UNIVERSITY of HULL | Energy & Environment Institute

Blueprint for Innovation in Property Flood Resilience (PFR):

Identifying Gaps and Opportunities in Product Development

Supported by

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Executive Summary

This report is part of a research partnership between the University of Hull and Intact Insurance on Property Flood Resilience (PFR). The project supports innovation in PFR through tools that help communities adapt to flood risk. More details about the partnership can be found at: https://www.hull.ac.uk/research/projects/intact-pfr-partnership

This document identifies strategic innovation gaps and proposes actionable solutions to improve the design, usability, and regulation of PFR products. It is intended to guide stakeholders in developing inclusive, multifunctional PFR solutions aligned with certification and insurance frameworks. The analysis considers three primary categories:

1. **Product Innovation** to identify current underdeveloped technologies and multifunctional design opportunities.
2. **Usability and Transferability** to explore how PFR products are deployed, adapted, and re-used across property types.
3. **Policy and Regulatory Innovation in PFR** to examine certification, planning, and financial mechanisms which can influence PFR uptake.

The main conclusions of this report highlight the need for automatic sliding flood doors, interoperability in products that combine flood resilience, fire safety and accessibility, and smart systems that can deploy passively, or via sensors. The report identified regulatory and insurance misalignments that create barriers to innovation and uptake and proposed a phased approach planning framework to develop inclusive, scalable and justified PFR solutions.

These findings are based upon analysis of commercial sites in Hull and East Riding of Yorkshire, UK that is site-specific, and an emphasis on a catalogue of modern PFR products. The outcomes align with local planning priorities, including Hull City Council's commitment to longer-term flood resilience.

Infographic 1 summarises some of the main PFR product categories and highlights key benefits. Infographic 2 illustrates the range of PFR products and approaches, including measures such as flood doors, barriers and air brick covers.

Infographic 1: A Blueprint for innovation in Property Flood Resilience (PFR).

PRODUCT INNOVATION

PFR helps protect people and property from flooding by reducing damage and speeding up recovery and reoccupation (CIRIA Code of Practice [C790], 2021).

WHY PFR MATTERS?

Risk Reduction
Targeted measures reduce direct damage and disruption.

Faster Recovery
Property ready solutions speed up clean-up and re-occupation.

Builds business resilience
Helps businesses to future-proof their buildings and operations.

TABLE OF PFR INNOVATION

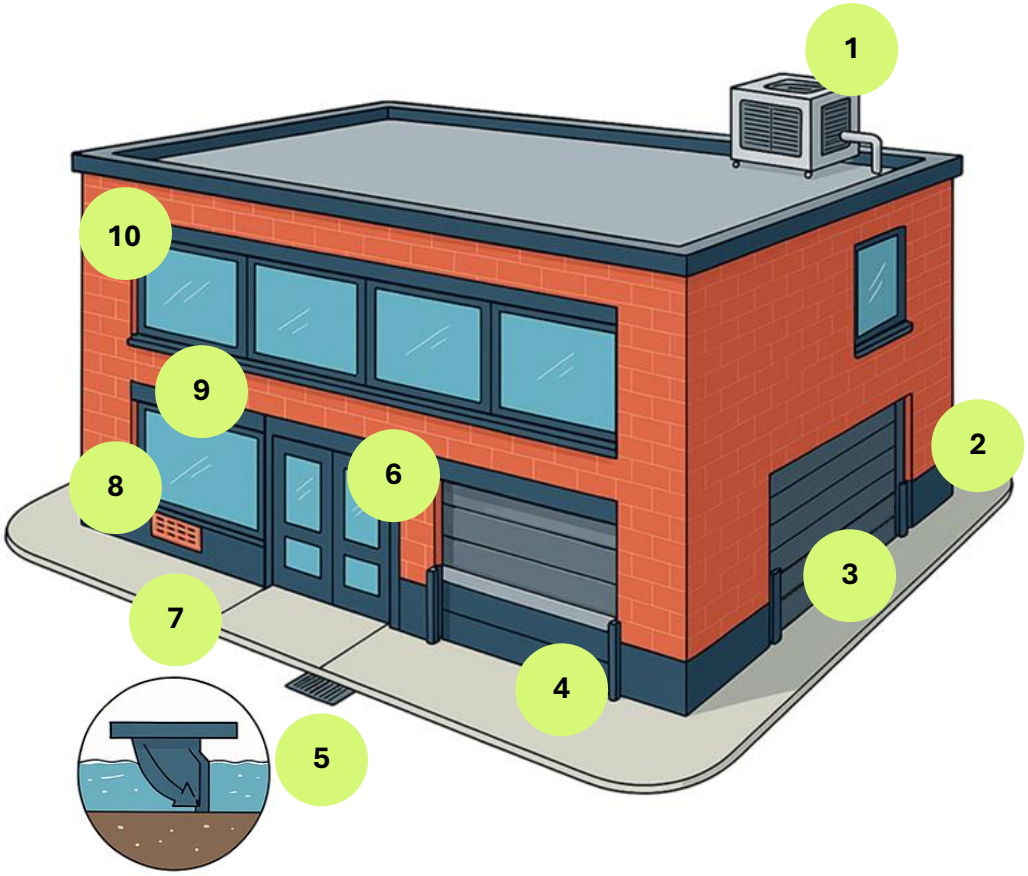
Flood doors	Develop multifunctional doors combining flood resistance, fire safety, and accessibility compliance	**Portable solutions**	Develop modular, retrofit-friendly PFR products for leased or temporary premises, requiring no specialist tools
Passive systems	Expand passive deployment mechanisms for flood doors and gates, triggered by hydrostatic pressure or predictive data	**Smart monitoring**	Integrate water-level sensors, connected alarms, and predictive activation into PFR systems
Automation	Create automatic, sensor-triggered sliding flood doors that meet BS 851188, BS 476, and accessibility standards	**Certification reform**	Establish new frameworks for multifunctional and modular products, expand UK testing facilities
Heritage compatibility	Design heritage-sensitive flood doors with modular, reversible installation and low thresholds	**Policy & Finance**	Introduce commercial Build Back Better scheme, parametric insurance models, and fast-track planning approvals

PRODUCT INNOVATION

Innovation opportunities

- Multifunctional flood doors – combine flood protection with features such as fire safety and accessibility.
- Automatic and passive systems – sensor-activated doors and barriers for rapid autonomous and reliable response.
- Inclusive, heritage-compatible, designs – modular, low-threshold solutions for listed and complex buildings.
- Portable and retrofit-friendly PFR products – tool-free, modular systems for leased or temporary premises.
- Smart flood monitoring and early warning systems – inclusive of water-level sensors and connected alarms which provide real-time alerts.
- Policy and certification reform - Potential expansion of testing facilities and fast-track approvals for certified PFR solutions.

Infographic 2: Reducing Flood Risk in Commercial Properties: A Visual Guide



1. **Roof mounted critical infrastructure:** Essential systems placed above flood level.
2. **Water repellent paint:** Exterior coating that reduces water absorption and protects building materials.
3. **Roller Shutter:** Protective shutters that can be deployed to shield doors and windows from floodwater and debris.
4. **Demountable barrier:** Temporary flood barriers that can be quickly installed during flood warnings.
5. **Non-Return Valve (NRV):** Prevents sewage or floodwater backflow.
6. **Flood Door:** Watertight doors designed to resist water pressure and prevent internal flooding.
7. **Raised ground:** Elevated surroundings reduce the likelihood of floodwater reaching the building.
8. **Air brick cover:** Temporary or permanent covers that block floodwaters from entering through ventilation bricks.
9. **Flood defender window:** Sealed window units for water ingress prevention.
10. **Flood Evacuation Plan (FEP):** Move occupants to upper floors during flooding.

1. Contextual background

This report, part of the Intact Insurance–Hull partnership, outlines innovation gaps in Property Flood Resilience (PFR) products, their usability, and policy to support the development of resilient infrastructure standards. This is the first part of a collaborative programme of research between the University of Hull and Intact Insurance to support the adoption of PFR in commercial properties. The expected outcomes of this collaborative research programme are:

1. A *Blueprint for innovation in PFR* report matching PFR products and product performance requirements to published flood risk data
2. A *PFR needs-assessment tool* linking PFR needs for different properties to flood risk, based on existing flood risk information
3. A new evidence-based testing and rating system which scores PFR product performance according to real-world flood risk.

The need for PFR is demonstrated by Environment Agency (2024a) analysis that shows ~6.3 million properties in England are currently at risk of flooding, potentially increasing to 8 million properties by 2050 owing to climate change and population growth. PFR uses measures such as flood doors, barriers, and sealed openings to limit damage and aid recovery, reducing repair costs and disruption (Lamond et al., 2018; Bonfield, 2025). The recent FloodReady review (Bonfield, 2025) introduces six strategic priorities for improving property-level flood resilience:

1. growing a coherent and trusted market for PFR products and professionals,
2. ensuring certified, accessible and consumer-protected solutions,
3. providing consistent and easy-to-find flood resilience information, including Flood Performance Certificates,
4. reducing surface water runoff at property level through measures like permeable paving and rain gardens,
5. embedding resilience into planning and building regulations,
6. supporting research and innovation to drive new standards and technologies.

