards a Flood Resilient Urban Environment, 26 November 2009 Paris. Urban Flood Management Cost Action Network C22.
90. LAMOND, J. & PROVERBS, D. 2009. Resilience to flooding : learning the lessons from an international comparison of the barriers to implementation. Urban Design and Planning, 162, 63-70.
91. LAMOND, J. E. 2010. Flood resilience technology and practice. Flood resilient planning and building. BRE, Watford.
92. LIANG, L. T. 2005. *Waterproofing materials in building.* BEng, Universiti Teknologi Malaysia.
93. LOPEZ, C., MASTERS, F. J. & BOLTON, S. 2011. Water penetration resistance of residential window and wall systems subjected to steady and unsteady wind loading. *Building and Environment,* 46**,** 1329-1342.
94. LSU AG CENTER 2012. The Flood-Hardy Wall - Wood frame method for a flood resilient home.
95. LUBELLI, B., VAN HEES, R. P. J. & GROOT, C. W. P. 2006. Investigation on the behaviour of a restoration plaster applied on heavy salt loaded masonry. *Construction and Building Materials,* 20**,** 691-699.
96. MESSNER, F., PENNING-ROWSELL, E. C., GREEN, C., MEYER, V., TUNSTALL, S. M. & VAN DER VEEN, A. 2007. Evaluating flood damages: guidance and recommendations on principles and methods. *Floodsite.* Oxfordshire, UK: H R Wallingford.
97. NADAL, N. C. 2007. Expected flood damage to buildings in riverine and coastal zones. PhD, University of Puerto Rico.
98. NATIONAL FLOOD FORUM 2008. Case Studies - Resilient Repair. *NFF Newsletter.* NFF.
99. NATIONAL FLOOD FORUM. no date. *Case Studies (all)* [Online]. Available: http://www.nationalfloodforum.org.uk/case-studies/.
100. NATIONAL TRUST var. various reports on historic building flood renovations - Case Study possibilities?
101. NORFOLK COUNTY COUNCIL 2005. Residential, low elevation infrastructure project, Norfolk 2005. WP2 FLOWS report. Norfolk County Council.
102. NORWICH UNION (NOW AVIVA). 2005. *CASE STUDY Mr Spybey, Northumberland* [Online].
103. NYGRÉN, N. A., KONTIO, P., LYYTIMÄKI, J., VARHO, V. & TAPIO, P. 2015. Early adopters boosting the diffusion of sustainable small-scale energy solutions. Renewable and Sustainable Energy Reviews, 46, 79-87.

104. OFFICE OF THE DEPUTY PRIME MINISTER 2003. Preparing for floods - interim guidance for improving the flood resistance of domestic and small business properties. London: ODPM.
105. OSBERGHAUS, D. 2015. The determinants of private flood mitigation measures in Germany - Evidence from a nationwide survey. *Ecological Economics,* 110**,** 36-50.
106. PARKER, D. J., PRIEST, S. J. & TAPSELL, S. M. 2009. Understanding and enhancing the public's behavioural response to flood risk. *Meteorological Applications,* 16**,** 103-114.
107. PERKES, D. 2011. Floodproof Construction: Working for Coastal Communities. Southeast Region Research Initiative.
108. PORTER, J. J., DESSAI, S. & TOMPKINS, E. L. 2014. What do we know about UK household adaptation to climate change? A systematic review. *Climatic Change,* 127**,** 371-379.
109. POUSSIN, J. K., BOTZEN, W. W. & AERTS, J. C. 2015. Effectiveness of flood damage mitigation measures: Empirical evidence from French flood disasters. *Global Environmental Change,* 31**,** 74-84.
110. PROVERBS, D. & LAMOND, J. The Barriers to Resilient Reinstatement of Flood Damaged Homes. 4th International i-Rec conference 2008. Building resilience: achieving effective post-disaster reconstruction, April 2008 Christchurch, New Zealand.
111. PROVERBS, D. & SOETANTO, R. 2004. *Flood damaged property: A guide to repair,* London, Blackwell.
112. RAWCLIFFE, P. 2008. Flood resilience - Well worth it! *National Flood Forum Newsletter.*
113. RHODES, D. A. & PROVERBS, D. G. An investigation of the current state of preparedness of the flood damage management sector in the UK: what lessons have been learnt. COBRA 2008, 2008 Dublin Institute of Technology. RICS foundation.
114. RICS 2011. A clear guide to … Flooding - For property owners. London: RICS.
115. ROSE, C. B., PROVERBS, D. G., BOOTH, C. A. & MANKTELOW, K. 2012. “Three times is enemy action” – flood experiences and flood perceptions. *In:* PROVERBS, D. G., MAMBRETTI, S., BREBBIA, C. A. & DE WRACHIEN, D. (eds.) *Flood Recovery Innovation and Response III.* Southampton: WIT Press.
116. ROSE, C. B., PROVERBS, D. G., MANKTELOW, K. & BOOTH, C. A. 2010. Psychological factors affecting flood coping strategies. *Flood Response Innovation and Repair II.* Southampton: WIT Press.
117. SALAGNAC, J. L., MARCHAND, D., FLORENCE, C., DELPECH, P. & AXES, J.-M. 2014. CSTB - Impacts des inondations sur le cadre bˆati et ses usagers, rapport final. *Maîtrise des risques.* Centre scientifique et technique du bâtiment,

Directions Economie et sciences humaines, Sécurité structures feu, Climatologie - Aérodynamique - pollution - épuration.
118. SALZANO, C. T., MASTERS, F. J. & KATSAROS, J. D. 2010. Water penetration resistance of residential window installation options for hurricane-prone areas. *Building and Environment,* 45**,** 1373-1388.
119. SAMWINGA, V. 2009. Homeowner satisfaction and service quality in the repair of UK flood-damaged domestic property. PhD Unpublished PhD, University of Wolverhampton.
120. SCHINKE, R., TOURBIER, J., GOLZ, S., NAUMANN, T. & LEIBNIZ INSTITUTE OF ECOLOGICAL URBAN AND REGIONAL DEVELOPMENT (IOER) 2013. Guideline for implementation of flood resilience construction, technology and systems. SMARTeST.
121. SHAFFER, P., GAMST, K., PROVERBS, D., LAMOND, J., DHONAU, M. & WATERHOUSE, L. 2009. Advice on flood resilience and resistance measures for those at risk of flooding, literature review. CIRIA.
122. SHEAFFER, J. R. 1960. Flood proofing: an element in a flood damage reduction progam. *Department of Geography research paper.* Chicago: University of Chicago.
123. SMARTEST PROJECT/Kelly 2011 SMARTeST WP2 - Report D2.1 - Innovative flood resilience technology. (EU Commission).
124. SOETANTO, R., PROVERBS, D., LAMOND, J. & SAMWINGA, V. 2008. Residential properties in England and Wales: an evaluation of repair strategies towards attaining flood resilience. *In:* BOSCHER, L. (ed.) *Hazards and the built environment : attaining built-in resilience.* Taylor and Francis.
125. SPENCE, A., POORTINGA, W., BUTLER, C. & PIDGEON, N. F. 2011. Perceptions of climate change and willingness to save energy related to flood experience. *Nature Climate Change,* 1**,** 46-49.
126. STEINFÜHRER, A., KUHLICKE, C., DE MARCHI, B., SCOLOBIG, A., TAPSELL, S. & TUNSTALL, S. M. 2009. Local Communities at Risk from Flooding: Social Vulnerability, Resilience and Recommendations for Flood Risk Management in Europe. Leipzig: Helmholtz Centre for Environmental Research – UFZ
127. SWINTON, M. C. & KESIK, T. 2005. Performance Guidelines for Basement Envelope Systems and Materials - Final Research Report. Institute for Research in Construction/ National Research Council Canada.
128. TAGG, A., ESCARAMEIA, M. & ORTIZ, J. M. 2007. Improving the flood resilience of buildings through improved materials, methods and details - Report WP6 - collation and analysis of post-flood observational data. *DCLG Building Regulations (Sanitation) Framework.*
129. TAGG, A., ESCARAMEIA, M., VON CHRISTIERSON, B., LAMOND, J., PROVERBS, D. & KIDD, B. 2010. CLG building regulations research programme

– lot 13 water management - Signposting of current guidance BD2760. London: Communities and Local Government.
130. THURSTON, N., FINLINSON, B., BREAKSPEAR, R., WILLIAMS, N., SHAW, J. & CHATTERTON, J. 2008. Developing the Evidence Base for Flood Resistance and Resilience - R&D Technical Report FD2607/TR. London: Defra.
131. UDDIN, N., DONG, L., MOUSA, M. A., MASTERS, F. J. & FERNANDEZ, G. Evaluation of system resilience of building panels through full-scale wind load and flood tests. 11th International Conference on Structural Safety and Reliability, ICOSSAR 2013, June 16, 2013 - June 20, 2013, 2013 New York, NY, United states. Taylor & Francis - Balkema, 1325-1329.
132. UNDERFLOOR HEATING STORE. no date. *Example of wet room kit* [Online]. Available: http://www.theunderfloorheatingstore.com/bal---wp1-waterproof-shower-kit-7272-p.asp?gclid=CKn_nr20isYCFQ-WtAodynQApQ 2015].
133. USACE 1998. Flood proofing performance: successes & failures.
134. VAN DEN BOSSCHE, N., LACASSE, M. & JANSSENS, A. Watertightness of masonry walls: an overview. 12th International Conference on the Durability of Building Materials and Components (12DBMC),, April 12-15 2011 Porto, PT, . 1-8.
135. WALLIMAN, N. 2012. Assessment of the vulnerability of critical infrastructure buildings to floods. FloodProBE.
136. WALLIMAN, N., BAICHE, B., OGDEN, R., TAGG, A. & ESCARAMEIA, M. 2013. Estimation Of Repair Costs Of Individual Non-domestic Buildings Damaged By Floods. *International Journal of Safety and Security Engineering,* 3**,** 289 - 305.
137. WALLIMAN, N., TAGG, A., ESCARAMEIA, M., BAICHE, B. & OGDEN, R. 2012. Assessment of the vulnerability of critical infrastructure buildings to floods. *Report of the EU Floodprobe project*
138. WASSELL, P., AYTON-ROBINSON, R., ROBINSON, D. & SALKELD, I. 2009. Resilient reinstatement - the cost of flood resilient reinstatement of domestic properties. *Research Paper.* London: Association of British Insurers.
139. WHITE, D. I., CONNELLY, D. A., LAWSON, N. & HARE, D. P. O. Integration of Flood Resilience Technologies, Systems and Tools (D5.3). SMARTeST Project.
140. WILSON, L., O'BRIEN, G., O'KEEFE, P. & ENGLAND, K. 2014. Barriers to adaptation in Newcastle upon Tyne, UK: Preliminary findings. Urban Climate, 7, 33-46.
141. WINGFIELD, J., BELL, M. & BOWKER, P. 2005. Improving the flood resilience of buildings through improved materials, methods and details. ODPM.

