# Fire and Flood in the Built Environment: Keeping the Threat at Bay Part 2: Flood


A COTAC REPORT: July 2015

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COTAC

*Fire and Flood in the Built Environment: Keeping the Threat at Bay*

## Part 2: Flood

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**COTAC, the 'Council on Training in Architectural Conservation'**

COTAC, now the 'Council on Training in Architectural Conservation', originated in 1959 as the 'Conference on Training in Architectural Conservation' in response to the need for training resources for practitioners so they could properly specify and oversee work involved in repairing and conserving historic buildings and churches.

Since its inception COTAC has successfully, persistently and influentially worked to lift standards, develop training qualifications and build networks across the UK's conservation, repair and maintenance (CRM) sector, presently (2014) estimated at 42% of all construction industry activities. This has involved working partnership with national agencies, professional and standard setting bodies, educational establishments and training interests.

**Acknowledgements**

On 20 November 2014 COTAC's Annual Conference entitled *"Fire and Flood in the Built Environment: Keeping the Threat at Bay"* was held in The Gallery at Alan Baxter and Associates, 75 Cowcross Street, London. This Report builds upon the information and advice that was freely offered by the speakers during the Conference programme. It aims to relate the presentations, and discussion outcomes, to emerging thoughts on the impact of flooding when creating a Building Information Modelling for Conservation (BIM4C) initiative by identifying what issues need to be considered in a Historic Building Information Modelling (HBIM) environment.

Thanks are due to the following speakers for the information that was offered through their various presentations, which underpins this report:

David Pickles, Senior Architect, National Planning and Conservation Department, English Heritage:
*Flooding and Historic Buildings*

Henry Russell, OBE, Chair Gloucester Diocesan Advisory Committee for the Care of Churches:
*Flooding: Tirley Church Case Study Lessons Learnt*

Katy Lithgow, National Trust Head Conservator:
*Flood and Fire: the National Trust Experience*

Stephen Hodgson, CEO, Property Care Association:
*Code of Practice for the Recovery of Flood Damaged Buildings*

Thanks are also due to Alan Baxter Associates for providing the venue, the Conference Sponsors: Historic Scotland; British Automatic Fire Sprinkler Association; Institute of Historic Building Conservation; Henley Business School, University of Reading; Building Crafts College; and to Graham Lee and Sophie Harman of COTAC, upon whose copious conference notes, this report is also founded.

**Background**

The climate in which conservation work is practiced is constantly changing, whether through weather, social or economic forces. Increasingly, it is about the process of managing change where detrimental forces, such as the increasing physical effects of rising sea levels and storms, are generally unstoppable.

In collating relevant HBIM data to help deal with consequential flooding there is a need to devise and incorporate a number of processes. Given the potential scale of the issues involved, this might best be considered at two levels: the geo-spatial large-scale flood, and the local physical, including equipment and pipe leaks.

As the inevitable consequences will be similar, but to different degrees, combining the various reactions should assist in making appropriate management decisions in the face of such diverse adversity.

East Anglia flooding 1607: Illustration in *'A true report of certain wonderfull overflowings of water, now lately in Summerfet-fhire, Norfolke, and other places of England: deftroying many thoufands of men, women, and children. Ouerthrowing and bearing downe whole townes and villages, and drowning infinite numbers of fheep and other Cattle'*

**Climate Change and World Heritage: UNESCO Discussion 2005**
The issue of the impact of climate change on World Heritage natural and cultural properties was brought to the attention of the 29th Session of the World Heritage Committee by a group of concerned organisations and individuals in 2005. The WH Committee requested the UNESCO World Heritage, in collaboration with its Advisory Bodies, interested States Parties and the Petitioners, to convene a broad working group of experts to consider the impacts of Climate Change on World Heritage. The Committee, in so deciding, noted: *"that the impacts of Climate Change are affecting many and are likely to affect many more World Heritage properties, both natural and cultural in the years to come".*
http://whc.unesco.org/en/climatechange/
Accessed 23 January 2015

The expert group subsequently prepared the report *' Predicting and Managing the Effects of Climate Change on World Heritage'* and proposed a strategy for addressing the issues. This was examined by the WH Committee in 2006, and led it to the decision to request that all the States Parties implement the strategy to protect the outstanding universal values, integrity and authenticity of the World Heritage sites from the adverse impacts of climate change. Whilst initially addressing the needs of the World Heritage Sites, the adopted UNESCO approach had the additional benefit of raising a more general awareness which, when coupled with an increasing number of detrimental climate related incidents, inevitably broadened the scope of concern.

**Global Climate Change Impact on Built Heritage and Cultural Landscapes: Report 2007**
Building upon the University College London 2005 report *'Climate Change and the Historic Environment'*, and their 2006 *'Engineering Historic Futures Stakeholders Dissemination and Scientific Research Report'*, between 2004 and 2007 the European Commission funded UCL to lead the Noah's Ark project "*Global Climate Change Impact on Built Heritage and Cultural Landscapes*" under its 6th Framework Programme for Research. This was aimed at mapping and modelling the likely impact of changing climate on the cultural heritage of Europe. In noting that over the next century this was likely to have a range of direct and indirect effects on the natural and material environment, including cultural heritage, four of the seven research objectives were capable of providing HBIM data that would be of some relevance in current terms. These were:

- *To research, predict and describe the effects of climate change on Europe's built cultural heritage over the next 100 years.*
- *To develop mitigation and adaptation strategies for historic buildings, sites, monuments and materials that are likely to be worst affected by climate change effects and associated disasters.*
- *To disseminate information on climate change effects and the optimum adaptation strategies for adoption by Europe's cultural heritage managers through a conference and guidelines.*
- *To provide electronic information sources and tools, including web-based Climate Risk Maps and a Vulnerability Atlas for heritage managers to assess the threats of climate change in order to visualize the built heritage and cultural landscape under future climate scenarios and model the effects of different adaptation strategies.*

The project outcomes aimed to produce a set of mitigation and adaptation guidelines, targeted by monument type and building material, that were to be made available for public use at the end of the project. However, as is often the case with the passage of time after completion of such grant funded projects, it can be difficult to readily access the results due to the lack of continued support to maintain the web-based results.
http://ec.europa.eu/comm/research/environment/newsanddoc/article_3903_en.htm
Accessed 23 January 2015

**Vulnerability of Cultural Heritage to Climate Change: Report 2008**
With a growing awareness of the concerns, a EUR-OPA and Council of Europe Report entitled *'Vulnerability of Cultural Heritage to Climate Change',* was published in 2008. This was primarily based on the results achieved within the Noah's Ark project and related studies. It included an understanding of the then state of the art, considered future developments, and made recommendations that included the need for future research into climate change and cultural heritage under 5 themes:

1. Understanding the vulnerability of materials to climate, to reliably assessed future impact
2. Monitoring change, especially on decadal and even century-long time scales
3. Modelling and projecting changes in heritage climate at high spatial and temporal resolution, with an estimate of reliability
4. Developing tools to manage cultural heritage in a changing climate
5. Preventing damage by developing long-term strategies.

http://www.coe.int/t/dg4/majorhazards/activites/2009/ravello15-16may09/Ravello_APCAT2008_44_Sabbioni-Jan09_EN.pdf
Accessed 23 January 2015

13th C Woking Palace, Surrey
http://i4.getsurrey.co.uk/incoming/article6496110.ece/alternates/s1227b/JS30931077.jpg

**A Climate Change Action Plan for Historic Scotland 2012 -2017**
This document sets out the approach by HS to address the challenges and opportunities presented by climate change to the historic environment. It identifies seven strategic themes that will define work in the area, addressed through forty-two specific actions. The Plan articulates HS's wider intentions to increase resilience, and helps prepare the broader historic environment for a future changing climate.
http://www.historic-scotland.gov.uk/climate-change-plan-2012.pdf
Accessed 25 January 2015

**Climate for Culture: Report 2014**
With a specific emphasis on addressing internal environmental concerns in consequence of climatic variations**,** the FP7 ENV 2008 project *'Climate for Culture'* concluded in July 2014. Its main innovation was to promote simulation and modelling tools to better predict the influence of the changing outdoor climate on the microclimate in historic buildings, and to assess the potential damage of future microclimates on art collections. For the first time, regional climate models, with a high resolution of 10x10 km, were developed and coupled with whole building simulation tools to identify the most urgent risks for specific regions.

