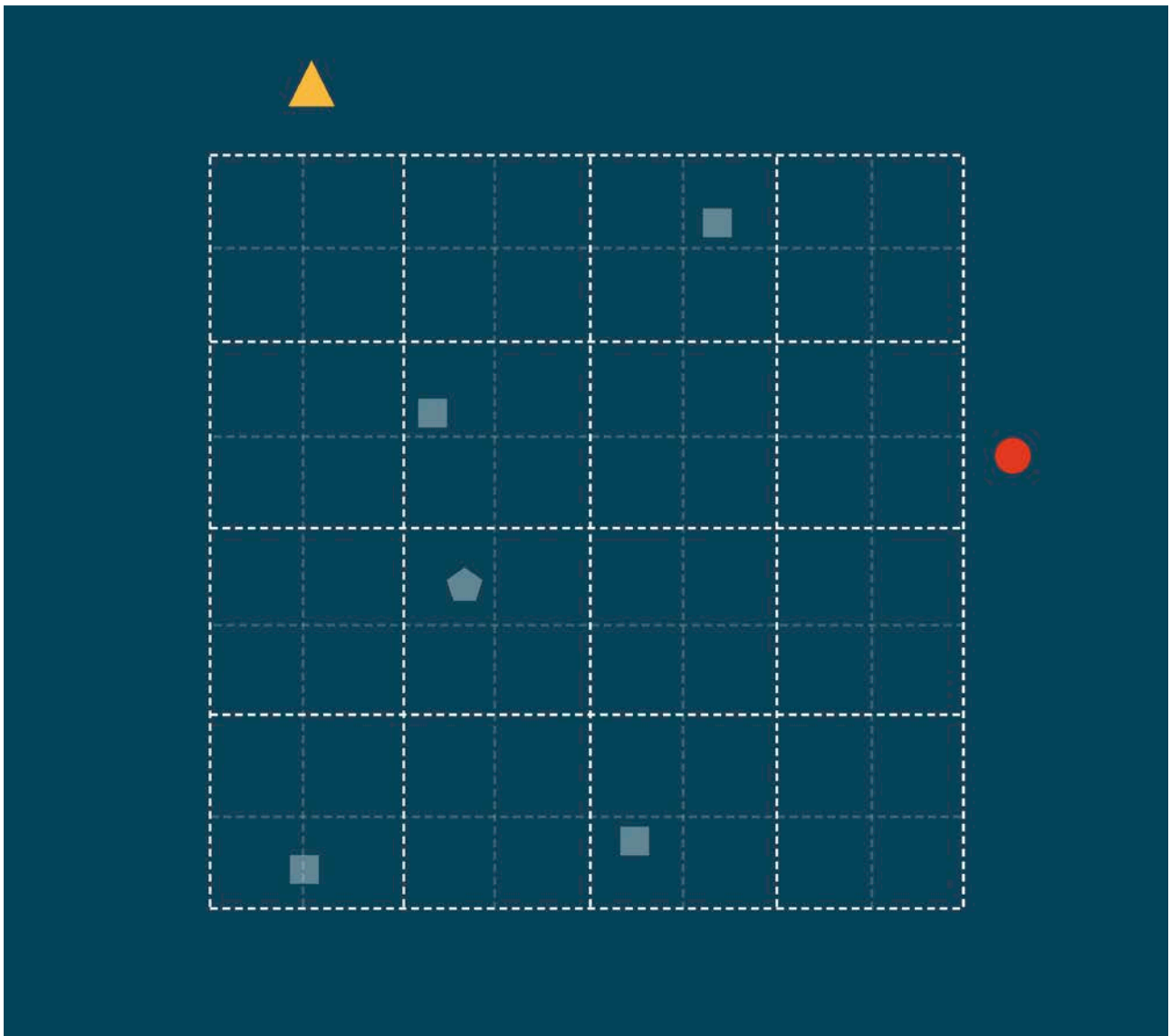


Property Flood Resilience

Outliers study: a historic building

Dr Edward Barsley, Joanne Williams



Property Flood Resilience

Outliers study: a historic building

Dr Edward Barsley, Joanne Williams
2025

The Environmental Design Studio
International House,
64 Nile Street,
London,
N1 7SR

Print: ISSN 2398-3841
Online: ISSN 2059-4453

The Research Report Series incorporates reports by Historic England's expert teams, their predecessors and other researchers. Many Research Reports are interim, to make available the results of specialist investigations in advance of full publication. Although subject to internal quality assurance they are not usually refereed externally and their conclusions may sometimes have to be modified in the light of information not available at the time of the investigation. Where no final project report is available, readers should consult the author before citing these reports.

For more information email Res.reports@HistoricEngland.org.uk or write to:

Historic England, Fort Cumberland, Fort Cumberland Road, Eastney,
Portsmouth PO4 9LD

Opinions expressed in Research Reports are those of the author(s) and are not necessarily those of Historic England.

Summary

With 1 in 4 buildings in the UK being at risk of flooding, it is important that solutions are found to prevent heritage buildings from falling into disrepair and out of use.

Historic England's guidance plays a crucial role in providing advice as to how our historic buildings can be successfully managed and adapted without harming their heritage values and significance. Ensuring they continue to play a part in England's future. More broadly the research undertaken is relevant to all buildings of traditional construction, which equates to roughly 30-40% of England's buildings.

A review of a previously funded government Property Flood Resilience (PFR) scheme in the village of Yalding in Kent (UK) had identified that listed buildings and buildings of timber framed construction had been overlooked and deemed inappropriate 'outliers' when it came to the retrofitting of property flood resilience measures. To understand why this was the case, The Environmental Design Studio (TEDS) were appointed to undertake this study and identify what prevented heritage assets from being eligible for funding. What PFR measures were appropriate, or alternatively what adaptation works could be undertaken to ensure the building continued to be used in the flood whilst being made more flood resilient.

Acknowledgements

The authors would like to thank the Environment Agency, Landmark Information Group and the owners of Lees Cottage.

Front cover image: Graphic interpretation of an outlier. © The Environmental Design Studio

Date of research;

Research was carried out between March 2022 and March 2024.

The report was written in March 2024.

Contact details;

Historic England, The Engine House, Fire Fly Avenue, Swindon SN2 2EH

Conservation@HistoricEngland.org.uk

Contents

Introduction	1
Methodology	6
Stage 1: Hazard assessment	9
Stage 2: Property Survey	17
Stage 3: Options Development and Design	26
MCDA Workshop	31
The Results.....	75
Key Findings	79
Conclusions	82

Introduction

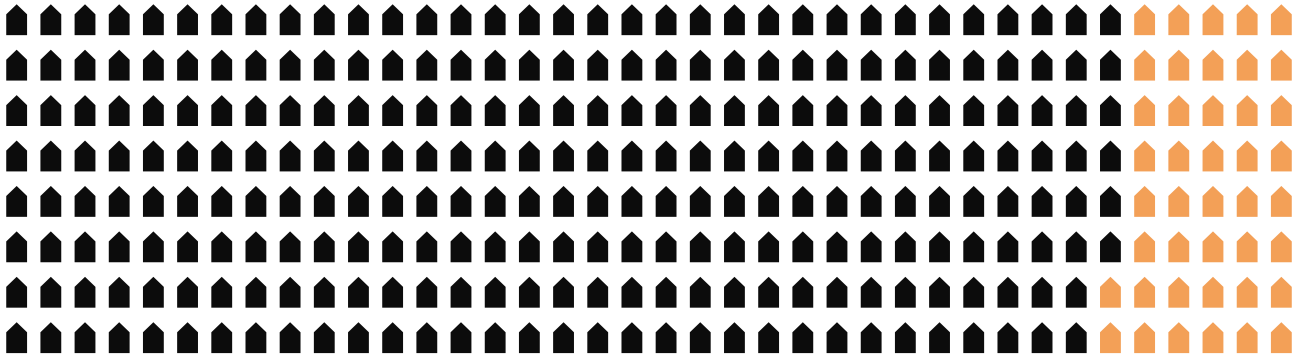


Figure 1: Graphic interpretation of percentage of historic buildings in the Middle Medway Flood Resilience Scheme. © The Environmental Design Studio

This study explores the impacts of flooding on a Grade II listed residential building within the village of Yalding, Kent. During the 'Middle Medway Flood Resilience Scheme', 304 homes in the parish were identified as needing to be made more 'flood resilient'. 46 of these homes were deemed to have no suitable 'standard' measures for Property Flood Resilience (PFR). This was due to the building's construction and materials, or because of its listing status.

This study explores the barriers to change for Lees Cottage, as well as a wider range of spatial strategies that could be considered for the adaptation and conservation of this 'outlier' property. This study has adopted a multi criteria decision analysis (MCDA) to review different design options for adaptation, whilst assessing considering their impact against the building's historic significance.

This study investigated the following key themes:

- What made a property a PFR outlier?
- What were the barriers to adaptation for these outliers
- How could outliers be adapted to make them more flood resilient?
- Did MCDA support in exploring, evaluating, and communication suitable adaptation strategies to reduce flood risk.

Outlier (noun)

'a fact, figure, piece of data, etc. that is very different from all the others in a set and does not seem to fit the same pattern. (Cambridge Dictionary, 2024)



Figure 2: Yalding 2013/14 flood. © The Environmental Design Studio

Outliers are important to consider for several reasons. In Yalding, it was deemed that 15% of the 'at risk' homes could not be made flood resilient using 'standard' resistance-based approaches under PFR.

Throughout the UK, roughly 30-40% of buildings are of traditional construction with owners in a similar situation. This study seeks to contribute to a crucial dialogue of research that considers how historic places and spaces can be made more resilient to the impacts of climate change. If outliers over time are not adapted, it is likely they would:

- become more exposed and inundated by flooding.
- be severely damaged and likely fall into disrepair.
- their owners may find they are unable to get insurance. Which could limit the quality or speed of repair/reinstatement.
- moisture issues are likely to escalate and cause further damage to the building and the occupants health.
- the price of the building will be affected.
- likelihood of obtaining a mortgage will be limited.

There are many ways to adapt an outlier and make it more flood resilient. This requires those involved to consider options beyond typical resistance measures such as barriers to make the building more resilient.

Recoverable and avoidance-based approaches to PFR are important to consider yet often overlooked. This study sought to identify a range of options for adaptation, specifically for Lees Cottage, that could offer alternative approaches for outliers. By adopting MCDA, we were able to cross-reference and consider different benefits and constraints for each option.

Real world build and proven precedents exist for each approach to PFR that is considered within this study. This is not to say that any given measure will be suitable in this specific context, but more substantial or seemingly unusual approaches to PFR should not be discounted because they appear different and aren't (yet) the usual tactics for adaptation in the PFR toolbox.



Figure 3: Yalding High Street ©The Environmental Design Studio

Why Yalding?

During the 2013/2014 floods, Yalding became one of the UK's most high profile 'at risk' communities, receiving visits from both David Cameron (Prime Minister at the time) and King Charles (Prince Charles at the time). These trips were features in national press and have since led to the management of flood risk in the village becoming a politicised and fiercely debated topic.

The pertinence and necessity for adaptation to flood risk in the village is however just one reason why Yalding has proved an ideal pilot study area. Its diverse range of house types, construction and materials also makes it relevant as a precedent to other 'at risk' communities throughout the UK and worldwide.

Yalding's mid catchment position also influenced its selection as the study area. At this point in the catchment, with large-scale mitigation strategies deemed unviable both technically and economically to protect the village. Residents of Yalding are having to explore how they can adapt the built environment to safely accommodate flooding throughout the village. A growing number of communities throughout the UK and worldwide are in a similar position in which large-scale flood protection or alleviation schemes are reaching capacity and adaptation through property level resilience is increasing necessary. Yalding has therefore made an ideal case study and precedent to consider spatial adaptation options for such a context.

Crucially the 'Middle Medway Flood Resilience scheme' has taken place in the parish of Yalding and 'Outliers' identified that were passed by and overlooked when it came to property flood resilience.

Lee's cottage is one of these 'Outliers' and was chosen to study in closer detail.

The Outlier – Lees Cottage

Lees Cottage was selected for the following reasons:

- It is a Grade II listed timber framed building.
- It is situated within Yalding's Conservation Areas.
- Home of the head of the parish council, who is proactive in helping make the village more flood resilient.
- It has been flooded on multiple occasions.
- It was excluded from the Middle Medway Flood Resilience Scheme (MMFR).



Figure 4: Lees Cottage, view from the street © The Environmental Design Studio

The building was excluded from the Middle Medway Flood Resilience (MMFR) scheme as it did not align with Environment Agency's (EA) PFR supplier standard questionnaire.

The MMFR scheme had a primary emphasis on 'resistance' measures for PFR which were not deemed as being suitable for use at Lees Cottage.

Perimeter protection was briefly considered but discounted due to cost. Its listed status was also noted as a limiting factor. Although other listed buildings in Yalding were adapted, this was because they were of brick construction and did not include any timber framed sections. Recoverability measures under PFR, were not considered within the MMFR scheme.

Methodology

People and Process

The primary research leads were TEDS and Historic England's Technical Conservation Team. A Design Research Methodology was adopted to inform the study. This included undertaking semi-structured interviews, a survey of Lees Cottage, iterative design process and undertaking a multi-criteria design analysis (MCDA).

The study began with a series of semi-structured interviews which provided insight as to the impacts of flooding on the property and work undertaken in the Middle Medway Flood Resilience scheme from the perspective of the project manager, contractor and the homeowner.

These included interviews with:

- Peter Waring, Environment Agency. Ran the MMFR scheme.
- Geraldine Brown, homeowner of Lees Cottage and Head of the Yalding Parish Council.
- David Christie, Watertight International. The contracting firm who undertook the works in Yalding.

The research then followed the first three stages of the Code of Practice for Property Flood Resilience (CIRIA, 2019):

Stage 1: Hazard Assessment

The property's flood risk was provided by Landmark Information Group.

Stage 2: Property Survey

In August 2022, representatives from TEDS and Historic England undertook a site visit and property survey of Lees Cottage.

During this time there was a photographic survey and 3D Matterport scan of the building.

Stage 3: Options Development and Design

After the site visit, a framework and process for evaluating the PFR adaptation options was developed. Design workshops were run online and throughout the study and there were two in-person workshops run between TEDS and Historic England. The first workshop was used to identify the strategies for consideration.

Stage 4: MCDA

MCDA is not part of the existing Code of Practise but it was decided to adopt this method as a way to assess and score each adaptation option.

What is Multi Criteria Design Analysis?

To evaluate these wide ranging and disparate adaptation options for Lees Cottage it was decided to adopt MCDA which is already a well established and recognised evaluation tool in government.

'MCDA is an analytic method used to select from or rank a set of choices where these can be assessed against delivery on a range of criteria or performance objectives – such as those to be found during the policy appraisal process. MCDA provides a clear rational structure for these decisions to be taken - most importantly it allows for detailed sensitivity analysis of how option preferences can be affected, not just by changes in the relative importance of one criterion over another but also by how significant the difference is between the best and worst performing choices in each criterion. This process is referred to as 'swing weighting'. It is the critical element that allows trade[1] off in performance between options to be fully explored with a group of subject matter experts and decision makers, illustrating how robust the final selection would be under different scenarios.' (DESNZ, 2024).'

MCDA's are used to turn qualitative information into quantitative. Put simply the process is as follows:

1. An expert panel is selected
2. Categories and criteria for analysis are identified
3. Weightings are given by expert panel
4. Scoring is undertaken.

The outputs are typically shown in what is known as a 'performance matrix' or 'consequence table'. In which each row describes an option and each column describes the performance of the options against each criterion.