Studies not available at full text or foreign language

1. BDMA. 2015. Draft BS 12999 Damage management – Stabilization, mitigation and restoration of properties, contents, facilities and assets following incident damage [Online]. Available: http://www.bdma.org.uk/node/2611 2015].
2. BOULET-DESBAREAU, C., BESSIS, B., MORONVAL, F. & SALAGNAC, J. 2005. La Mitigation en zones inondables. Éléments pour l'élaboration des plans de prévention des risques inondation. Réduire la vulnérabilité des biens existants (Mitigation in floodplains . Elements for the development of flood risk prevention plans. Reducing the vulnerability of property ...). Paris: Ministère de l'Ecologie et du Développement Durable (MEDD).
3. BRE SCOTTISH LABORATORY 1996. Design guidance on flood damage to dwellings. London: HMSO for Scottish Office Development Department.
4. DE BOER, J., BOTZEN, W. & TERPSTRA, T. 2012. Relationships between perceived flood risks, problem ownership and household and business adaptation choices (HSRR07/HSGR08) report in Dutch. Knowledge for Climate (inc Deltares and others).
5. DILL, M. J. 2000. A review of testing for moisture in building elements. Construction Industry Research and Information Association.
6. EUROPEAN CENTER FOR FLOOD RISK PREVENTION (CEPRI). no date. Available: http://www.cepri.net/home.html.
7. FUGLER, D., FOREST, T. & ACKERMAN, M. Avoiding molds in finished basements. Moisture, Microbes and Health Effects: Indoor Air Quality and Moisture in Buildings Conference, IAQ 2001, November 4, 2001 - November 7, 2001, 2001 San Francisco, CA, United states. Amer. Soc. Heating, Ref. Air-Conditoning Eng. Inc.
8. GARVIN, S., ZEVENBERGEN, C. & SALAGNAC, J. 2012. Urban flood resilience: Beyond vulnerability using innovative non-structural measures. *In:* KLIJN, F. & SCHWECKENDIEK, T. (eds.) *Comprehensive Flood Risk Management: Research for Policy and Practice.* CRC Press.
9. GERMAN GOVT PUBLICATIONS 2013. Flood Protection Primer - Object protection and structural prevention (in German). German govt.
10. IHRR 2011. Prof Paul Slovic – 'The Feeling of Risk' - May 27, 2011. Institute of Hazard, Risk and Resilience.
11. INGARGIOLA, J., JONES, C. & QUINN, R. 2012. ASCE 24: Improving the Performance of Buildings and Structures in Flood Hazard Areas. *Advances in Hurricane Engineering.* American Society of Civil Engineers.
12. INGARGIOLA, J. & MOLINE, J. 2012. Flood Damage-Resistant Materials: Research and Evaluation. *Advances in Hurricane Engineering.* American Society of Civil Engineers.

13. INGARGIOLA, J. & MOLINE, J. Draft standard for flood damage-resistant materials. 6th Congress on Forensic Engineering 2012: Gateway to a Better Tomorrow, October 31, 2012 - November 3, 2012, 2013 San Francisco, CA, United states. American Society of Civil Engineers (ASCE), 575-584.
14. KAKULU, I. I. & BRISIBE, W. G. 2014. Increasing flood resilience in buildings through adaptable designs: learning from the Bayelsa experience. *2nd International Conference on flood and erosion prevention, protection and mitigation.* Port Harcourt, Nigeria.
15. MOUSA, M. A., DONG, L. & NASIM UDDIN, P. 2014. Risk-Consistent Design Approach for Designing Innovative Hazard-Resistant Structures. *Second International Conference on Vulnerability and Risk Analysis and Management (ICVRAM) and the Sixth International Symposium on Uncertainty, Modeling, and Analysis (ISUMA).* Liverpool, UK.
16. NAUMANN, T., NIKOLOWSKI, J., GOLZ, S. & SCHINKE, R. 2011. Resilience and Resistance of Buildings and Built Structures to Flood Impacts – Approaches to Analysis and Evaluation. *In:* MÜLLER, B. (ed.) *German Annual of Spatial Research and Policy 2010.* Springer Berlin Heidelberg.
17. NIKOLOWSKI, J., GOLDBERG, V., ZIMM, J. & NAUMANN, T. 2013. Analysing the vulnerability of buildings to climate change: Summer heat and flooding. *Meteorologische Zeitschrift,* 22**,** 145-153.
18. SALAGNAC, J. L. 2006. Rendre les bâtiments moins vulnérables aux risques naturels (Reducing the vulnerability of buildings to natural hazards). *Ann ales des Mines, Responsabilite et Environnement - Catastrophes et Territoires,* 43**,** 47-52
19. SOETANTO, R., PROVERBS, D. & NICHOLAS, J. 2002. Benchmarking domestic property flood damage assessment. University of Wolverhampton report for LLoyds TSB insurance.
20. TAGGART, M. & VAN DE LINDT, J. W. 2009. Performance-Based Design of Residential Wood-Frame Buildings for Flood Based on Manageable Loss. *Journal of Performance of Constructed Facilities,* 23**,** 56-64.
21. THE SCOTTISH GOVERNMENT. 2004. *Planning Advice Note PAN 69 - Planning and Building Standards Advice on Flooding* [Online]. Available: http://www.gov.scot/Publications/2004/08/19805/41597.
22. VAN BUUREN, A., DUIJN, M., TROMP, E. & VAN VEELEN, P. 2014. Adaptive flood risk management for unembanked areas in Rotterdam. *Action Research for Climate Change Adaptation: Developing and Applying Knowledge for Governance.* Routledge.
23. VAN DE LINDT, J. W. & TAGGART, M. A. Performance-based design of residential structures for flood. 2008 Structures Congress - Structures Congress 2008: Crossing the Borders, April 24, 2008 - April 26, 2008, 2008 Vancouver, BC, Canada. American Society of Civil Engineers.

24. WILLIS, V. L., SCHIFF, S. D., ROSOWSKY, D. V. & NELSON, J. K. 1999. Lessons learned from the structural retrofit of a historic Charleston house. *In:* SICKELSTAVES, L. B. (ed.) *Use of and Need for Preservation Standards in Architectural Conservation.*
25. YOUNG, W. R., JR. 2009. Emergency Power For Critical Items. *In:* NELSON, G. L. & HRONSZKY, I. (eds.) *Sustainability 2009: The Next Horizon.*

Studies accessed but rejected at full text

1. AGLAN, H., WENDT, R. & LIVENGOOD, S. 2004. Field testing of energy-efficient flood-damage-resistant residential envelope systems summary report. U.S. Department of Energy.
2. ASSOCIATION OF BRITISH INSURERS 2010. A guide to resistant and resilient repair after a flood. London: ABI.
3. ASSOCIATION OF BRITISH INSURERS/NATIONAL FLOOD FORUM 2006. Repairing your home or business after a flood - how to limit damage and disruption in the future. London: Association of British Insurers/ National flood forum.
4. AVIVA. no date. *AVIVA -Flood resilience measures to consider* [Online]. Available: http://www.aviva.co.uk/home/home-advice/video/flooding-information/#BeforeFlooded 2015].
5. AXA 2006. Preparing for climate change - a practical guide for small businesses. AXA.
6. BEDDOES, D. W. IN PRESS. *Structural Survey*.
7. BOOYSEN, H. J., VILJOEN, M. F. & DE VILLIERS, G. T. 1999. Methodology for the calculation of industrial flood damage and its application to an industry in Vereeniging. *Water SA,* 25**,** 41-46.
8. BOUWER, L. M., PAPYRAKIS, E., POUSSIN, J., PFURTSCHELLER, C. & THIEKEN, A. H. 2014. The Costing of Measures for Natural Hazard Mitigation in Europe. *Natural Hazards Review,* 15.
9. BOWKER, P., ESCARAMEIA, M. & TAGG, A. 2007. Improving the flood performance of new buildings - Flood resilient construction. London: Department for Communities and Local Government.
10. BRAMLEY, M. E. & BOWKER, P. M. 2002. Improving local flood protection to property. *Proceedings of the Institution of Civil Engineers-Civil Engineering,* 150**,** 49-55.
11. BRANZ 2014. Resilient Homes - Storms, Floods and Heavy Weather. New Zealand: BRANZ.
12. BRANZ (?) 2010. ASSESSING WATER DAMAGE TO PLASTERBOARD LININGS (supplement 22 to GIB site guide).
13. BRANZ/DES MOLLOY 2004/05. Repairing flood damage to houses. BRANZ.
14. BRANZ/JOHANNES ROBERTI 2011. Tool 4.8: Overview of a Building Flood Protection Decision Framework. *Impacts of Climate Change on Urban*

Infrastructure & the Built Environment - A Toolbox. Porirua, New Zealand: BRANZ.

15. CHIOVITTI, D., GONCALVES, M. & RENZULLO, A. 1999. Performance evaluation of water repellents for above grade masonry. *In:* LACASSE, M. A. & VANIER., A. D. J. (eds.) *Durability of Building Materials and Components.* Ottawa: Institute for Research in Construction, .
16. CIRIA. 2003. *Improving the flood resistance of your home - advice sheet 1: Identifying flood risk* [Online]. London: CIRIA. Available: http://www.ciria.com/flooding/pdf/CIRIA_Advice_sheet_1.pdf [Accessed 20/03/15.
17. CIRIA. 2003. *Improving the flood resistance of your home - advice sheet 2: How does flood water enter a house above ground* [Online]. London: CIRIA. Available: http://www.ciria.com/flooding/pdf/CIRIA_Advice_sheet_2.pdf [Accessed 20/03/15.
18. CIRIA. 2008. *Repair and restoration of buildings following floods* [Online]. London: CIRIA. Available: http://www.ciria.com/flooding/index.html.
19. DE MOEL, H., VAN VLIET, M. & AERTS, J. C. J. H. 2014. Evaluating the effect of flood damage-reducing measures: a case study of the unembanked area of Rotterdam, the Netherlands. *Regional Environmental Change,* 14**,** 895-908.
20. DELUCCHI, M. & CERISOLA, G. 2001. Influence of organic coatings on the stability of macrodefect-free cements exposed to water. *Construction and Building Materials,* 15**,** 351-359.
21. FEMA SUPERSEDED Flood-resistant materials requirements for buildings located in special flood hazard areas in accordance with the National Flood Insurance Program (2-93). *Technical Bulletin.* FEMA.
22. FEMA 2006. Summary report on building performance, Hurricane Katrina 2005. FEMA.
23. GARVIN, S. L. & KELLY, D. J. 2007. Flood repair standards for buildings. *In:* ASHLEY, R., GARVIN, S., PASCHE, E., VASSILOPOULOS, A. & ZEVENBERGEN, C. (eds.) *Advances in urban flood management.* London: Taylor Francis.
24. GRUNTFEST, E. Long term social and economic impacts of extreme floods. US - Italy Research Workshop on the Hydrometeorology, Impacts, and Management of Extreme Floods, 13-17th November 1995 Perugia (Italy).
25. H M GOVERNMENT. 2013. Approved Document C - Site preparation and resistance to contaminates and moisture (2004 Edition incorporating 2010 and 2013 amendments) [Online]. London: H M Government. Available: http://www.planningportal.gov.uk/buildingregulations/approveddocuments/partc/documentc#Download.