The objective for its Work Package No 8 was to provide decision makers, conservators and engineers with a general software tool that would enable them to make the best decisions based on online collection data from any kind of buildings; and to develop a software based *'Analysis and Decision Support System'* embracing a new and powerful independent tool for online analysis of climate data.
http://www.climateforculture.eu/index.php?inhalt=project.workpackages
Accessed 19 January 2015

Whilst a number of these researched issues and findings have a bearing on how HBIM data might be collected and collated for buildings in flood stricken situations, there is a need to assimilate the most relevant findings and approaches in a user friendly and readily accessible manner.

**Pitt Review: Learning the Lessons from the 2007 Floods: 2008**
After the floods of 2007 that devastated parts of England, Sir Michael Pitt was asked by Government to carry out a review of the country's flood defences. In summarising the consequences of the 2007 event, his subsequent report noted that some 55,000 properties had been flooded; 7,000 people were rescued; 13 people died, and almost 500,000 people were without mains water or electricity.

In addition, transport networks failed, a dam breach was narrowly averted, emergency facilities were put out of action, and the insurance industry was expected to pay out over £3 billion, with other substantial costs being met by central government, local public bodies, businesses and private individuals. The combined devastation and effect was considered as being *'the largest loss of essential services since World War II'*.

The Review report also noted "*The impact of climate change means that the probability of events on a similar scale happening in future is increasing"* and its findings called for "*urgent*

*and fundamental changes in the way the country is adapting to the likelihood of more frequent and intense periods of heavy rainfall".*

In summary, the report recommendations called for a more integrated approach to flood risk management; Environment Agency improved flood risk mapping and forecasting; and the setting up of Local resilience forums.

***Lessons Learnt from the 2007 Floods: Pitt Review: Forword (25 June 2008)***

*We have searched for practical solutions to highly complex problems and thought carefully about the public interest. Our recommendations are challenging and strong national leadership will be needed to make them a reality.*

- *We believe that there must be a step change in the quality of flood warnings. This can be achieved through closer cooperation between the Environment Agency and Met Office and improved modelling of all forms of flooding. The public and emergency responders must be able to rely on this information with greater certainty than last year.*

- *We recommend a wider brief for the Environment Agency and ask councils to strengthen their technical capability in order to take the lead on local flood risk management. More can be done to protect communities through robust building and planning controls.*

- *During the emergency itself, there were excellent examples of emergency services and other organisations working well together, saving lives and protecting property. However, this was not always the case; some decision-making was hampered by insufficient preparation and a lack of information. Better planning and higher levels of protection for critical infrastructure are needed to avoid the loss of essential services such as water and power. There must be greater involvement of private sector companies in planning to keep people safe in the event of a dam or reservoir failure. Generally, we must be more open about risk.*

- *We can learn from good experience abroad. People would benefit from better advice on how to protect their families and homes. We believe that levels of awareness should be raised through education and publicity programmes. We make recommendations on how people can stay healthy and on speeding up the whole process of recovery, giving people the earliest possible chance to get their lives back to normal.*

http://webarchive.nationalarchives.gov.uk/20100807034701/http://archive.cabinetoffice.gov.uk/pittreview/_/media/assets/www.cabinetoffice.gov.uk/flooding_review/pitt_review_full%20pdf.pdf
Accessed 13 January 2015

One positive consequence to the Pitt Report was the introduction of the *'Flood and water Management Act 2010'* to provide for *"better, more comprehensive management of flood risk for people, homes and businesses, helps safeguard community groups from unaffordable rises in surface water drainage charges, and protects water supplies to the consumer"*.

The Act has the overall aim of reducing flood risk associated with extreme weather.
http://www.legislation.gov.uk/ukpga/2010/29/contents

**Mapping**

**EUROSION database**
Concluding in 2004, the EUROSION database was built to support the assessment of the coastal erosion status and trends throughout Europe. It is also aims to provide input data for the calculation of indicators and the definition of appropriate coastline management strategies at European, national and regional levels. The database is structured in various data layers. Each of these highlights a specific factor considered to impact on coastal erosion processes or human responses to them. The layers are:

- Terrestrial Administrative Boundaries
- Maritime Boundaries
- Shoreline
- Bathymetry
- Elevation
- Geomorphology and geology
- Erosion trends and coastal defense works
- Hydrology
- Infrastructure
- Wave and wind climate
- Tidal regime
- Seas level rise
- Land cover and land cover changes since 1975
- Areas of high ecological value

From an HBIM point of view, the study's GIS database of 19 layers of information contains relevant materials in geo-spatial terms that could help contextualise the risk for historic properties in affected coastal zones.
http://www.eurosion.org/project/eurosion_en.pdf

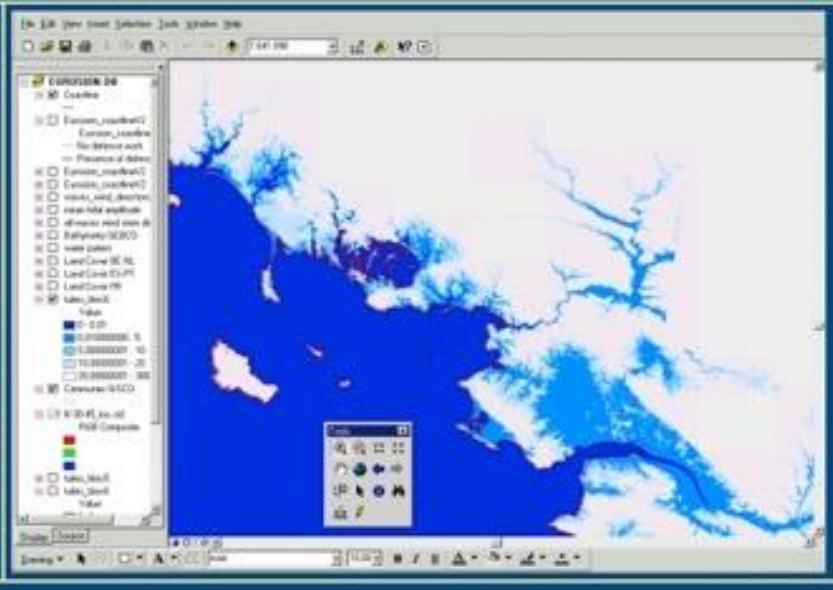
**Accelerated Coastal Erosion Mapping Risk**
The 2004 *'Living With Coastal Erosion in Europe Sediment and Space for Sustainability'* EC EUROSION projects' case study investigation into the Essex Estuaries indicated that Essex was one of the most threatened areas with respect to coastal flooding in England, and that over:

> *…the whole country, over 1,8 million residences and 180,000 commercial properties are considered at risk, potentially 5 million people, and 1,4 million hectares of agricultural land including 61% of the total of grade 1 land in England and Wales. The total value of the assets at risk is estimated to be over 350 billion Euros for England.*

With regard to the Elevation database layer, the following guideline information is offered in the identification of lowlands that *'are vulnerable to significant sea level rises and the risk of flooding':*