Refinements and additional capacity for PFR infrastructure are a good investment, which should include resilience measures in both new build and retrofit opportunities. The Bonfield review (2025) also emphasises insurance and finance integration, highlighting the Build Back Better scheme and lender engagement as key enablers, alongside the creation of a multi-sector Leadership Group to oversee delivery. Additionally, the review highlights the need to increase product trustworthiness, confirming that PFR products are properly installed, tested to perform and certified with flood performance credentials to increase trust and encourage wider uptake by stakeholders across the industry and by consumers. Competent professional training and licensing are also identified as critical to mainstreaming resilience, similar to fire safety or insulation standards.

The Royal Institution of Chartered Surveyors (RICS, 2025) identifies future flooding as one of the most significant threats to UK property, with flood risk projected to increase by up to 27% by 2050 and 40% by 2080. RICS emphasises the role of property professionals in enhancing resilience through construction advice, property valuation and flood risk awareness. It also highlights the importance of certified PFR measures in both new developments and retrofit applications. These

measures not only help mitigate damage during flood events and support ongoing insurability, but also strengthen valuation practices and ensure resilience is embedded in property advice, encouraging wider engagement in resilience and mitigation initiatives.

In recent months, policy and industry interest in PFR has accelerated significantly. DEFRA's consultation on the reform of funding for flood and coastal erosion risk management (2025) confirms a shift towards more flexible funding for resilience measures. Importantly, government ideas in this consultation are aimed at supporting PFR by creating funding models based on a program's outcomes and support collaboration (DEFRA, 2025). This implies a move toward flexible and adaptable ways of embedding resilience in property-level planning, rather than relying on larger-scale capital investment. The Environment Audit Committee's inquiry (2025) lays out a rationale and urgency for statutory duties and integrating resilience into planning. These signals are now informing numerous industry-led developments such as FloodReady (2025), RICS' guidance (2025) and JBA/Flood Re's Build Back Better assessment (2023). Collectively, these shifts mark a transition from reactive flood defence to proactive adaptation in the built environment. This momentum underscores the need for coordinated action between government departments, insurers and property professionals to embed resilience within climate adaptation strategies.

Nonetheless, PFR cannot offer safety in every situation (Beddoes et al., 2018). PFR can reduce both recovery times and repair costs, yet, its effectiveness related to flood depth, duration and product performance will vary (Lamond et al., 2018). Even with a growing number of PFR products on the market, many therefore continue to not be appropriate for heritage buildings or buildings which would benefit with better accessibility. Regulations such as the Equality Act 2010 and BS 851188 can overlap requirements that standard solutions can struggle to achieve. This is particularly evident in public-facing buildings or in arrangements where spatial usage is complex and multifunctional. At the regional level, Hull City Council recommends that commercial buildings are designed for a flood risk of 75 years and domestic buildings for a flood risk of 100 years. This indicates an expectation of long-term resilience in new builds and retrofits (R. Glossop, pers. comm. 2025).

Research conducted by the FloodProof Research Roundtable (2025) highlights that current standards often prioritise high resistance over usability, creating barriers to mass-market adoption. It also identifies a lack of systematic testing and reliance on anecdotal evidence, underscoring the need for a standardised evidence base to support product development and policy. This includes interdisciplinary approaches, advanced testing protocols and digital tools for certification and modelling. The Roundtable further stresses the importance of behavioural and social research to understand how property owners and managers make decisions about PFR.

Despite these actions, there is still a disparity between the perceptions of underwriters regarding performance refinements and the effect on insurance premiums (Figure 1). This disparity is not only theoretical, but it has a clear implication for innovation and uptake. If insurers under-price the benefits of PFR, then property owners lack incentives to invest, stifling market growth as well as discouraging manufacturers from driving innovation. Conversely, if underwriters inaccurately assess performance and overestimate benefits, they may not appropriately fund those costs and

other customers would effectively subsidise the risk. Research conducted by Aviva (2025) on climate risk to properties across the UK highlights the urgency of integrating resilience initiatives into property development and insurance policies. It warns that countries failing to take a proactive adaptability approach will amplify threats to cultural and economic assets in the years leading up to 2050. This means that pricing mechanisms must adapt to resiliency initiatives because the failure to adapt would only serve to otherwise prolong systemic risk for both property owners and insurers.

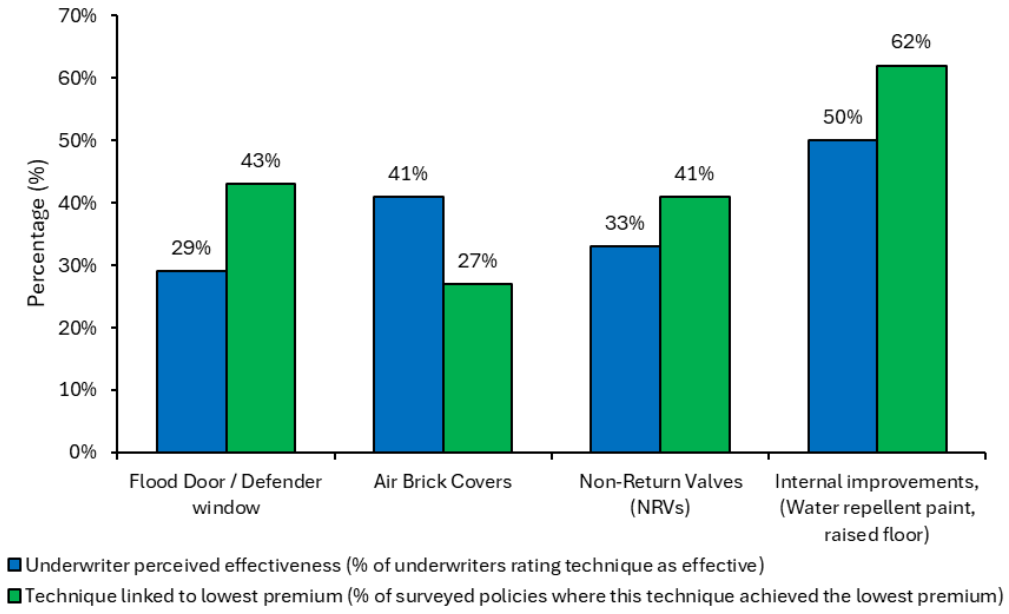


Figure 1:Comparison of underwriter perceptions of PFR effectiveness and their impact on insurance premiums. Data sourced from Bonfield (2016).

This disconnect demonstrates that from an innovation perspective, technical developments alone are not sufficient. Systemic solutions related to certification, insurance alignment and market assurance are also needed. As Bonfield (2025) states this disconnect indicates a need for:

1. Stronger evidence-based performance data that aligns insurance pricing with real-world outcomes.
2. Standardised rating frameworks that insurers can rely on whilst assessing risk.
3. Including PFR performance into Flood Performance Certificates to enhance transparency and build uptake.
4. Joint research including insurers, manufacturers and regulators to close the perception gap that demonstrates the new innovation can meet technical performance while developing market confidence.

This report evaluates PFR products currently available on the market for commercial properties, assessing them against regulatory and performance standards to identify gaps in innovation. Using a case study database of technologies and commercial buildings in Hull and the East Riding of Yorkshire, it aims to construct a blueprint of innovation opportunities in PFR across multiple performance layers including flood resistance, fire safety, activation type and accessibility.

2. Methodology - Innovation Framework

This report explores gaps in innovation for PFR, following the principles of the OECD Oslo Manual (2018) where innovation refers to the implementation of a product or process introducing new or significantly improved products or processes that differ from existing solutions. The concept of innovation in this report is used as a means to assess where existing products, systems or practices do not meet the performance, usability or regulatory expectations. The analysis captures these gaps through a structured review of current PFR products alongside site-specific analyses of commercial properties to identify potential areas for technical improvement and system alignment that can improve resilience outcomes.

2.1 PFR Product Catalogue Development

Appendix A provides an extensive list of existing certified and non-certified PFR products. Each product was assessed against key performance criteria, including flood depth resistance, installation options, activation type (passive versus active) and applicability to different property types. Additional criteria such as accessibility, fire resistance and costing, were included to facilitate a multidisciplinary assessment of innovation potential. Supporting the catalogue, Infographic 2 conceptualises the range of assessed PFR techniques, including measures such as barriers, flood doors and air brick covers.

2.2 Site Analysis of Commercial Properties

To identify PFR innovation gaps from existing practice, this report applies a site-specific assessment framework to three commercial properties located in Hull and the East Riding of Yorkshire, UK (Appendix B). These sites were selected based on their flood exposure and their relevance to accessibility and heritage constraints. Each property was assessed for flood risk features, current PFR installations and contextual limitations that may affect the viability of resilience measures.