26. HAMMOND, M., CHEN, A. & DJORDJEVIC, S. 2014. Report on assessment of cost-effectiveness of flood resilience measures (WP3 Impact Assessment). University of Exeter/CORFU project (FP7).
27. HAN, D., JDAVIS, J., HU, Z., LAN, G., MAREN, E. & TWYMANC. 2002. Design Studies on Flood-Proof House.
28. INSTITUTE FOR BUSINESS AND HOME SAFETY (IBHS) 2006. Water damage prevention for commercial buildings. IBHS.
29. J.B.A. CONSULTANTS 2005. Scoping study into the cost of flooding, using the August 2004 event as a case study. *Research report.* Scottish Executive Environment Group.
30. JOSEPH, R., PROVERBS, D. G., LAMOND, J. & WASSELL, P. 2012. Towards the development of a comprehensive systematic quantification of the costs and benefits of property level flood risk adaptation. *In:* PROVERBS, D. G., MAMBRETTI, S., BREBBIA, C. A. & DE WRACHIEN, D. (eds.) *Flood Recovery Innovation and Response III.* Southampton: WIT Press.
31. KANG, S.-J., LEE, S.-J. & LEE, K.-H. 2009. A Study on the Implementation of Non-Structural Measures to Reduce Urban Flood Damage-Focused on the Survey Results of the Experts. *Journal of Asian Architecture and Building Engineering,* 8**,** 385-392.
32. KINGSPAN INSULATION. 2009. *Flood Resilience and Insulation - technical bulletin - STEPS TO IMPROVE THE FLOOD RESILIENCE OF BUILDINGS* [Online]. Kingspan Insulation. Available: http://www.kingspaninsulation.co.uk/Knowledge-Base/Flood-Resilience.aspx.
33. KVANDE, T. & LISØ, K. R. 2009. Climate adapted design of masonry structures. *Building and Environment,* 44**,** 2442-2450.
34. LAMOND, J., PROVERBS, D., ESCARAMEIA, M. & TAGG, A. 2014. Towards improved guidelines for drying flood-damaged buildings. *Journal of Flood Risk Management,* 7**,** 195-204.
35. LASAGE, R., VELDKAMP, T. I. E., DE MOEL, H., VAN, T. C., PHI, H. L., VELLINGA, P. & AERTS, J. C. J. H. 2014. Assessment of the effectiveness of flood adaptation strategies for HCMC. *Natural Hazards and Earth System Sciences,* 14**,** 1441-1457.
36. MEMARI, A. M., GROSSENBACHER, S. V. & IULO, L. D. 2012. Comparative Evaluation of Structural and Water Penetration Performance of Three Different Masonry Wall Types for Residential Construction. *Journal of Civil Engineering and Science,* 1**,** 9-21.
37. NETHERTON, C. 2006. PAS64. EPSRC flood repair network workshop on identification and facilitation of flood damage research. Sheffield.
38. NICHOLAS, J. & PROVERBS, D. 2002. Benchmarking the assessment of flood damaged domestic properties. Royal Institute of Chartered Surveyors.
39. NIKOLOWSKI, J., GOLDBERG, V., ZIMM, J. & NAUMANN, T. Analysing the vulnerability of buildings to climate change: Summer heat and flooding.

METTOOLS VIII - a conference of the speciality group on, 2013 Johannesstrasse 3A, Stuttgart, D-70176, Germany. Gebruder Borntraeger Verlagsbuchhandlung, 145-153.

40. NORWICH UNION A guide to flood resilient repairs. Aviva.
41. POUSSIN, J. K., BUBECK, P., AERTS, J. C. J. H. & WARD, P. J. 2012. Potential of semi-structural and non-structural adaptation strategies to reduce future flood risk: case study for the Meuse. *Natural Hazards and Earth System Sciences,* 12**,** 3455-3471.
42. SCOTTISH FLOOD FORUM 2012. Flood Protection Guide. Edinburgh: Scottish Flood Forum.
43. SMARTEST PROJECT various not directly relevant.
44. SMARTEST PROJECT 2013. Guidance for flood resilience systems. SMARTeST Project.
45. TAGG, A. 2006. Research on flood resilient construction. EPSRC flood repair network workshop on identification and facilitation of flood damage research. Sheffield.
46. US ARMY CORPS OF ENGINEERS 1988. Flood proofing tests. Washington D.C., USA: Structures Laboratory, US Army Engineer Waterways Experiment Station, Corps of Engineers National Flood Proofing Committee.
47. USACE 1988. Tests of materials and systems for flood proofing structures.
48. VICKAS, M. 2013. *Australians aren't learning lessons from recent flood disasters* [Online]. Available: http://www.australiangeographic.com.au/news/2013/03/aussies-refuse-to-flood-proof-homes-report [Accessed 14/04/15 2015].
49. WEDAWATTA, G. & INGIRIGE, B. 2012. Resilience and adaptation of small and medium-sized enterprises to flood risk. *Disaster Prevention and Management,* 21**,** 474-488.
50. WHITE, I., CONNELLY, A., GARVIN, S., LAWSON, N. & O'HARE, P. 2015. Towards best practice in property level flood protection. *Town & Country Planning***,** 83.
51. WILLIAMS, G. P. 1978. *Canadian Building Digest - 198 Flood Proofing of Buildings* [Online]. Institute for research in construction. [Accessed 6th March 2009].
52. WOODHEAD, R. 2008. Reinstatement - a considerate approach. *Joint CILA, CII Scotland and FloodRepairNet workshop.* Edinburgh.
53. WORDSWORTH, P. & BITHELL, D. 2004. Flooding in buildings: assessment, limitation and rehabilitation. *Structural Survey,* 22**,** 105-109.

Additional reference material arising from consultee/interviewee recommendations and Project Board feedback

1. Association of British Insurers 2015. Responding to major floods. London: ABI.

2. Association of British Insurers, Warren, R., Tindle, A. & Whalley, R. 2011. Flood resilient repairs and resistance measures (ABI research paper no 28). ABI.
3. AVIVA. 2005. *AVIVA - Flood Resilient Project* [Online]. AVIVA. Available: http: www.aviva.co.uk/home/home-advice/video/flooding-information #FloodResilientProject 2015].
4. AVIVA. no date. *AVIVA - Guidance for Businesses - Managing your Flood Risk [Hardfacts]* [Online]. Available: http://www.aviva.co.uk/risksolutions/help/faq answer/1773/ 2015].
5. Baca Architects, BRE, Cyril Sweett, Halcrow Group Ltd, Fulcrum Consulting & LDA Design 2009. Long-term initiatives for flood-risk environments (LiFE project). London: Defra.
6. Blong, R. 2004. Residential building damage and natural perils: Australian examples and issues. *Building Research and Information,* 32**,** 379-390.
7. Bowker, P. 2002. Making properties more resistant to floods. *Proceedings of the ICE - Municipal Engineer* [Online], 151. Available: http: www.icevirtuallibrary.com/content/article/10.1680/muen.2002.151.3.197.
8. BRANZ/Ian Page 2011. Tool 4.4: Individual house flood mitigation measures – Costs and benefits. *Impacts of Climate Change on Urban Infrastructure & the Built Environment - a Toolbox.* BRANZ.
9. BRE, Baca Architects & Aquobex 2014. Flood Resilient Property Handbook. London: Defra.
10. British Board of Agrément 2013. *Functional description of testing of the water resistance of a cavity wall after installing cavity wall insulation* [Online]. Available: http://www.bbacerts.co.uk/wp-content/uploads/2014/07/Functional-description-of-testing-of-the-water-resistance-of-a-cavity-wall-after-installing-cavity-wall-insulation.pdf
11. British Gypsum. 2015. *Board products* [Online]. Coventry: British Gypsum. Available: http://www.british-gypsum.com products?cat=bg-boards&ShowAll=True.
12. BSi 2003. BS EN 13564-3:2003 - Anti-flooding devices for buildings BSi 2013. PAS 64-2013 Mitigation and recovery of water damaged buildings - Code of practice.
13. Buchecker, M., Salvini, G., Baldassarre, G. D., Semenzin, E., Maidl, E. & Marcomini, A. 2013. The role of risk perception in making flood risk management more effective. *Natural Hazards and Earth System Science,* 13**,** 3013-3030.
14. Coed Cymru. 2011. *Tree species - softwood* [Online]. Newtown, Wales: Coed Cymru. Available: http://www.coedcymru.org.uk/softwood.html.
15. CORDIS. 2015. *SMARTeST Report Summary (Project reference: 244102)* [Online]. Available: http://cordis.europa.eu/result/rcn/155562_en.html.
16. Crichton, D. 2005. Flood Risk And Insurance In England and Wales: Are There Lessons To Be Learned From Scotland? Available: http: www.benfieldhrc.org/activities/tech_papers/tech_paper1 flood_risk_and_ins_Mar05.pdf
17. Davis Langdon 2011. Research to identify potential low-regrets adaptation options to climate change in the residential buildings sector. London: Adaptation sub committee, Commission for Climate Change.

18. Environment Agency 2009. Prepare your property for flooding - a guide for householders and small businesses. Bristol: Environment Agency.
19. Environment Agency & CIRIA 2001. After a Flood - How to restore your home. Bristol/London: EA/CIRIA.
20. Environment Agency & CIRIA 2001. Damage Limitation - How to make your home flood resistant. Bristol/London: EA/CIRIA.
21. FEMA 2014. FEMA P-312, Homeowner's Guide to Retrofitting (3rd Edition). FEMA.
22. FEMA & American Red Cross 1992. Repairing your flooded home. FEMA/ARC.
23. Fidler, J., Wood, C. & Ridout, B. 2004. Flooding and Historic Buildings, technical advice note. *In:* WEDD, K. (ed.). English Heritage.
24. Garvin, S., Reid, J. & Scott, M. 2005. Standards for the repair of buildings following flooding (C623). London: CIRIA.
25. Georgia Pacific Gypsum. 2013. *The 2008 FEMA Flood Damage Resistant Materials Guide accepts the use of "Non Paper-Faced Gypsum Board" for use on walls and ceilings* [Online]. Available: http://www.buildgp.com.
26. Historic England (formerly Eng Heritage)/Pickles *et al.* 2015. Flooding and Historic Buildings. Historic England (formerly Eng Heritage).
27. Ingirige, M. J. B. & Russell, R. 2015. Investigating SME resilience to flooding – the Braunton report. Oxford: UK Climate Impacts Programme.
28. Ingirige, M. J. B. & Wedawatta, H. G. 2014. Putting policy initiatives into practice : Adopting an "honest broker" approach to adapting small businesses against flooding. *Structural Survey,* 32**,** 123-139.
29. Joseph, R., Proverbs, D., Lamond, J. & Wassell, P. 2011. An analysis of the costs of resilient reinstatement of flood affected properties: a case study of the 2009 flood event in Cockermouth. *Structural Survey,* 29**,** 279 - 293.
30. Kelman, I. 2002. *Physical Flood Vulnerability of Residential Properties in Coastal, Eastern England.* PhD, University of Cambridge
31. King, C. 2016. Solid wall heat losses and the potential for energy saving - consequences for consideration to maximise SWI benefits: a route-map for change. Watford: BRE.
32. Lstiburek, J. 2002. Moisture control for buildings (Research Report - 0205). *ASHRAE Journal,* 2002**,** 36-41.
33. Norfolk County Council 2005. Residential, low elevation infrastructure project,
34. Norfolk 2005. *WP2 Flows report.* Norfolk County Council.
35. O'Leary, P. 2014. Timber suits flood situations. *TRADA Timber Industry Yearbook 2014* [Online]. Available: http://www.trada.co.uk/publications/download ?id=9B9683DF-011E-4E4B-BE9E-6E7D22D63DA1.
36. Office of the Deputy Prime Minister 2003. Preparing for floods - interim guidance for improving the flood resistance of domestic and small business properties. London: ODPM.
37. Pettit, A. J. C. 2015. Assessing the Benefits of Property Level Protection. *Sniffer 2015.*
38. RICS 2011. A clear guide to … Flooding - For property owners. London: RICS.