**5. ELEVATION**

This screenshot features elevation in the areas of Lorient and Saint-Nazaire (France). Elevation has been displayed using five different classes: (i) below 0 meter (marine blue), (ii) between 0 and 5 meters, (iii) between 5 and 10 meters, (iii) between 10 and 20 meters, and (v) above 20 meters (white).



| | |
|---|---|
| **Data description** | The Elevation layer makes it possible to identify lowlands which are vulnerable to significant sea level rise and the risk of flooding. Elevation data are provided in two forms:<br>• A Digital Terrain Model (DTM) which consists in a grid data of altitudes with a 90 to 100m resolution<br>• 5 meter and 10 meter height contour lines, in vector format, derived from the DTM and completed where needed with other sources of data. |
| **Source of data** | The Digital Terrain Model, MONA PRO Europe©, is a copyrighted product provided by Geosys Data. To derive contour lines of 5 and 10 meters, the data were locally complemented with other sources, namely national DTM and digitised topographical maps. |
| **Geographical restrictions** | Restrictions for Scandinavian countries. |
| **Quality** | The resolution of grid data is 90 to 100 meters. Its geometrical accuracy in x,y and z does not exceed 5 meters for lowlying areas and 15 meters for mountainous areas. |
| **Copyright and data access conditions** | MONA PRO Europe© is copyrighted. A multi-posts "agency" license has been acquired for the European Commission, which makes the product available for applications developed within the European Commission. Dissemination outside the European Commission is restricted to raster representations (i.e. images) of the DTM. However, most of contour lines are copyright-free and publicly available. |

http://www.eurosion.org/database/elevation.html

A complete list of the projects' outputs are available for download, and its Infrastructure layer at scale 1:1,000,000 and in vector format, provide a cartographic representation of harbours, jetties, airports, railways, terrestrial and maritime roads, and industrial facilities, It ought, therefore, to be possible to also locate and identify vulnerable cultural heritage and historic building sites in coastal regions in a similar manner, but, unfortunately, this

categorisation was not part of the EUROSION approach. Consequently, related information would need to be sourced from elsewhere to effectively integrate that approach.
http://www.eurosion.org/reports-online/reports.html
Accessed 13 July 2015

The full GIS database is now part of the Geographical Information System of the European Commission (GISCO) and has to be requested directly from EUROSTAT. Of relevance to an HBIM approach, the GISCO site states that:

> *GISCO's main task is to provide reference geographical information and related services for use within Eurostat and the Commission and to the European citizens at large. It also coordinates Commission-wide geographical information activities and common strategies and has the goal to promote and stimulate the use of geographical information within the European Statistical System and the Commission.*

http://ec.europa.eu/eurostat/statistics-explained/index.php/Geographical_information_system_of_the_Commission_(GISCO)
Accessed 13 July 2015

Clonakilty, Ireland, Storm surge: 2014

**Flood Maps and Planning**

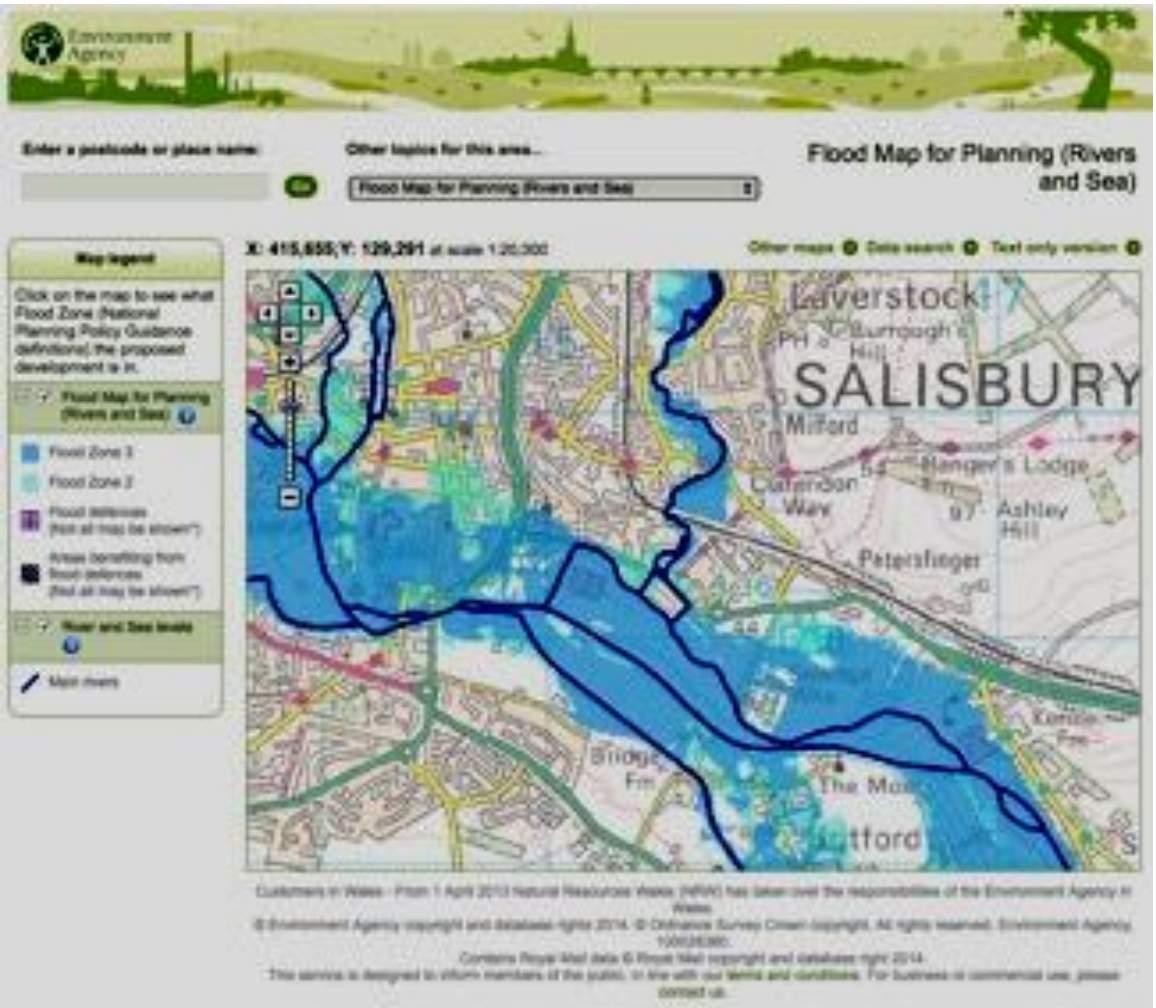
The Environment Agency (EA) also has accessible on-line interactive mapping that, together with their guidance on how to understand *'Flood Map for Planning'*, offers information on floodplains, flood defences larger steams and rivers, and flood warnings. The *'Risk of Flooding from Rivers and the Sea Map'* shows the Agency's assessment of the likelihood of flooding from rivers and the sea at any location.

This is based on the presence and effect of all flood defences, predicted flood levels, and ground levels. Potentially, such material (and other Agency interactive geo-spatial maps, such as *'Risk of Flooding from Surface Water'*) is of considerable interest in contextualising

building specific HBIM information in a broader setting through over-laying their National Grid map referenced locations.

However, the website warns that flood defences do not remove the risk of flooding due to the potentially of defences being over-topped. The EA also notes that their powers to carry out defence work only applies to main rivers - with DEFRA deciding what constitutes a 'main river' in England, and the Welsh Government so deciding in Wales.
http://apps.environment-agency.gov.uk/wiyby/37837.aspx
Accessed 21 January 2015

In addition, although warning that the data cannot provide details on individual properties due to the adopted approach as it primarily maps areas of land, the higher scaled maps do provide pointers to help consider the local situation that could be taken into account during HBIM work, as the example of the potential for flooding Salisbury Cathedral illustrates.



