SBRI End of Phase Report Form

This report is the company's opportunity to describe the work undertaken during the contract. Describe what work was completed during the project and why this was important. If the work was part of a two phased programme this report will form part of the assessment for Phase 2, it is therefore important that applicants complete the form as completely as possible.

This report must be submitted within 14 days of the completion, or termination, date. The successful contractor should be well motivated to complete this report as completion of this report forms part of the contract.

The report should be submitted to Defra's Climate Ready team at Nobel House, 17 Smith Square, Westminster, SW1P 3JR.

The objectives of reporting:

- to report on the work undertaken, its success in meeting the project's agreed objectives and to provide information on the work so that this can be used in the assessment of further applications (if required and appropriate);
- to explain and prove expenditure; and,
- also provides the company with a comprehensive report to share with stakeholders and those that may help further commercialisation.

The report should be completed by the lead contractor, with input from any sub-contractors or project partners as appropriate. Please answer, wherever possible, on behalf of the business units, divisions, or companies which were involved in the work. If this is not possible (as a result of merger or acquisition, for example), please specify the organisation to which your answers refer.

Please answer the questions in the spaces provided. Try to answer fully, but keep your answers succinct and no longer than necessary to clearly explain them. When describing technical solutions, please regard your audience as being someone familiar with the technology, but not an expert. The report may be done in narrative alone, however diagrams or pictures may be added where these aid clarity within the restriction on the page limit of a total of eight sides of A4.

Because the true impact of an R&D project often takes several years to emerge, Defra or the Technology Strategy Board may approach you for up to six years after project completion to follow up on the questions in this report. Your co-operation with any such follow up work is greatly valued.

1. Details

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Project Reference: SBRI CA0517_5 Building Research Establishment Limited (BRE) – The Flood Resilient (TFR) Project.

Report Type:	Final		
Total Contract Cost: (£s)	50,000		
Start Date:	01/01/14	End Date:	31/03/14

2. At the outset of this piece of work what were your aims and objectives?

The Flood Resilient Property (FRP) project represents a major step forward in the area of flood resilience in England. The project has developed a detailed climate resilient design for low-rise properties that is designed to cope with the type of flooding that accounts for over 95% of flood events in England.

The overall aim of the project was to produce a property design for the construction of low rise housing, commercial property and industrial units in flood risk areas. The design is intended to show through a demonstration building at the BRE Innovation Park, Watford, that new buildings can withstand the worst effects of flooding. The demonstration design will be open source, allowing designers, developers, contractors and clients to readily adopt flood resilience within their work in flood risk areas of England.

The project had the following objectives:

- To develop a fully costed (capital and whole life) FRP design.
- To create a full specification for the FRP.
- To produce a set of design drawings that will form a template for future development.
- To devise a forward plan for development of the FRP at the BRE Innovation Park at Watford.
- To undertake stakeholder engagement workshops to build a team for the phase 2 development.

The detailed (and costed) design will go forward to construction on the BRE Innovation Park (BRE IP) at Watford. The IP offers a route to market as it will demonstrate and showcase a cutting edge design formed from innovative technologies, including resistance and resilience measures. In line with the other properties on the IP, the FRP meets high sustainability standards.

The current rate of development in flood risk areas (outside of the highest risk areas) is around 10,000 properties per annum. The potential for the FRP is to create a market of 1,000 properties per annum within a period of 5 to 10 years. It is recognised that in an era of 'deregulation' that the market development will be based upon demand from clients, tenants and insurers as opposed to building regulation. Although, the FRP will allow a means for developers to comply with any planning conditions placed on a new development.

The resilience measures to be used will address the lower ground walls and the ground floor. It will also address fenstration and services. It will use leading edge technologies, materials and approaches to develop whole building resilience solutions.

3. Please provide a summary of the outputs of this project and relate these to the original objectives. How do the outputs address the requirements of this competition?