Table 1: MCDA Process

1 Select expert panel	2 Category / criteria	3 Weighting	4 Score	Result
Heading	%	/10	X	
E.G. Accessibility	50%	4/10		2
E.G. Durability	25%	5/10		2.5
				<hr style="width: 50%; margin: 0 auto;"/> MCA Score

DCLG (2009) also highlight several advantages of using multi criteria analysis. This includes:

- It is open and explicit.
- The choice of objectives and criteria that any decision-making group may make, are open to analysis and to change if they are felt to be inappropriate.
- Scores and weights, when used, are also explicit and are developed according to established techniques. They can also be cross-referenced to other sources of information on relative values and amended if necessary.
- Performance measurement can be sub-contracted to experts, so need not necessarily be left in the hands of the decision-making body itself.
- It can provide an importance means of communication, within the decision-making body and sometimes later, between the body and the wider community.
- Scores and weight are used to provide an audit trail.

Stage 1: Hazard assessment



Figure 5: Map of rivers © Google Maps

Flood hazard

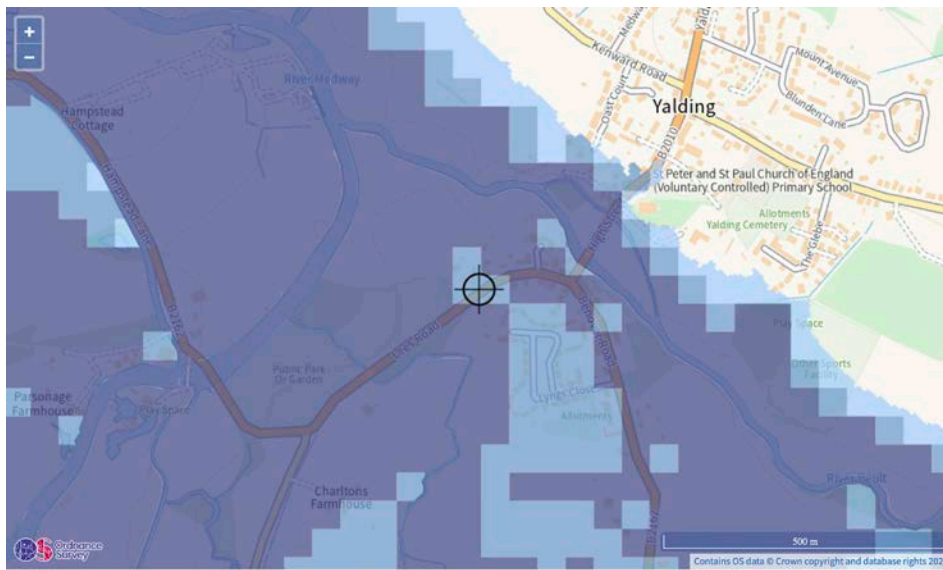
Yalding is a small village and civil parish in the Borough of Maidstone in Kent, England. The village is situated in the Medway Valley at the confluence of three rivers, the Teise, Beult and Medway. Each of the three rivers can flood the village and it is an area that is also exposed to flooding from reservoirs. The Environment Agency is tasked with the responsibility of managing flood risk in the Medway catchment. After the 2013/14 floods, there were calls at the local and national level for a review of the catchment flood management strategy in the Medway Valley.

Alongside the Beult scheme there are flood risk management strategies being explored to upgrade the level of protection of the Leigh Barrier. These strategies are aimed at ‘managing’ flood risk in the catchment. The Environment Agency have been working on the feasibility and flood risk reduction of different options, but detailed flood modelling revealed large scale mitigation measures (such as flood alleviation) will have minimal reduction in flood risk for the village. Flooding in Yalding is not a new phenomenon. Records show the village has flooded for centuries and at one point even had a harbour. Data collated from historic flood outline data (Open access information via the Environment Agency) shows that with the past century there has been a significant

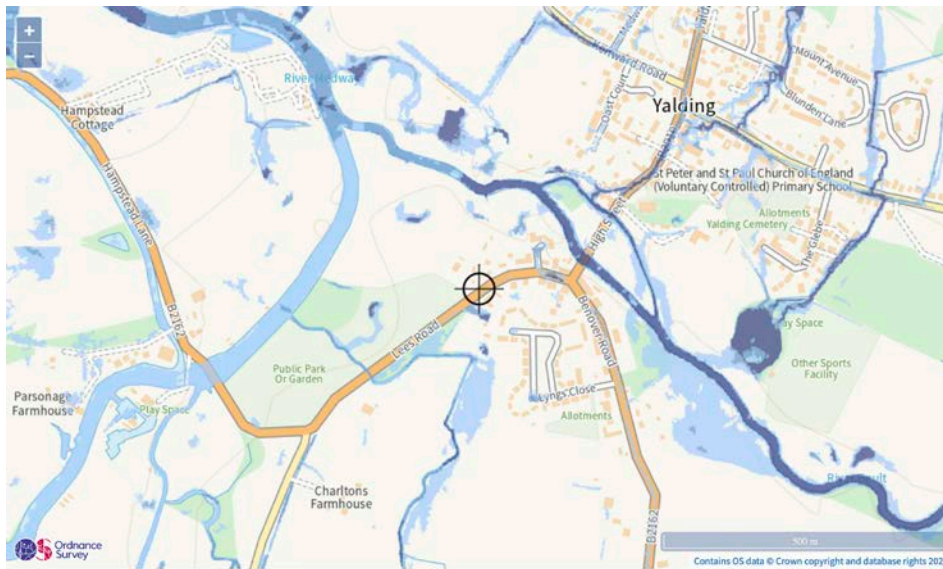
increase in the frequency of flood events as have their extents and depths. Local experiences align with these findings, with residents citing the 2013/14 floods as ‘the worst in living memory’ (Barsley, 2017).

With regards to the future flood risk in the village, the latest data from the EA reveals flood risk is expected to significantly increase. After a major flood event such as that experienced in the winter of 2013/14, the EA is obliged to conduct a detailed end-to-end assessment of the river. For Yalding, this included an upgrade from a 1D to 2D flow model, which has enabled a more accurate understanding of the hydrology of the Beult and Teise rivers (Barsley, 2017). Using this model, revised flood maps have been created and flood alleviation strategies tested. However, this increased understanding and resolution of data has revealed that flood risk in the village is worse than had previously been predicted.

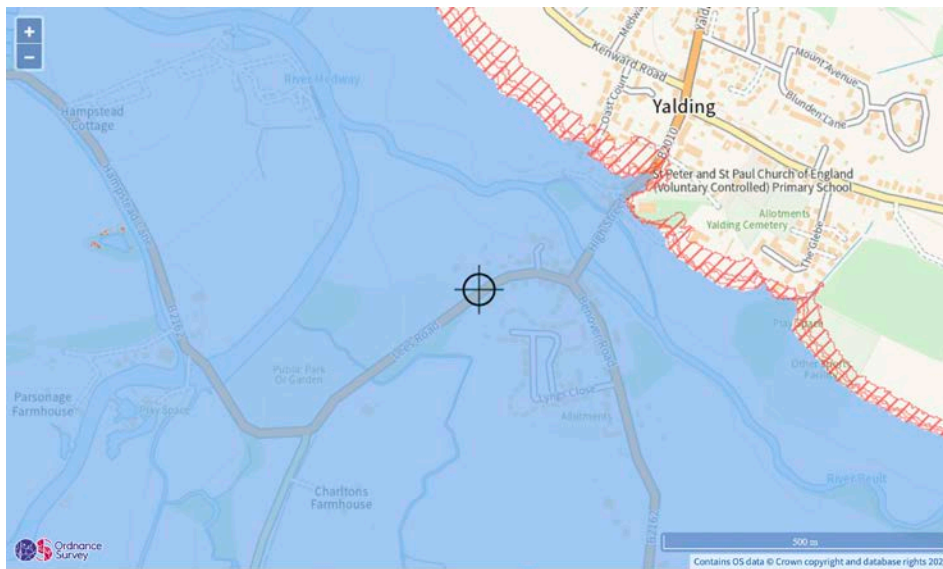
Figure 6 shows the EA flood maps for flood risk from rivers and the sea, surface water and reservoir flooding. Lees cottage is at risk of each of these but to varying degrees and shown in figure 7 and 8.



Extent of flooding from rivers or the sea ● High ● Medium ● Low ● Very low ⊕ Location you selected



Extent of flooding from surface water ● High ● Medium ● Low ● Very low ⊕ Location you selected



Maximum extent of flooding from reservoirs: ● when river levels are normal ● when there is also flooding from rivers ⊕ Location you selected

Figure 6:
EA Flood Maps
© Environment Agency



Overall Flood Risk



FURTHER ACTION
CLICK TO VIEW ONLINE VIEWER

The property is at a significant risk of River and Other flooding. Further assessment is recommended to understand the likely depth of flood waters. Please refer to the Professional Opinion and Recommendations section on page 1 of this report. To explore the risk further, please visit the online viewer.



Insurability

Despite the risk identified, flood insurance for most residential properties will remain available and affordable providing they are eligible for the Flood Re scheme. Please see details of eligibility at <http://www.floodre.co.uk/homeowner/eligibility/>. We recommend you obtain buildings and contents insurance terms before exchange of contracts.



Flood Defences

Are there existing river/coastal flood defences that have been identified and taken into account in our overall risk assessment?	Yes
--	------------



Individual Flood Risks

The gauges below detail the level and type of individual flood risks at the property. If flood defences are present, the gauges presume these are operational.

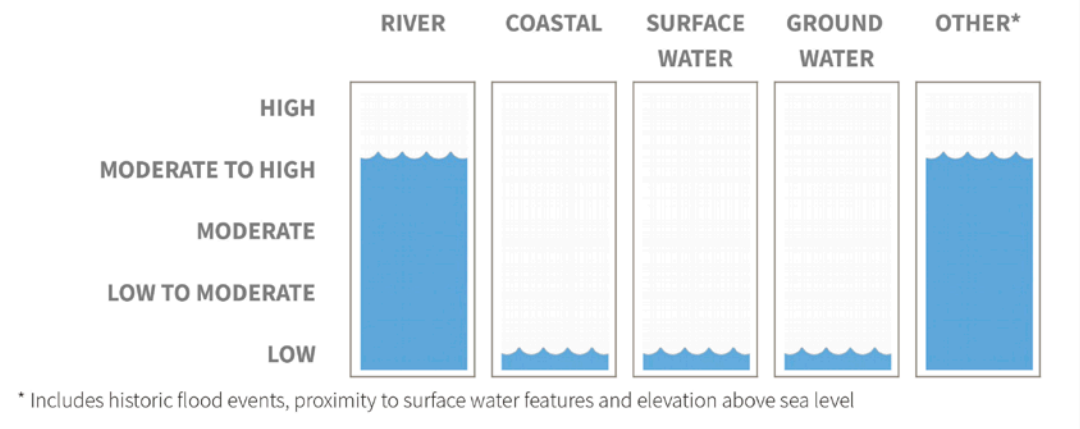


Figure 7: Flood Risk Assessment © Landmark Information

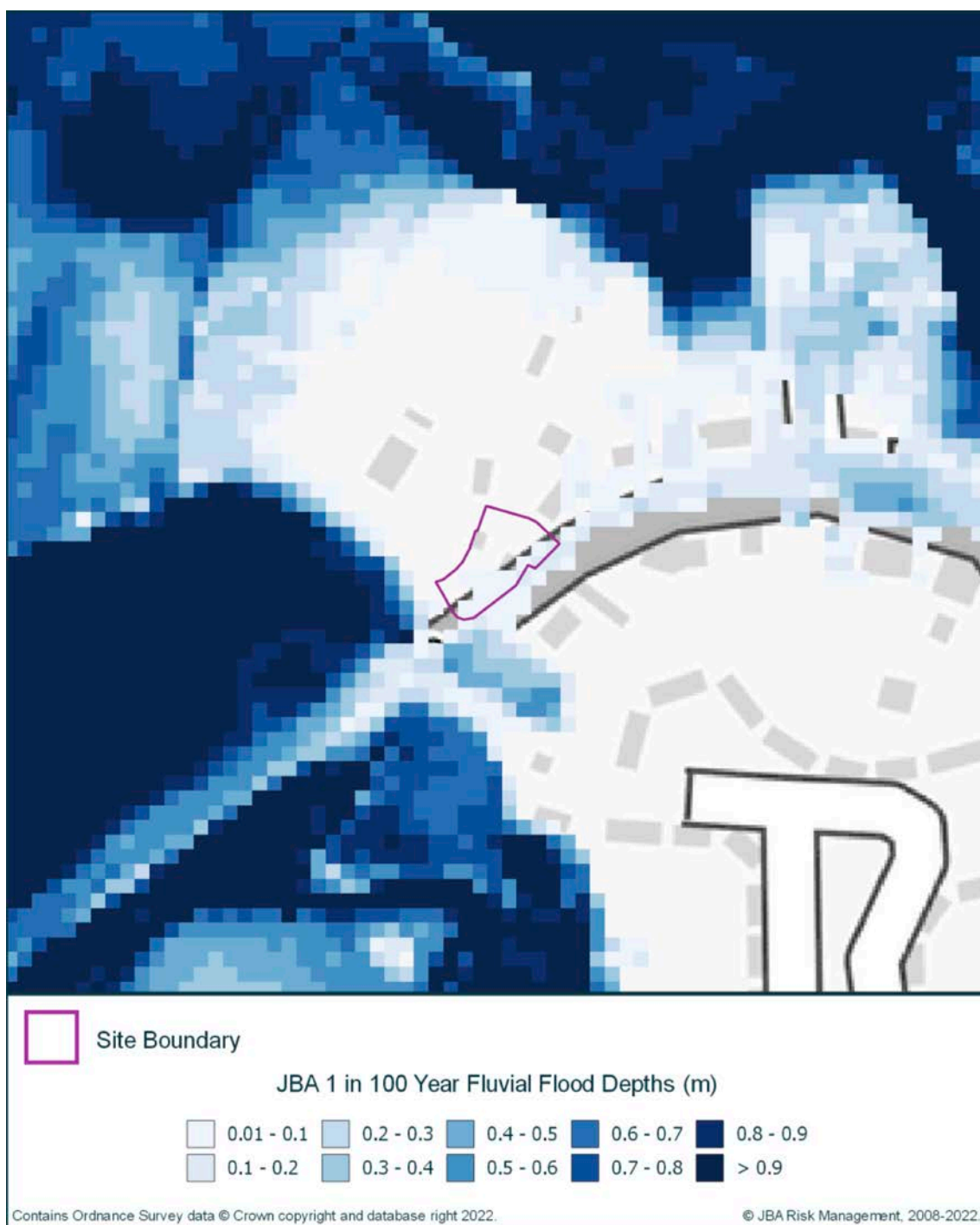


Figure 8: JBA Flood Risk Map © Landmark Information & JBA



Figure 9: Yalding Floodplain Meadows © The Environmental Design Studio

Lees cottage sits alongside a floodplain meadow. Desktop research by Landmark Information revealed the site has flooded four times in the past. These events have extended across the entire site. They were all fluvial events and occurred in:

- November 1960 – Heavy rainfall caused all four rivers to overtop their banks resulting in a catchment-wide flood throughout the borough.
- September 1968 – between the 14/15th September 150-200mm of rainfall was recorded across Kent and caused the River Medway to exceed its channel capacity. Causing inundation along the River Medway through Maidstone and upstream of Teston.
- October 2000 – Autumn was the wettest on record since records began in 1766. It caused the largest floods in recent history as many river catchments were subjected to multiple flood events
- December 2013 – a series of Atlantic depressions brought heavy rainfall and stormy conditions to England and Wales. Flows in the River Medway were the highest ever recorded. Over 900 homes and businesses in Tonbridge, Maidstone, Yalding, East Peckham and other smaller communities were flooded. With roughly 700 of them being in Yalding.



Figure 10: 2013 Flood height in relation to the property © The Environmental Design Studio

Geraldine, the owner of Lees Cottage shared with the research team her own experience of the flood events since she has lived at Lees.