Salisbury: EA map illustrating potential extent of flooding, including the Cathedral

http://maps.environment-agency.gov.uk/wiyby/wiybyController?topic=floodmap&layerGroups=default&lang=_e&ep=map&scale=7&x=531500&y=181500#x=415655&y=129291&lg=1,2,&scale=9
Accessed 23 January 2015

As indicated by the EUROSION approach, and using the EA Salisbury mapping as a related example, it ought to be possible to similarly locate and identify other vulnerable cultural heritage sites in pre-determined high flood risk areas.

Salisbury Cathedral in the aftermath of the 1915 flood

An eyewitness recounted how:

*'The unceasing rain of that first autumn of the war had turned the five chalk streams which meet at Salisbury into five raging torrents which no hatches could control….'.*

**The Scale of Properties at Risk of Flooding**

Currently it is considered by English Heritage that there are some 400,000 homes and 75,000 businesses located in areas where there is a high risk of annual flooding. Many of these were traditionally built before 1919, and are likely to be of historic interest. Combined with the current trend to continue to build on flood plains, it is estimated that by 2080 the number of properties at a high risk of flooding could increase to 1,500,000.

**Climatic impacts on National Trust Properties**

Although historic structures are inherently durable, and are relatively resistant to flooding compared with modern building methods, they are still vulnerable.

The National Trust list of their properties that have recently been affected by flooding and other climatically induced threats makes for sobering reading.

**Levels of Increasing storminess experienced over 3 decades:**

- 1987 Hurricane

- 1993 Flash and fluvial flooding Buscot

- 2000 Hurricane
- 2001 Tidal and flash flood Westbury Court Gardens
- 2001 Flash flood Blickling, rain penetration at Coughton Court
- 2004 Flash flood Blickling, rain penetration at Coughton Court
- 2004 Flash flood Boscastle

- 2006 Tidal surge Elizabethan House Museum, Great Yarmouth
- 2007 Tidal surge Elizabethan House Museum, Great Yarmouth
- 2007 Flash flood Blickling, rain penetration at Coughton Court
- 2007 Flash flood Boscastle
- 2007 Flash flood Calke Abbey, The Vyne, Coughton Court
- 2007 Flash and fluvial flood Buscot and Coleshill
- 2007 Rain penetration Ham, Hughenden, Packwood, Knole etc.
- 2008 Flash flood Blickling, rain penetration Coughton Court
- 2008 Flash flood Cragside
- 2009 Flash flood Lake District

- 2010 Freezing
    - Dunham Massey
    - Powis
    - Castle Coole
    - Anglesey
    - Blickling
    - Wimpole and
    - 20 other properties + cottages
- 2010 Rain penetration Waddesdon
- 2011 Freezing
    - The Argory
    - 31 other properties
- 2011 Rain penetration Ickworth
- 2012 Rain penetration
    - Sizergh
    - Nostell, and,

    - 16 other properties in the Midlands and the North

- December 2013 to February 14: Rainstorms
- Minor leaks at 15 properties,
    - Knole
    - Polesden
    - Sutton House
    - Dunster
    - Montacute
    - Tredegar
    - Dyffryn
    - Cotehele
    - The Vyne
    - Hatchlands
    - Ham
    - Hinton Ampner
    - Winchester City Mill
    - Killerton
    - A La Ronde

- Major flooding in the landscape:
    - Runnymede,
    - Wey Navigation
    - Somerset Levels

- Severe coastal erosion:
    - Abereiddi
    - Birling Gap
    - Mullion Harbour
    - Formby
    - Brownsea Island
    - Rhossili and South Gower Coast
    - Murlough (NI)
    - Blakeney
    - S Milton Sands
    - Studland Beach

- 2014 Heavy rain - 8 houses June to Sept:
    - Melford
    - Vyne
    - Coughton
    - Springhill
    - Sizergh
    - Ham
    - Wandsworth Road, and
    - Tyntesfield.

**Working with Natural Processes**

Clearly, the way that land and water is managed in one place can have a much wider impact elsewhere. As a nation we have drained wetlands for agriculture and development, and introduced non-native invasive plant species that disrupt natural systems, changing the flow of many watercourses. In addition, the overall surface area of hard landscaping has constantly increased, and by making rainwater drain off roofs, paths, streets, and land as quickly as possible, the risk of downstream flooding has been exacerbated. Wastewater from 1.3 million properties goes straight into rivers, rather than sewage systems. Run-off from building construction, agricultural applications and other industrial pollutants can also readily enter the water system. As a result, when flooding occurs there is also a need to cope with unsavoury contamination and faecal pollution. (Currently, some 50% of water has to be treated to make it safe to drink).

From a range of recent research findings, flooding is predicted to become more frequent and more intense as a result of climate change, bringing home the need to adapt to the threats. But, more sensitive management of rivers and catchments can help reduce the risk of flooding, through advocating making more space for water. Every parcel of natural terrain can play a part in absorbing and storing water, making them an integrated part of flood management and defence. It could be argued that, unless a new, more holistic, and sustainable approach is adopted in a wider geo-spatial context, localised flood risk management for property will require increasingly expensive defences that need to be accommodated with an HBIM context.

**Flash Flooding**

Flash floods can happen quickly and their impact on settlements, infrastructure and people can be devastating. 75% of the UK's freshwater originates in the uplands making down-steam properties vulnerable to what might happen as a result of heavy up-stream rainfall. It might also be noted that, the Environment Agency Flood Risk Assessment does not include a consideration of the potential of flash floods. From an HBIM point of view, an independent assessment of this risk is therefore required.

The experience of the flash flood at Boscastle in August 2004 (where 200mm rain fell in 4 hours, releasing some 440 million gallons of water cascading through the streets at 40 miles/hour, resulting in £50m insurance claims, 150 people airlifted to safety, and 60 cars washed away) and other incidents, highlit a variety of issues that are likely to arise and need to be considered following such events. These included:

- Structural damage and undermining
- Floating debris deposition
- Contamination and pollution
- Salt efflorescence
- Dirt/mud deposition and staining
- Significant internal environmental changes
- Mould growth
- Erosion and corrosion
- Swelling, shrinkage and cracking
- Pest infestation