The requirements of the competition were to produce climate resilient designs for the built environment or infrastructure. Severe weather events are expected to increase due to climate change and the Climate Change Risk Assessment (Defra, 2012) stated that as a consequence of this, the risks of flooding are projected to increase significantly across the UK.

The key outputs of this project are described as follows:

- **Industry engagement –** Stakeholder engagement workshops to build a team for the phase 2 development. The workshops also led to amendments being made to the draft design and specification to ensure that they were in-line with industry recommendations whilst still offering an innovative solution to flood and climate resilience. The engagement process raised awareness of the project and the innovation in design.
- **Specification development –**This project has produced a fully specified design for the FRP, which also aims to meet considerations in the Code for Sustainable Homes, thus improving the environmental performance, reducing and mitigating the effects of climate change.
- **Design drawings –** A set of design drawings has been prepared that will form a template for future development has been produced. The design drawings contain the key features for the resistance and resilience requirements
- **Costing –** A costing for the FRP specification and design. The costing exercise indicated the difference between a standard construction and one built to flood resilience standard with high sustainability levels. It should be noted that the cost plan developed refers mainly to the ground floor of the property. Further cost planning would be required in order to address the differences between the whole house design and construction.
- **Build Plan (Phase 2) –** A forward plan for development of the FRP at the BRE Innovation Park at Watford. The addition of a build plan, stakeholder engagement and consideration of potential funding streams means that progress can be made towards the development of the demonstration FRP at the BRE Innovation Park at Watford.

4. Describe any changes to the original project. What was the reason for these changes? Please include any circumstances that aided or impeded the progress of the project and the actions taken to overcome them.

The FRP project has coincided with a series of severe flooding events across the UK, particularly in the south of England. These events resulted in substantial press interest in flood prevention, including a focus on flood resilient housing and businesses. It has been said that avoidance is the best way to prevent homes flooding, or else many have looked to the Netherlands and their floating and amphibious properties.

For severe flood risk (greater than 1 in 75), the floating or amphibious approach, or adopting avoidance measures (e.g. through raising the building above the expected flood level) could be considered. However, for the majority of homes at flood risk, those which are at flood risk of less than 1 in 75, but greater than 1 in 1000, resilience is the best solution, and as such it is this approach that the project team have chosen to remain with for the FRP design.

The FRP design was achieved with the full set of A3 design drawings being completed. The full specification was also completed. The costing exercise was not as extensive as originally intended. The cost plan has addressed the difference between a standard ground floor and the FRP. As such there is an understanding of the costs involved in providing flood resilience, which is focussed upon this level of the building. Further costing will be required in order to take the project forward.

The design of the FRP aimed to achieve the Code for Sustainable Homes Level 6. However, although many of the requirements have been addressed a Code Level 4 for the current design is more realistic. It is the aim of the project to design a FRP that could be widely adopted, and as

such it must be cost effective to build, with level 4 being more appropriate at present.

Overall the project has gone to plan with all tasks being completed as per the original plan.

5. Please provide a short factual summary of the most significant outcomes of your work.

The outcomes of the work are described below under the headings of the five work packages of the project. The original concept was to produce a flood resilient property design, which is based upon a three bed detached or semi-detached house to be built at the BRE IP. The design can be used for any low rise property in a flood risk area. The principles of resistance and resilience developed can also be used and adapted for other forms of construction.

Stakeholder Engagement (WP1)

An initial stakeholder workshop was held on the 29th January 2014 at BRE Watford. Stakeholders in attendance included innovative product manufacturers and suppliers, Government officials (Environment Agency and Defra), environmental and engineering consultants and insurers. The workshop was successful in focusing the specification of the FRP. The key themes that arose in the first FRP workshop were:

- Ensuring that message of resilience is appropriately disseminated, including to the public, to encourage personal responsibility on risk management.
- Early engagement with planning and building control departments would be important for the demonstration build, and for future FRP developments.
- The idea of 'levels of resilience', or a star rating scale. These could be based on cost or time of recovery.
- BREEAM or Code for Sustainable Homes credits could be awarded depending on the level of resilience adopted.