39. Rochdale Borough Council/ Comyn, F. 2015. *Building bridges and grass roots change - Pathfinder in Rochdale and Heywood* [Online]. Available: http: www.nationalfloodforum.org.uk/wp-content/uploads 2.-Rochdale-Pathfinder-Francis-Comyn-Rochdale-Borough-Council.pdf). 2016].
40. Sanders, C. 2014. Laboratory tests and modelling to investigate the effect of flooding on mineral wool cavity insulation batts in masonry walls (prep'd for MIMA). Centre for Research on Indoor Climate and Health, School of Engineering & Built Environment, Glasgow Caledonian University.
41. Sheaffer, J. R. 1960. Flood proofing: an element in a flood damage reduction progam. *Department of Geography research paper.* Chicago: University of Chicago.
42. Straube, J. F. 2000. Moisture Properties of Plaster and Stucco for Strawbale Buildings. Canada Mortgage and Housing Corporation (CHMC).
43. Straube, J. F. 2002. Moisture in Buildings. *ASHRAE Journal,* 2002**,** 15-19.
44. Straube, J. F. 2003. Moisture Properties of Plaster and Stucco for Strawbale Buildings. Balanced Solutions.com/http://www.ecobuildnetwork.org/. The Gypsum Association. no date. *Homepage* [Online]. Hyattsville, Maryland, USA:
45. The Gypsum Association. Available: http://www.gypsum.org/technical using-gypsum-board-for-walls-and-ceilings using-gypsum-board-for-walls-and-ceilings-section-i/.
46. The Resin Flooring Association (FeRFA). no date. *Home page* [Online]. Available: http://www.ferfa.org.uk/publications.phpThe Revival Company. no date. *Hydrothermic drying - case studies* [Online]. Available: http://revivalco.co.uk/case-studies/ 2015].
47. UK Centre for Moisture in Buildings (UKCMB). no date. *Home page* [Online]. Watford: BRE. Available: http://www.centre4resilience.org/?p=1003 2016].
48. United States Gypsum Company (USG) 2012. Fiberock® Tile Backerboard and Underlayment - Submittal Sheet 09250.
49. Wade, M. 2015. Lessons of 2009 help speed community's recovery. *The Times*, 09/12/15.
50. Walliman, N., Baiche, B., Ogden, R., Tagg, A. & Escarameia, M. 2013. Estimation Of Repair Costs Of Individual Non-domestic Buildings Damaged By Floods. *International Journal of Safety and Security Engineering,* 3**,** 289 - 305.
51. Wassell, P., Ayton-Robinson, R., Robinson, D. & Salkeld, I. 2009. Resilient reinstatement - the cost of flood resilient reinstatement of domestic properties (ABI research paper no 14, 2009). *Research Paper.* London: Association of British Insurers.
52. Which? 2015. *Best kitchen brands* [Online]. London: Which? Available: http: www.which.co.uk/.
53. Williams, J. & Evans, O. 2010. The influence of insulation materials on corrosion under insulation. Houston, Texas USA: NACE.
54. Wilson, A. 2008. Passive Survivability: A New Design Criterion for Buildings. *Better Buildings by Design.*
55. Wright, M., Miskin, N., Flower, A. & Rhydwen, R. 2012. Dry-lining versus a hemp and lime insulating render for internal thermal renovation of a stone cottage in West Wales, including embodied energy assessment, interstitial

wall monitoring, In-situ U-Value and WUFI modeling. *Retrofit 2012 Academic Conference.* Salford University.

Appendix 1: Evidence Review Summary Details

Review Details	Review title	How can low cost adaptation approaches be used in existing residential and small business properties to limit the damage from flood water?
	Review methodology used (QSR/REA/SR)	Rapid Evidence Assessment (Interim scoping reported to date)
	Policy lead	Mary Stevens
	Review leader	Jessica Lamond
	Review team members	Jessica Lamond, Carly Rose, David Proverbs, Rotimi Joseph, Mary Dhonau
	Steering group members	Mary Stevens, Stacey Sharman, Robbie Craig
Search details	Languages used in search	English
	Search terms used	TS = (Flood AND (hous* or domestic or home or basement or wall or insur* or fixtures or fittings or boiler or electric or services or meter or cladding or plaster or ventilation or Sealant or Particle board or concrete or lining or foundation or membrane or Floor* or Insulation or Building or Brick* or Cellar or Commercial property or Residential or Business or sacrificial) AND (reinstatement or adaptation or proof or water entry or resistant or drying or repair* or reduce vulnerability or retrofit or flood-aware or betterment or sacrificial) AND (damage or loss or recovery or disruption or cost or destruction or claim or reoccup* or displace*) NOT “fuel cell")
	# databases searched	11
	Name of databases	ISI-WebofScience; Compendex/Geobase; Directory of Open Access Journals; Sciencedirect; Infotrac; EBSCO host research databases; ICE virtual library; Knovel Interactive; Construction Information Service; Ethos; IngentaConnect
	# search-engines used	1

	Name of search-engines	Google Scholar (2000-2015)
	# organisation websites searched (UK and non-UK)	26
	Name of organisational websites searched	Historic England; National Trust; CII; AXA; RSA; Aviva; Knowledge for Climate; CAMINO; SMARTeST; FloodProbe; CORFU; FLOODsite; FLOWS; European Environment Agency; UNEP; ASCE; USACE; FEMA/NFIP; NRC/IRC; BRANZ; Insurance Council of Australia; Emergency Management Australia; EULIFE Programme/Inter-Reg; CEPRI; CILA; NFF/Blue Pages
Search Results	# of search results from databases	1387
	# results after title filter	215
	# of search results from search engines	587
	# results after title filter	35
	#combined results from databases and search engine, before dups removed	250
	#combined results from databases and search engine, after dups removed	201
	# of search results from organisational websites (full docs)	53

	# results (no change – grey literature)	53
	# of additional results (full docs) (E.g. from stakeholders/steering group/calls for submission of evidence etc.)	192
	Total number of search results	2199
	Total number of search results (before duplicates removed)	201+53+192=446
	# of records after abstract screening	219
	# Unobtainable as Full Texts	25
	# Obtainable as Full Texts	194
	#of records after full text review	141
Synthesis	Was a quantitative synthesis conducted (if yes how many studies were included?)	No

Appendix 2: Sources explored

Database sources:

- ISI web of Science
- Compendex
- Directory of Open Access Journals
- Sciencedirect
- Infotrac
- EBSCO host research databases
- ICE virtual library
- Geobase
- Knovel Interactive
- Construction Information Service
- Ethos
- IngentaConnect

Websites of Specialised organisations, UK:

- CIRIA
- BRE (Building Research Establishment)
- HR Wallingford
- RICS (Royal Institution of Chartered Surveyors)
- ABI
- NFF (National Flood Forum)
- Scottish Flood Forum
- Environment Agency (Research
- Flood risk management research consortium
- SEPA (Scottish Environment Protection Agency)
- Scottish Government
- DARD (Northern Ireland)
- Office of Public Works (Rep of Ireland)
- Defra (Department of the Environment Food and Rural Affairs) RANDD
- Community Resilience to Extreme Weather
- CLG (Communities and Local Government)
- Property Care Association
- British Damage Management Association
- Know your flood risk
- Adaptation Sub-Committee
- English Heritage
- National Trust
- CII

- BSI
- Individual Insurance company websites – Axa, RSA and Aviva

Websites of Specialised organisations, international:

- Knowledge for Climate
- Camino
- Smartest
- Floodprobe
- Corfu
- FLOODsite
- Flows (Norfolk Council)
- European Environment Agency
- UNEP
- ASCE (US)
- USACE (US)
- NFIP (US)
- FEMA (US)
- NRC (IRC) Construction (Canada)
- BRANZ (New Zealand)
- Insurance Council of Australia
- Emergency Management Australia
- EU Life Programme and Interreg
- CEPRI

Search websites:

- Google Scholar

Appendix 3: Categorisation of studies by sub question

REF.	Identifies interventions?	Costs interventions?	Evidence for performance of interventions?	Covers implementation/ barriers/ behavioural aspects	Unproven innovation(s)	Case Study/ies included	No unique information
af Klintberg T, Bjork F (2012)	Y	N	Y	N	n	n	
Aglan H, Ludwick A, Kitchens S, Amburgey T, Diehl S, Borazjani H (2014)	Y	N	Y	N	n	n	
Anand KB, Vasudevan V, Ramamurthy K (2003)							y
ASCE (2015) Flood Resistant Design and Construction (ASCE/SEI 24-14).						n	y
Ass BI 2003	y	y	n	n	n	n	
Ass BI 2006	y	y	n	n	n	n	y
ASTM 2014 (re	n	n	n	n	n	n	

Nieves)							
AVIVA (2005) AVIVA - Flood Resilient Project	Y	Y	N	N	n	y	
AVIVA (no date) BUSINESS specific	y	n	n	n	n	n	
Beddoes DW, Booth C (2011)	Y	Y	N	Y	y	n	
Beddoes DW, Booth CA	Y	Y	N	Y	y	n	
BIA 2005/6 (3 notes)	n	n	n	n	n	n	y
Bichard and Kaz. 2009	y	y	n	y	n	n	
Binda 2010	Y	N	N	N	N	N	
Birkholtz 2014	n	n	n	y	n	n	
Blong 2004	n	n	n	y	n	n	
Blue Pages (NFF)	y	n	n	n	n	y	
BMG Research 2010	n	n	n	n	n	n	y

Bowker 2007	y	y	n	n	n	n	
Bradley 2014	y	n	y	n	n	n	
BRANZ/Ian Page	n	n	n	n	n	n	
BRANZ/Patricia Shaw 2015	y	n	y	n	n	n	
BRE/Katy Hunter	y	n	n	n	n	n	y
Brisley 2012	n	n	n	y	n	n	
Broadbent 2004	y	n	n	n	n	n	y
BSi 2015	y	n	n	n	n	n	y
Carlisle HA 2007	y	n	n	n	n	n	y
Cassar 2007	y	n	y	n	n	y	
CIRIA 2003 (6 advice sheets)	y	n	n	n	n	n	
Davies 2008	y	n	n	n	n	y	
Davis Langdon 2011	y	y	n	n	n	n	y
Defra 2014	y	n	n	y		y	

Dhonau and Lamond 2011	y	n	n	n	n	y	
Dhonau and Rose	y	y	n	n	n	y	
Diekmann 2003	n	n	n	y	n	n	
Domone 2010	n	n	y	n	n	n	
Drdácký 2010	N	N	N	N	N	N	y
Dufty 2014	n	n	n	y	n	n	
Duží 2013	y	n	n	y	n	n	
EA 2009	y	n	n	n	n	n	y
EA/Defra 2011	n	n	n	n	n	n	y
Elliott 2002	y	n	n	n	n	n	
Escarameia, 2006	y	n	y	n	n	n	
Escarameia, 2007	y	n	n	n	n	n	y
Escarameia, 2012a	y	y	n	y	n	y	
Escarameia, 2012b	n	n	n	n	n	n	y

Escarameia, 2013	n	n	n	n	n	n	y
Evans 2012	n	n	n	y	n	n	
Everett and Lamond	n	n	n	y	n	n	
eXtension 2014	y	n	n	n	n	n	y
Fell 2014	n	n	n	y	n	n	
Feltmate 2014	n	n	n	y	n	n	
FEMA 1999	n	n	n	n	n	n	y
FEMA 2008	n	n	n	n	n	n	y
FEMA 2008	y	y	y	n	n	y	
FEMA 2010	y	n	n	n	n	n	y
Fidler 2004	y	n	n	n	n	n	y
Flood Manager 2010	n	n	n	n	n	n	y
FRF/Proverbs 2005	y	n	n	n	n	n	y
Gabalda (SMARTeST) 2012	n	n	Y	n	n	n	y