Boscastle flash flood Summer 2004

**Making Space for Water Defences**

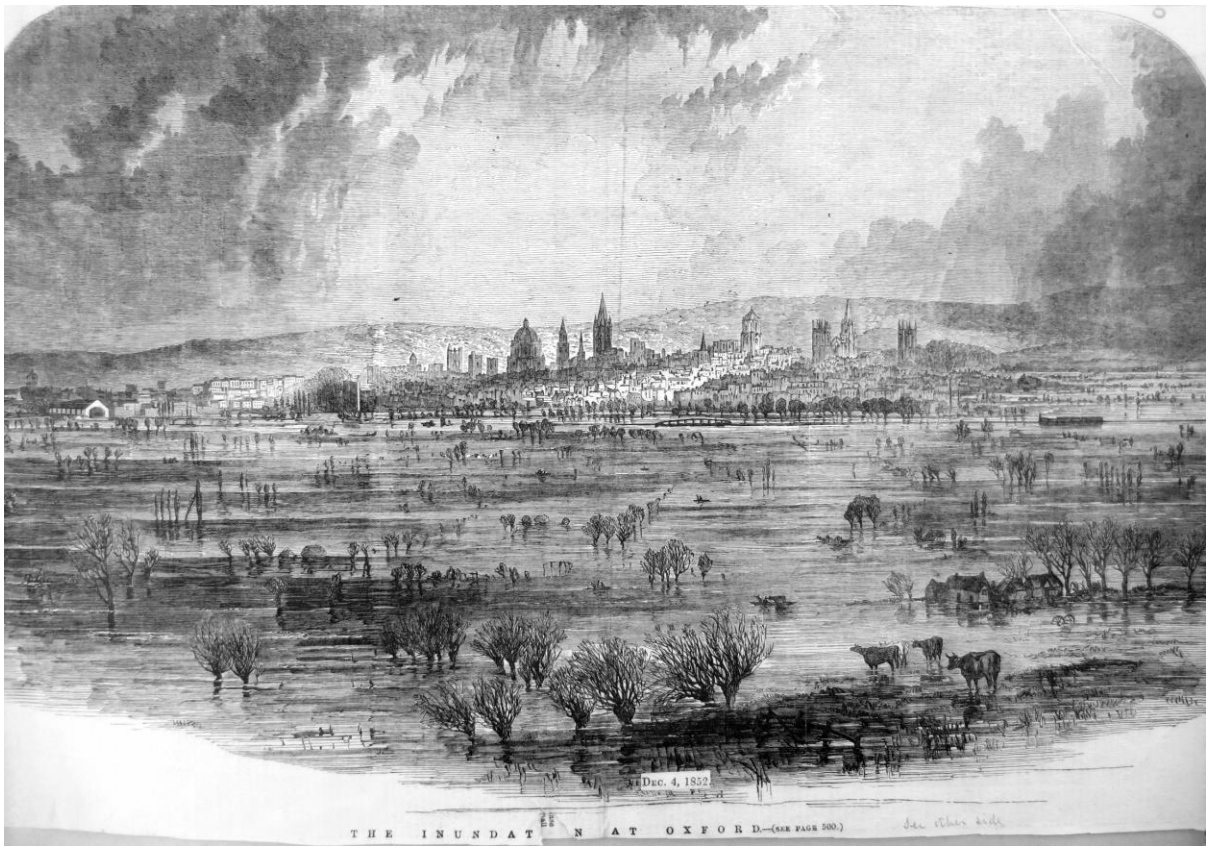
In starting to address the wider issues, in 2005 DEFRA published *'Making space for water Taking forward a new Government strategy for flood and coastal erosion risk management in England. First Government response to the autumn 2004* 'Making space for water' *consultation exercise'*. The document offered a strategic direction, and a programme of work across a variety of flood and coastal erosion risk management aspects in England. This included how to assess risk, how to approach urban drainage issues, manage coastal flooding and erosion, and how to raise awareness and provide support for those at risk - a number of which issues have also been overtaken by subsequent events.
http://archive.defra.gov.uk/environment/flooding/documents/policy/strategy/strategy-response1.pdf
Accessed 24 January 2015

Since December 2013 many parts of the UK have been inundated by high tides, constant rainfall and flooding. January 2014 was also the wettest on record, and there have been numerous significant incidents that have badly affected many communities. Consequently, there is an even greater need to come to terms with the difficult challenges of living in an age of extreme weather by making 'space for water'. When this comes with the aim of reducing the risk of flooding there is a need to confront the issues holistically: the underlying objective being to slow down the flow of water from source to sea.

Initiated in 2009, the National Trust *'Holnicote Multi-Objective Flood Management Demonstration Project'* supported by DEFRA aimed to show how land management can alleviate flood risk whilst also improving the wider environment.
http://ccmhub.net/wp-content/uploads/2013/01/Holnicote-final.pdf
Accessed 24 January 2015

Recognising that key Interventions, applied throughout an entire catchment area, is about using natural processes to slow water flow down, the critical need is to work with other interested parties, in a collaborative manner, to achieve the end results. On moorland, work to reduce the run-off by blocking ditches, creating catch pools and diverting surface water from paths and tracks could start the process. Planting wet woodland en route helps to further slow the progress of water, as trees are effective at absorbing it.

As the 2009 pioneering *National Trust Holnicote Multi-objective Flood Management Scheme* illustrates, reinstating water meadows, where fields are allowed to flood in winter, creates much needed space for water holding around the catchments of the Horner and Aller Rivers. With due regard to archaeology, the adoption and construction of earth bunds in appropriate circumstances could provided additional temporary holding places during intense rainfall events elsewhere whilst, post-event, allowing for a naturally slower release.
http://www.ntsouthwest.co.uk/2014/02/flood-management-project-shortlisted-at-the-2014-climate-week-awards/
Accessed 24 January 2015



Oxford: A natural floodplain in effective operation: 4 December 1852

Given the comprehensive nature of the NT approach, such an 'up-stream' tactic to use the natural environment to make arrangements and space for diverting water to limit its downstream impact has HBIM lessons for other 'down-steam' properties at risk. The NT 2008 report *'From Source to Sea: Working with Water'* offers additional useful information. http://www.nationaltrust.org.uk/document-1355766981420/

**Advisory Publications**

A range of other recent relevant advisory and technical publications aimed at mitigating risk and offering remedial guidance, are also available.

**Flooding and Historic Buildings 2nd Edition: 2010**
First published in 2004 this updated guidance from English Heritage is available as a free download from its web site. The information in it aims to assist those who live in, own or manage historic buildings with fixtures and fittings that are threatened by periodic flooding. Advice is provided on preventative measures to minimise flood damage, and on the inspection, conservation and repairs required after flooding.

In describing the purpose of the advice, the guidance notes:

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

From an HBIM point of view the promoted approach emphasises the need to fully understand the construction, detailing and finishing of a traditionally constructed building, whilst also being aware of the damaging consequences of inappropriate post event remedial work.
http://www.english-heritage.org.uk/publications/flooding-and-historic-buildings/flooding-and-historic-buildings-2nd-ed.pdf
Accessed 24 January 2015

**Guidance and Standards for Drying Flood Damaged Buildings: 2010**
Published by the Department for Communities and Local Government in 2010 the *'Guidance and Standards for Drying Flood Damaged Buildings: Signposting current guidance – BD2760'* [ISBN: 978 1 4098 2656 9] was based on research to address recommendations in the Pitt review to examine the processes involved in drying out flooded buildings, and to identify the guidance that is available.

The report recommendations were based on the belief that the drying process was a major contributor to the delay in reinstating flooded properties following the summer 2007 floods. Specific project objectives were to:

- Identify and examine existing guidance on the drying of flooded properties and the current use of such guidance
- Produce generic guidance
- Establish how it could be made more widely available
- Identify areas where knowledge gaps exist.

In the adopted approach, whilst calling for new guidance to be prepared and adopted, the identified stages in the restoration of flooded buildings still provide a useful signposting checklist of sequences from existing guidance that could inform HBIM data gathering.
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/6326/1773816.pdf
Accessed 22 January 2015

**INFORM: Flood Damage to Traditional Buildings: 2014**
As one of a significant series of brief advisory publications aimed at assisting home and building owners better understand a variety of conservation related topics, this Historic Scotland INFORM leaflet offers guidance on how to protect traditional buildings from flood damage, and how to mitigate the effects if flooding does occur. It is available as a download from the Historic Scotland website.
http://conservation.historic-scotland.gov.uk/publication-detail?pubid=10901
Accessed 20 January 2015

**The Need for Resilience**

With a definition of 'the ability to quickly recover from setbacks, and the need for a speedy recovery from problems', Resilience from the effects of flooding might be considered on two levels: Permanent and Temporary, with each level applying solutions in different degrees to effect better Community Protection and Property Level Protection. Against assessed degrees of risks, Community protection will inevitably involve HBIM considerations in a geo-spatial context, whilst Property level protection will involve more specific HBIM considerations tailored to the needs of individual structures, their construction, materials, design and detail.