The second stakeholder workshop was held on the 21st March 2014, again at BRE Watford. Many of the delegates from the first workshop attended, plus a number of other product suppliers and construction and waterproofing specialists. Delegates at the second workshop were presented with a draft specification and design and asked to offer their professional opinions, including on the 'buildability' of the FRP. As such, some of the detailing for the FRP was subsequently altered to incorporate the views of the industry. Two short workshop reports were written and are included as appendices to this report.

Specification Development and Design (WP2 and WP3)

The project team together developed a specification for the FRP focusing on the ground floor and wall construction. The specification was narrowed from a wide range of possible compositions and material choices. For each option, the benefits and potential issues were highlighted to help in decision making. The elements which have been specified are: ground floor construction and fabric, windows, doors (external and internal), services (electricity, mains water, sewerage, gas supply, heating provision), internal fit out (furnishing, finishes, kitchens, bathrooms and staircases), flood warning systems and emergency provisions. Water reduction and wider sustainability issues (e.g. green infrastructure) have also been identified.

Following from the first workshop discussions, different scales of resilience (e.g. avoidance, impervious, non-perishable, and sacrificial; or resistance, resilience) were considered. It was agreed that the buildings structure should be resistant, and, following guidance in the CLG 2007 document: 'Improving the flood resilience of new construction', it was decided that the FRP would be specified such that it would be resistant to flooding to a depth of 600mm, with additional resilience measures incorporated, should the flood depth be greater. Adopting a resilience approach internally will allow for more rapid recovery times, and will also allow for safe evacuation if required.

The specification and design were analysed by delegates at the second workshop. Overall, delegates were positive about the design, but suggested alterations to some of the detailing, particularly around the wall/floor junction. This was considered by the project team and the specification and design was amended accordingly. For the floor and wall constructions, there were two final options detailed, classified Type A and Type B.

The final specification is attached as an Appendix to this report. A full set of A3 design drawings have also been completed and are appended to this final report.

Costing (WP4)

The cost analyses have been conducted, using Spon's Price Books and additional online resources. The costing is related to the ground floor of the building in the main, and to the additional flood resilience and sustainability measures, as follows:

- Cost schedule of FRP for ground floor construction and additional flood resilient measures adopted;
- Cost schedule of standard construction for the ground floor construction of a property of the same size/shape as the FRP;
- Life cycle estimates for the FRP designs.

The full cost schedule is appended to this report and the total costs determined were as follows:

- Standard Construction: £25,684.26
- FRP Type A: £77,904.89 (3 x standard)
- FRP Type B: £89,984.56 (3.5 x standard)

The cost of the inclusion of flood resilience and sustainability measures was approximately three times the standard construction for Type A, and three and a half times for Type B. Type B is more expensive than Type A due to the use of waterproof concrete for the internal leaf of the wall construction, rather than concrete blocks and waterproof membrane.

Maintenance and life cycle costing produced the following results:

- Annual Maintenance: £1,229.20
- Life Cycle Replacements: £65,282.63 (over 30 years)
- Total Annual Cost: £2,176.09

Build Plan (WP5)

The build plan has been developed using RIBA's Plan of Work 2013. Tasks have been assigned to each stage to ensure the build plan results in the construction of a demonstration FRP on the BRE Innovation Park, Watford.

- Stage 0 (Strategic Definition) – concept submitted to Defra for funding of the design stage
- Stage 1 (Preparation & Brief) – initial cost estimates, design principles outlined
- Stage 2 (Concept Design) – planning pre-application, design discussions and decision making.
- Stage 3 (Developed Design) – site investigations, updated cost plan, appointment of contractors/consultants, planning consent, CfSH preliminary assessment.
- Stage 4 (Technical Design) – building warrant application, CfSH design stage assessment, CDM risk assessment, tender to contractors.
- Stage 5 (Construction) – certification at required stages, CDM (Health and Safety)
- Stage 6 (Handover & Close Out) – Building Warrant approval, practical completion.