Garvin (CIRIA) 2005	Y	Y	N	N	N	N	
Golz 2013	y	n	n	n	n	y	y
Grothmann 2006	n	n	n	y	n	n	
Gupta 2014	y	n	y	y	n	y	
Harries 2008	n	n	n	y	n	n	
Harries 2010	n	n	n	y	n	n	
Harries 2011	n	n	n	y	n	n	
Harries 2012	n	n	n	y	n	n	
Harvatt 2011	n	n	n	y	n	n	
Hawkesbury-Nepean 2007	n	n	n	n	n	n	y
Hershfield 2013	n	n	n	n	n	n	y
Historic England 2015	n	n	n	n	n	n	y
Howe 2011	n	n	N	Y	n	n	
Ibrekk 2005	n	n	n	y	n	n	
JBA 2012	n	n	n	n	n	n	y

JBA 2013	y	y	n	n	n	n	
Johnson 2011	y	n	n	y	n	n	
Jones 2006	n	n	n	n	n	n	y
Joseph 2011	y	y	n	y	n	n	
Joseph 2014	y	n	n	y	n	n	
Kasperson 1988	n	n	n	y	n	n	
Kelman 2004	n	n	n	n	n	n	y
Koerth 2013	n	n	n	y	n	n	
Koerth 2014	n	n	n	n	n	n	y
Kreibich 2011a	n	n	n	y	n	n	
Kreibich 2011b	n	n	n	y	n	n	
Laks 2002	n	n	y	n	n	n	
Lambert 2006	n	n	y	n	n	y	
Lamond 2009a	n	n	n	n	n	y	
Lamond 2009b	n	n	n	y	n	n	
Lamond 2010	y	n	n	n	n	y	
Liang 2005	n	n	n	n	n	n	y

Lopez 2011							y
LSU Ag Cent 2012	n	n	n	n	y	n	
Lubelli 2006	n	n	n	n	n	y	
Messner 2007	n	n	n	n	n	n	y
Nadal 2007	n	n	n	n	n	n	y
National Trust (var)	n	n	n	n	n	y	
NFF 2008	n	n	n	n	n	y	
NFF no date	n	n	n	n	n	y	
Norfolk CC	y	n	n	n	n	y	
Norwich Union 2005	n	n	n	n	n	y	
Nygren 2015	n	n	n	y	n	n	
ODPM 2003	y	n	n	n	n	y	
Osberghaus 2015	n	n	n	y	n	n	
Parker 2009	n	n	n	y	n	n	
Perkes 2011	n	n	Y	n	n	n	

Porter 2014	n	n	n	y	n	n	
Poussin 2015	y	n	y	n	n	n	
Proverbs 2004	y	n	n	n	n	n	y
Proverbs 2008	y	n	n	y	n	n	
Rawcliffe 2008	y	n	y	n	n	y	
Rhodes 2008	n	n	n	n	n	n	y
RICS 2011	y	n	n	n	n	n	
Rose 2010	n	n	n	y	n	n	
Rose 2012	n	n	n	y	n	n	
Salagnac 2014							y
Salzano 2010	n	n	n	n	n	n	y
Samwinga 2009	n	n	n	n	n	n	y
Schinke 2013	n	n	n	y	n	n	
Shaffer 2009	y	n	n	y	n	n	y
Sheaffer 1960	y	n	n	n	n	n	y
SMARTeST 2011 (Kelly)	y	n	n	n	y	n	

Soetanto et al 2008	y	n	n	n	n	n	
Spence 2011	n	n	n	y	n	n	
Steinfuhrer 2009	n	n	n	y	n	n	
Swinton 2005	n	n	n	n	y	n	
Tagg 2007	y	n	n	n	n	n	y
Tagg 2010	n	n	n	n	n	n	y
Thurston 2008	y	y	n	y	n	n	
Uddin 2013	y	n	y	n	y	n	
Underfloor HS no date	y	n	n	n	y	n	
USACE 1998							
Van Den Bossche 2011							
Wallimann 2012	y	n	n	n	n	n	y
Wallimann 2013	n	n	n	n	n	n	y
Wassell 2009	y	y	n	n	n	n	

White 2013	n	n	n	y	n	n	
Wilson 2014	n	n	n	y	n	n	
Wingfield 2005	y	n	y	n	n	n	y

Appendix 4: Summary of studies containing evidence of performance of measures

1. **Aglan *et. al.* (2014).** Contains experimental evidence.

   This study simulated prolonged flooding followed by a variety of drying processes on housing units and wall assemblies. The research compared long flood impacts measured in the study with previous work by Aglan on shorter term inundation. The results clearly show that reinforced gypsum board exposed to prolonged flooding loses integrity with blistering and peeling of paper and mould growth. Shorter flooding did not destroy the integrity of the reinforced gypsum board and only redecoration was required. Drying observations were also taken showing that accelerated drying was most successful in drying the walls.

2. **Af Klintberg and Bjork (2012)**

   Examines the impact of air gap construction as a method for allowing fast reoccupation of flooded buildings without mould growth or dampness. This may be a low cost option at reinstatement - costing could be followed up.

3. **Binda et al (2010)** Contains experimental evidence.

   Part of the CHEF project on historic buildings this paper is mainly about moisture testing. However the experiments included observations about water penetration that observed sandstone to be less water absorbent than brick masonry. This research is also intended to look at surface treatments in the future.

4. **Bradley (2014)** Contains experimental evidence

   The paper presents work in progress at Bath on wetting and drying processes for timber walls. It is primarily testing different drying techniques but within the work the wetting process is also recorded. This may produce findings about water resilient assemblage components. (This was followed up, but thus far subsequent publications have not been found to be of direct relevance to this project).

5. **Branz (2015)** Contains experimental evidence.

   This short note describes the construction of some timber frame test facilities in Judgeford, New Zealand. Presently this has been limited to drying tests to establish the impact of reinstatement techniques that minimise destruction. Two types of insulation used -

	Insulation was found to be an influencing factor on drying and also remained wet after 6 weeks in sealed walls. Testing is ongoing - but no results have been published as yet.
6. **Cassar (2007)** Contains experimental evidence.	In situ monitoring and experiments on replica historic type walls. Problems with curing of the lime were experienced causing cracks so walls had to be dismantled. Brick wall with lime mortar allowed water penetration quite slowly. After flooding surfaces dried quickly but the cores remained wet for some length of time even with dehumidification. Internal wall was also slow to dry out. Sandstone wall was only tested by spraying.
7. **Escaramaeia (2006)** Contains experimental evidence.	The report details the wetting and drying testing carried out on wall assemblages carried out for the Department of Communities and Local Government with a variety of materials supposed to have different resilience to water immersion. Mainly aimed at resistance of external walls it demonstrates that masonry walls constructed in laboratory conditions allow floodwater through, at leakage rates up to 400 litres/hour/m^2. This experiment tested filled and unfilled cavity walls of masonry and timber frame construction types common in the UK (as determined by a steering panel). The head of water was held constant at 1m and a 1m panel was tested. The results confirmed that assemblages are only as strong as their weakest component. Some reflections on insulation are contained here confirming the unsuitability of loose fill in terms of collapse during wetting therefore requiring removal. The rigid insulation was seen to absorb water but did not affect the drying time of the internal face of the wall. However drying time was seen to be very long and the potential for mould to accumulate inside the cavity is noted. Reflection on plaster confirmed the unsuitability of standard gypsum but did not confirm the properties of lime due to lack of curing time. Internal cement renders are effective at minimising water ingress into a property and also appear to promote rapid drying of the surface of the wall. The extent to which the render prevents drying of the substrate is not currently clear and may be

important to consider, particularly for solid wall construction.

Floor tests were also designed to measure resistance. However the strengthening of floor slabs to withstand water pressure was recommended. Concrete has low sorpivity and so it is slow to wet and dry but the slow wetting is seen to offset slow drying unless prolonged immersion is expected. Concrete can be dried without loss of integrity. High cement mixes were not seen to be advantageous. Placement of membranes and joints were also discussed but in terms of resistance.

Fermacell boards were tested and found to deform under high water pressure in a resistant scenario. However the presence of the board (not removed for drying) also slowed the drying process.

8. **Gabalda (2012)** Contains reference to experimental evidence on building materials.

As a part of the EU SMARTEST project some materials testing was carried out. Blown in closed cell insulation (Technitherm) was tested for water repellency and found not to absorb water. It was noted that slight shortcomings in construction processes may have allowed for some leaks.

9. **Gupta (2014)** Anecdotal/Testimonial evidence

This reports the successful implementation of a combination of resistant and resilient measures installed in a frequently flooded property in Kent. The recent floods demonstrated the success of the installation as water levels were kept low. However the measures are mainly resistant. Electrical cabling is dropped from the ceiling.

10. **Laks (2002)** Experimental results

The findings are potentially relevant to the resilience of different wood types. Mould growth is investigated and it is shown that the hardwood content is more significant than coatings in preventing decay and mould growth in damp timber.

11. **Lambert (2006)** Contains experimental results

A presentation of work to study the effects of heat assisted drying. Materials tested included brick masonry, wooden doors and gypsum panels. The study confirmed the tendency of composite wood panel doors and gypsum panels to distort when wet. By contrast the hardwood front door, floorboards, chair and skirting board suffered minor distortions only.

12. **Perkes (2011)**
Contains experimental results

The paper reports results of wetting and drying of wall assemblies within an open air test facility. The tests measured the ingress into, and drying properties of, a variety of building assemblies including metal stud, cavity wall with and without insulation and sealed block. The tank was filled over a period of 4 hours – representing a reasonably slow rise flood and then maintained for a further 22 hours before emptying. These experimental results reinforce the expectations that in normal construction and long duration flooding some water will usually seep through. Insulation and waterproofing treatments were found to affect drying rates.

13. **Poussin (2015)**
contains survey evidence

Reports tests of the effectiveness of measures implemented in France in preventing damage to property. Some measures were found to be effective under all types of flooding, while others were found to be type specific. Attempts to quantify the impact of individual rather than packages of measures.

14. **Uddin (2013)**
Contains experimental evidence.

Composite Structural Insulated Panels (CSIP) are used in the US for modular construction. Four panels were tested for up to 7 days immersion in flood water. The conclusion was that the panels were resilient to short duration flooding but that degradation increased as the length of flood increased.

15. **Wingfield (2005)**
Contains testimonial and theoretical evidence.

Is a review of existing information and experience of the flood resilience and flood resistance of buildings. The review focuses on the interactions between building fabric and floods and includes: an overview of the interaction of buildings with flood water; a review of existing practice and guidance in the UK and overseas; an assessment of available data on the effect of flood water on building materials and structures. It builds on previous reports such as ODPM 2003. Importantly it contains the substance of the BRE Scottish guidance (1996) not obtained by this review. Concludes that the although there is information about the sorpivity of individual materials used in construction the evidence for actual performance of materials in constructed facilities is very slight and further testing is required.