**Resilience at Community Level**
Endorsing the English Heritage's *'Flooding and Historic Buildings'* recommendations, Annex 3 of the 2013 publication '*Six steps to flood resilience – guidance for local authorities and professionals*' reiterates the EH advice on buildings of architectural or historical interest. However, the rest of the document also contains relevant crossover guidance that has a wider application in HBIM data gathering situations. Its Introduction states:

> *This document is aimed at local authorities and other professionals who manage flood risk in England, particularly those who may need to procure flood resilience technologies for a community. It may also be relevant for community flood action groups.*

Funded by the EC's 7th Framework Programme, the *'Six steps to flood resilience guidance'* was written by researchers at the University of Manchester and Manchester Metropolitan University in collaboration with the Building Research Establishment. The pragmatic

information contained in it comes from interviews, surveys and workshops with flood risk management professionals, manufacturers, community representatives, together with a desk-based review of existing academic, policy and technical literature and historic flooding incidents.

Permanent Community Protection Schemes will become more necessary in many situations. Whilst being essential, they can be visually intrusive in their positioning and effect. Photos: D Pickles EH

Drawing on existing flood resilience information, the guidance provides advice on making flood resilience technologies, at property and neighbourhood level, as part of an overall Flood Risk Management strategy. Of particular interest in developing HBIM data, the focus is on retrofitting technologies to buildings and/or through community-wide flood resilience systems.
http://www.sed.manchester.ac.uk/research/cure/research/documents/SMARTeST-Six-Steps-To-Flood-Resilience-Local-Authority-Professionals.pdf
Accessed 13 January 2015

In 2012, DEFRA launched a scheme to support innovation by funding projects that improve resilience in communities through working with key partners to develop innovative local solutions. These were required to enhanced flood risk management and preparedness in ways that improved the community's overall and financial resilience in relation to flooding, in a manner that delivered sustained improvements with the potential to be applied in other areas.


http://s0.geograph.org.uk/geophotos/03/00/15/3001595_621f77a6.jpg

Riverside, Upton upon Severn: Temporary community protection in action

In suggesting some examples of approaches that might be eligible for support, a consideration of the themes could well be of benefit for other HBIM data gathering in geo-spatial terms. The examples included:

- *Combining detailed mapping of local flood risk with installation of measures to quantifiably reduce the level of risk to households at a community level.*
- *Building a community's capacity to manage flood defence locally by putting in place local response arrangements that help to address risks identified in the Local Flood Risk Management Plan, e.g. through taking responsibility for the deployment of demountable defences.*
- *Developing local initiatives to help build financial resilience of those at risk, particularly lower income or socially vulnerable people where present rates of insurance uptake are low……*
- *Improved local flood risk mapping and modelling where existing data sets do not accurately capture (and may overstate) the local level of risk. This could, for example, include property-level surveys to quantify existing levels of risk, completed on a street-by-street basis to reduce unit costs*.

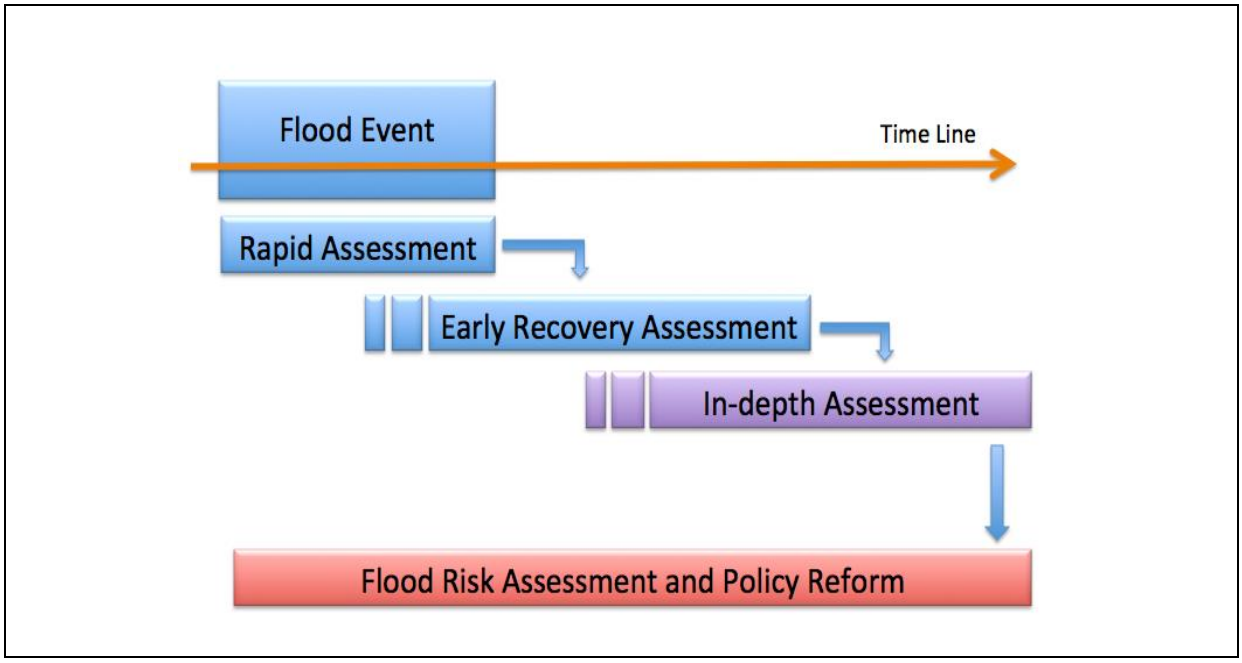
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/69621/pb13841-frco-prospectus-20121206.pdf
Accessed 21 January 2015

Following consideration of the applications, 13 communities and/or Local Authorities in Blackburn, Buckinghamshire, Calderdale, Cornwall, Devon, Liverpool, Northamptonshire, Rochdale, Slough, Southampton, Swindon, Warwickshire and West Sussex have benefited by being supported through the DEFRA £5million fund.
https://www.gov.uk/government/news/5-million-to-support-innovative-flood-defence-schemes
Accessed 21 January 2015

**Resilience at Property Level**
In tandem with its publication addressed to Local Authorities and Professionals, a '*Six steps to flood resilience – guidance for property owners'* pamphlet was also prepared in 2013 by the Manchester team of researchers in collaboration with the Building Research Establishment. This document contains pragmatic advice in the form of useful checklists, web references, and key contact details that could support related HBIM considerations.
http://www.sed.manchester.ac.uk/research/cure/research/documents/Property_owners_booklet_v1_print_000.pdf
Accessed 21 January 2015

**Post Flood-assessment and Recovery Approach**
At an international level the *'Associated Programme on Flood Management'* published the *'Integrated Flood Management Tool Series: Conducting Flood Loss Assessments'* in June 2003. This tool aims to provide practitioners with relevant guidance to conduct flood loss assessments within an assessment time framework of various progressive phases.

This phased approach (as set out in the publications' Figure2, page 4) could helpfully inform and sequence the structure of HBIM data collection and collation:



Types of flood loss assessments in various phases: After 'Associated Programme on Flood Management' Fig2

In overlapping stepped stages, it suggests that the initial need is for a 'rapid assessment' for emergency relief coordination during a flood. The second stage, involving an initial damage assessment should inform and guide the recovery process in the first few weeks after floodwaters have receded (noting that this step is vital, for example, for insurance claims allocation of recovery funds from national budget and guidance for external aid agencies).

The third need is for a comprehensive assessment of flood losses, some 3 to 6 months after the event to inform policy and reconstruction needs. The final stage would then deal with the use of the data for flood risk assessment, the appraisal of flood defences, and mitigation options.