A range of milestones (both achieved and future) are outlined in the full build plan which is appended to this report.

Summary

The most significant outcomes of the work are as follows:

- Full FRP design and specification
- Full A3 design drawing set
- RIBA Plan of work build plan and exploration into potential funding mechanisms
- Stakeholder engagement (including noted enthusiasm for the project and FRP demonstration build amongst key stakeholders)

6. Describe the innovative aspects of the work including any new findings or techniques.

The design approach used in the FRP design is innovative. It uses the principles of resistance and resilience of the property, but it sets out how to deliver such an approach to the mass market house building sector and the low rise non-domestic market. The FRP is directed towards the use of innovative technologies and designs.

As the flood depth increases above 600mm, water is allowed to enter the property at a designed safe flow rate through windows and doors. For the windows sensors will be linked to automatic opening devices that will open when the flood depth reaches 600 mm. The flood doors will have built in devices related to the inundation depth. The controlled inundation of the property avoids the risk of structural collapse through pressure being applied on the walls.

The controlled inundation is linked to a resilient indoor design and construction. Internally, material choices and design decisions mean that little or no damage will be done to fittings, furniture, services and appliances. Post-flood, once the water has receded, the recovery period will be brief, simply requiring the internal finishings to be quickly dried, cleaned and sanitised. No 'stripping out' of materials will be required, and full habitation can be achieved much more quickly as services can be simply switched back on.

New innovative materials and products, or existing products used in a new way, are incorporated into the design to ensure this occurs, such as closed-cell cavity wall insulation and automatic shut off valves on water and electric services, linked to flood alarm systems. In addition, measures will be provided so that a family living in a FRP have all emergency provisions at hand, including dedicated storage space for a flood kit and ground floor escape windows for safe evacuation.

The innovative FRP design has the potential to address the insurability of buildings. The target area of risk does not concern the highest level (i.e. greater than 1 in 75), but does address less than 1 in 75 to 1 in 1000, where a substantial number of properties are being built. As the insurance market adapts to Flood Re from 2015, the FRP approach will be important to address new development, especially in the absence of any meaningful standards or regulations in this area.

7. Please give a description of how funds were spent with reference to the original budget and explain any significant variations.

The project funds have been spent in accordance with the original project plan. The overall budget was £50,000 (ex VAT), which was split amongst the partners as: BRE (£25K), Baca Architects (£15K) and Aquobex (£10K). The majority of the funding was allocated to staff costs (including overheads), with lesser amounts for travel and consumables. For BRE (the lead partner) £24K was allocated to staff costs and £1K to other costs.

The actual spend was in line with expectation. The split between work packages was much as planned. Overall the resources allocated to the project were expended on the research.

8. Describe any potential long-term collaborations/partnerships entered into. Please list the company and the role they played in the project.

A number of collaborations have taken place during the project, particularly as part of WP1, stakeholder engagement. Potentially long-term collaborations include:

- The project team: BRE, Baca Architects and Aquobex intend to work together following the completion of this project, to take forward the design and specification towards the construction of a demonstration FRP at the BRE Innovation Park, Watford.
- Stakeholders present at the two project workshops (delegate lists attached) offered a range of assistance including:
    - Critique of draft design and specification,
    - Potential product suppliers for the demonstration FRP,
    - Potential funding partners for the demonstration FRP.
- Those workshop delegates who offered further assistance out-with the workshops (e.g. by forwarding product details or specifications) include Roger Bullivant, NHBC and Newton Waterproofing Systems Ltd. The Brick Development Association held their AGM at BRE Watford and when taking a tour of the Innovation Park, expressed to a BRE colleague that they were very interested in being involved in the demonstration FRP.
- Delegates who attended the 'Britain Under Water' Conference which was held at BRE on 20th March were invited to 'express interest' in the FRP project and demonstration build.