Appendix 5: Summary of studies containing evidence of how and when to implement measures

1. Bichard and Kaziermczak (2009)	Major review of studies into climate adaptation through flood protection and energy saving
2. Birkholtz (2014)	Reviews previous work on motivation for protection and risk perception and investigated the flood risk perceptions and motivation to prepare in the case studies of Hamburg (Wilhelmsburg) and Dhaka City (Badda).
3. Blong (2004)	Discusses the building lifecycle and appropriate times to undertake adaptation
4. Defra 2014	Stresses the importance of engagement and options appraisal in the decision making process
5. Diekmann 2003	Argues that environmental concern influences environmental behaviour primarily in situations and under conditions connected with low costs and little inconvenience for individual actors using a survey of German households
6. Dufty 2014	Reviews the use of social media in forming communities of practice in resilience learning.
7. Duzi 2013	Survey of factors affecting adoption of measures in Czech republic
8. Escarameia 2012a	Highlights the lack of standards and institutional support for resilience measures. Considers whether markets need to be created to drive uptake.
9. Evans 2012	Community engagement as a route to resilience.
10. Everett and Lamond	Review of behavioural literature, includes key differences between people's desire to act and their ability to do so.

11. Feltmate 2014	Examined policy options to encourage uptake of measures in Canada
12. Grothmann 2006	Psychological study looking at factors that make individuals more or less likely to adapt in Germany through survey and regression modelling
13. Gupta 2014	Anecdotal description of reasons for adapting due to trauma of flooding and determination to avoid unpleasant consequences
14. Harries 2008 + 15. 2011 + 16. 2012	Examines the emotional aspects of adaptation and the alternative methods of ontological security- that is denial. Reasons for reluctance to adapt even when individuals are aware of risk are given including worries about changing the home and standing out from the norm.
17. Howe 2011	Business resilience as a function of the socio-cognitive characteristics of business owners
18. Ibrekk 2005	Communication of risk, including dissemination techniques.
19. Johnson 2011	Perception of ‘contamination’ following flooding can dissuade property owners from adopting water entry strategies.
20. Joseph 2011 + 21. 2014	Examines willingness to pay to avoid the intangible effects of flooding and the need to provide targeted and specific information to householders. Suggests shifts in ownership of the issue but still uncertainty in the benefits of adaptation.
22. Koerth 2013	Develops a typology of household attitudes and behaviours that can be used to target risk communication in coastal communities in Denmark, Germany and Argentina
23. Kreibich 2011a + 24. 2011b	Looks at perceptions and risk behaviour in Germany through household surveys.
25. Nygren 2015	Role of the diffusion of innovations theory in climate

	change adaptation uptake.
26. Osberghaus 2015	Links broader climate beliefs to mitigation actions in German Households at a variety of different risk levels
27. Parker 2009	Exploration of why some members of the public fail to respond to flood warning information, including lack of understanding, mistrust in authority and a lack of ownership of flood reducing actions.
28. Porter 2014	Systematic review of households adaptation behaviour to climate change. Supports the idea that low cost low skill reactive responses are most likely to be adopted by households in the UK
29. Proverbs and Lamond 2008	Review of international studies on the barriers to implementation of measures finds that the desire and ability to implement changes hinges on informational, resource, emotional and timing aspects
30. Rose 2010 + 31. 2012	Reviews of psychological factors relevant to flood risk perception and adaptation, including perceived responsibility, blame-shifting and ontological security and their effects on decision-making processes.
32. Schinke 2013	Discusses capacity building in professional stakeholders as a necessary precursor to increasing uptake and market for resistance and resilience measures.
33. Steinfuhrer 2009	Factors influencing preparedness actions, and social vulnerability implications.
34. Thurston 2008	Survey of households reveals barriers to implementation of measures that include lack of ownership and worries about loss of property value, cost and uncertainty.
35. White 2013	Proposes a roadmap to increase uptake of measures based on an analysis of barriers and opportunities : Understanding the risk; Planning - first considerations; Surveying; Design and Specification; Installation; Operation and maintenance.
36. Wilson 2014	Adaptation in the wider context of socio-economic and

political drivers, including vulnerability issues.

Appendix 6: Flipchart outputs from 1st Project Board meeting

	To validate the draft report and steer the evidence assessment.	
Q&A on presentations	Notes and response from project team	
Question 1 – What is missing from the draft report? 1. Methods/materials/ Intervention opportunities	Do we need to strip off plaster? The thinking here is that we should considered measures which would require just drying and no strip out.	Should be judged on case by case and depends on plaster type– detailed analysis needed Addressed in technical report.
	Don't strip out, dry things slowly. If this can be achieved, it may means that there may not be a need for stripping out.	Case by case issue the need to assess before strip out highlighted in REA from interviews
	Ensure any works do not create moisture problems – where can moisture get out? Beware impermeable coatings and linings . We need to consider the permeability level of the recommended/suggested materials within the report, as some of the materials may be categorised as low cost but if these would cause damp problem later on, it should be avoided	Contrasting advice here – highlighted in technical Report. Judged on a case by case basis and buildings expertise needed. Highlighted in REA and tech report
	Oak doors instead of flush doors. This is missing from the list, but it is a good example of low cost measure because oak doors are more resilient to water damage when compared to flush doors	Now included but with caution Cheapest 'oak' doors from DIY chains are NOT suitable, they will still swell and warp – despite the added expense comp to normal ie sacrificial cheap doors

	Speed drying. This needs to be considered as the effectiveness of speed drying would result in reduce cost of reinstatement. However, the cost of speed drying also needs to be considered.	A little out of scope Diff between short-term cost, and long term cost-effectiveness (saving on temp accom costs if prop re-occupied faster). (See Lambert)
	Understanding cost of resilience – material replacement ie dragon board /plasterboard only extra material cost.	Dragon board costs were examined and found to be out of scope as a low cost measures notwithstanding it may be cost beneficial after a flood
	Materials that can withstand steam cleaning for de-contamination eg steel, plastic , hardwood. The suggestion is considered to be a good idea, the issue of permeability needs to be given greater consideration especially with plastic material.	Permeability issue has been highlighted but plastics Suitable for kitchen units/ furniture not for walls Unless air gaps are provided.
	Do we need drainage grate within floor to remove water.	Sumps and pumps are covered (gravity drains not appropriate)
2. Documents/ reports/ guidance	How do we get around vested interests and assess best drying out method? Are householders getting the best bespoke deal	Important issue not just related to drying. Interview analysis address the fact that the industry Does not recognise one optimum approach. Lambert's report on Speed Drying was

		undertaken with academic rigour but limited. No other rigorous studies supporting dehumidifier method have been identified.
	Is plaster and plasterboard not resilient?	Depends on specific type – see detailed analysis on plasterboard types.
	Need to classify the building materials. The list appears to be too much and difficult to comprehend. Therefore it was suggested that the list could be categorised, for instance, we could have material for walls under one category and another for floor etc.	It is now categorised in this way (orig table represented raw data).
3. Evidence sources/case studies	Risk reports from insurers with identities removed	Commercial sensitivity issue
	Zurich Insurance risk Nexus reports	Commercial sensitivity issue
	Effect of water on Rockwool by a Scottish university	Report accessed and included. (Mineral wool insulation manufacturers association (MIMA) report by Glasgow Caledonian 2015)
	Historic England (EH) literature on Lime repairs in old buildings	Material is covered by other sources therefore examined (and discarded) this at an earlier stage.

BRE flood resistance studies	Included
Loss adjusters/insurer post event reviews	Commercial sensitivity issue
RICS building surveying journal (Jun 15)	We now have this, but derivative info only.
PCA technical literature on timber and integral plastics	derivative info only
Axa Insurance reports/studies	Commercial sensitivity issue
North West Water reports	Commercial sensitivity issue
Edinburgh Napier University	Land mgt and flooding, so n/a.
PAN 69 being updates by Scottish Govt	Issued Jun 2015, water entry strategy mentioned only as an aside, no detail.
Scottish Flood Forum	We already have these, no additional info.
National Flood Forum	We already have these, no additional info.

Evaluation of Pathfinders	This Defra initiative was community focussed; water entry strategy does not appear.
UK flood barriers Defra 2010 PLP	Water exclusion approach, n/a
Flood protection resilience consultation	See Defra/JBA 2014, already in list.
Flooding on estates (similar identical) houses +different approaches taken	This is a well-documented Ins industry issue - no new data available

	Repair and renew grant evaluation	This was largely a review of process, not methods. JL + RJ pursuing for final report
	Community groups	Covered via relevant householders from comm gps.
	Dublin Flood resilient city	Not water entry strategy.
	Loss adjusters case study reports/CILA	Commercial sensitivity issue - none identified
Question 2 – How does this report relate to Building standards and British Standards? 1. Building standards that relate to the measure 2. British Standards that relate to the measure 3. Material properties that could indicate resilience to floodwater 4. Any conflicts that arise between standards and resilience		
	Plastic cladding could cause dampness in buildings. Where it was suggested that plastic cladding can be used instead of either plasterboard or plaster for internal walls. This was considered as against the building standards because it could result in dampness of the building, which may be expensive to rectify. Therefore, this needs to be reconsidered and probably the use of plastic should be limited to skirt boards and kitchen cabinets.	see previous comment
	This was considered a conflict between resilience and building standard	Insulation an electricals Issues discussed in tech report
	11,12,&13 already in the draft British Standard.	fio
	Raising services above flood line or anticipated flood levels is seen as a low cost option, this approach supports British	fio

	standards and it has been included in the draft British standards document. The inclusion of these items in the report relates perfectly with British standard.	
	Types of insulation. Difference types of insulation can be considered but type of wall construction in most cases dictates the type of insulation to be used.	Further analysis now reported in tech report
Question 3 – Which elements of the new materials are worth investigating and why? 1. Is it likely to be low cost at reinstatement 2. Is it likely to be low cost at other times 3. For less well evidenced measures if worth pursuing more evidence about the performance of the measure 4. For newly suggested measures – Is this worth investigating	Understanding of context – some of the measures listed from the literature have to be considered in the context of the building and nature of the flood risk exposure	fio
	Unexpected consequences - recognising that some measures may have undesirable or unexpected implications that may cause other issues for the property.	See previous comments
	Recognising that the existing condition of the building and the materials / components within may include defects that are not related to the flood. Timber for example is resilient to water – so there is no need to install solid floors if the joists are in good condition.	This also emerged from inerviews and is reflected in tech epor and REA. Known issues re shallow flood levels creating stagnant water in void beneath floorboards, AND customer's preferences?
	Caution use of plastics and similar materials re breathability as these may cause unexpected consequences such as dampness	See previous comments

	Context of the works need to be considered – for example solutions may differ depending on whether the measures are being considered as part of a planned refurbishment, as part of post flood reinstatement works or as a new build	See previous comments
	Oak floorboards need not be removed as timber is resilient	Timber types analysis reported in tech report and REA.
	There is a need for the development of a methodological approach to the specification of these measures taking into account the building (age, type, condition, etc), nature of flood risk, and homeowner preferences / characteristics	Fio – needs to be considered by building professional on case by case basis
	Electrics need not be removed as wiring is generally resilient	Interviews support this but need to get a qualified electrician's comments on case by case basis.
	Dry or not to dry – the debate about drying approaches including use of speed drying solutions and to be aware of unexpected consequences such as mould growth	See previous comments
	Strengthened gypsum being used in US worth investigation	Investigated, see analysis of plasterboard types