To understand the existing product types employed to manage flood risk within commercial settings, the assessment involved reviewing technical documents, planning applications, flood-risk maps and relevant policy constraints. Recent industry research, such as Aviva's Building Future Communities report (2025), reiterates that heritage and iconic buildings can be susceptible to climate-induced flood risk and add pressure for PFR solutions that are resilient while also accommodating conservation orders for listed buildings and historic buildings.

2.3 Innovation Gap Identification

The report sets out to identify critical gaps in the current PFR market by comparing product capabilities with site-specific needs. These include the absence of flood resilient automatic sliding doors, passive systems suitable for high-depth flooding and multifunctional products which combine flood resistance with fire protection and Disability Discrimination Act (DDA) compliance.

The preliminary analysis of PFR solutions suggests that there is a wide range of options such as flood barriers, doors, gates, pumps and coatings. These solutions can be classified by respective

flood depth suitability and measured performance metrics. However, reviewing the range of PFR solutions suggests potential gaps in automation, accessibility and compatibility with heritage or modular buildings. Assessment of performance metrics and gaps in the types of products available could inform a future review of required standards and inform an assessment of the commercial availability and opportunities to improve the inclusivity, flexibility and evidence-based solutions. The emerging insights from this methodology serves to guide the innovation recommendations provided later in the report.

3. Product Innovation

Flood doors are an essential component of PFR, but most available products only satisfy one or two of the required building standards. An innovation gap exists in the development of doors that simultaneously satisfy flood resistance, fire protection and accessibility requirements. This is especially important in public buildings, health care settings and heritage buildings where the issues of space, safety and legal compliance must be resolved at the same time (Historic England, 2015; PS Flood Barriers, 2025).

For example, the Lakeside Steel Fire & Flood Door provides robust flood resistance and fire protection, with certification to BS 851188 and BS 476 Part 22:1987 (Lakeside Flood Solutions, 2025). However, it does not have a certification to meet Disability Discrimination Act (DDA) requirements, making it potentially unsuitable for buildings with public access requirements. An example of an alternative is the StormMeister Low Threshold Outward Opening Flood Door which offers level access and flood resistance, satisfying Part M of the Building Regulations (Figure 2) (StormMeister, 2021; StormMeister, 2025), but has no fire protection. This highlights a gap where there is no single fully-certified product that integrates flood resistance, fire safety and accessibility compliance.

Figure 2: StormMeister Low-Threshold Outward Opening Flood Door demonstrating accessibility and flood resistance. The design supports level access for wheelchair users while providing certified flood protection. Source: StormMeister (2021).

The fragmentation of product capability obliges building managers to make choices between resilience and compliance, often resulting in compromises that reduce overall effectiveness.

These choices can bring significant implications around safety, usability and regulatory approval, especially in Care Homes and hospitals (Hull City Council, 2016a; Equality and Rights Network, 2023). Hull New Theatre is an example of this challenge. During renovations, internal raised floors were excluded due to accessibility issues necessitating a demountable external flood barrier instead (Appendix B) (Hull City Council, 2016a; GGP Consult Ltd., 2016). Although the barriers were effective, they illustrate the potential conflict between resilience and usability in public buildings.

Although many PFR products focus on one aspect of flood resilience, solutions that consider combining inclusive access with conservation-sensitive design are still rarely seen. This is a significant gap especially for heritage and public buildings where planning restrictions and legal obligations meet (Historic England, 2015). For example, the Floodguard Heritage Door, produced by Aquobex (now Apex Flood Solutions) is designed for use in listed and conservation areas. It has a low-threshold design that may enable wheelchair access but is not officially certified to any accessibility assessments such as Approved Document M or BS 8300. This product illustrates how flood resilience can be achieved in heritage contexts, but also highlights the need for multifunctional products combining flood resistance with accessibility and fire safety (Aquobex, 2025a).

INNOVATION OPPORTUNITY
Develop a new class of multifunctional flood doors that:

- Are fire-rated to BS 476 or equivalent standards.
- Are flood-resistant to BS 851188 with passive or automatic sealing.
- Meet inclusive access standards, with low thresholds and accessible handles.
- Are heritage-compatible, using materials and finishes suitable for listed buildings.
- Feature modular or reversible installation methods to avoid permanent alterations.

Such products would simplify installation, align with regulatory standards, improve accessibility for vulnerable users and maintain heritage conservation. By enabling multiple performance criteria within one solution, this innovation would fill a critical gap in the PFR market and set a new benchmark for integrated, sustainable flood resilience (University of Cambridge, 2020; Flood Re, 2023).

3.1. Passive systems and Automation

Passive deployment mechanisms and automation are increasingly recognised as essential components for effective PFR. These systems improve response times, reduce reliance on human action and improve resilience during flash floods.

3.1.1. Passive Flood Barriers

Passive flood barriers activate without human intervention, and usually engage via buoyancy or hydrostatic pressure, triggered by rising flood waters. This makes them particularly important where access and operational continuity are of high importance, such as in public buildings, healthcare organisations and industrial facilities (FloodBreak, 2025; Automatic Flood Barrier UK,

2025) or in areas at risk from rapid flooding. In contrast, the vast majority of flood doors still require manual closure in emergencies (Flood Control International, 2025). Examples of passive systems are presented in Appendix A.

Despite their merits in specific product categories, passive systems are not widely used, especially for flood doors and modular systems, where manual operation has been the common method.

INNOVATION OPPORTUNITY
Expand passive deployment mechanisms to include flood doors and gates. Future designs should:

- Work with building management systems for easy operation.
- Be low-maintenance and retrofit friendly, especially in heritage or space-limited buildings.
- Meet accessibility standards.
- Adapt to different building types and flood depths.
- Incorporate preparatory deployment triggered by predictive data (e.g., hyperlocal rainfall or SuDS monitoring) to activate barriers before water contact, reducing reliance on reactive systems.

3.1.2. Automatic doors for flood prevention

Automatic flood protection systems remain underdeveloped in the PFR market, particularly in the category of flood doors. Despite progress in barrier automation, deployment of flood doors is most commonly a manual task, which is a limitation as it undermines rapid deployment in high-risk environments such as in high-footfall areas or emergency scenarios (e.g. Flood Control International, 2025).

In the context of PFR, it is useful to distinguish between the two types of flood-resilient door systems.

- **Automatically operating doors that are PFR** are designed for everyday use, These automatic sliding doors incorporate flood-resilient features such as watertight seals or reinforced frames. They open and close automatically for access control but do not deploy in response to flooding.
- **Automatically deploying flood doors** are specifically designed to activate automatically during flood events, either through sensor-based systems or passive mechanisms like hydrostatic pressure. Their main function is flood defence, not daily access.

Automated flood shutters, such as Aquobex's accredited roller door (Appendix A, Figure 3), demonstrate the feasibility of compact, deployable systems. However, they are not widely available, especially for heritage or modular applications.

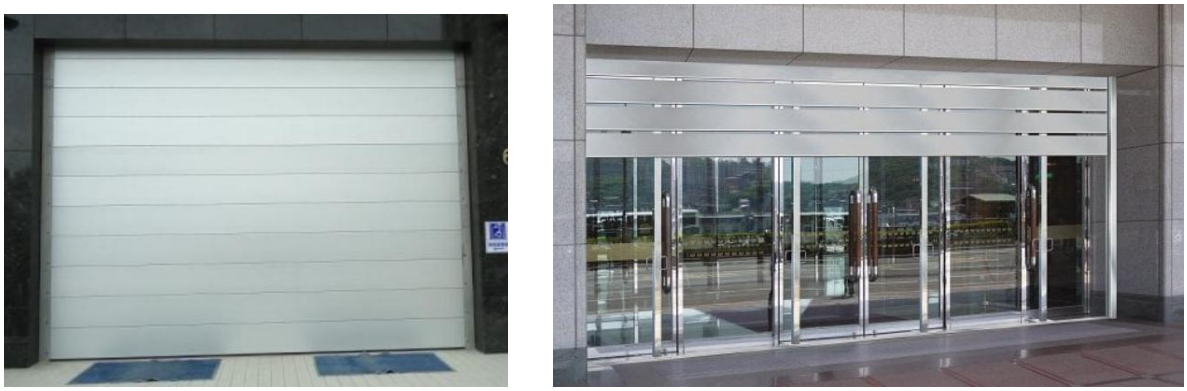


Figure 3: Example of a shutter-style flood protection system. The Floodguard Accredited Roller Door from Aquobex (now Apex Flood Solutions) demonstrates the feasibility of compact, deployable flood shutters for residential and commercial properties. Source: Aquobex (2025b).

Some innovative solutions exist, such as the QuiXseal system (Abbey Heritage78, 2025), which is an inflatable seal activated by sensors, and the Aquobex drop-down barrier, which uses electric motors and sensor activation with backup power (Aquobex, 2025c). However, flood doors that automatically deploy using passive mechanisms like hydrostatic pressure rather than powered sensors, remain underdeveloped. Systems of this type would allow flood doors to respond to rising water levels without manual intervention, while also enabling accessibility and rapid deployment should the situation require within a commercial or public building where space is limited.