- October 2000 – Having been in the house nearly 20 years this was their first flood. The flood water contained sewage and smelt strongly. It took 8 months to recovery, with the lounge floor taking the longest period to dry and cost the insurer roughly £75,000.
- December 2013 – This time the flood was much deeper than in 2000, reaching the top of the fence and up to the underside of the sofa in the lounge. On this occasion it took 6-7 months to recover and cost the insurer roughly £85,000.

There are a range of flood water entry points to the property (see figure 11) and these were recognised as key factors for consideration when reviews PFR options.



Figure 11: Floodwater entry points © The Environmental Design Studio

Avoidance-based approaches to PFR have already been undertaken in the village of Yalding. Figure 12 shows an example of a property which, after flooding had an extra storey added to it and living areas reconfigured. This approach to vertical adaptation was employed as the previous resistance-based approach of flood barriers and a flood skirt (protecting up to 1.2m) were overtopped. The barriers are still used to limit damage from small to medium flood events but for more severe floods (as was experienced in 2013/14) the raised living areas and backup power provide more safety, security and enable a quicker recovery and a greater degree of maintained occupancy and inhabitation.



Figure 12: Vertical adaptation in Yalding © The Environmental Design Studio

Stage 2: Property Survey



Figure 13: Lees Cottage © The Environmental Design Studio

The Survey

To understand the condition of the property and to identify appropriate adaptation options, a survey was undertaken by Joanne Williams MRICS in August 2022. As the survey was not commissioned by the owner of the building, it did not seek to advise on timeframes, cost of remedial works, energy efficiency or condition of the building services. The survey did note some concerns, and the owner was advised that they may wish to consider a structural survey and undertake some routine maintenance.

Though a survey was undertaken of the whole building from top to bottom, this summary will only discuss the findings relating to the ground floor which are at risk of flooding. The upper floors were assessed to get a wider picture and understand the implications that adaptation measures could have on the building, but they will not be commented on below.

A visual inspection was undertaken throughout the property, no testing or opening up works were completed. This was in part due to the listing of the building and the requirement for consent for more invasive review to undertake a level 3 but also because a level 2 was enough to understand how the building might allow water in and how the material may respond. If the owner was to decide to opt for any of the adaptation options proposed a more detailed survey of buildings would be required.

Figure 14 shows a 3D scan of the building via Matterport.



Figure 14: Matterport Scan of Lees Cottage © The Environmental Design Studio

Form of Construction

Lees Cottage is Grade II listed within Yalding conservation area and was constructed C18 or earlier. The construction of the building was originally timber framed, but its frame is now concealed thus the percentage of timber remaining and its condition is unknown without intrusive works. In addition, it was not possible to confirm the material of any infill panels. A more comprehensive timber and damp survey would be beneficial to understand its condition and would inform how the building is responding to flood events and how it should be dried. The front elevation and left gable end are clad with channelled render. The right gable end and wing are weather boarded and have been replaced in 1989 and again in 2000. Conversations with the owner identified that during these works two different structural oak timbers were replaced due to the damage caused by flooding. It is unknown if the damage to the oak timbers was because of impeded or inaccurate drying of the structure after the flood or whether other issues had caused the deterioration of the oak structure. In 2015, it was proposed to replace the weatherboard with Cedral weatherboarding, which is constructed of fibre cement. This application was denied.

The house was built at right-angles to the road and faces west. It's 2 storeys and has a plain tile roof with a projecting red and grey brick stack towards rear of left gable end, and multiple brick ridge stack to left of centre. The house has had several new extensions since its original construction, which has included the introduction of concrete foundations, underpinning and modern materials in conjunction with the original traditional constructed elements.

Obvious defects

The building has seen some movement on its west corner which was evident externally and from the gradient of one of the first-floor bedrooms floor and ceiling. The suspected cause is a failed rainwater pipe on the same corner, that is concentrating water at the footing of the building. A structural engineer was recommended to the owner of the property during the survey to undertake an assessment as to whether the movement was historic or continuous and to advise on any remedial work required.

Though not relevant to the impact flooding might have on the building, it was noted that the some of the bathrooms are in the centre of the building with no access to natural ventilation or mechanical ventilation. Damp, mould and condensation were present on the ceilings, it was recommended that mechanical ventilation be installed, or the bathrooms relocated to an area where natural ventilation was possible.



Figure 15: Building defects © The Environmental Design Studio

Flood resilience of building elements

Wall construction

The walls are known to be a mixture of historic timber framed with unknown infill panels, and areas of modern brick. In the kitchen, the walls have been covered in faux brick tiles and porcelain tiles. These tiles have been bedded using tile adhesive and may be trapping moisture after a flood occurs and has reduced the hygroscopic area, which is likely to be impacting the equilibrium of moisture and vapour.

In the other downstairs rooms, the owner informed us that the plaster had been repaired with lime, but the type of lime used, and its mix is unknown, as is the finish. Review of the paint whilst on site, determined it was unlikely to be lime wash. It is known that where impermeable materials are used in flood zones, they will trap moisture and it's likely the covering will fail, or cause damp, mould and condensation.

On the outside, it was unclear what render or mortar mix had been used but it is assumed from prior experience to likely be cementitious. As the mortar could be seen to be having an impact on the surrounding masonry. Taking samples of the mortar, render and yellow paint would be beneficial to ascertain if the buildings permeability has been compromised.



Figure 16: Wall materials in Lees Cottage © The Environmental Design Studio

Cladding

The south facing external wall has been cladded with timber, but the species is unknown, as is the detailing of how it has been fixed. Depending on the construction and material of the weatherboarding it may be inhibiting the drying capabilities of the wall behind and further review is required.

In 2015 permission was sought to replace the weatherboarding with Cedar, which was denied. Across the road another home has removed the lower metre of their weatherboard. Which could be an option that Lee Cottage could seek to discuss with the council but it would be important to establish whether this would benefit or hinder the property during another flood.



Figure 17: Cladding on Lees Cottage © The Environmental Design Studio

Floor construction

The living room floor is brick, with an unknown base. As the brick floor is reported to take the longest time to dry after a flood, it would be beneficial to identify if it is original to the building or a later intervention.

The dining room is the original timber suspended floor. It is constructed higher than the living room floor and has not yet been submerged during a flood. The timbers would be vulnerable to a flood if appropriate repair and drying was not undertaken swiftly.

The other floors in the rest of the building are all concrete slabs with tiled finishes. This means that they are easier to clean after a flood event but will still take longer to dry due to the concrete.



Figure 18: Living room floor © The Environmental Design Studio

Services

Even though the property has flooded in the past the electric sockets are still relatively low. Upon the next rewire or flood event it would be recommended to install these higher with an upper ring main.

The kitchen at some point has been replaced with an MDF kitchen, which will not be durable against flood water and a more resilient kitchen would be recommended.

The position and weight of the cooker means there is no mitigation measures that can be implemented and thus will need to be replaced after every flood event.

An alternative solution would be to relocate the kitchen to the dining room, or to the upper floors.



Figure 19: Electrical sockets © The Environmental Design Studio

Windows

At present flood water is not reaching the bottom of the window sills.

If the flood levels were to increase dramatically it is possible that flood water would be able to enter between the sill and the frame and that the hydrostatic pressure of the flood water might break the single glazing and warp the lead. There is some secondary glazing throughout the property that might prevent water ingress but would not protect the windows.



Figure 20: Windows at Lees Cottage © The Environmental Design Studio

Doors

The front door is in good condition and constructed of oak. However, it is not sitting flush within the frame and there is obvious gaps that causes draughts and would allow flood water to enter between the door and frame.

The back door is modern and presently not at risk of flood water. It sits tightly within its frame preventing draughts. Other doors throughout the property appear to be original.



Figure 21: Front door at Lees Cottage © The Environmental Design Studio

Landscape

The external ground levels are high around the north and west of the property. The north side ground levels are at roughly the height of the internal floor levels. The west side ground levels are higher than the internal floor levels. The south and east outside ground levels are lower than the internal floor finishes.

It would be beneficial to lower the ground levels and to introduce more permeable surfaces. The area is largely clay and as a result, post flood the ground remains saturated for long periods of time which in turn impacts the rate of drying to adjacent building elements.



Figure 22: The landscape around Lees Cottage © The Environmental Design Studio

Conclusion

The hygroscopic nature of the construction has been reduced by the introduction of cement, modern tiles and inappropriate finishes. This means that not all building elements can contribute to the buffering of liquid or vapour in the room.

Where impermeable materials have been introduced this has resulted in the building taking substantially longer to dry and recover after a flood event.

The owner has largely kept the home in a good state of repair and has aimed to improve her knowledge regarding appropriate materials to be used.

Discussions with the owner and other neighbours affected by flood events, identified that a lack of competent and knowledgeable contractors was a key issue during the recovery phase. Where an informed homeowner wasn't present this has resulted in inappropriate works being undertaken to several properties in the village.

Stage 3: Options Development and Design

The below graphics show the wide range of PFR strategies that were considered in relation to Lees Cottage.

Some approaches are taken from already adapted buildings in the UK. Such as the building in Yalding adding an additional storey. As well as a five bed detached brick house by the river Thames being lifted 5 feet (using computerised jacks at a cost of £80,000). This vertical adaptation not only meant that the finished floor levels of the property were up above the previous flood level, but the change in the setup resulted in the house price doubling.

These scenario's/ strategies are all possible, but that is not to say they are all suitable for every building, that is why MCDA is part of the evaluation, and a wider range of factors are required as part of any consideration.

Clearly some of these, such as Scenario 14 'Knock it down' are not wholly preferable from a heritage, placemaking or homeowner perspective, but they are still important to review and audit as part of the full suite of strategies.

Criteria for the MCDA

The Code of Practice for Property Flood Resilience recommends a range of criteria to be considered when assessing the suitability of different PFR measures for a property. These include:

- Performance
- Time for construction
- Ease of maintenance
- Suitability for the end user's needs (function, cost, access)
- Cost (indicative and lifetime)

The above criteria were agreed to be part of the MCDA assessment.

In addition, prior research and experience from TEDS identified an additional four sets of criteria, which were agreed important:

- The consequences they would ensue if the building flooded.
- The exposure and vulnerability to flooding before and after.

- Identifying how occupants and habitable spaces are affected over time.
- Heritage Values.

This is because a limitation of current assessments for understanding flood performance of a building, is that it focuses solely on existing conditions but neglects to consider future flood risk context. In this study, the evaluation method has been setup to consider both current and future scenarios. This provides the opportunity for cross-comparisons and will help reveal the limitations of a strategy. For example, barriers may only be effective for the short-term and it may be worth considering avoidance-based approaches to ensure long term resilience and conservation of the building's heritage.

Consequences if flooded

If a property has flood risk insurance, it can be that the building is reinstated post flood. However, the time and process for these works to be undertaken can still be arduous and the homeowners may have to live in temporary accommodation throughout the 6–9-month recovery process. It's important that this consequence is factored in and considered when evaluating suitable strategies for flood risk adaptation. If a property is made flood recoverable then it can be reinstated back to a fully functional state in a matter of hours, days or weeks, rather than months or years. During interviews with Geraldine, the homeowner from Lees Cottage, it was made clear her, and her husband did not want to live in such a disrupted state again and over in the coming years.

Time is yet another factor to consider in relation to consequences. The current consequences endured because of a flood event in the village may not in particular locations be deemed severe, but highlighting the future conditions and consequences of a flood can help understand the potential implications of a given strategy. It can help shine a light on measures that are short term and not future proof. It is for this reason that the evaluation criteria within this study looked at both the 'current' and 'future' consequences.

For this criterion a 'low' consequence score of 1 would mean that the homeowner would not have to leave the building and there would be no significant consequences from the flood.

Conversely, a 'high' consequence score of 10 would indicate that there would be severe consequences from flood event and that it is likely that there would be significant disruption to the occupant's lives and that it would take substantial time, effort and cost to fully reinstate the property

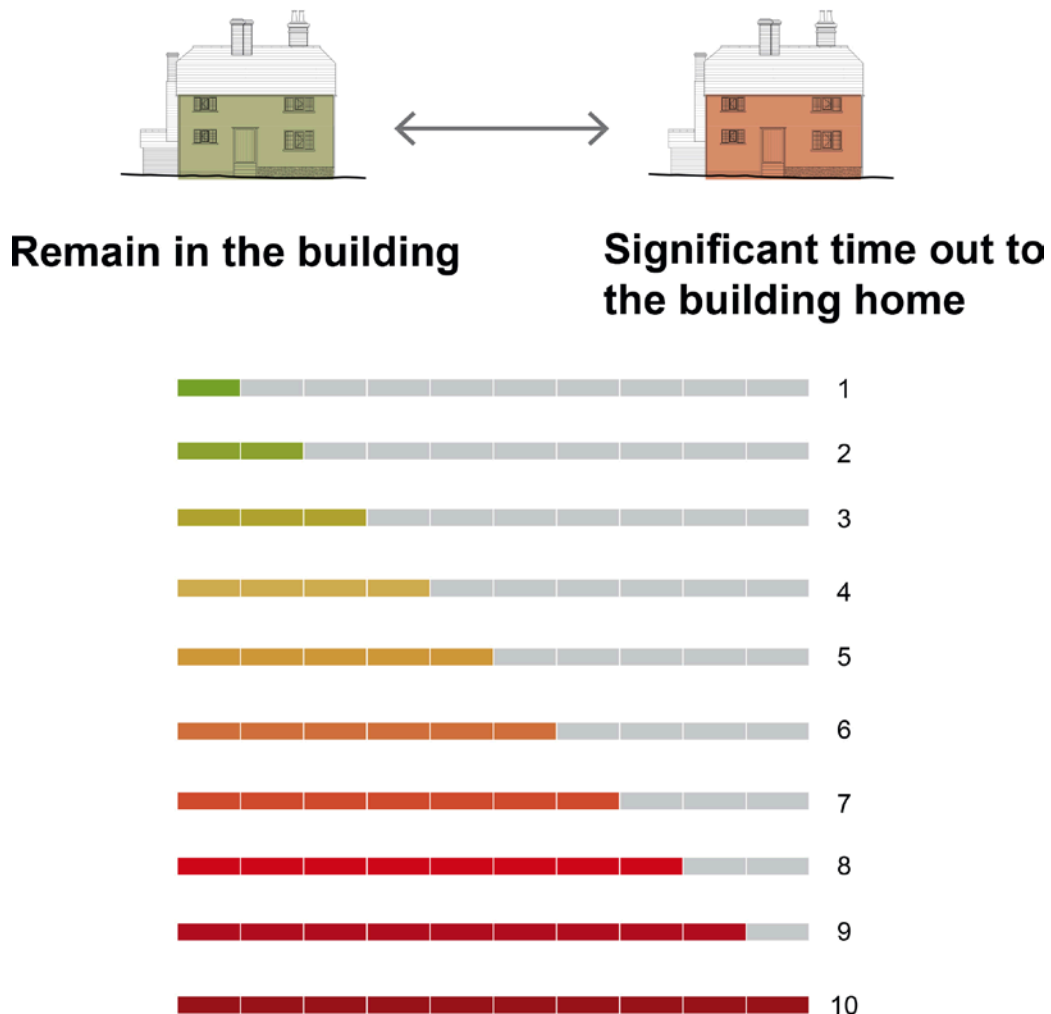


Figure 23: Consequences rating © The Environmental Design Studio

Flood exposure vs vulnerability

Flood risk can often be oversimplified and proximity to rivers and/or the sea used as a guide to consider the degree of flood risk to a building. What this approach largely neglects to consider is the difference between the flood risk exposure and vulnerability of the property. Just because something is exposed to a risk, it does not have to be vulnerable. The consequences that ensue can vary drastically.

For example, a houseboat is highly ‘exposed’ to water, but due to its buoyancy, materials and adaptive capacity it has low ‘vulnerability’ (Figure 24).