	Plaster to be removed or not? Experience suggests that often traditional plaster is able to withstand flooding and is resilient	See previous comments
	Suspended timber to be removed or not?	See previous comments
	Reliable source of information needed to guide professionals and other property stakeholders	Need for new guidance will be considered in later project stages.
	Education and training needed for surveyors as part of CPD. Also need to embed this in the curriculum for building surveyors	Need for further training emerges in interviews Type of training is out of scope.
	Levels of 'contamination' can vary and need to be aware of vested interests from eg mould that might increase the scope of strip out works	Lack of robust evidence on contamination issue to be highlighted in final REA.
Question 4 – What are the unanswered questions? Technical questions, Resource questions, what is low cost? What is the role for proprietary products/kits? Ideas for increasing uptake	Neutral at reinstatement = low cost but need the customer consent	Interviews shed some light on this see final REA. Also investigated in next phase.
	What is low cost? Refinement in the assessment of low cost. The report uses a cost of under £750 to mean 'low cost', however this assumption must be caveated to recognise that depending on the community and individuals	Good point, needs articulating in report

	in hand, that assessment may vary significantly. Seeing how cost is a main criterion for the choice of suggested PLP measures it would be useful to understand how/why we are using that sum.	
	How about the link between cost and benefit? Are we exploring that?	Yes see final reports
	A list of examples should be provided to households that includes potential measures and a cost range. There are examples (e.g. Houselogic website) that also provide an indication of effort or time (e.g. Low-one weekend). Considering inconvenience (the 'hassle factor') is one of the reasons of reluctance to uptake house improvements that would also be useful to include.	Case studies are being developed but impossible to be comprehensive given the variety of different starting conditions and adaptation options
	When thinking of cost we need to consider indirect cost that might occur, which could range from the cost of installation (service) to potential maintenance costs down the line.	Valuable but not possible in the timescale
	Similar to the above argument – do we need to consider the longevity of the measure?	Valuable but not possible in the timescale
	There was also a discussion around the different brands and qualities available for the same measure or product and how that might affect	Will need to be assessed on a case by case basis

	the choice of measures. For instance would it be preferable to purchase/install one ‘good’ quality product or two that are lower in cost (but may not be a well-known brand or perhaps lack certification- ISO), with a similar ‘low cost’ budget?	
	Timing in the claims process is critical – need to inform BEFORE the loss adjusters get there. There are windows of opportunity for measures to be taken up that do not necessarily follow a flooding event but could follow any sort of catastrophe or accident causing damage to the house, structural or otherwise.	Interview analysis covers this. Also next Phase of project. Another issue for individual ins company processes , add suggestion to report
	Consistency not there on normal reinstatement – let alone resilience	Industry Quality Control issues = beyond scope, but Material for addenda.
	Minimum standards/industry guidance for claims	PAS exists. Industry Quality Control issues = beyond scope, but Material for addenda.
	This gives opportunity for insurers to differentiate by offering better service	Industry Quality Control issues = beyond scope, but Material for addenda.
	Think about resilience in	See above and demonstration project

	all reinstatements not just flooding – may already be happening	
	Why is it not taken up when offered (denial)	Complex psychological issues here, to be examined in later stage of project
	Non ABI affiliated insurers – how to reach	Out of scope.
	Embed in govt initiatives (Green deal, insulation)	Good point for Addenda.
	Think about climate change and where might be at risk in future	fio
	Water proof grout should be standard for all tiling	Waterproof grout more expensive – costed in tech Report.
	Standardised kits for houses	Already offered by some flood product vendors
	Consistent messaging about schemes	
	Can existing kits be branded as flood products Similar labelling and messages could be included in other products and materials whose primary purpose is other than flood protection (e.g. insulation) but can have co-benefits for flooding	Addressed in interviews Someone has to pay for Kitemarking, and unlikely to appeal to manufacturers of items with existing market anyway
	Insurance is a key driver – some insurers won't pay claims unless resilience is purchased – but this has to be in terms and conditions and not seen as constructive	Insurers require improved evidence Such as this REA – lack of industry consistency is out of scope

Appendix 7: Comments from second project board consultation

1. Concerns around the ‘breathability’ of older (pre-1930’s) properties

It was highlighted that inappropriate and/or improperly fitted insulation materials have the potential to adversely affect the behaviour of water vapour in some older structures: this issue is covered in some detail in a recently issued report from BRE (King, 2016), and is also reflected in the recent establishment (May 2016) of a dedicated research initiative (UK Centre for Moisture in Buildings (UKCMB), no date) which incorporates the Building Research Establishment (BRE), University College London, Heriot Watt University and the London School of Hygiene and Tropical Medicine. The outputs from this centre are expected to inform industry practices in future years, enabling improvements in this controversial area.

2. Contamination (by sewage or other substances)

It was agreed there is a perception among some insured householders that any ‘contaminated’ furniture and fittings (particularly in kitchen areas) can never be cleaned and sanitised to an acceptably high standard, leading to the stripping out of otherwise resilient materials. Although best practice advice includes testing (for example swabs taken for laboratory analysis that can confirm the materials have been decontaminated) this may not allay the fears of building occupants and so a pragmatic approach currently regards many fittings as sacrificial. As a corollary to this issue, it was also suggested that there have been instances of over-zealous and unnecessarily costly decontamination procedures or strip out that reinforce the public perception regarding contamination. Although some of the major water companies (which regularly deal with sewer leaks and therefore have extensive specialist knowledge) already offer advice in this area, it was suggested that the communication could be further improved by working in conjunction with a reliance agency such as Public Health England (PHE) and this avenue could beneficially be explored at the earliest opportunity.

3. Timescale impacts (real or perceived) of adopting resilient measures

As discussed by Soetanto *et al.*, (2008) installation of some resilient measures may indeed involve additional repair time, but most do not. An example is the use of lime-based plasters, as these take longer to ‘cure’ compared to gypsum products: it was suggested that some builders are reluctant to use this approach, due to fears of being fined for ‘over-runs’ on the contract, and that there could also be impacts upon temporary accommodation costs. However, one industry expert asserted that the overall time required, including the application of the porous paint finish, should be within normal time-scales, with the added benefit that residual moisture within the masonry will be able to dry more readily than would be the case with impermeable cement-sand renders. Improved information on repair times could be a feature of industry guidance.

4. Use of under-floor heating in flood resilient cement-rich screeds

Contrasting views existed on this topic: concern was expressed as to the advisability of this approach, owing to the risk that water may be able to penetrate through any ‘micro cracks’ (causing damage that is hard to detect). It was, however, suggested that the use of the plastic-tubing-style heating systems, accompanied by a waterproof insulation layer, can result in enhanced floor drying times (compared to unheated cement-rich screeds) which would constitute an additional advantage. There is an over-arching need (as with all such measures) to ensure that such installations are undertaken by a suitably qualified professional and completed to a high standard to manage down the risks.

5. Maintenance

The importance of maintaining the envelope of all buildings in good condition was mentioned as a key ‘no regrets’ solution: by ensuring that (for example) wall materials remain dry, they will be better able to resist moisture uptake in a flood situation, whereas poorly maintained structures may already contain moisture which will tend to draw in additional water. The importance of quality construction and prevention of defects is evidenced by Escarameia *et al.* (2007) and Kelman (2002).

Appendix 8: Semi-Structured interview protocol - Professional interviews

PART A: Your experience and role in supporting property adaptation
1. Can you tell me about your level of experience in carrying out resilient adaptation?
2. Now can you tell me under what circumstances you normally do this work – how you are approached?
3. When you undertake a project – how do you decide what measures to install?
PART B : Materials and methods you use in low cost resilience
4. What are the most common treatments you employ?
5. What resilient treatments /materials do you give to internal wall surfaces?
6. Are there any special treatments for cavity walls?
7. What are your thoughts on suitable insulation materials?
8. What sort of changes do you make to floors?
9. Do you move electrical, gas or plumbing services above the expected flood depth?
10. How do you make windows and doors resilient without too much extra expense?
11. What do you do about kitchens and built in cupboards?
12. What other measures/materials have you used?
PART C : Your experience of the performance of different materials and methods in limiting damage
13. What sort of evidence do you have that the approaches work (or don't)?
14. Do you issue any guarantees or certificates?
15. What happens during reinstatement, are resilient features treated in the expected way or do they get ignored?
16. Have you changed what you do over the years?
PART D: The challenges and limitations you face and ways of overcoming them
17. What are the biggest challenges in increasing the uptake of measures?
18. Do you have problems with sourcing contractors, builders understanding the approaches or not carrying out the work properly?
19. Can you think of a specific property that can serve as a good example of a low cost resilient package?
20. Is there anything else you would like to talk about that we have not discussed?

Appendix 9: Semi-Structured interview protocol - Householder interviews

Questions for households and small businesses
1. Can you tell me how many times you've been flooded and when? How long were you out of your home for?
2. What made you decide to take moves to adapt your home to reduce the damage a flood could do in the future?
3. When you decided to adapt your home– how do you decide what measures to install? 3a Where or who did you get advice/information from
4. Let's start with your floors. What sort of changes did you make?
5. What resilient treatments /materials did you give to internal wall surfaces?
6. Do you have cavity walls? If so, did you use any special treatments for cavity walls? If not, did you treat any external/internal walls?
7. Did you make any changes to external or internal doors?
8. Did you do anything to your stairs?
9. Do you move electrical, gas or plumbing services above the expected flood depth?
10. Did you do anything to your windows without it costing too much? If not, do you have any ideas as to what you could do?
11. What do you do about your kitchen and built in cupboards?
12. What other measures/materials have you used?
13. Did you adapt your downstairs toilet or utility room? If so what did you do?
14. Have you bought any furniture that you think may be more resilient to a future flood?
15. Are there any other changes you have made to your home- no matter how small or insignificant you think it may be? Your knowledge and experience will help us.
16. Since you adapted your home, have you been flooded again?
17. Is there anything else you would like to talk about that we have not discussed?

Appendix 10: List of suggested low cost measures for water entry strategy

MEASURE TYPE	Depth	Low-cost items	SPECIFIC interventions
Key:	*Low up to 100mm, Medium = up to 300mm, High = up to 900mm, Any = up to one storey*		
	****** potential to be installed at low cost*		
Water compatible walls	Any		Silicon-mineral/Magnesium Oxide board, instead of plasterboard (concerns with breathability)
	Any	*****	Use cement based moisture-resistant plasterboard or waterproof board
	Any	*****	Use cellulose-fibre reinforced gypsum for areas with short duration floods
	High	*****	Fix plasterboards horizontally on timber framed walls rather than vertically (aka sacrificial plaster board/dry-lining)
	High		Plastic lining of walls/membrane /tanking
	High	*****	Plastic cladding materials (such as simulated wood panelling, per 2009 paper from a case study) (caution - concerns over dampness hence against Bldg Regs)
	Any	*****	Removable timber (or other) cladding material
	Any		Cement Render/cement sand render/water-resistant cement-based plaster coated on to internal walls then skimmed
	Any		Lime based plaster/ hydraulic lime coating with Porous paint on top of plaster, (and salt resistant additive) to allow water vapour to pass out as drying proceeds.
	Any		Hydraulic lime on stainless mesh, mounted on tanalised battens, with membrane to sep this from wall. (Hyd lime also contains an additive making it impermeable to water but permeable to water vapour; finish with compatible permeable paint.)
	High		Ceramic/porcelain tiles (with water-resistant grout and adhesives, as used in swimming pools)
	Any	*****	Closed-cell type insulation (to replace mineral insulation in cavity walls) (eg sprayed polyurethane foam or SPF)
	Any	*****	Cavity wall - use insulation materials that are water resistant/low absorption (expanded polystyrene sheets, EPS water-resistant beads, or semi-rigid self-draining mineral wool slabs/batts that will not collapse on wetting) with stainless steel fixings
	Any		Replace timber wall plates and joists on sleeper walls with corrosion resistant steel alternative
	Any		Install a damp proof material around the ends of floor joists where built into walls
	Any		Internal lining of timber-framed walls - use marine ply/WBP-bonded ply, BS1088. demountable fixings, sacrificial joints and lime-based finishing layer
	Any		Replace corroded timber frames with treated timber