INNOVATION OPPORTUNITY
Develop automatic, sensor-triggered sliding flood doors that:

- Meet flood resistance standards (BS 851188).
- Are fire-rated (BS 476 Part 22).
- Comply with accessibility legislation (Equality Act 2010; Part M of the Building Regulations).
- Offer heritage-compatible design with discreet finishes and reversible installation options.

These systems would be user-friendly, reduce human error and present mostly accessible resilience measures. They could also decrease the need for training and promote operational continuity in flood-prone areas (University of Cambridge, 2020 ; PS Flood Barriers 2025). In addition, integrating with automated systems to collectively monitor hyperlocal hydrology data (such as rainfall intensity measurements, groundwater levels, or SuDS' activities) could facilitate predictive activation and improve pre-flood resilience.

4. Usability and Transferability

This section examines how PFR products operate in commercial settings, and how they could be designed to be more flexible, more portable and easier to use. It will look at how companies react to flood events, what types of PFR measures are possible for different types of properties, and how design and deployment may facilitate or hinder adoption.

4.1. Commercial Property Response and minimising operational disruption

Commercial properties face distinct challenges during flood events, especially in sectors where operational continuity is necessary. Flooding can damage infrastructure, contaminate stock and disrupt services. The Environment Agency (2023) has established that properties with PFR installed recover considerably faster than those without PFR in place. PFR systems have an advantage over traditional flood defences, since they can be more adaptable to the spatial and operational constraints of commercial buildings. Recovery from flooding is reliant on more than just physical defences; it also relies on whether the physical defence is integrated into business continuity planning.

Flood-resistant doors, Non-Return Valves (NRVs), waterproof membranes, elevated electrical systems, and passive or automated barriers are proven effective measures (Flood Control International, 2025; Aquobex, 2025c). Procedural strategies such as Flood Evacuation Plans (FEPs), inventory buffers and decentralised operations also help reduce financial losses. For example, Smith & Nephew Healthcare Ltd, located in flood zone 3, diversified internationally to maintain operations during the 2013 flood events in Hull (Appendix B).

INNOVATION OPPORTUNITY
To reduce disruption and financial loss, future PFR products and strategies to adopt PFR products should:

- Be rapidly and easily deployable.
- Automated deployment options should be developed for use where appropriate.
- Intergrate with building management and or hyperlocal monitoring systems for real-time monitoring and activation.
- Facilitate post-event resilience audits and data collection to inform adaptive planning and continuous improvement.

4.2. Portable and Retrofit-Friendly PFR Products

Permanent installations may be impractical where businesses operate in leased or temporary premises. In such cases, portable and modular PFR products may offer a flexible alternative, allowing usability, transferability and retrofit applications. As shown in Appendix A, examples include demountable barriers (e.g. Nautilus® from Floodstop UK, 2025), airbrick covers and absorbent flood sacks. These solutions will be particularly useful for small and medium-sized businesses and tenants that have limited opportunity or budget to make structural alterations to the property they occupy. However, there remains a challenge with regards to durability, certification and insurance acceptance which emanates from the absence of standardised testing to improve market acceptability.

INNOVATION OPPORTUNITY
To improve transferability, future PFR products should:

- Be easy to install and remove without the need for specalist tools or extensive training.
- Include clear guidance and visual indicators to ensure of correct installation and performace.
- Be compatible with heritage and multi-occupancy buildings.
- Certification schemes that allow in-situ testing and validation, making them transferable across locations and building types.

4.3. User Experience and Accessibility in PFR

In commercial buildings, the effectiveness of PFR products depends on ease of deployment and user accessibility. Businesses often operate with limited staff during emergencies, so systems must be intuitive, quick to deploy and usable by individuals with varying capabilities and / or technical expertise.

As mentioned in Section 3.1, a key challenge that PFR needs to meet is to also satisfy both fire safety and accessibility requirements. Some products can perform adequately well in one of these areas, but few products attempt to meet the full range of required compliance. Accessibility is governed by the Equality Act (2010), Approved Document M and BS 8300, which in particular highlight where accessibility is of high importance in commercial and public sector buildings where access is a condition of law (HM Government, 2015; Soundcraft Doors & Windows, 2015). This legislative landscape also makes it difficult to transfer existing PFR between different types of buildings, especially if there are structural issues or if the building is historical.

The usability of a product could be improved by using inclusive design features and principles, including low-force activation mechanisms, remote activation, and clear visual instructions. Studies have demonstrated that having a diverse range of users and user groups involved in the product development process can improve clarity and perceived reliability of the product (Meléndez-Landaverde et al., 2023; Renville et al, 2025).

Hull City Council encourages two-storey buildings for the purpose of providing vertical evacuation, as was seen with the Flood Emergency Plan (FEP) at St Mary's Care Home (Appendix

B). This design approach complements product-level accessibility by enabling in-situ refuge during flood events, particularly for vulnerable occupants.

INNOVATION OPPORTUNITY

- Commercial PFR products should be co-designed with end-users.
- Products should meet universal design standards and be tested in operational settings.
- Embedding accessibility and user experience into product development will ensure resilience measures are practical, inclusive and effective.

5. Policy and Regulatory Innovation in PFR

5.1. Certification and Testing Gaps

PFR innovation faces limitations not just by product design constraints but also by the limited availability of BSI accredited testing centres (BSI Group, 2025). Flood Divert, for example, withdrew from the BSI scheme since there was no UK facility large enough to test their product under the new standard (FloodDivert, 2025). While British Standards, such as BS 851188 and PAS 1188, have established benchmarks for flood resistance, the limited availability of independent testing centres in the UK has caused delays in product development and the introduction of certified products to the market. This causes delays and increases development costs, particularly for products marketed in the commercial and heritage buildings sector (see Table 1).

Considering these sector-wide issues, the FloodProof Research Roundtable (2025) suggested targeted reforms to improve testing and certification of products. These included amending the existing British Standards to support modular and multifunctional products and exploring bolder partnerships with universities in the UK to improve testing options. The FloodProof Research Roundtable also suggested the certification process be modernised to better reflect evolving resilience needs and wherever appropriate, apply digital modelling to help demonstrate the performance of products. Besides the regulation and testing of products, and as part of the FloodProof Research Roundtable recommendations, collaboration across disciplines and sectors is critical to ensure standards reflect user needs and technical performance, underpinned by a robust evidence base.

Table 1: UK Test Facilities for Property Flood Resilience (PFR) Products, Including Operational Start Dates and Locations.

Site	Location of UK test facility	When facility became operational	Notes
University of Hull, Energy and Environment Institute (EEI)	Hull	Began testing PFR products 2025. Still operational.	Able to test multiple PFR products at once.
Whitehouse	Derby	Began testing PFR products circa 2005 (Marketing Derby, 2025). Still operational.	Owned and operated by PFR manufacturers / suppliers
M3 Floodtec	Worcestershire	Began testing PFR products in March / April 2021 (M3 Floodtec, 2021). Still operational.	
HR Wallingford	Wallingford	Began testing PFR products in 2010 (BBC News, 2010; Environment Agency, 2010). BS 851188 published in 2019; third-party facilities and manufacturer-led testing took place subsequently (BSI Group, 2019).	Currently not performing PFR testing
Aquobex / Apex flood Solutions	Watford	Began testing PFR products on 3rd February 2017 (British Damage Management Association, 2017). Still operational.	Owned and operated by PFR manufacturers / suppliers.

INNOVATION OPPORTUNITY
To support a more dynamic and inclusive PFR market, the sector should:

- Establish additional independent testing capability.
- Develop certification frameworks for modular and portable systems.
- Facilitate integration across multiple standards for flood, accessibility and fire.
- Review and update British Standards for alignment with the latest national flood and real-life risk assessments, with the aim of consistent products and performance in relation to resilience.

5.2. Barriers and Opportunities for Innovation in Commercial PFR

Planning regulations, accessibility requirements and financial mechanisms often restrict the deployment of PFR measures in commercial and heritage buildings. Structural alterations to listed buildings are often difficult to implement, particularly when installing permanent flood defences. While modular and demountable barriers may offer viable alternatives, planning frameworks rarely support their rapid approval (Historic England, 2015; Hull City Council, 2016a). Accessibility legislation, including the Equality Act (2010), Approved Document M and BS 8300,

adds further complexity. Products must meet inclusive design standards, yet few flood doors are both effective and compliant. Limited coordination between planning authorities and flood risk managers continues to hinder their innovation in complex urban environments (Environment Agency, 2023; Urban Water, 2025).