In contrast, a property could be halfway up a hill and deemed to have a low exposure to flooding. However, it could be highly vulnerable if/when a flood occurred, due to the property’s construction or material (Figure 25). If flooded it could take months to repair and reinstate, at a significant cost and carbon expenditure.

With the frequency and severity of flood events increasing as a result of climate change, many more properties in the UK are becoming exposed to flooding.

To consider the impacts of climate change through this method, both the ‘current’ and ‘future’ scores for exposure and vulnerability are considered. A scenario/setup may appear low risk when reviewing its existing condition, but a tipping point may be reached, and its future condition may be much more at risk. The exposure vs vulnerability matrix helps plot the context the situation and the state change now and in the future. Each quadrant and sector of the matrix has a different risk profile and consequence to consider. This approach applied in Yalding is only done so in relation fluvial and surface water flood risk, not that from ground water.

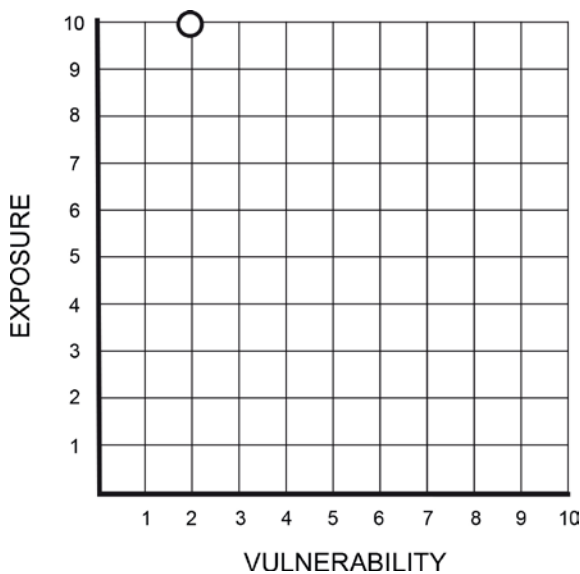


Figure 24: A houseboat scored in the Exposure vs Vulnerability Matrix
© The Environmental Design Studio

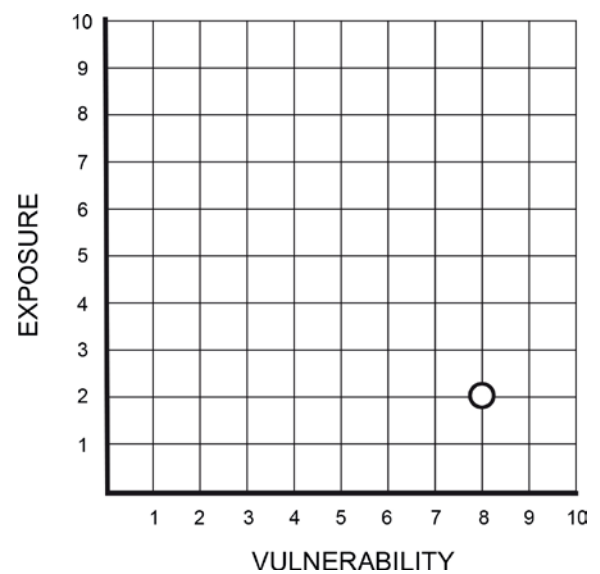


Figure 25: A hillside property scored in the Exposure vs Vulnerability Matrix
© The Environmental Design Studio

End user suitability and wider benefits

When interviewing Geraldine the homeowner of Lees Cottage, she mentioned that during the recovery phase from previous flood events the family have lived upstairs and with a temporary kitchen. She did however note that in the coming years, age and mobility it would not be so easy. These concerns amongst others were taken into consideration when reviewing options.

Wider benefits relate to the home being a healthy environment to the occupant, having improved energy efficiency, and reducing its carbon. These were evaluated in detail within this specific stage of the study but were recognised as important ‘wider benefits’ for consideration.

Heritage values

As per Historic England's remit, the project also had to consider the impact that flooding and PFR measures had on the significance and heritage value of the building.

Conservation philosophy is about the management of change of our heritage assets. They do not just stand still in time without some alteration. With a changing climate that is seeing more buildings at risk of flooding it is important that the heritage sector considers what can be done to adapt our heritage buildings to make them resilient to climate change and able to have a continued use.

One of the key reasons for undertaking this study was to consider how a heritage building could be made more flood resilient. A crucial aspect to consider is the impact these property flood resilience strategies options have on 'significance' (NPPF, 2023).

'Significance' in terms of heritage-related planning policy is defined in the Glossary of the National Planning Policy Framework (NPPF, 2019) as the value of a heritage asset to this and future generations because of its heritage interest. Significance derives not only from a heritage asset's physical presence, but also from its setting. The National Planning Policy Framework definition further states that in the planning context heritage interest may be archaeological, architectural, artistic or historic.

This can be interpreted as follows:

Architectural and Artistic Interest

These are interests in the design and general aesthetics of a place. They can arise from conscious design or fortuitously from the way the heritage asset has evolved. More specifically, architectural interest is an interest in the art or science of the design, construction, craftsmanship and decoration of buildings and structures of all types. Artistic interest is an interest in other human creative skill, like sculpture.

Archaeological Interest

As defined in the glossary of the National Planning Policy Framework, there will be archaeological interest in a heritage asset if it holds, or potentially holds, evidence of past human activity worthy of expert investigation at some point.

Historic Interest

An interest in past lives and events (including pre-historic). Heritage assets can illustrate or be associated with them. Heritage assets with historic interest not only provide a material record of our nation's historic but can also provide meaning for communities derived from their collective experience of a place and can symbolise wider values such as faith and cultural identity.

Each of the three heritage values/interests have been used as criteria for consideration within the MCDA.

MCDA Workshop

An expert workshop took place at Historic England’s office in Swindon on the 28/02/2023.

Attendees at the workshop included:

The Environmental Design Studio
 Dr Edward Barsley, Founder & Director.

Historic England

Morwenna Slade, Head of Historic Building Climate Change Adaptation.
 Joanne Williams, Historic Building Climate Change Adaptation Surveyor.
 David Drewe, Head of Engineering and Emergency Planning.
 Hannah Reynolds, Historic Building Climate Change Adaptation Architect.
 Maria-Elena Calderon, Senior Building Conservation Advisor.
 Kate Gunthorpe, Head of Construction Surveying and Landscapes.
 Alison Henry, Head of Building Conservation and Geospatial Survey.
 Erika Diaz Petersen, Landscape Architect.
 Nicholas Molyneux, Principal Adviser in Development Advice.

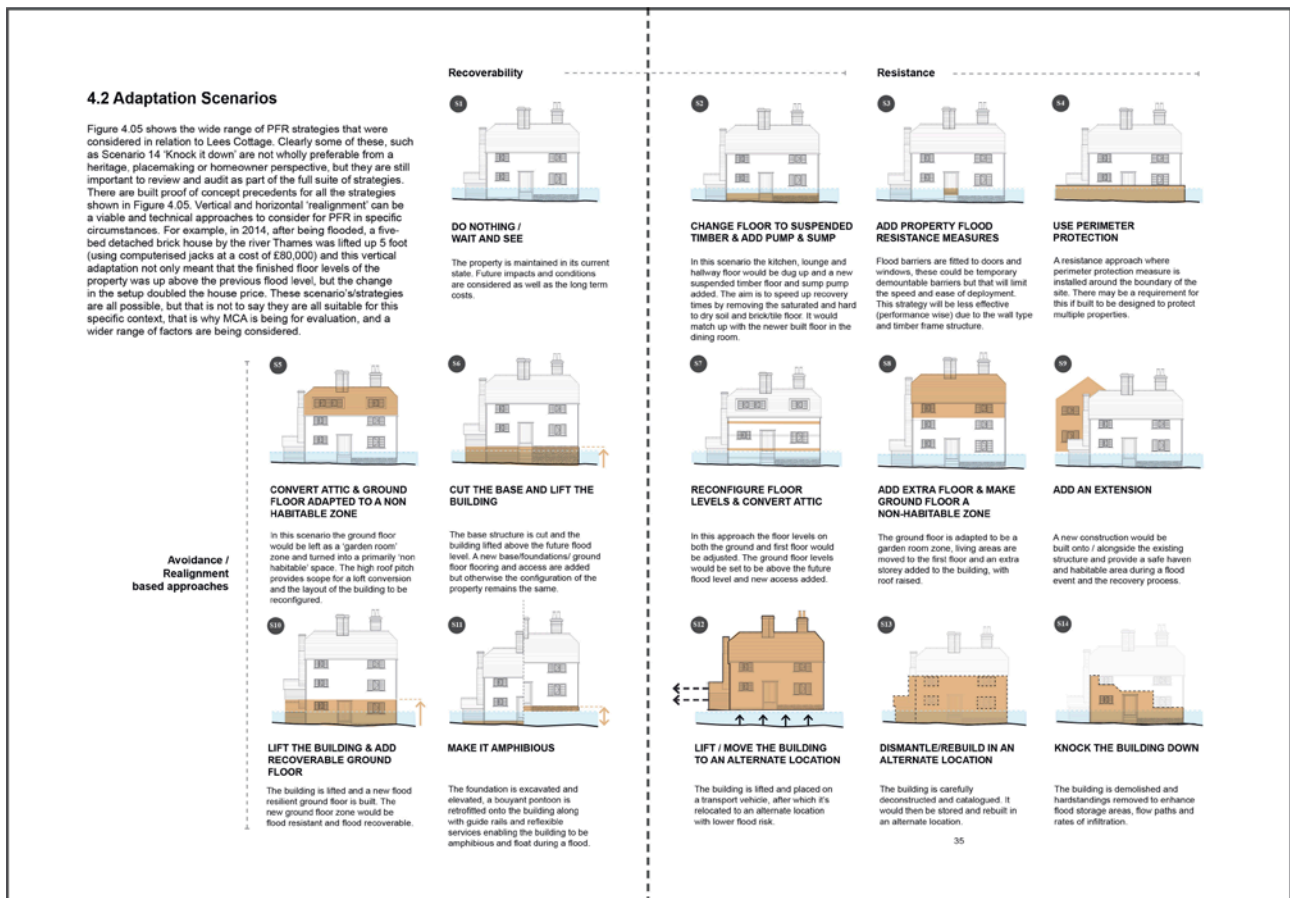


Figure 26: PFR adaptation scenarios © The Environmental Design Studio

Criteria weightings

A weighting was given as part of the MCDA process. This weighting acts as a way of calibrating the sensitivity of a particular criteria. It may for example be important that strategies are easy to maintain, but this may not be deemed by the expert panel to be on par in terms of importance as the costs or consequences of a strategy. Table 2 shows the weightings that have been given to each criteria for the purposes of this specific study.

Table 2: Criteria Weightings © The Environmental Design Studio

Construction process and Costs

Ease of construction	10%
Estimated time for construction	35%
Ease of maintenance	50%
Indicative costs	80%
Lifetime costs	80%

Heritage Values

Architectural and Artistic Interest	56%
Archaeological Interest	36%
Historic Interest	47%

Consequences

Current	90%
Future	90%

Risk Profile

Exposure	90%
Vulnerability	90%

Wider Benefits / Suitability

Wider Benefits	25%
Suitability for the end user needs	25%



Scenario #01

Do Nothing / Wait and See

Figure 27: Scenario #01 © The Environmental Design Studio

Description of the strategy

The property is maintained in its current state. The owners currently rely on flood insurance to have the property reinstated so would not currently have to pay out for recovery and reinstatement beyond their usual rates.

Pros:

- Less upfront disruption.
- The owners know what to do to the building after flood, as they already have a defined plan and process.
- No additional upfront cost.

Cons:

- Damage to the building if a flood occurs again.
- Stressful recovery process if a flood occurs again.
- Not a future proof strategy.
- Continuous loss of historic fabric.
- Insurance cover may not be as simple to attain in the future.
- The owners have to live upstairs and with a temporary kitchen post flood.
- The situation will only get worse over time.
- Significant of carbon and materials / energy used to reinstate the building.
- Prevents energy efficiency measures on the ground floor.
- Risk to occupants life.

Scenario 01

Do Nothing, Wait and See

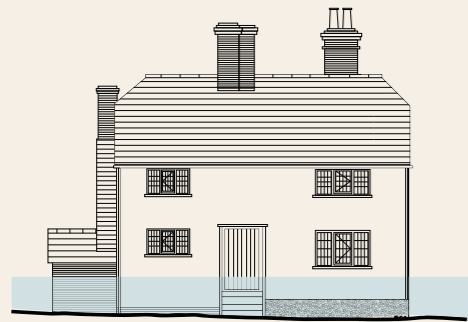
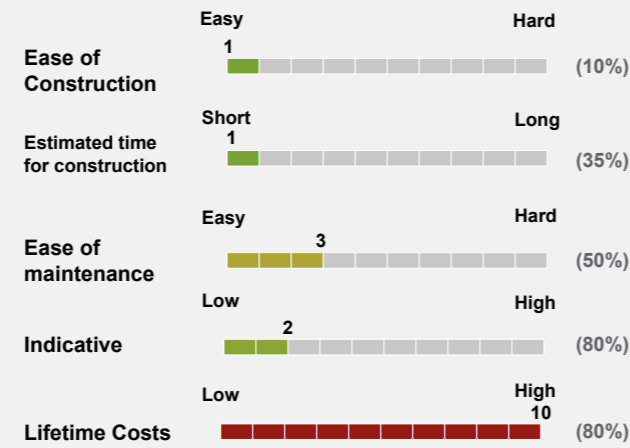
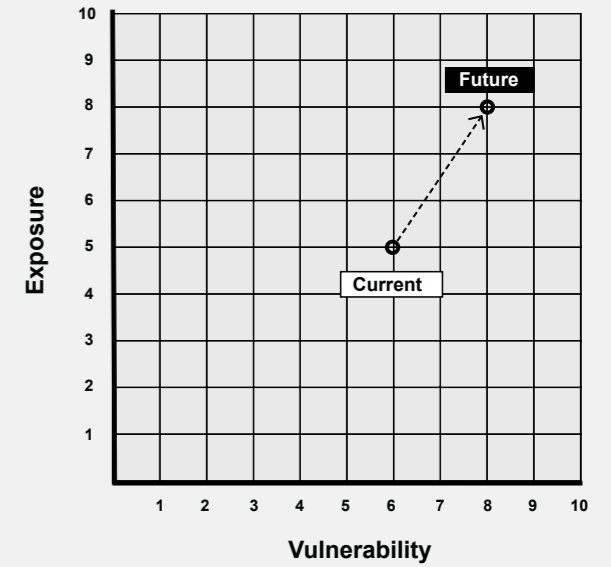
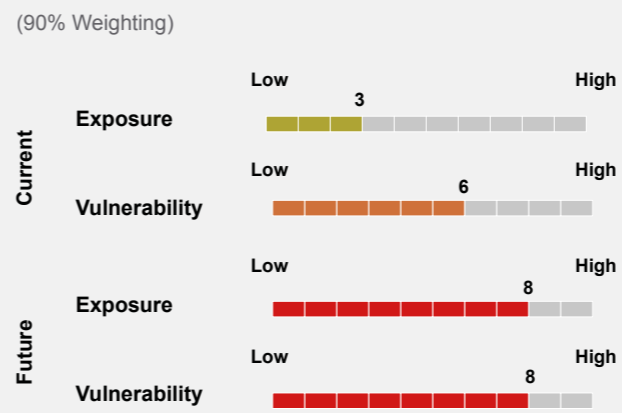