9. Please describe how your company has gained from this project. What new business opportunities have been created? Do you expect your company to grow as a result of this project?

BRE and partners (Baca and Aquobex) have the opportunity to gain from the project. The partners have agreed to a share of the Intellectual Property through the project. The partners will look at the commercial exploitation of the design through licensing agreements with house builders and other developers. The commercial exploitation will depend upon further research through the construction of the demonstration building on the IP. The demonstration building will be constructed in such a way that testing of the resistance and resilience measures will be possible.

BRE has the opportunity to host the demonstration FRP on the IP Watford; this should encourage increased visitor numbers to the site, especially in light of the recent flooding events which have raised public awareness of flood risk and the mitigation measures that may be available.

In addition, BRE and partners have experienced additional publicity related to the FRP project, in part due to the increased press interest around flooding in general. Members of the project team have been interview for BBC and ITN news programmes.

The project team also have the opportunity for commercial exploitation. Also, BRE have the opportunity to offer consultancy expertise, or testing of flood resilient technologies and materials. Aquobex are likely to see a rise in sales of technologies which will be demonstrated in the FRP. Baca Architects are already internationally recognised for their work in flood resilient design, but their involvement in this project can only increase that reputation.

10. Describe the potential for exploiting the work. Please identify any new IP which has been filed or for which filing is anticipated.

The work undertaken as part of this project will be exploited by the construction of the demonstration FRP at the BRE Innovation Park, Watford. The demonstration FRP will allow the design and specification to be disseminated to a wide range of parties including the construction industry, insurers, product manufacturers and suppliers.

The intention of the design of the FRP is that it should be an open source design. In this respect BRE and partners will not be seeking to patent the design or otherwise to develop an exclusive design. The intention is that the project team can work collectively or individually with developers to seek solutions for specific projects. The exploitation will therefore be completed by providing design, construction and consultancy services to developers, as well as supplying flood resilience products. BRE and partners will gain directly through consultancy services, but will also attract a fee for each housing unit or commercial building constructed that meets the requirements of the planning conditions for a site.

In turn developers using the FRP approach will have the potential to satisfy planning requirements for flood risk sites. Where the design changes or new technologies are introduced then the IP demonstration building can be used as a test bed for such innovation.

The FRP design will be exploited through a variety of dissemination channels, including the 'FRP brochure' a draft of which is appended to this report. The brochure will be circulated in electronic format to a range of developers, insurers, local authorities, housing providers and government departments.

BRE will also develop a web page to promote the FRP approach. The web page will give the design concept, construction details and the downloadable brochure. The web page will also link to other innovative initiatives in the area of flood resilience.

11. Please insert additional information that may be pertinent. This may be in the form of text, pictures, diagrams, data, graphs that support the work.

In addition to this report, the FRP design has been elaborated through a number of formats. The following items are appended to this report:

- Set of A3 design drawings: these include the site layout, building layout, elevations, ground floor details, wall details, flood resilience details and drainage. The design drawings effectively form the design, in association with the specification.
- Full specification: the specification addresses the whole of the building, including foundations, floors, walls, roofs, fenestration and flood resilience aspects. The materials and building elements have been fully specified for resistance and resilience measures.
- Outlined build plan: the plan invokes the RIBA stages of design and development. The plan also covers funding of the demonstration FRP at the BRE IP.
- A brochure for the FRP: the brochure is a colour illustrated document, including descriptive text. The brochure contains extracts from the design drawing and the specification.
- Cost schedule and supporting methodology: a spreadsheet has been used to develop the costings of the FRP. The supporting methodology explains how the costs were built up and summarises the findings.
- Reports on two stakeholder engagement workshops (including delegate lists).