Uptake of PFR measures is also limited by financial constraints and despite ongoing technology innovation, adoption remains limited due to systemic challenges and planning constraints (Bonfield, 2016). A major issue is the lack of recognition by insurers, 95% of insurers do not acknowledge any specific certification/standards for firms installing resilience measures (Bonfield,2016). Funding is another barrier, Bonfield (2016) notes that even with access to a £5,000 government-backed grant, a third of insurers indicated this would not influence their ability to place flood risk.

Parametric insurance models such as those offered by Flood Flash (FloodFlash, 2024) provide a potential alternative. These policies are triggered by on-site water depth sensors enabling rapid payouts when flood water exceeds a specified level (FloodFlash, 2024). However, most commercial insurers still rely on conventional underwriting models that overlook the presence or effectiveness of PFR, limiting financial incentives for businesses. The Association of British Insurers has called for improved data sharing and risk modelling to better integrate PFR into commercial insurance frameworks (The Association of British Insurers, 2025).

In the domestic domain, the Build Back Better scheme, supported by Flood Re, provides funds for resilient reinstatement after flooding (Flood Re, 2022). However, there is no formal scheme for commercial properties, and opportunities for subsidised funding to support resilience improvements in commercial properties remain undefined. Despite the Build Back Better scheme being available for domestic properties since 2022, uptake of this scheme has also been minimal, with some early reports suggesting only a few hundred claims originating in total from across the entire country, and insurers stating there were as few as 13 eligible cases (CIWEM, 2024; Woodgate & Clark, 2025). Ultimately, there is no indication that funding alone will guarantee the uptake of resilience measures if the scheme mechanics and other support systems are not in place. Such gaps discourage investment in resilience, particularly by small- and medium-sized businesses which frequently may be unable to afford to retrofit their buildings with PFR in the absence of external financial support (Bonfield, 2016). Hull City Council has observed low uptake of PFR grants by commercial property owners. In areas at high flood risk such as English Street, Hull, this limited uptake indicates that funding alone is not sufficient without additional incentives, outreach, and simplified application processes (R. Glossop, pers. comm. 2025).

Planning policy is also problematic. Commercial developments in flood risk areas, such as heritage or conservation areas are often delayed or restricted by processes that seek approval for PFR installations. While National frameworks such as the National Planning Policy Framework (Ministry of Housing, Communities and Local Government, 2024) acknowledge flood risk they seldom include a route to fast track certified resilience products (Town and Country Planning Association, 2024). The disconnect between flood risk management, planning policy and financial incentives continues to hinder PFR installation. Hull City Council suggested a coordinated multi-agency flood response to involve emergency services, infrastructure

providers, and local planning authorities. This coordinated approach seeks to streamline decision making to support effective operational use of PFR, during flood events (R. Glossop, pers. comm. 2025).

In light of these issues, the FloodProof Research Roundtable (2025) identified that more research is needed into the behaviours and socio-economics of householders and building managers in relation to PFR decision-making. The Roundtable also noted the opportunity for stronger alignment of PFR with national resilience standards being proposed by, for example, the National Infrastructure Commission and the Climate Change Committee. In addition, integration of a range of digital tools, such as flood modelling, certification platforms, and standardised data, would be essential to support both policy development and product uptake (FloodProof Research Roundtable, 2025).

INNOVATION OPPORTUNITY
To address financial barriers restricting PFR uptake, insurers could:

- Expand parametric insurance models to more sectors.

To address planning barriers restricting PFR uptake, planning authorities could:

- Fast-track planning approvals for certified PFR products.
- Support low-threshold, heritage-compatible flood doors.
- Promote interdisciplinary collaboration across planning and resilience sectors.

To address regulatory barriers restricting PFR uptake, Government could:

- Introduce a commercial Build Back Better scheme.
- Offer financial incentives such as tax relief and grants for small and medium-sized businesses.
- Support public-private partnerships for coordinated retrofitting.
- Embed PFR into climate adaptation and resilience frameworks.

6. Conclusion

This document identifies gaps in the current property flood resilience (PFR) product market for commercial properties and provides innovation pathways that provide solutions. The key opportunities include the development of automatic sliding flood doors, multifunctional products that merge flooding resistance with fire safety and accessibility, and smart systems for passive or sensor triggered deployments.

The report compares on-site specific needs to product capabilities illustrating how innovative PFR solutions can be matched to real-world risk scenarios. This characterises product development that is not only technically appropriate, but contextually relevant to the depth, duration, frequency and nature of flooding affecting different property types.

Through clarifying regulatory barriers and market challenges to the certification of PFR products, this report outlines the conditions under which the next generation of PFR technologies can be developed. The report also indicates how to remedy immediate performance gaps in the market to seek broader uptake of climate adaptation strategies.

By promoting resilience actions that are scalable, inclusive and sustainable, including those designs that are modular and can be retrofitted, future PFR solutions can productively support national and local initiatives to manage flood risk. Collaborative work with manufacturers, local authorities, regulatory agencies and academics will be necessary to bring these innovations forward. These findings provide a strategic roadmap for insurers and stakeholders seeking to invest in resilient infrastructure and reduce long-term flood-related losses.

Looking ahead, the Intact Insurance–Hull partnership will build on the findings of this report to explore some of the identified PFR innovation gaps. The next phase of the project will develop a PFR needs-assessment tool to link commercial property risk profiles with appropriate PFR measures. This will be followed by an evidence-based performance rating system for PFR products, using data from real-world testing at the PFR*lab*, a collaborative research facility co-created between the University of Hull, the Environment Agency, and insurers such as Flood Re. Together, these initiatives aim to create a framework for selecting and certifying PFR products that enables insurers, local authorities and businesses to invest confidently in resilient infrastructure and reduce flood losses over the long term.

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Appendices

Appendix A – Catalogue of PFR Products (Excel format): Available as a supplementary file accompanying this report (accompanying file).

Appendix B – Evaluating Property Flood Resilience (PFR) in Hull and the East Riding: A Case Study Approach to Industrial, Commercial and Residential Sites.

Appendix B – Evaluating Property Flood Resilience (PFR) in Hull and the East Riding: A Case Study Approach to Industrial, Commercial and Residential Sites

Introduction

This investigation evaluates property planning applications submitted to Hull City Council and East Riding of Yorkshire Council to analyse the integration of Property Flood Resilience (PFR) methods in both new construction and retrofitted sites. Planning policy documents, case studies and best practice guidance documents are referenced to evaluate the level of PFR implementation and possible opportunities for resilience improvements.

Hull is highly vulnerable to flooding given the geographical low lying land and proximity to the Humber Estuary. The Hull City Council Strategic Flood Risk Assessment (SFRA) identifies Hull to be at risk from fluvial, surface water and tidal flooding and provides detailed modelling of flood depths and extents under a range of different scenarios (Hull City Council, 2016b). In partnership with Yorkshire Water, The Living with Water Supplementary Planning Document (SPD) aims to assist developers with sustainable drainage and flood risk mitigation strategies and to ensure that new developments do not increase flood risk (Hull City Council, Yorkshire water, 2020). As part of the planning process, applicants are required to submit Flood Risk Assessments (FRA) and Drainage Impact Assessments (DIA), and demonstrate compliance with Sustainable Drainage Systems (SuDS) and PFR standards (Hull City Council, 2022a).

In comparison, the East Riding of Yorkshire encompasses a mix of urban, suburban and rural areas, each with distinct flood risk profiles. The East Riding of Yorkshire Council SFRA and planning guidance documents specify flood mitigation measures for developments proposed in possible flood affected areas, including Sustainable Drainage Systems (SuDS), FRAs and PFR measures. This research examines planning applications made to both authorities as a means to identify how PFR measures are considered in different geographical, political and administrative contexts within the Humber region.

Methodology

This study adopts a case-based approach to evaluate the implementation of physical PFR measures, including the use of flood doors, barriers and gates, in three selected commercial / industrial buildings in Hull and East Riding of Yorkshire. The methodology is designed to assess both existing resilience features and opportunities for further enhancement.

Research Objectives

Three research objectives have been developed:

1. To evaluate the extent to which PFR techniques have been incorporated into three specific industrial / commercial buildings in Hull or the surrounding East Riding of Yorkshire.
2. To determine whether these measures were part of the original construction or added during retrofitting.
3. To identify gaps and recommend additional PFR strategies tailored to each site.

Site Selection

Three industrial / commercial buildings were selected based on the following criteria: Location within flood-prone areas of Hull or the surrounding East Riding of Yorkshire, Availability of planning documents and flood risk assessments (FRAs), Relevance to current or recent development or retrofitting activity. These sites included:

- St Mary's Care Home, Chanterlands Avenue, HU5 4DT
- Smith & Nephew Healthcare Limited, 101 Hessle Road, HU3 2BJ
- Paper Mill House, Nordham North Cave East Riding Of Yorkshire, HU15 2LT

Results

St Mary's Chanterlands Care Home

St Mary's Chanterlands Care Home is a residential home for people over and under the age of 65, including care of elderly persons, those with physical disabilities and nursing and personal care. It is located at 344 Chanterlands Avenue, Hull, HU5 4DT and operated by Private Medicare Ltd (Care Quality Commission, 2023). This accommodation is an 86 bed facility within a 1-3 storey building (Care Quality Commission, 2023; Hull City Council, 2024a).