Figure 28: Scenario #01 © The Environmental Design Studio

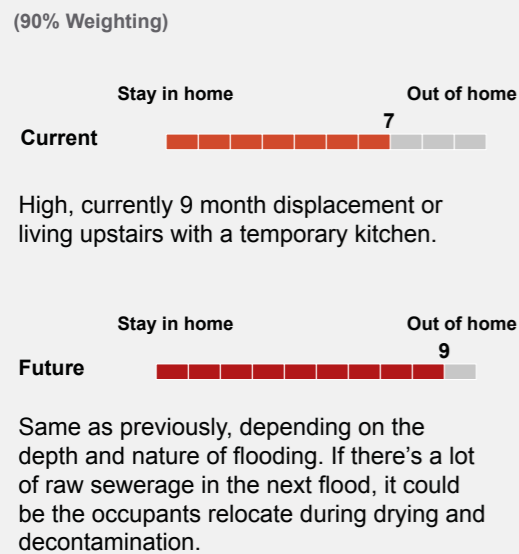
Construction Process and Costs



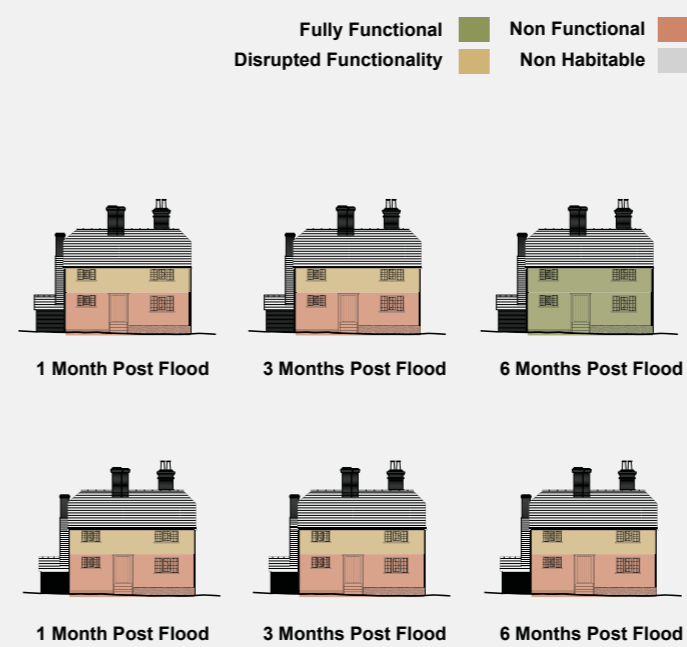
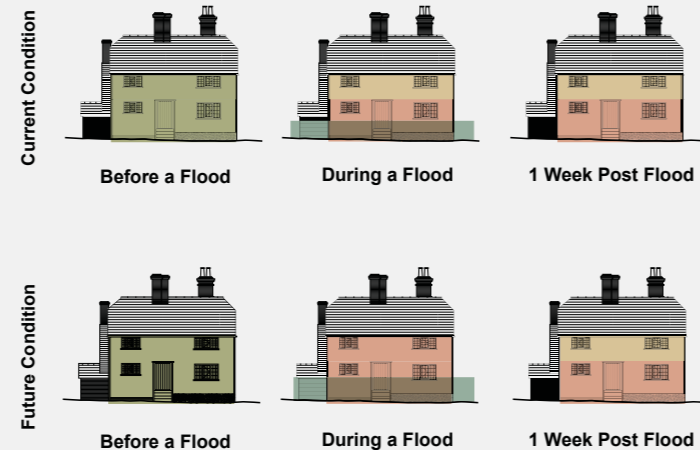
Flood Exposure vs Vulnerability Matrix



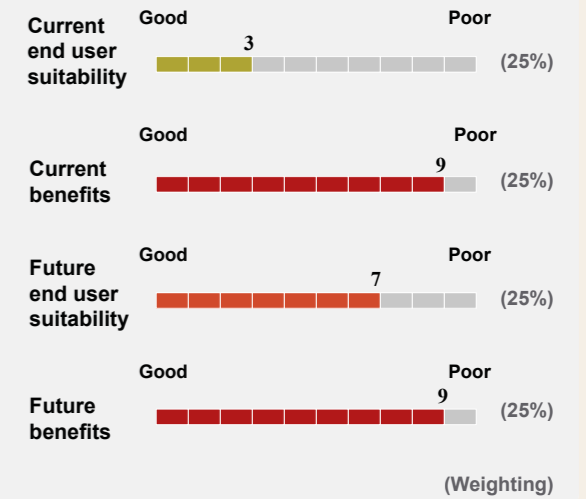
Consequences if Flooded



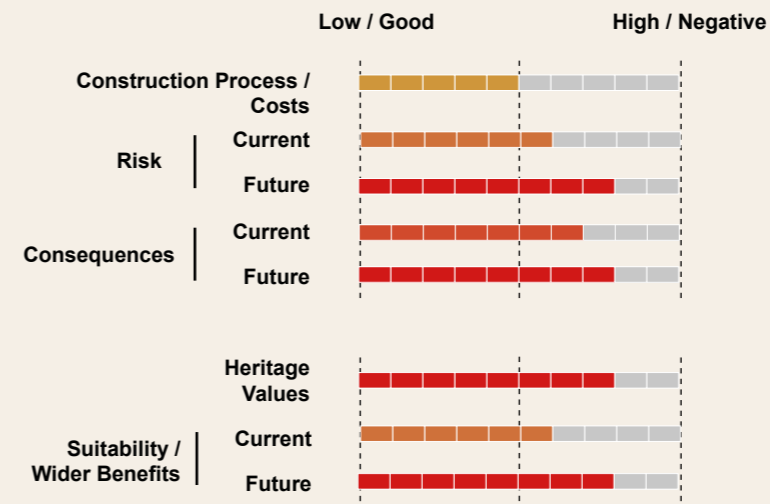
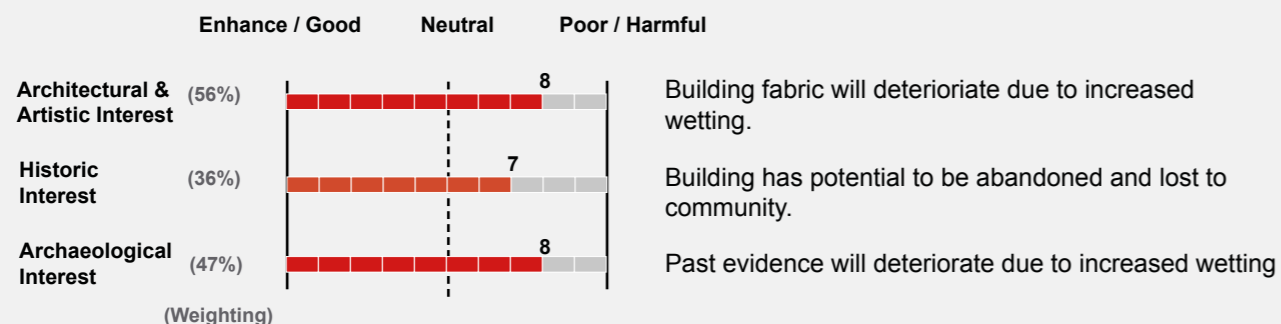
Occupancy



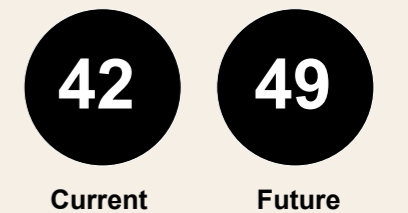
End User Suitability / Wider Benefits



Heritage Values



MCA Score





Scenario #02

Change the Floor / Add Sump + Pump

Figure 29: Scenario #02 © The Environmental Design Studio

Description of the strategy

In this scenario the kitchen, lounge and hallway floor would be dug up and a new suspended timber floor and sump pump added. The aim is to speed up recovery times by removing the saturated and hard to dry soil and brick/tile floor. It would match up with the newer built floor in the dining room. The kitchen would be moved, sockets raised, wiring fed from ceiling, boiler relocated upstairs, underfloor heating added and a temporary barrier on front and back doors.

Pros:

- Improved drying ability / less moisture retained in the building.
- Less constant pressure from soil saturation.
- Quicker recovery times.
- Reinstatement of a lost historic feature.
- Less energy use to reinstate.

Cons:

- Not a highly future proof strategy as thresholds (finished floor levels for habitable areas) remain the same.
- Flood water can and will still get in and could again be raw sewage.
- Power (inc. back up power) will be needed for the pump and sump.
- Disruption would be caused by moving kitchen.
- The strategy is not futureproof.

Scenario 02

Change the floor and add a pump and sump system

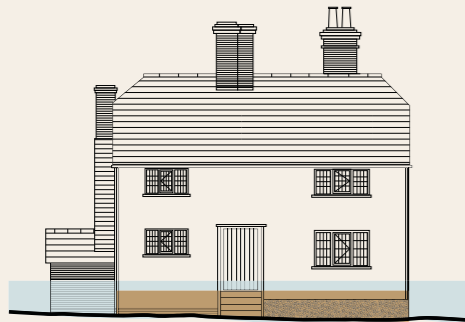
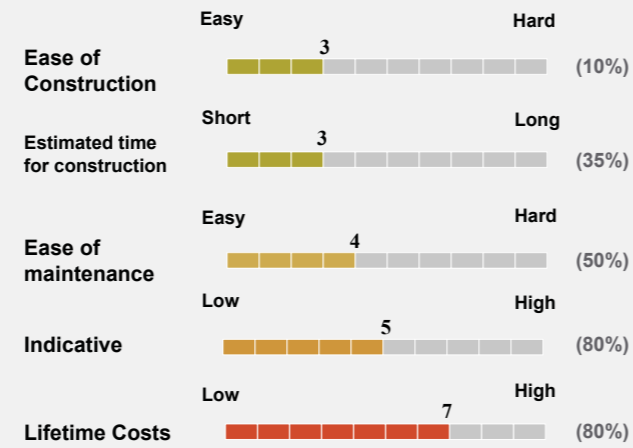
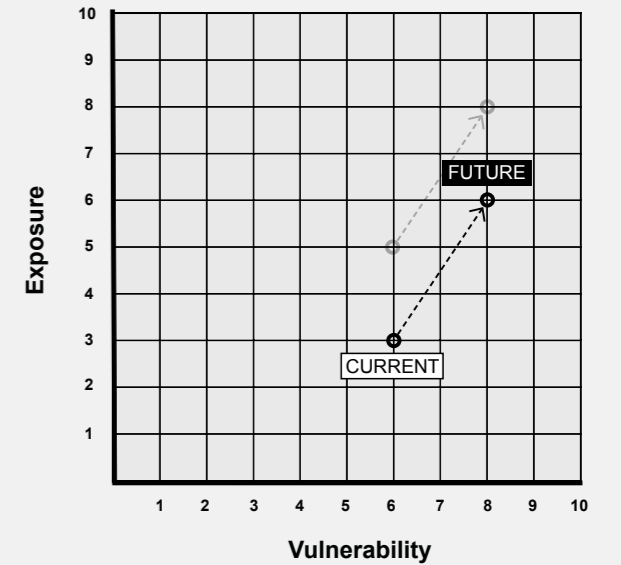
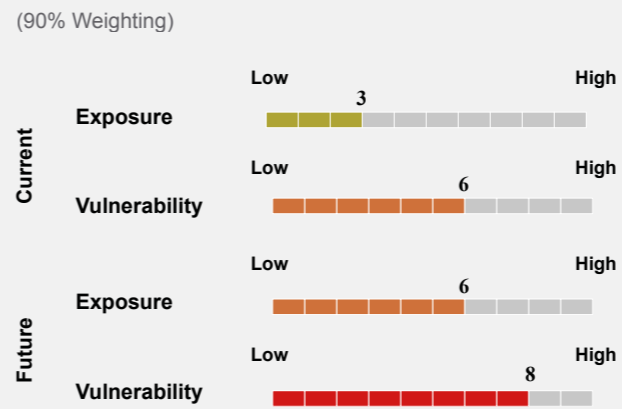


Figure 30: Scenario #02 © The Environmental Design Studio

Construction Process and Costs

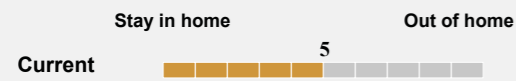


Flood Exposure vs Vulnerability Matrix



Consequences if Flooded

(90% Weighting)

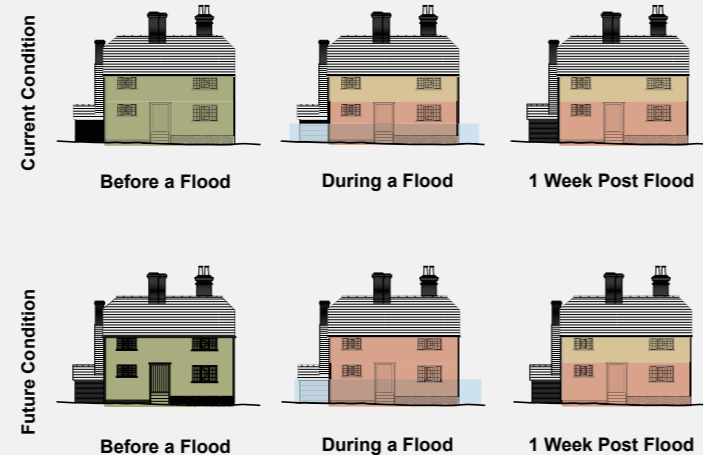


Brief disruption, does not have to move out for long time, more active maintenance required. Floor dries quicker.

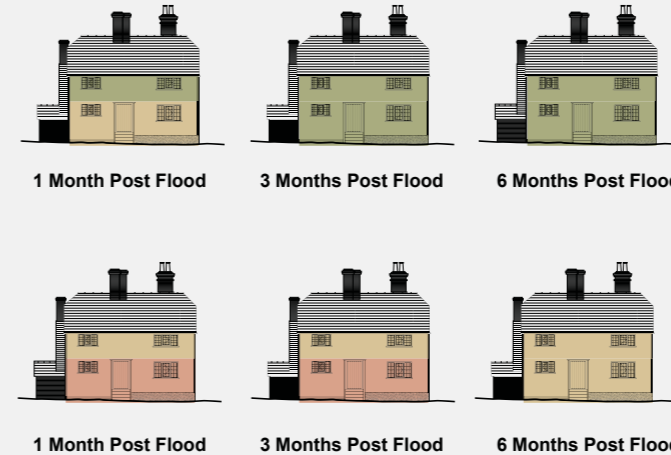


It will be quicker to dry than the previous solid floor and amended electrics / kitchen setup provides improved recoverability.