Excerpted from the *'Disaster Loss Assessment Guidelines Emergency Management Australia (2002)'*, *[Australian Emergency Manuals Series, Part III, Volume 3, Guide 11],* an Annex advises that each loss assessment should be approached in a logical and structured manner. Of significance for HBIM data collation, 10 of the suggested 12 excerpted steps are relevant:

- *Identify the purpose of the loss assessment*
- *Organise consultation and information collection*
- *Define the area and timeframe of the assessment*
- *Selected type of assessment to be made*
- *Obtain information about the Hazard*
- *Obtain information about the people, assets and activities at risk*
- *Identified the types of losses*
- *Measure the extent of losses from all sources*
- *Decide whether to count 'actual' or 'potential' losses*
- *Collate and present the results of the loss assessment*

http://www.apfm.info/publications/tools/APFM_Tool_02.pdf
Accessed 21 January 2015

**Understanding the Building**

In a post-flood recovery process, there is a need to understand how the affected property was built and with what, how long floodwater has been in the building, and where did it go. Practitioners must understand the problems, possibilities and pitfalls BEFORE any actions are implemented.

Stone, brick and concrete are generally resilient to flood water damage, but gypsum based products fail quickly. Timber can be resistant to short term wetting, but decays when it remains wet. Dense materials retain little water but dry slowly, whereas more porous materials can retain large amounts of water but tend to dry quickly.

The importance of latent defects also needs to be established if they pre-date the flood, how they are quantified and addressed. Failure to do this inevitably leads to repair failures, and disputes often follow, with implications for surveyor and insurers if they are not taken fully into account.
In the first step in the recovery process the following questions might be considered. To fully answered then, this may involve detailed investigations and opening up:

- Is the building fully understood?
- Has the structure been affected?
- Is there contamination present?
- Is water trapped in voids?
- Are there underlying defects?

As the best plan for effective remediation will be based on that understanding of the problems, it will be relevant to communicate the researched findings, backed up with appropriate observations, sampling and recording evidence.

Internal flooding

**Property Care Association (PCA) Code of Practice 'For the Recovery of Flood Damaged Buildings': 2013**

The Property Care Association (PCA) represents the UK's structural waterproofing, wood preservation, damp proofing, flood remediation, structural maintenance, invasive weeds and flood protection industries. Its 2013 Code of Practice *'For the Recovery of Flood Damaged Buildings'* provides practical guidance for the effective recovery of flood-affected buildings in addressing:

- Standards
- Training
- Health and safety
- Initial assessments
- Surveying and investigation
- Recording information
- Stripping out
- Drying
- Monitoring
- Repair and re-fit
- Flood resilience and resistance
- Problem solving

In doing so, much useful information is available to guide HBIM data gathering considerations.
http://www.property-care.org/ProGuidance.TechRef.asp
Accessed 24 January 2015

Post flooding stripping out

**BRE Digest 245 'Rising damp in walls: diagnosis and treatment'**
The method of moisture analyses and removal of samples is offered in Building Research Establishment *Digest 245, 'Rising damp in walls: diagnosis and treatment'*. The Digest describes the method of sampling, and the regimes for drying and weighing, in order to obtain an objective distribution of moisture. Whilst the method described is basically for evaluating rising dampness, it is useful for evaluating any source of dampness, including post flood consequences.

However, repairs will be dictated by the amount of free water that remains in the building, the levels of salt contamination, and the repair materials and techniques that are to be adopted.
http://www.buildingpreservation.com/index.php?option=com_content&view=article&id=93:bre-digest-245-rising-damp-in-walls-diagnosis-and-treatment-a-guide-or-a-specification-&catid=7&Itemid=84
Accessed 24 January 2015

In monitoring the wider effects of water saturation there is a need to establish an accurate baseline. A variety of equipment and approaches can be considered, including the use of:

- Conductivity meters
- Speedy moisture meters
- Data loggers
- Atmospheric sampling RH/vapour pressures
- Gravimetric testing

**Drying the Building**
The speed of drying a flooded structure will be dictated by how much energy is introduced and how this is then managed. This could result in a protracted drying period. Some materials don't dry, whilst others dry and then seem to get wet up again without any apparent explanation. In most situations, the ideal drying conditions should be approx. 40% - 50% relative humidity with a temperature range between 18 and 23 degrees C.

But, the decision of when to start to reinstate can be difficult to determine. It needs to be set against the information gained through monitoring, and a comprehensive knowledge of what materials and techniques can be used in the repair process. Some basic principles that might be adopted include the need to eliminate gypsum and other salt sensitive materials, reduce the amount of embedded timber and the use of impervious materials such as concrete screeds over existing floors.

**Drying out**
An inevitable difficulty will emerge in determining what is an appropriate drying out time. To a great degree this will depend upon the severity of the circumstances, but an effective regime might also depend upon the:

- Time of year
- Building fabric and structure
- Porosity and permeability of the materials
- Flood duration
- Degree of contamination or pollution

- Type of flooring
- Water table levels
- Ambient relative humidity
- Weather conditions

Whilst targeted drying could involve fan assisted techniques and de-humidification technologies, there will also be a need to establish relevant control and monitoring points to check progress and efficacy. It has to be recognised that 'one size does not fit all' and realistic contractual timescales need to be established to avoid future pitfalls.

The inappropriately named Drybridge, Monmouth: 1947 Floods

**Certificate of Drying**

Knowing that a 'Certificate of Drying' given in good faith by an attending Contractor might be taken as a license to start remedial work, there is a need for caution given the considerable caveats that can apply in such a document. The publication *'The Investigation and Repair of Flood damaged Domestic Properties: A Guide for the Insurance Industry'* by the Flood Repairs Forum provides useful material that might be considered in an HBIM approach.
http://www.cunninghamlindsey.com/publications/flood_repairs_manual.pdf
Accessed 21 January 2015

Longer-term effects and the consequences of flooding can, of course, persist, including the following latent defects:

- Damp staining
- Shrinkage
- Salt deposition

- Unpleasant odours
- Mould growth
- Fungal decay
- Insect attack

Many, if not all, post repair problems can be connected to flooding and the need is to identify as many latent defects as possible during the early stages of the inspection and evaluation process, whilst allowing the appropriate duration for drying out to be fully effective if they are to be avoided.

**Remedial Work**

Consequential remedial works can also have an HBIM impact (that might run contrary to conservation requirements) in creating flood-tolerant buildings through the need to plan for future incidents by putting:

- All electrics (1 metre) above floor level,
- Cabling runs coming down from ceiling level,
- All services and equipment on plinths above flood level,
- Durable paints and plasters on walls, and
- Wash-down surfaces on floors

Accommodating increased rainfall can also raise the need for HBIM remedial considerations in the maintenance approach and in preventative conservation. This might entail:

- Reinstating culverts and ditches
- Clearing gutters and rainwater goods
- Up-sizing rainwater goods
- Monitoring collections

Rainwater gutters need to be of adequate sixe to cope with increased volumes of water. Extra care will be required where they discharge through the building rather than by external drop-pipes


Adjusted lead rainwater hopper head with failsafe overflow. Photo: Steve Hempstock http://www.buildingconservation.com/articles/lead-gutters/pic_3.jpg

From an HBIM point of view, underlying relevant and appropriate data should support the development of better communication across all involved in the incident and its aftermath. Promoting greater cognizance amongst owners, better training for recovery contractors whilst developing their awareness along with educating insurers and loss adjustors that a specialist knowledge and understanding will be required. Transferable experiences from the resolution of similar incidents can be of value in helping to achieving this.

**St Michael's Church, Tirley, Gloucestershire**

Inundated by the 2007 floods, the Church of St Michael and All Angels sits on the edge of the village of Tirley, Gloucestershire. Pictured in the midst of the floodwater, it received national attention when featured on the front page of newspapers.