In 2023, the Care Quality Commission (CQC) inspected the home and awarded an overall rating of "Requires Improvement". Individual ratings of "Good" for effectiveness, caring, and responsiveness, and "Requires Improvement" for safety and leadership were given. This demonstrates ongoing efforts to improve the quality of care and standards of operation (Care Quality Commission, 2023).

Despite the CQC scoring St Mary's Care Home "Requires Improvement" in relation to safety, this does not acknowledge other risks associated with environmental hazards such as flooding. The CQC "Safety" domain focuses mainly on clinical and operational safety, i.e. medication management, infection control and safeguarding, and does not determine whether any structural flood resilience existed, or whether there were any PFR measures (Care Quality Commission, 2023).

Planning Context / Flood Resilience Strategy

The planning application 20/01378/FULL (2023/24) which was later amended under Section 73 of the Town and Country Planning Act, concerns the development of the 86-bed residential care home for the elderly. The original approval included a number of conditions that ensured the scheme would include appropriate flood resilience measures. Among these, Conditions 27 and 28 required the implementation of a comprehensive drainage strategy, while Condition 31 addressed specific flood risk mitigation requirements (Hull City Council, 2024a).

After the project was first approved, St Mary's Care Home made a further application to amend the project. This included the removal of the requirement for 600mm high demountable flood barriers at all external ground floor door openings, the removal of permeable paving from the external works, and minor alterations to the external design and layout of the building. Although changes to the application included the removal of the physical PFR (Property Flood Resilience) features, the application was granted, subject to the preparation and implementation of a Flood Evacuation Plan (FEP) (Figure 4). The council's response is in line with a broader trend elsewhere in Hull that commercial properties prepare site-specific FEPs which align with the coordination of the city-region emergency planning strategy guided by Hull City Council and the Humber Local Resilience Forum (Hull City Council, 2022b). According to Hull City Council, new commercial properties are now required to retain occupants within the building during flood events, rather than

relying on external council-led evacuation. This indicates a shift toward internal vertical evacuation plans in addition to emergency planning response (R. Glossop, pers. comm. 2025).

The multi-storey design of the building, allows residents to move to upper levels and out of the reach of floodwaters during emergencies. Hull City Council has indicated its preference for a commercial building of two storeys for evacuations, particularly in instances when external refuge is impractical, or not safe (R. Glossop, pers. comm. 2025). The two-storey design option provides procedural resilience and affirms inclusive planning for vulnerable occupants.

According to Hull City Council (2025), the flood doors were originally proposed in the submitted Flood Risk Assessment (FRA) for application ref. 20/01378/FULL, even though the finished floor levels were already being raised by the required 600mm, with an additional 300mm of flood resilience measures. As flood doors were included in the FRA, they were incorporated into the planning condition. In the subsequent application ref. 22/00989/S73, St Mary's Care Home proposed to change the wording of the flood risk condition to remove the flood doors, which the council accepted. The application also proposed the removal of the permeable paving, which again was accepted. The modified design offered appropriate attenuation measures including above-ground SuDS such as a pond and water butts. The FEP remained a condition separate from the other flood risk provisions in the original and subsequent applications.

The decision to remove physical flood defences from St Mary's Care Home was grounded in an updated flood risk classification as outlined within the site-specific FRA provided by JC Consulting (2022). Although the Environment Agency (2020) mapping indicates that the site is situated within Flood Zone 3 categorisation, this Flood Zone classification derives from broad modelling factors that do not always account for localised improvements to flood defences. JC Consulting (2022) determined that the site is not now classified to be at high risk, due to the substantial flood defence infrastructure constructed by the Environment Agency (EA) between 2019 and 2021. More specifically, the site appears to be protected by the wider Humber: Hull Frontages Flood Defence Scheme which includes tidal flood walls and embankments designed to protect over 113,000 properties across Hull (Environment Agency, 2022).

JC Consulting's assessment was based on existing datasets from the EA flood maps and the River Hull Integrated Catchment Study, which indicated that the defences would not be overtopped in a 1% Annual Exceedance Probability (AEP) event. The FRA considered the mapped flood extents as theoretical, assuming complete defence failure, and noted: "Given that there is a flood defence constructed south of the site, it is considered that this area of the site is no longer within Flood Zone 3" (JC Consulting, 2022). It is important to note that the FRA was written in July 2021 (almost a year after the EA had published their 2020 flood mapping) which was completed prior to the full completion of the Hull Frontages Scheme. This suggests that the context of JC Consulting's assessment was meant to be reflective of the updated context of flood protection, which may have included aspects of flood protection that the earlier EA mappings may not have fully captured. This reclassification formed the planning basis for the removal of previously mandated PFR features, such as flood doors and permeable paving, in favour of procedural measures like a FEP. Nevertheless, this reliance on consultancy-led modelling contrasts with Hull City Council's preference for site-specific FRAs conducted by individual property owners. Council officers have indicated that tailored, site-led assessments offer greater responsiveness to local flood risk and planning constraints than those produced by consultancies (R. Glossop, pers. comm. 2025).

Although the planning reports for St Mary's Care Home do not refer to accessibility legislation, the removal of the demountable flood barriers may reflect a broader challenge observed in Hull, where physical flood resilient measures can be at odds with inclusive design standards. For example, Hull New Theatre was unable to install flood doors due to level access requirements under the Disability Discrimination Act (DDA) (GGP Consult Ltd., 2016). This contrast may also represent differences in planning context; Hull New Theatre's heritage status versus St Mary's Care Home being a new build. Nonetheless, it does illustrate the greater complexity of satisfying flood resilience and accessibility/conservation requirements in planning decisions.

Although this method adheres to national planning policy directives, it is worth noting that when the planning application for St Mary's Care Home was submitted, there was no site-specific hydraulic model or quantitative assessment. Without having a site-specific model this constrains the ability to accurately determine residual flood risk, particularly in breach or overtopping scenarios. Solely relying on external defences and reactive strategies, such as a FEP, for a facility accommodating highly vulnerable residents, raises concerns regarding the overall flood resilience approach.

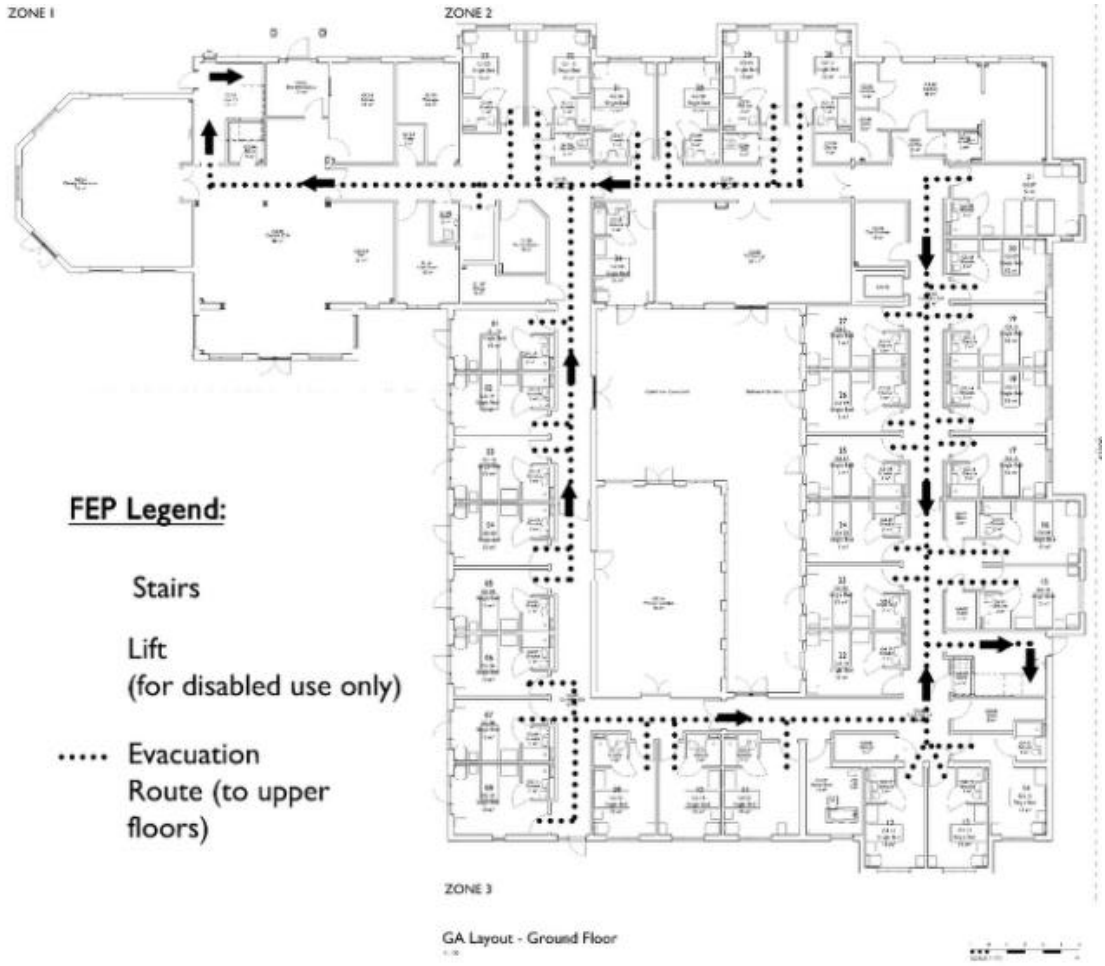

Figure 4: Displaying Flood Evacuation Plan (FEP) at St Mary's Care Home, Hull. This plan shows exit routes to stairs to move residents to higher floors in the building. Sourced: Hull City Council (2024b).