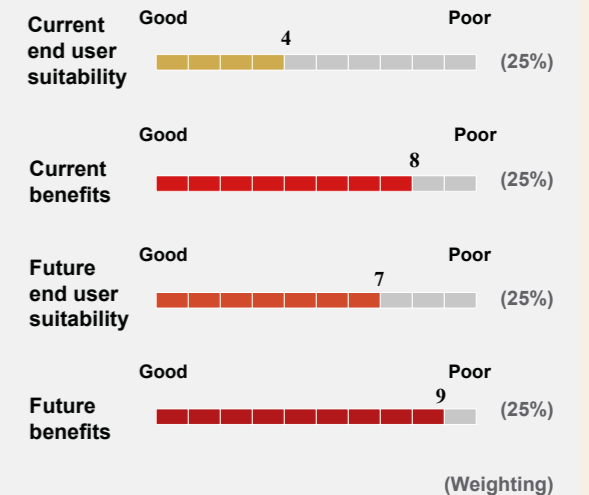
Occupancy



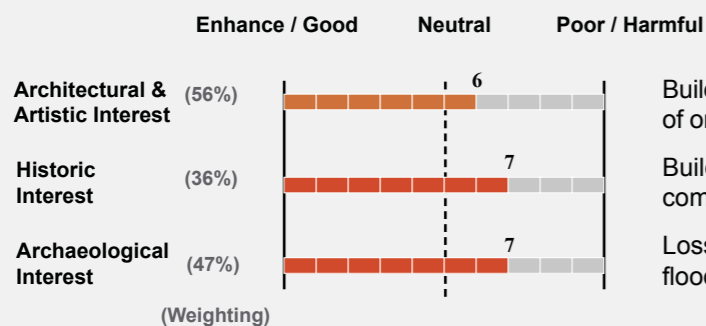
Fully Functional (Green), Non Functional (Red), Disrupted Functionality (Yellow), Non Habitable (Grey)



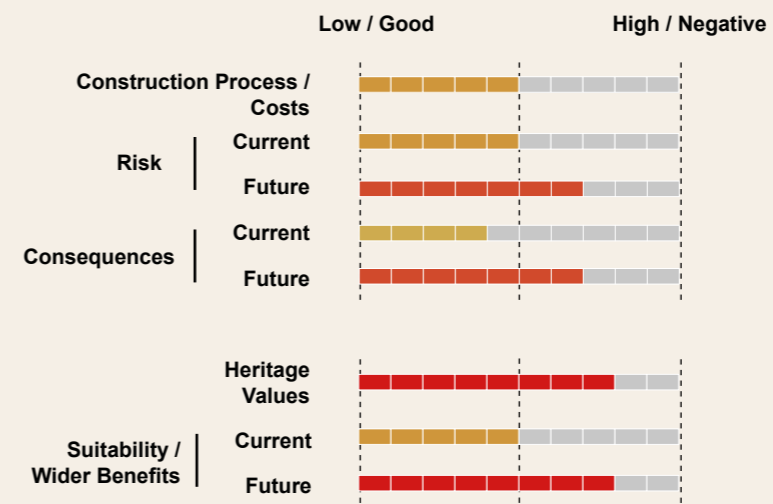
End User Suitability / Wider Benefits



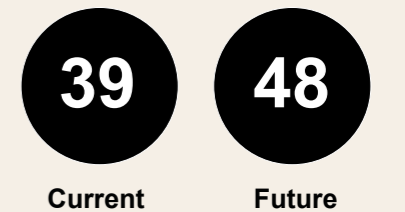
Heritage Values



Building Fabric more resilient and potential reinstatement of original suspended timber floor in sitting room.
 Building has potential to be abandoned and lost to community still.
 Loss of historic fabric but minimise further loss through flooding.



MCA Score





Scenario #03

Add Flood Resistance Measures

Figure 31: Scenario #03 © The Environmental Design Studio

Description of the strategy

Flood resistance measures such as deployable flood barriers are fitted to doors and windows of the cottage.

Pros:

- The PFR measures are mainstream products, so familiar to the supplier and installer.

Cons:

- This strategy will be less effective (performance wise) due to the wall type and the timber framed structure.
- Flood water will still find a way in through other points of water entry (e.g. the floor).
- The deployable barriers can take time to fit and both storage and maintenance is required.
- The seal and fit of the barrier could be undermined by the shape of the doorway and threshold, causing more leakage.

Scenario 03

Add flood resistance measures

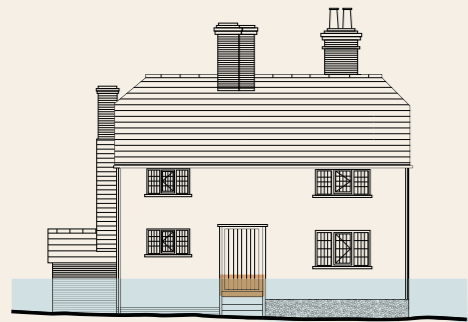
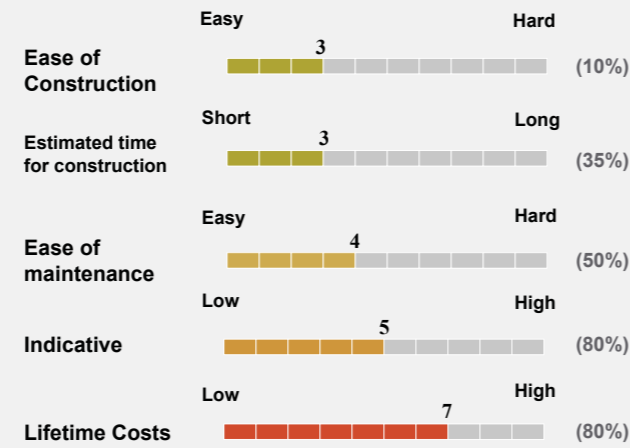
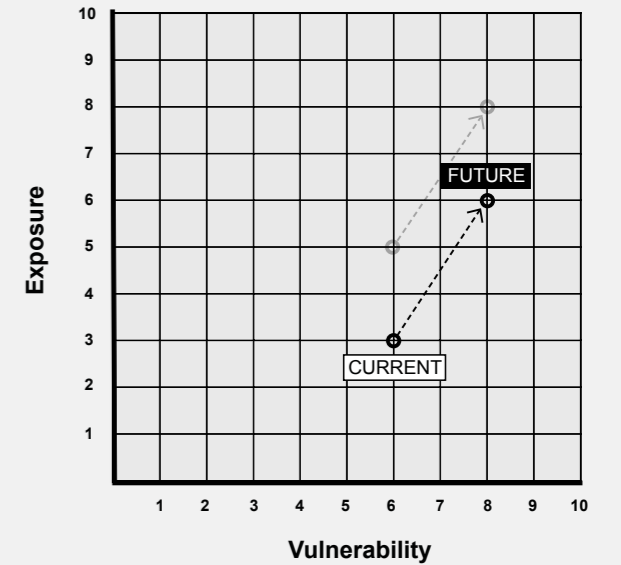
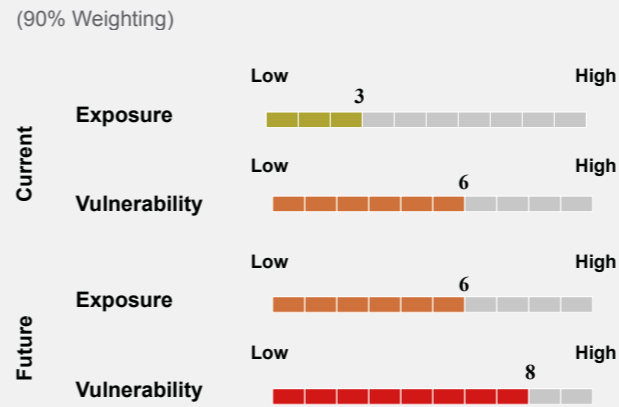


Figure 32: Scenario #03 © The Environmental Design Studio

Construction Process and Costs



Flood Exposure vs Vulnerability Matrix



Consequences if Flooded

(90% Weighting)

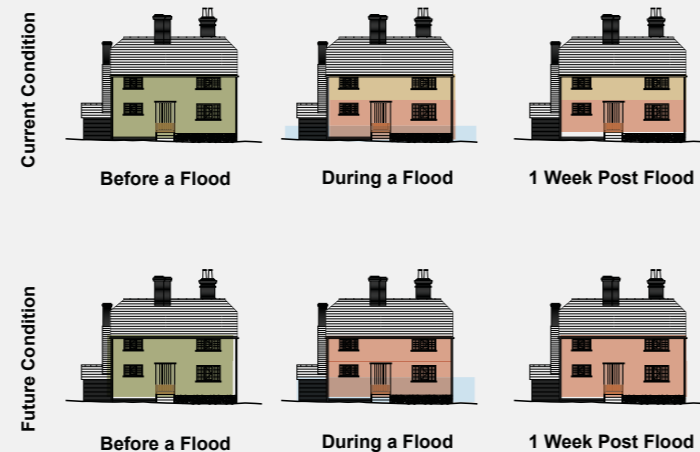


The flood barrier would reduce water enter to an extent but flood water would still enter the building and cause damage.

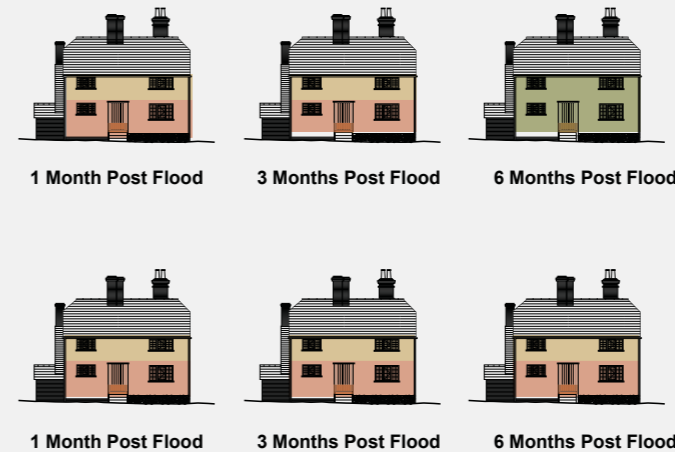


Any deployable barrier would be overtopped and significant damage caused to the building, leading to long recovery times.

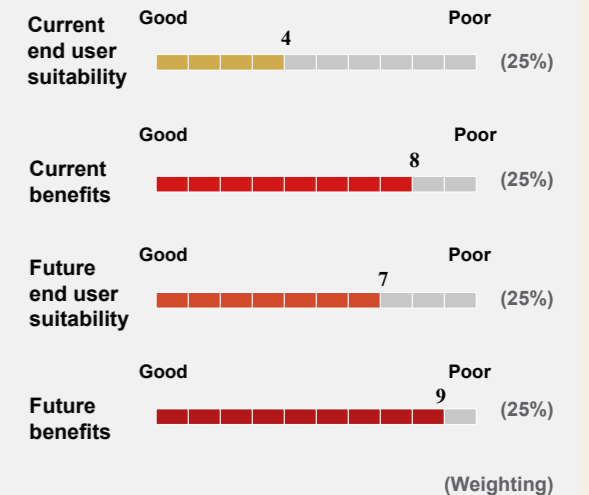
Occupancy



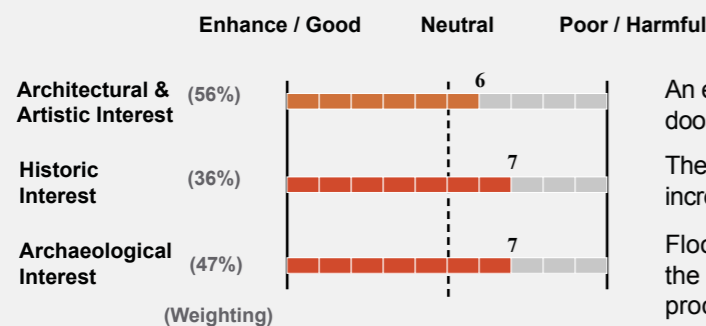
Fully Functional (Green), Non Functional (Red), Disrupted Functionality (Yellow), Non Habitable (Grey)



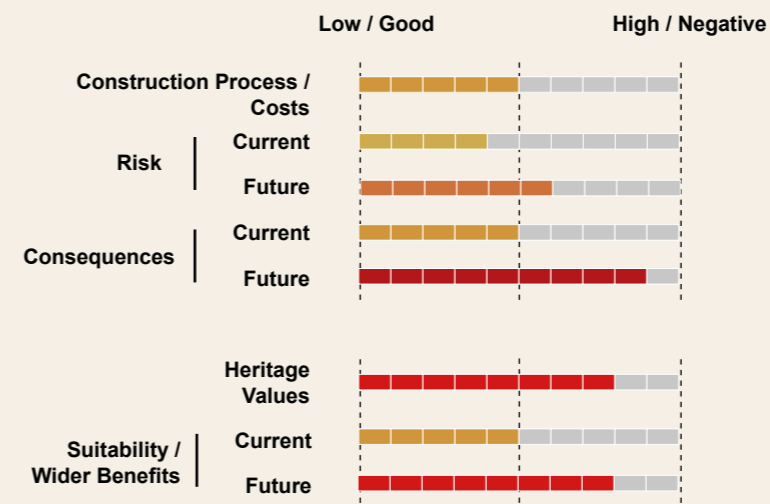
End User Suitability / Wider Benefits



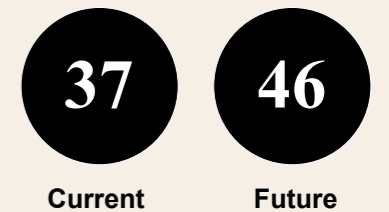
Heritage Values



An expandable flood barrier could be used to fit the doorway to reduce the need for brackets to be on display
 The buildings fabric would be damaged and the barrier increase hydrostatic and hydrodynamic loading on walls.
 Flood water would still enter up through the base of the building and damage caused during the recovery process.



MCA Score





Scenario #04

Add Perimeter Protection

Figure 33: Scenario #04 © The Environmental Design Studio

Description of the strategy

A resistance-based approach where a perimeter protection measure (e.g. a flood wall with flood gates) is installed around the boundary of the site. There may be a requirement for this if built to be designed to protect multiple properties.

Pros:

- Would keep flood water away from the property during medium and large flood events.

Cons:

- Significant upfront cost.
- Large foundations require.
- Could increase flood risk elsewhere.
- May require manual intervention to close the barrier.
- Can still be over-topped.
- Reduce quality of environment behind the barrier.
- Eyesore.
- Ground water saturations would still pertain.

Scenario 04

Add perimeter protection

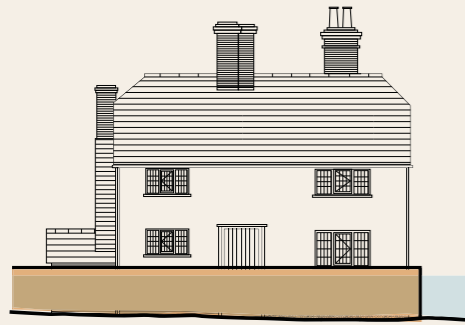
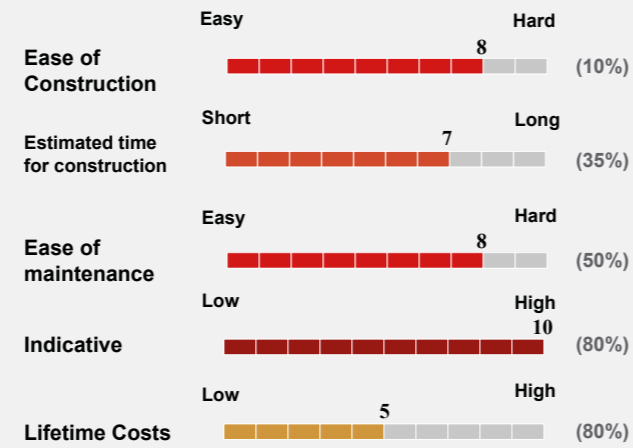
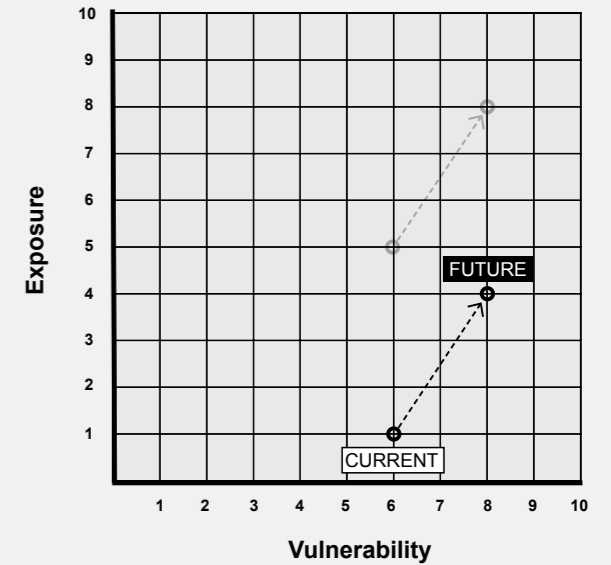
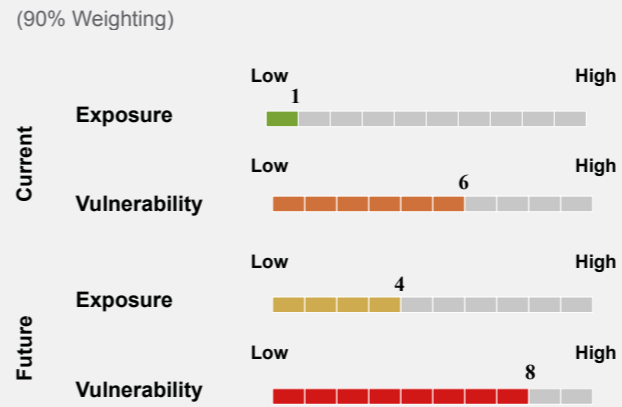


Figure 34: Scenario #04 © The Environmental Design Studio

Construction Process and Costs

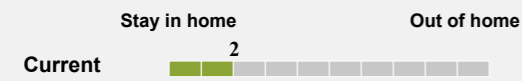


Flood Exposure vs Vulnerability Matrix



Consequences if Flooded

(90% Weighting)

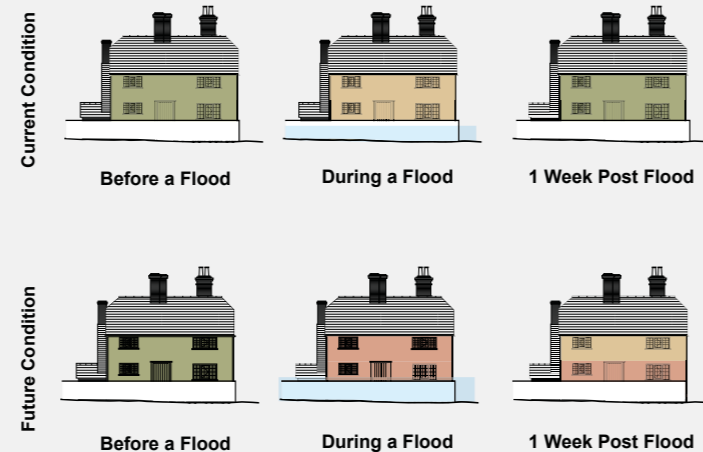


The flood wall would stop flood water reaching the building, access would be limited during that time.