St Michael's Church, Tirley (2007). Photo: © SWNS.com

After 3-years' work the church has been restored with a view to minimize future flood damage with a new stone floor, movable chairs rather than pews, and with a new organ gallery set on stainless steel columns some 2.4m above the floor to offer protection for the organ and a refuge to store items of value during future incidents.
http://www.bbc.co.uk/news/uk-england-gloucestershire-11459503

Looking at options to increase flood resilience and assess the significance of individual elements to balance potential harm against possible closure, the original floor and pews were considered of moderate significance. In carrying out the rehabilitation, where electrical services were run above flood level, and overhead electrical heaters were considered appropriate, architect Neil Birdsall observed in April 2008:

> *"The important thing here is that there should be as little fixed furniture as possible within the building so that, when the floods come again, such furniture as there is can be moved to safety."*

Prophetically speaking in 2008, he also wrote in the Summer 2014 edition of the SPAB Cornerstone magazine that:

> *"Since this major repair and reordering, the church has been flooded - twice, in both January 2013 and 2014. But the fabric did not suffer to anything like the same degree as in the past. The new stone floor throughout is now relatively easy to clean, the columns of the west gallery can be washed without too much difficulty and, as long as the floods do not rise above the new dado all around the interior, the extensive renewal of render is avoided and any lime washing can be contained to that height."*

**Inadvertent or Inappropriate Damage During Recovery Work**

In the inevitable haste to effect a rapid return to some semblance of normality after a flood event a number of problem areas can arise that could compound the situation with regard to the value and significance of damaged heritage properties.

The lack of involvement of professional and other specialists with experience in historic buildings work can risk inappropriate recovery work resulting in the unnecessary removal of fittings and finishes that had been subject to flooding, but could still be retained. This could be compounded through Loss adjustors making decisions on repairs without sufficient knowledge of traditional construction, and contractors being appointed by insurance companies that have no experience of working on historic buildings. The adoption of rapid drying techniques and the inappropriate reinstatement using incompatible or inappropriate materials might also be of concern.

Finally, in the haste to resolve matters, reinstatement works could be inadvertently carried out to listed buildings without consent.

**It Will Happen Again**

Inevitably, most strategies aim to prepare for, and reduce the impact of flooding and this might be recognised in an HBIM approach. As they cannot prevent flooding from occurring in the future to reduce the impact, at property level, a number of standard measures can be considered in isolation, or in combination, including:

- Flood gates and air brick covers
- Durable renders – inside and out
- Waterproof fittings and fixtures
- Raised services
- Non return valves on drains
- Revise openings
- Channels, sumps, pumps
- Cavity drain systems
- Renewable wall linings
- Elimination of voids
- Resilient sacrificial spaces

But, flood resilience measures could impact upon the structure in ways that may not be immediately apparent so care is required in deciding what to adopt in the more innovative

forms of flood resilient design that are becoming available. So, in considering flood resilient options when recovering a flood affected building, it is important to remember the importance of: -

- Specialist knowledge applied to flood recovery
- Undertaking a thorough post flood investigation
- Recognising and avoiding pitfalls
- A robust yet flexible repair strategy

**Building Insurance**

It is estimated that there are 5.2 million properties at risk of flooding in England. Of these, 1.4 million are at risk from rivers or the sea, 2.8 million from surface water, and 1 million at risk from both. If property has suffered from flood damage in the past, if there is a history of flooding, or the property is in an identified flood risk area, it can sometimes be difficult to find insurance cover. The 2012 DEFRA guide '*Obtaining flood insurance in high risk areas'* aims to provide information on how to obtain a suitable policy, get specialist help, what information may be asked for, whilst also providing tips on how to reduce the impact of flooding. Concerns however can remain, and further consideration has been given to the issue with the mutual establishment of the 'Flood Re' scheme.
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/69578/pb13082-flood-insurance.pd
Accessed 24 January 2015

**Spreading the Risk: The 'Flood Re' Insurance Scheme**

In face of the rising flood risk, it is estimated that between 300,000 – 500,000 flood-risk UK households would struggle to obtain affordably priced flood insurance without a scheme like Flood Re.

It is anticipated that by Summer 2015, the Flood Re scheme will be running as a not-for-profit flood reinsurance fund. Owned and managed by the insurance industry, it will be established to ensure that UK domestic properties at the highest risk of flooding can receive affordable cover for the flood element of household property insurance. In essence, reinsurance is a way for insurers themselves to insure against large-scale losses with other insurers.
https://www.abi.org.uk/Insurance-and-savings/Topics-and-issues/Flooding/Government-and-insurance-industry-flood-agreement/Flood-Re-explained
Accessed 22 Jan 2015

**Related Initiatives: Remotely Controlled Data Gathering**

With recent developments in the growing use remotely controlled UMAV survey drones, considerable data gathering potential exists that greatly reduces, or eliminates, related health and safety access issues in dangerous and inaccessible circumstances. Having the ability to beam back live high-quality video imagery, the potential exists to increasingly use such vehicles in a variety of flood and disaster situations. These benefits are being recognized internationally, with one such initiative being the *ICARUS Unmanned Search and Rescue project*.

Following the earthquakes in l'Aquila, Haiti and Japan, the European Commission considered that a large discrepancy existed between (robotic) technology developed in the laboratory and the use of that technology for Search and Rescue operations and crisis management. Consequently, the EC's Directorate-General for Enterprise and Industry has funded the *ICARUS* with a global budget of 17.5M€ with the aims to develop robotic tools that can assist "human" crisis intervention teams. Recognising that although much research literature on the development of unmanned search and rescue tools, this was being undertaken in isolation to the practical reality of needs in the field. The ICARUS project aims to bridge the gap between the research community and end-users, by developing a toolbox of integrated components for unmanned search and rescue to inform crisis personnel about the real dangers on the ground, and thus increase performance in resolving situations.

The eventual outcomes of this research initiative could well have a considerable bearing on search and rescue, building investigatory work, and routine monitoring, in extreme flood disaster situations.
http://www.fp7-icarus.eu
Accessed 24 February 2015

**Conclusions**

As indicated in the Fire Section conclusions of this report, the existing built heritage is an irreplaceable asset, and a full range of appropriate HBIM flood prevention and salvage data should be incorporated in any BIM4C approach. With the aim of ensuring its future wellbeing, the seriousness and rigour by which the HBIM data should be compiled would do well to acknowledge the high levels of loss and damage that has already occurred through the overall effects of flooding.

BIM4C HBIM data on flooding should incorporate a balanced approach, integrating conservation requirements with effective knowledge and risk assessment analysis to cover:

- Investigate the relevance of available information in the Environment Agency guidance on how to understand *'Flood Map for Planning'*

- Investigate the relevance of available information in the Environment Agency's geo-spatial flood risk mapping

- Investigate the relevance of the National Trust *Holnicote Multi-objective Flood Management Scheme*

- Investigate the relevance of the Historic Scotland seven strategic themes in its *'Climate Change Action Plan'*

- Investigate the relevance of the *Climate for Culture 'Analysis and Decision Support System'* microclimate indoor modelling tool

- Investigate the practical guidance offered in a range of relevant advisory publications including:

- English Heritage's '*Flooding and Historic Buildings'*
- Historic Scotland's '*INFORM: Flood Damage to Traditional Buildings'*
- DCLG's *'Guidance and Standards for Drying Flood Damaged Buildings'*
- BRE/ Manchester University's '*Six steps to flood resilience – guidance for property owners'*
- Associated Programme on Flood Management's *'Integrated Flood Management Tool Series: Conducting Flood Loss Assessments'*
- Australian Emergency Manuals Series *'Disaster Loss Assessment Guidelines Emergency Management Australia (2002)*'
- Property Care Association's '*Code of Practice*: *For the Recovery of Flood Damaged Buildings'*
- Building Research Establishment's '*Digest 245: Rising damp in walls: diagnosis and treatment*'
- Flood Repairs Forum's *'The Investigation and Repair of Flood damaged Domestic Properties: A Guide for the Insurance Industry'*
- DEFRA's guide '*Obtaining flood insurance in high risk areas'*

- Consider how robotic drone survey and data gathering techniques could assist in localised and extreme circumstances