Assessment

The removal of key physical PFR measures, namely the flood doors and permeable paving, from the original design of St Mary's Care Home constitutes a significant reduction in the passive flooding resilience of the building. This decision was based on an updated flood risk classification supported by the site-specific FRA (JC Consulting, 2022) which concluded that the site would benefit, at least to a certain degree, from substantial EA flood defences. Notwithstanding, this raises concerns because these features were originally conditioned under planning, reflecting the historical flood risk of the Hull city area (Hull City Council, 2022c). Even considering the vulnerability of the residents and potential for residual and/or surface water flooding, a precautionary approach to flood resilience is still needed.

The EA's long-term flood risk map classifies flood risk separately for different sources. St Mary's Care Home is designated as having a "very low" annual probability of flooding from both rivers and the sea, and from surface water, in both current and future projections (Environment Agency, 2025). A "very low" classification indicates a 0.1% or less annual probability of flooding, but it does not mean there is zero risk. For example, flooding from surface water may be possible due to localised drainage problems or extreme rain events, which may not be fully reflected in national models (Grantham Research Institute on Climate Change and the Environment, 2021). Given the site's conditions registering in Flood Zone 3a and the vulnerabilities of its residents, it remains important to be cautious about flood resilience (Environment Agency, 2014).

The choice to remove the demountable barriers is concerning given the building's function as a residential care facility for elderly individuals. The property has 14 ground-level external door openings leading out to the grounds. This increases the risk of the building being inundated with surface water during times of high-intensity rainfall (Hull City Council, 2024a; Hull City Council, 2022c).

While a site-specific FEP is a type of resilience strategy that introduces a procedural way of creating resilience, it is, in fact, reactive rather than preventative. It relies on timely flood warnings, available staff able to undertake the evacuation, and the effective implementation of evacuation protocols, factors that may be compromised during extreme weather events. Furthermore, the FEP's success is contingent upon training staff regularly, undertaking evacuation practices, and having direct links with local flood alert systems (Hull City Council, 2022b).

Nevertheless, the multi-storey dasign of the building partially mitigates this risk by enabling vertical evacuation. Hull City Council expressed a preference for commercial buildings of two storeys or over to facilitate in-situ refuge during a flood event, particularly where external evacuation is either impractical or unsafe (R. Glossop, pers. comm. 2025). This factor adds resilience to a procedure and connects to a plan developed to protect vulnerable residents. Beyond this, the removal of physical flood defences may have financial implications. Insurance companies often assess flood risk based in part on geography and mitigation features. The lack of demountable barriers and permeable paving may result in higher insurance premiums and/or restricted coverage specific to a facility occupied by vulnerable residents, despite having received planning permission (Dam Easy Flood Barriers, 2024).

In summary, although the FEP will add an essential level of procedural protection, it does not compensate for the loss of structural flood mitigation measures. A more resilient approach would be to use a combination of physical, and procedural measures to protect the users and maintain the operationality of the building during flooding events. The dual approach is illustrated by Hull New Theatre, which retains significantly robust physical PFR features, including demountable flood barriers, basement tanking and flood-resistant construction up to +3.7m above ordnance datum (AOD), whilst also implementing a FEP as guided by the EA (GGP Consult Ltd, 2016). Hybrid approaches are developing in some commercial properties in Hull. Other sites, for example St Mary's Care Home, have opted to remove PFR features in favour of procedural resilience, highlighting a divergence in flood mitigation strategies across the city.

Recommendations

To enhance PFR for St Mary's Care Home, three recommendations are given:

- Consider reinstating physical PFR measures such as flood-resistant doors or raised thresholds to complement the evacuation plan.
- Ensure the evacuation plan is reviewed annually and updated in line with changes to flood risk mapping or resident needs.
- Explore the use of Non-Return Valves (NRVs) and internal resilient finishes to reduce damage in the event of water ingress.
- Future care home designs should incorporate multi-storey layouts to enable vertical evacuation, enhancing procedural resilience in flood-prone areas and aligning with Hull City Council's planning guidance.

Smith & Nephew Healthcare Ltd

Smith & Nephew Healthcare Ltd operates a major industrial and research facility located at 101 Hessle Road, Hull, HU3 2BJ. The site forms part of the company's global operations in medical technology, with a focus on the development and manufacture of advanced wound care products (Smith & Nephew, 2016). Smith & Nephew is a long-established healthcare company, founded in 1856 in Hull, and is recognised for its innovation in surgical devices, orthopaedics and wound management solutions (Smith & Nephew, 2016).

The Hessle Road site includes manufacturing facilities, laboratories and a state-of-the-art Research & Development (R&D) Centre, which opened in 2016 following an £8 million investment. The R&D Centre houses specialist laboratories in surface analysis, biomechanics, toxicology, chemistry and microbiology, and is considered one of the most advanced medical device R&D centres in Europe (Ridings Consulting Engineers, 2016).

Following a significant flood event in 2013, when the River Humber overtopped its banks and inundated the site, Smith & Nephew invested over £3 million in bespoke flood defences. These include reinforced perimeter walls, flood gates, flood doors and Non-Return Valves (NRVs) (Smith & Nephew, 2016). These investments illustrate not only the site's strategic importance in the healthcare supply chain, but also its location in an area of Hull that is at risk of flooding.

The 2013 tidal surge caused over six weeks of raw material contamination and halted manufacturing, resulting in lost income and disruption to the supply chain. Smith & Nephew Healthcare Ltd. showed commitment to their workforce by not making redundancies, instead standing by the staff by redeploying them to recovery efforts, while insurance covered much of the loss (Adeyemo, 2023).

Although the site is industrial and not subject to CQC regulation, its strategic importance and vulnerability to flooding necessitate robust resilience planning.

Planning Context / Flood Resilience Strategy

The planning application 14/00378/FULL (2014) is specifically about external alterations to the Smith & Nephew Healthcare Ltd site, which are intended to improve the flood resilience of the existing industrial buildings. A scheme of work was approved which included specific physical measures that were intended to reduce flood risk, and improve the flood resilience of the site from surface water and tidal flooding (Hull City Council, 2014).

The key elements included the replacement of existing external wooden doors with steel fire / flood doors, and a waterproof wall membrane and render applied to the external facades. These interventions were intended to reduce the potential for water ingress during flood events and protect essential infrastructure and equipment inside the building. The planning conditions also required a surface water drainage strategy and an elevation of finished floor levels to a minimum of 300mm above the existing ground level.

In addition to physical improvements, Smith & Nephew Healthcare Ltd. has established a distributed manufacturing system capable of transferring production to other sites in the USA and China during disruptions. Having six weeks of inventory buffers around their manufacturing sites was critical in 2013, when they retained the ability to meet client demand, including NHS procurement contracts (Adeyemo, 2023).

Unlike plans that stress mitigation by way of process, the example of Smith & Nephew Healthcare Ltd. reflects a commitment to using robust physical PFR measures. This is relevant given the industrial nature of the site and the impact of flood-related disruption to manufacturing.

Annual flood response simulations are undertaken at the site to test its flood gates and ramp systems and check emergency procedures. With a 24/7 staffing rota, trained staff can proceed with flood defence measures in real time, with continuous tidal monitoring carried out in coordination with the EA and the Associated British Ports (ABP) (Adeyemo, 2023).

Assessment

The flood resilience strategy implemented at the Smith & Nephew Healthcare Ltd. site demonstrates a proactive, technically robust, approach to flood risk management in an industrial setting. The physical PFR measures, especially the use of waterproof wall membranes and the replacement of external timber doors with steel fire/flood doors is a clear indication of dedication to reducing potential future flood vulnerability of critical infrastructure (Hull City Council, 2014).

The choice to elevate finished floor levels 300mm above existing ground levels, lower than the 600mm generally advised in national guidance, appears to have been founded on the site-specific FRA (Environment Agency, 2024b). This is possibly taking into account other resilience measures in addition to the operational characteristics of the facility and the flood risk at the site. Though the site is located within Flood Zone 3 and was severely affected by flooding during the 2013 tidal inundation (Environment Agency, 2014), the combination of structural interventions and drainage improvements may have been deemed sufficient to mitigate residual risk.