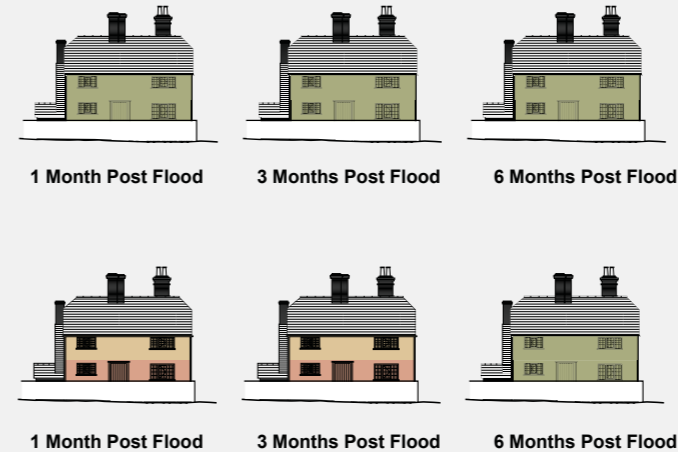


The barrier could be overtopped by a severe future flood event and if this occurred consequences would be dire.

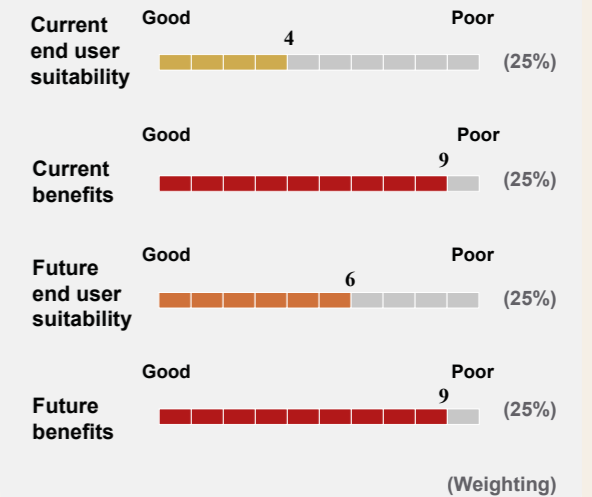
Occupancy



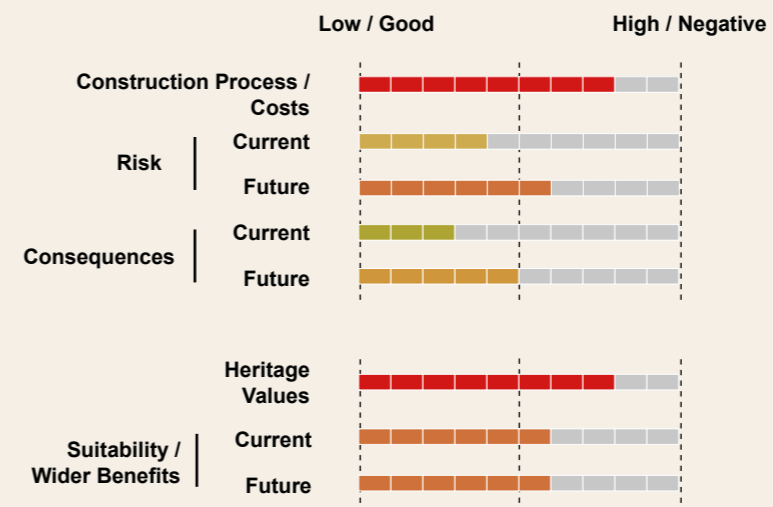
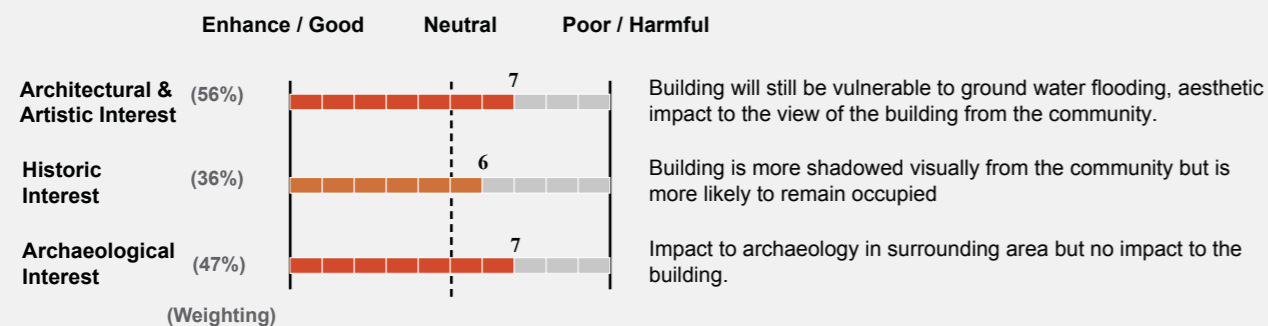
Fully Functional (Green), Non Functional (Red), Disrupted Functionality (Yellow), Non Habitable (Grey)



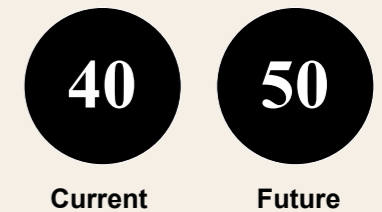
End User Suitability / Wider Benefits



Heritage Values



MCA Score





Scenario #05

Convert the Attic and Ground Floor Adapted to a Non-Habitable Zone

Figure 35: Scenario #05 © The Environmental Design Studio

Description of the strategy

In this scenario the ground floor would be left as a 'garden room' zone and turned into a primarily 'non habitable' space. The high roof pitch provides scope for a loft conversion and the layout of the building to be reconfigured.

Pros:

- Habitable areas would remain unaffected by flood water.
- Very future proof as at-risk areas of the property would no longer be used.
- Occupants would not necessarily have to leave before, during or after a flood.
- Less disruption when flood waters arrive.

Cons:

- Ground floor has more limited types of use.
- Major reconfiguration would be required to achieve this layout.
- Access and egress would need to be adjusted.
- Conversion would change roof volume and aesthetics.
- Ground floor could deteriorate if regularly damp.
- Additional structural support for extra floor may be required.
- Ground floor zone when not flooded has less functionality.

Scenario 05

Convert attic and ground floor adapted to a non habitable zone

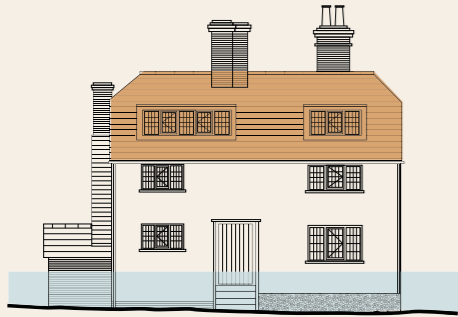
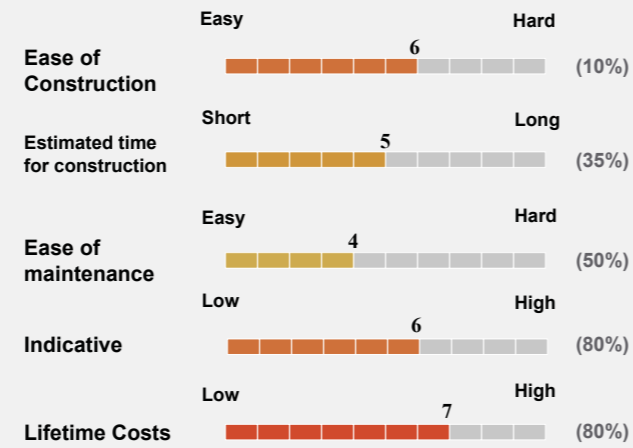
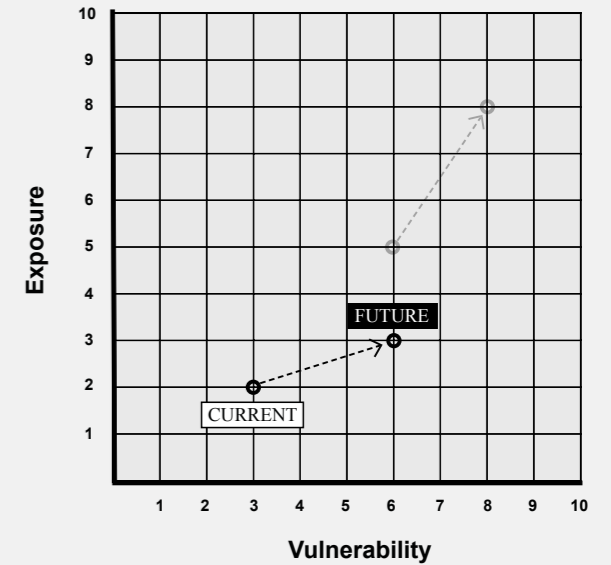
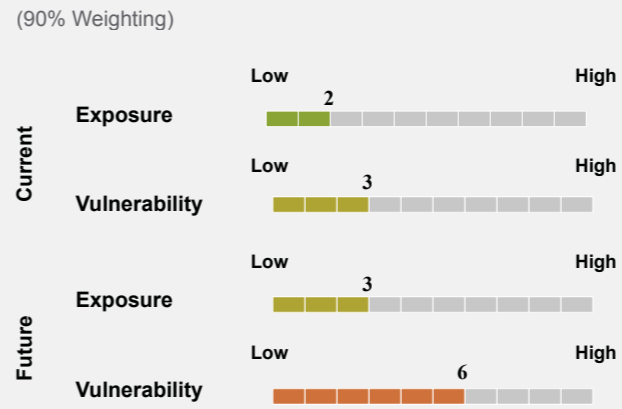


Figure 36: Scenario #05 © The Environmental Design Studio

Construction Process and Costs

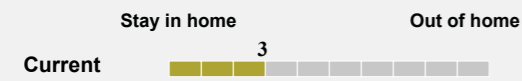


Flood Exposure vs Vulnerability Matrix

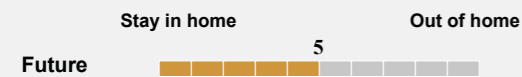


Consequences if Flooded

(90% Weighting)

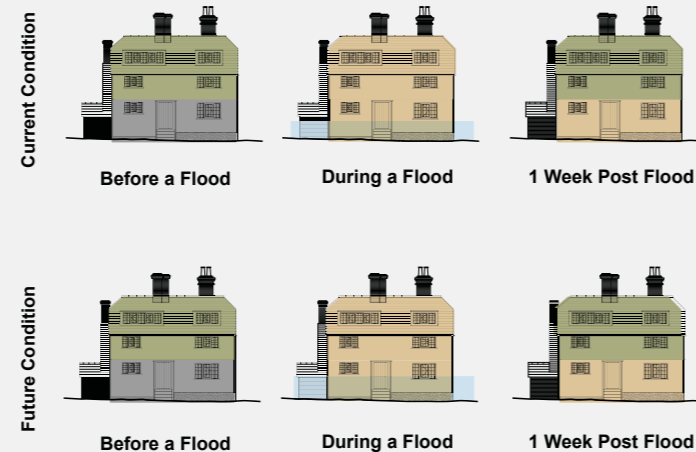


In this configuration flooding would not cause significant issues to the lives of the occupants. The ground floor rooms would be able to flood.

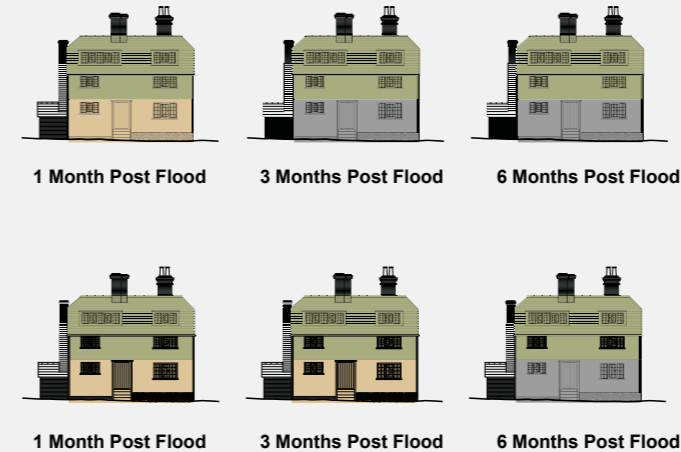


Occupants would not necessarily have to leave before, during or after a flood. Depending on the type of flood (sewage, silt etc.) the ground floor zone may require cleaning and removal of debris.