	Any		Replace corroded steel frames with galvanised steel equivalents
	High	*****	Seal between wall, floor and partitions (continue concrete seal 0.5m up walls)
	Any	*****	Avoid (non-breathable) vinyl wall-coverings, use microporous paint temp finish, then paper (breathable wallpapers must be affixed with breathable adhesives)
Water compatible floors	Any	*****	Avoid fitted carpets, parquet and laminate flooring: use ceramic tiles, loose fitting rugs; removable carpets (eg fixed with hook-and-loop -tape or hooks-&-eyes set into floors)
	Any	*****	Vinyl/thermoplastic tiles replaced by ceramic tiles (vinyl sheet flooring can be retained)
	Any	*****	Quarry tiles, coated to prevent staining
	Any	*****	Cement-rich floor screed
	Any		Foam glass and mastic asphalt screed
	Any	*****	3mm epoxy resin waterproof floor treatment added to concrete floor screed
	Any	*****	Suspended floors - preservative-treated joists/ floorboards
	Any		Marine ply (instead of chipboard/ other timber)
	Any	*****	Suspended floors (brick and block) - need to create low point/well in soil or sub-floor, to collect water then pump out
	Any		Solid floor/Replace timber floor with solid concrete (and tile finish with falls for drainage to sump/pump) concerns with breathability
	Any	*****	Ensure effective connection between the damp-proof membrane for the floor and the damp proof course in the wall
	Any		If oak blocks on concrete need replacing, use tiles. If oak blocks set in bitumen need replacing, then use screed and new finish on top.
	Any	*****	For suspended floors, if oak floorboards need replacement, then use (cheaper) treated timber.
	Any		Treated floorboards, WBP plywood, screed or tiles to replace chipboard
	Any	*****	Remove ash-bedding from underneath quarry tiles in Victorian houses (retains moisture and impedes drying out)
	Any	*****	Clear and repair air bricks/vents to suspended timber ground floors (aids drying out process via airflow imps)
	Low		Move airbricks to above expected flood level and duct down to floor void (periscope principle)
	Any	*****	Closed cell insulation in boards for floors
	Any		Silicon-mineral board instead of chipboard (concerns with breathability)
	Any		Design floor levels and exit routes to shed water once flood has receded to minimise standing water.
	Any		Replace the kitchen units with proprietary plastic or water-resistant alternatives (PVC or steel) and build off floor; use acrylic or removable wooden doors; steel kick-boards.

Water compatible kitchen fittings	Low	*****	Fit kitchen units with extendable plastic or stainless steel feet or support on raised brick/stonework (for floods <50mm deep only)
	High	*****	Replace ovens with raised, built under type
	High	*****	Oven/microwave mounted part way up wall (shoulder height/eye-level)
	Med		Tanking around cooker, with its own flood barrier.
	Any	*****	Specify the least expensive kitchen possible and to expect to replace it (aka Sacrificial approach)
	Any	*****	Free standing removable units (eg pitch pine), then carry upstairs when flood warning rec'd.
	Any		Use Belfast sink on brick base, not a 'sink unit'
	Any		If space permits, brick-built carcasses concealed by 'normal' looking but removable doors
	High	*****	Limit number of base units and have removable doors so only bottom carcases need replacing
	High	*****	Avoid built in appliances and have strong work surfaces that can support appliances during a flood
	Low	*****	Removable kick boards - wrapped around units avoiding end sections that extend to the floor
	High	*****	Better to have a table and/or high-level 'breakfast bar' than a (fixed) island.
	Any		Avoid kick heaters and use radiators instead.
Water compatible bathroom fittings (ground flr/ basements)	High	*****	Waterproof tile adhesive and water-resistant grout for tiled walls
	Any		Replace baths having chipboard stiffening panels with cast iron or pressed steel models
	Any	*****	Some acrylic baths have integral encapsulated (ie waterproofed) base-boards (cost same as normal acrylic baths).
	Any	*****	Have a wet room rather than shower tray.
	Any	*****	Use of an anti-siphon toilet
	High	*****	No vanity unit around wash-hand basin use wall mounted cupboards/shelves
	Any	*****	Gravity drained toilets (grnd floor) replaced with pumped system
	Med		Sump and pump system (with alarm in case pump fails)
Building Services	High		Raised electrics = dual purpose, as more accessible for older/less mobile people when raised.
	High	*****	Electric cables drop from first-floor level down to sockets at high level on walls;
	Any	*****	Central heating pumps and controls raised above max expected flood level; and any pipe insulation below exp'd flood level replaced by closed-cell type
	Any		CH control unit moved upstairs, so radiators serving upper floor(s) can still be used (ground floor underfloor heating only).
	Med	*****	Wall-hung fires >1m above flood level (depending on expected flood depth)

	Any	*****	Raised meters 1m above expected flood level, and use plastic housing.
	Any	*****	Boiler mounted above max expected flood level
	Any	*****	Seal radiators with polyethylene sheeting
	Any		Use enamelled radiators, which wipe clean after flood.
	Any	*****	Use demountable radiators.
	Any		Use an enamelled finish woodburning stove (cast iron rusts after a couple of floods)
	Any		Ensure woodburners allowed to go completely cold before water enters (cast iron will crack if still hot)
	Med		Raise woodburner up on robust metal support.
	Any	*****	Where possible, incoming telephone lines/cable services/ and internal control boxes should be raised above the expected flood levels.
	High		Through-wall service connections raised >900mm above the ground floor level
	Any	*****	A house can be wired so that the ground floor ring main can be switched off, leaving supply to the upper floors still available; likewise, smaller vulnerable circuits can be isolated.
	Any	*****	Place services including electrics in easy to access conduits to allow draining and drying
	Any		Anti backflow devices on foul drainage
	Any		Anti-backflow valves (NRVs) to sewer pipework AND dishwasher/washing machine pipes.
	Any	*****	Toilet 'bungs' ; sink and shower 'bungs' (to prevent sewage ingress)
	Any	*****	Water supply pipework insulation can be replaced with flood resistant closed cell material below the expected flooding level.
	High		Outside fuel tanks raised on concrete plinth (standard plastic bunds float, pipes then fracture)
Doors/windows/staircases	Any	*****	Water compatible steps/stairs (partly or fully eg resilient staircase of solid timber/steel
	Med	*****	Sep piece of carpeting for bottom-most stairs, removable when flood warning received - then nail back down (but looks like normal fitted stair carpet).
	Any	*****	If normal staircase has to be replaced, use open-tread type made of oak. (Half the wood, so cost-neutral at rebuild stage).
	Any		Replace internal doors with solid hardwood doors (caution - avoid cheap 'oak-style' doors)
	Any	*****	Consider installing cheapest possible doors to be sacrificial.
	Any	*****	Removable /light weight internal doors/replace door hinges with rising butt hinges. These allow doors to be lifted off.
	Any		Internal hollow cellular-fill type doors - replaced with solid timber types (and paint these before hanging, with water-resistant paint, to ensure sides and bottom fully covered)
	Any	*****	Retain traditional solid wood doors, on rising butt hinges, and use on trestles to support furniture etc

	Any	*****	For wooden windows and external doors - use oil-based or waterproof stains, paint or varnish timber
	Any	*****	Replace doors, windows, skirting boards, architraves, doorframes and window frames with fibreglass (GRP), PVC-U or similar
	High	*****	Hopper style windows with fixed lower panels below the likely flood depth. (caution ensuring adequate low level escape routes)
	Any		Replace skirting boards with ceramic tiles
	Any	*****	Treat wood skirting, painted on ALL sides
	Any	*****	Oak skirting held with screws, removable.
	Any	*****	Use of toughened glass in doors/windows /cabinets (reduce damage from floating debris)
	Any	*****	Use non-corrosive door/window hardware fittings (eg stainless)
	Med	*****	Wall cupboards/built-in-wardrobes - rebuild off floor with plastic legs, concealed by removable plinth
	Any	*****	Use PVC wall cupboards instead of timber
	Any		Bookcases formed of fixed brackets but with easily removed shelving.
	Any	*****	Oak exterior doors oiled repeatedly with linseed oil
Speed of reoccupation/drying	Any		Speed reoccupation and drying through optimum height of the floor air gap (to aid speed of drying of gypsum boards) needs heating cable in vertical air gap.
	Any	*****	Rapid drying techniques (rather than trad slow drying/dehumidifiers etc) - depends on building suitability
	Any	*****	Steam cleaning of plastics/hardwoods
	Any	*****	Buy wet/dry vacuum cleaner to remove pockets of water
	Any	*****	Maintain stock of water absorbing bags to absorb seepage/clean up water
Contents Protection	Med	*****	Plinths (or equivalent methods) for white goods
	Any	*****	Waterproof bags for furniture
	Ay	*****	Water-tight covers for appliances
	Any	*****	Use polytunnel-grade thick plastic, plus recycled carpet underlay to prevent corner puncturing it, and duct tape to hold it all in a parcel
	High	*****	Raise furniture on bricks/breeze blocks/plastic trestles (or similar) before water enters.
	High	*****	Robust shelving system (marine ply) to support white goods
	Any	*****	Relocate valuables/docs etc
	Any	*****	Move furniture to pre-arranged storage / used pre-arranged removal firm; Hire/borrow etc van/flat-bed to move your furniture etc to a location out of floodplain.
	Any		Cast iron woodburning stove enamelled (or they rust)
	Low		Woodburner raised up 6"
	Any	*****	Plastic kitchen stools
	Any	*****	Lightweight settees etc, easily lifted upstairs
	High	*****	Wall mounted TV
	Any	*****	Buy a sack truck for moving things
Miscellaneous	Any	*****	Businesses should include flooding in continuity plans

Any	*****	Locate computers above flood level (businesses and domestic users)
Any	*****	Flood warning devices/alarms property-specific Community-based (eg for small watercourses/surface water flooding) - high overall cost but shared among multiple beneficiaries.
Any	*****	Ext walls - Re-point brickwork with a mix of 1:2:9 - cement: lime: sand mortar (far more likely to survive flood conditions without need for repair)
Any	*****	Protect the upstairs carpets (plastic sheeting/dust sheets) before carrying loads up from ground floor
Any		Flood flaps/vents/ports - allow water to enter and exit sealed 'crawlspaces' or unoccupied basements, thus equalising hydrostatic pressure (FEMA requirement in USA)
Any	*****	Sealed buckets and lids, to allow small items to float
Med	*****	When raising wooden furniture on bricks, wrap bricks in plastic to prevent water wicking up into legs
Any	*****	Switch off all electrical appliances before floodwater enters, to avoid damage from short-circuiting
Low	*****	Plastic furniture raisers, as sold for use by older people to raise seat heights
Low	*****	Choose furniture with legs, not castors (eg sofas), easier to raise further with bricks
High	*****	Use carpenters' telescopic metal trestles to raise heavy furniture (more robust than plastic trestles)
Low	*****	Choose TV stand made of glass and metal, not wood
Any	*****	Generator back up for pumps, in case electrics fail
Any	*****	Biocidal detergent for post-sewage flood clean up (as used in hotel/catering trades)

Appendix 11: Flow diagram showing full evidence review process, with number of results at each phase