Unlike residential or care-based developments, industrial sites such as Smith & Nephew Healthcare Ltd. are classified as “less vulnerable” under the National Planning Policy Framework (Ministry of Housing, Communities and Local Government, 2024). This may have influenced the planning authority’s acceptance of a lower finished floor level, particularly where operational continuity and access constraints are a concern. Nevertheless, the strategy aligns with key principles of PFR by focusing on resistance and recoverability, rather than solely on avoidance or elevation.

Recommendations

To further enhance PFR at Smith & Nephew Healthcare Ltd. the organisation could implement the following measures:

- Toilet bungs provide a low-cost, quick-deploy backup to NRVs, helping prevent sewage backflow during flood events. This PFR measure may already be in use, as it does not require planning permission.

- A FEP should be periodically updated and actively implemented across all departments. This includes clear evacuation routes, asset shutdown procedures, communication protocols and staff role assignments, supported by regular flood drills and staff awareness sessions (Adeyemo, 2023).

- Carry out post-event reviews and resilience audits following real-world flood events or simulation drills. This would involve logging outcomes, staff feedback, timing of response actions, equipment performance and any procedural bottlenecks. These audits could feed into adaptive planning and strengthen future decision-making, with results stored in a central resilience record (Adeyemo, 2023).

Paper Mill House

Paper Mill House is a residential property in the village of North Cave, East Riding of Yorkshire which is a listed Grade II building. It is part of a former paper mill complex from the 19th century. It retains many significant architectural details, such as the timber sash windows and pantile roof (Historic England, 1987). Paper Mill House is now privately owned, and reflects the many challenges to address flood risk in heritage contexts, balancing the needs of heritage conservation with the need for resilience.

Its rural location positioned in a conservation area on a watercourse makes Paper Mill house an interesting case study to explore how PFR measures can be sympathetically integrated into historic properties (East Riding of Yorkshire Council, 2020a).

Planning Context / Flood Resilience Strategy

The planning application 20/01561/PLF (2020) was made for the construction of a flood wall and flood gate at Paper Mill House. The application was made because the proposal site is located in Flood Zone 3, with Mill pond and North Cave Beck located adjacent to the proposal site which are notorious for overtopping. The proposal includes a FRA and Design, Access and Heritage Statement that identifies the need for physical flood resilience measures to protect the property (East Riding of Yorkshire Council, 2020a).

The scheme that has been approved includes a natural stone flood wall, which is 1.2 metre high, alongside the driveway. This feature is intended to be in keeping with the existing boundary and serve to maintain the character of the conservation area (Figure 5). The scheme also proposes a manually operated steel flood gate, approximately 1–1.5 metres wide, to allow for access maintaining a continuous line of defence. These measures are proposed for the purpose of preventing fluvial flooding to the lower ground floor of the property, and are designed to withstand a 1 in 100-year flood event + climate change, in accordance with EA guidance (East Riding of Yorkshire Council, 2020b). These measures together provide a greater standard of protection than was in place previously (Figure 6).

The FRA also recommended the use of flood-resistant materials and the elevation of electrical services above predicted flood levels. These recommendations were incorporated into the design to enhance the building's resilience without compromising its heritage value. The application demonstrates how site-specific PFR infrastructure can be sensitively integrated into a rural residential setting, offering a practical model for flood protection in conservation areas.

Figure 5: Two 3D Views of Stone Stile added to the planning application. Sourced: East Riding of Yorkshire Council (2020c).

Figure 6: View of the fence before the installation of the flood wall and gate. Sourced: East Riding of Yorkshire Council (2020a).

Assessment

The flood resilience strategy at Paper Mill House reflects a strong commitment to physical protection, particularly considering the property's location within Flood Zone 3 and its proximity to a watercourse with a history of overtopping (East Riding of Yorkshire Council, 2020a). In contrast to schemes and similar applications which have lessened their dependence on structural measures, this application proposes to incorporate a permanent flood wall and the installation of a gate designed to provide passive protection.

The installation of a 1.2 metre high flood wall and gate that can be operated manually indicates that all these design features are taking a proactive approach to achieving resilience in the long term. These features are designed to withstand a 1 in 100 year flood event plus climate change allowance, reducing reliance on temporary or procedural responses (East Riding of Yorkshire Council, 2020a). This is significant in rural locations, such as North Cave, where emergency response times may be slower and access to demountable defences more limited.

The strategy also incorporates internal resilience measures, including the raising of electrical sockets and services above predicted flood levels. While less visually prominent than the external defences, these adaptations are critical for minimising post-flood disruption and facilitating rapid recovery (East Riding of Yorkshire Council, 2020a; Hull City Council. 2016). The use of traditional materials ensures that these interventions are compatible with the conservation area, avoiding the visual intrusion often associated with modern flood defences.

In contrast to developments that prioritise procedural mitigation, such as FEPs, the Paper Mill House scheme demonstrates how physical PFR measures can be integrated into the fabric of a building without compromising its heritage value. This approach reflects best practice guidance, which advocates combining structural measures with planning and adaptive strategies to enhance long-term flood resilience (Rözer and Surminski, 2020).

In summary, the Paper Mill House case study provides an example of site-specific flood resilience that can be established through a permanent pre-flood resilience intervention. This example illustrates the potential returns of investing in passive protection, especially in high-risk rural contexts, where the consequences of flooding can be severe and response capacity limited.

Recommendations

To further enhance PFR at Paper Mill House, the following measures could be considered:

- Installing NRVs on all drainage outlets would prevent backflow of water and sewage into the property during flood events. This is particularly important given the site's proximity to a watercourse and the potential for surcharging of combined systems during heavy rainfall. Typically, planning permission is not required for this type of PFR measure and NRVs may already be in place.

- Flood-resistant landscaping and site grading can help direct surface water away from the building, reducing the risk of surface water pooling. This could include shallow swales, gravel strips, or subtle bunds that blend with the rural character of the site.

- Installing a water level sensor or smart flood alarm system would provide early warning of rising water levels near the property. This would allow residents to close the flood gate in time and take additional protective actions, especially in the absence of formal flood alert infrastructure in rural areas. As with NRVs, planning permission is not typically required for installing flood monitoring systems.

Summary

This report examines the extent to which Property Flood Resilience (PFR) measures are incorporated into planning applications in flood risk areas of Hull and the East Riding of Yorkshire. Through analysis of selected case studies consisting of industrial and residential properties, the study highlights a varied range of flood resilience approaches derived from geographical and policy contexts.

In Hull, planning frameworks such as the Strategic Flood Risk Assessment (SFRA) and the Living With Water Supplementary Planning Document (SPD) offer a robust policy basis to support the adoption of PFR into development proposals. Yet, as highlighted above, there was general inconsistency in the delivery of PFR. Some applications showed good dedication to physical resilience, using a range of measures including flood doors, raised thresholds, and sustainable drainage, while other applications had diminished PFR over time. St Mary's Care Home presents one example where important aspects of PFR, including demountable barriers and permeable paving, were removed from the completed development proposal, despite being positioned in Flood Zone 3a. This shift toward procedural mitigation, such as Flood Evacuation Plans (FEPs), raises issues about long-term protection, particularly in the case of vulnerable people.

In comparison, the East Riding of Yorkshire offers a more rural and heritage-sensitive context, in which flood risk is often managed by bespoke, site specific solutions. The example of Paper Mill House illustrates how permanent structural defences, such as a 1.2m high flood wall and steel flood gate, can be sympathetically integrated into the historic built environment. This was achieved, not as part of the original design, but through retrofitting existing structures to respond to site-specific flood risk. Further recommendations, including Non-Return Valves (NRVs), flood monitoring, and flood-aware landscaping, can further enhance resilience without compromising conservation values.

The difference between St Mary's Care Home and other commercial properties, for example, Smith and Nephew Healthcare Ltd. or Hull New Theatre, highlights a larger discrepancy in the flood risk management approaches throughout the city. JC Consulting (2022) justified the removal of physical PFR measures at St Mary's Care Home as a result of updated flood defence infrastructure, but the absence of hydraulic modelling at St Mary's Care Home limits the ability to quantify residual risk. Both Smith and Nephew Healthcare Ltd. and Hull New Theatre retained structural and procedural measures, emphasising how different interpretations of flood risk can result in different resilience outcomes.

Overall, the results show that while planning policy establishes a clear approach to flood risk management, the implementation of PFR measures is not always consistent. A more holistic and consistent approach, combining strong physical and robust procedural preparedness, is important in developing long-term resilience, especially with climate change increasing the frequency and intensity of flooding. Crucially, a robust system for evaluating the effectiveness of implemented PFR measures is needed to ensure that interventions deliver meaningful protection and inform future improvements. The analysis also distinguishes between original and retrofitted measures, highlighting opportunities for further site-specific enhancements, particularly where current strategies rely heavily on procedural rather than physical resilience.

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