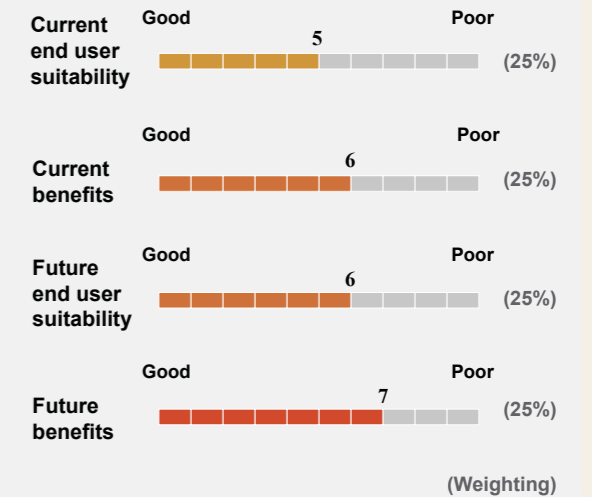
Occupancy



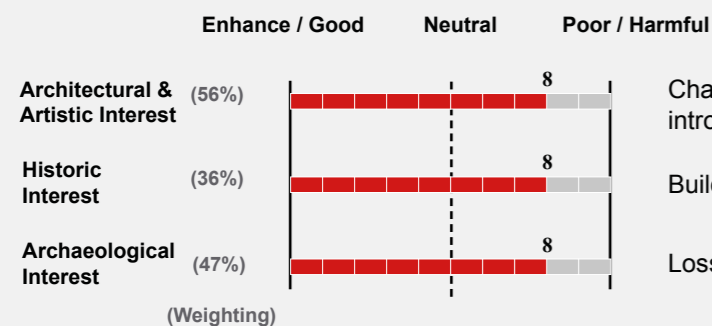
Fully Functional (Green), Non Functional (Red), Disrupted Functionality (Yellow), Non Habitable (Grey)



End User Suitability / Wider Benefits



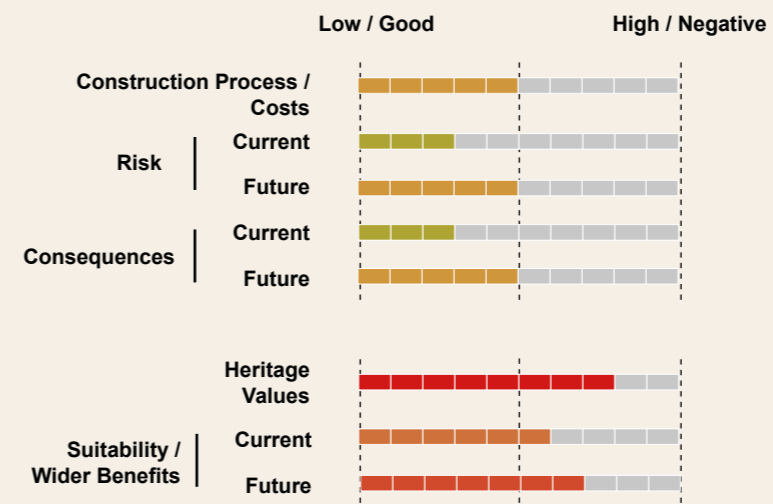
Heritage Values



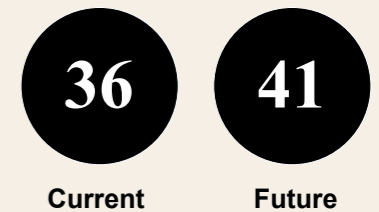
Change of visual appearance with raising the roof and introducing more windows.

Building will still flood and not be resilient.

Loss of internal historic fabric



MCA Score





Scenario #06

Lift the Building

Figure 37: Scenario #06 © The Environmental Design Studio

Description of the strategy

The base structure is cut and the building lifted above the future flood level (raised 1.5m+). A new base/foundations/ground floor flooring and access are added. The beneath building zone can be kept permeable for parking / storage, but not filled in. Stairs, ramp or lift can be fitted. The fence would be raised to minimise the sight of the pile structure.

Pros:

- Habitable areas are no longer exposed to and at risk of flooding.
- The form and design of the building would remain largely similar/consistent.
- Internal property layout/configuration remains the same.
- Opportunity to storage/parking beneath the building.
- Building fabric is no longer damp or exposed to flooding.

Cons:

- Although the buildings form stays the same, it has been changed in relation to its setting.
- The buildings construction provides challenge for lifting the structure as one element.
- New foundations will need to be added.
- Lifting could damage the structure.
- Utilities would have to be raised.
- New access route to the building would need to be constructed.

Scenario 06

Lift the building

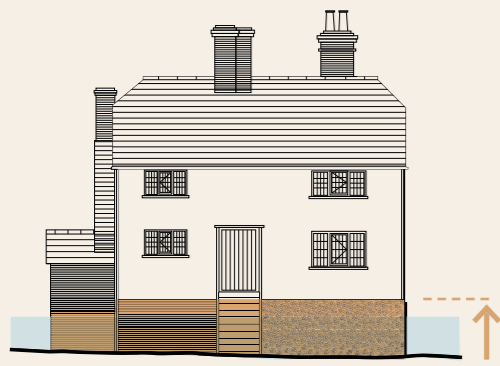
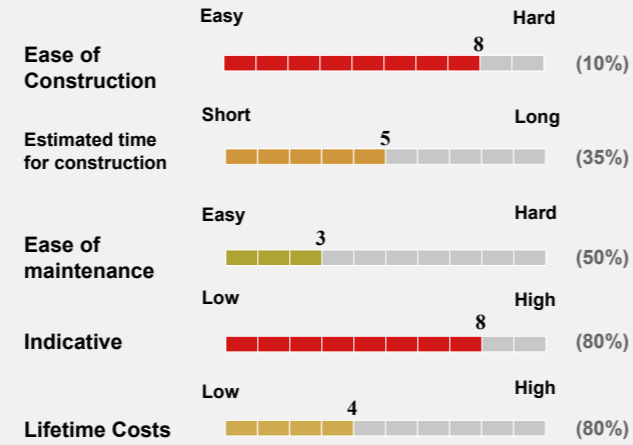
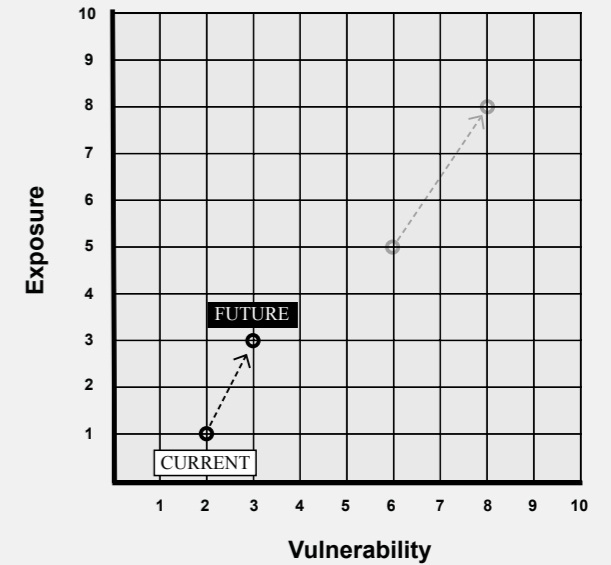
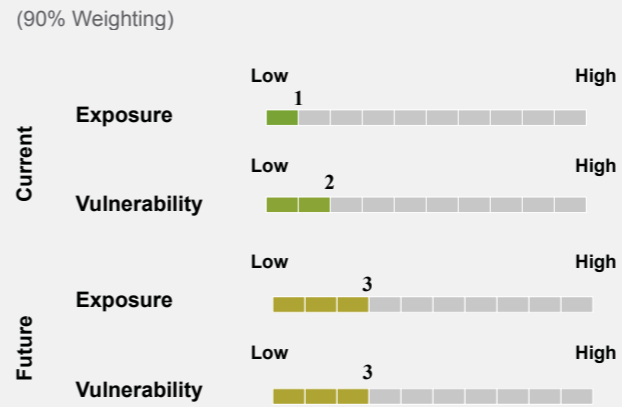


Figure 38: Scenario #06 © The Environmental Design Studio

Construction Process and Costs

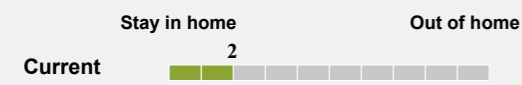


Flood Exposure vs Vulnerability Matrix

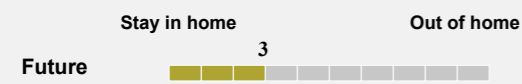


Consequences if Flooded

(90% Weighting)

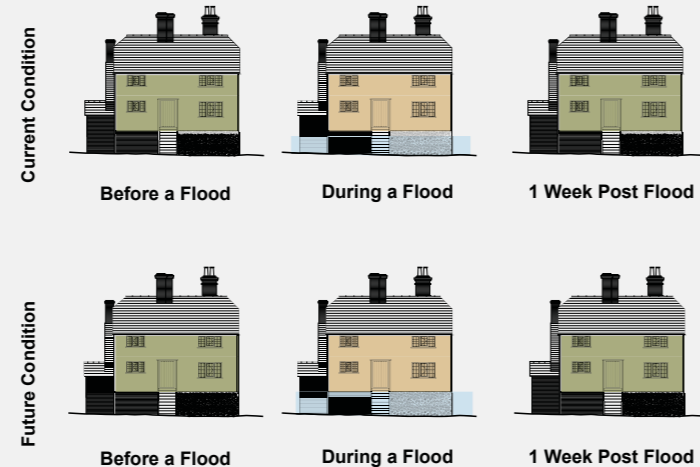


During a flood the building can be occupied minimal repairs required post flood.

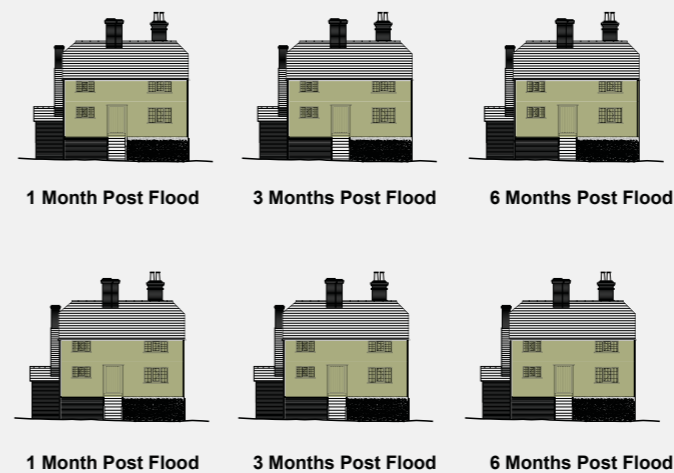


During a flood the building can be occupied, even during very deep flood events.

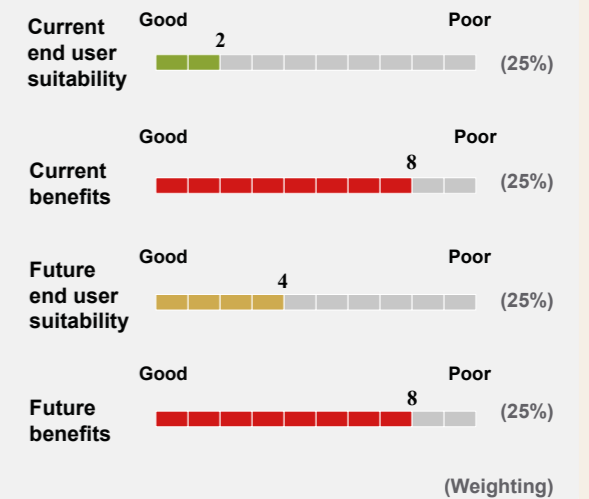
Occupancy



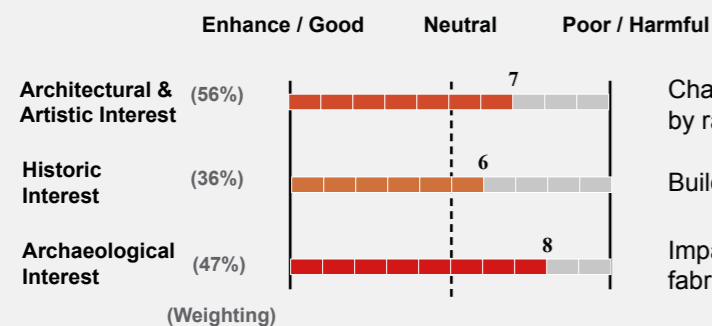
Fully Functional (Green), Non Functional (Red), Disrupted Functionality (Yellow), Non Habitable (Grey)



End User Suitability / Wider Benefits



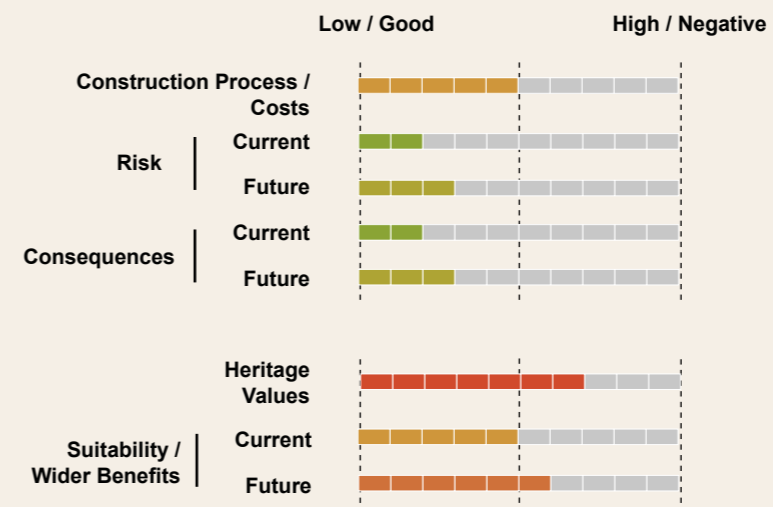
Heritage Values



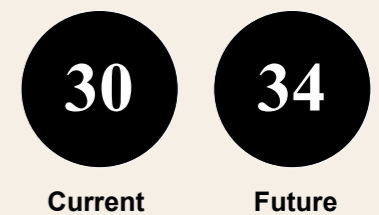
Change of visual appearance but this can be mitigated by raising fencing.

Building will remain in use in the community.

Impact to underground archaeology but the building fabric is not changed



MCA Score





Scenario #07

Reconfigure Floor Levels

Figure 39: Scenario #07 © The Environmental Design Studio

Description of the strategy

In this approach the floor levels on both the ground and first floor would be adjusted. The ground floor levels would be set to be above the future flood level and new access added.

Pros:

- More future proof.
- Building room layouts can remain similar.
- If the property is flooded the occupants do not have to leave.
- No change in ridge height.

Cons:

- Significant adjustments to built form.
- Window positions on facade would have to change.
- New volume added to roof, would change aesthetics.
- Significant cost to adapt.
- Configuring access to new level could prove problematic.
- Structural reinforcement may be required.
- Adjusting floor levels may influence structural integrity of original configuration.

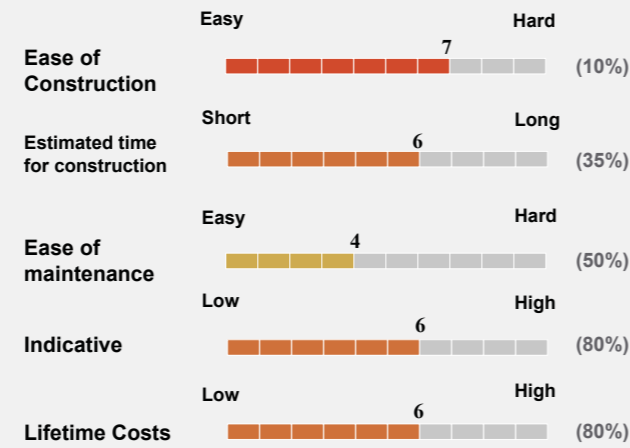
Scenario 07

Reconfigure floor levels



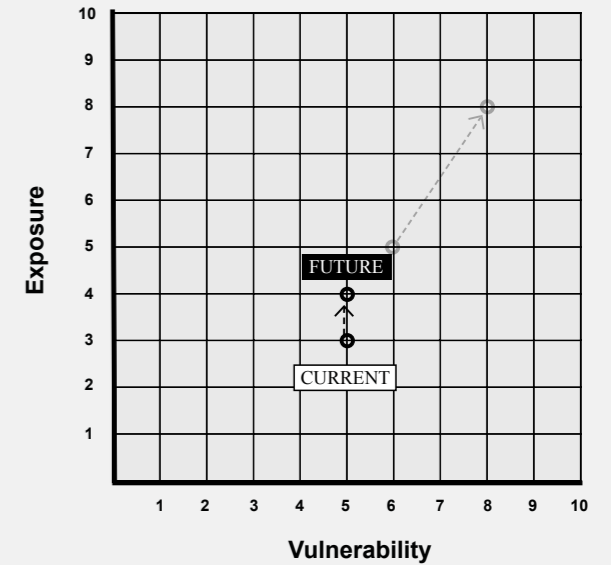
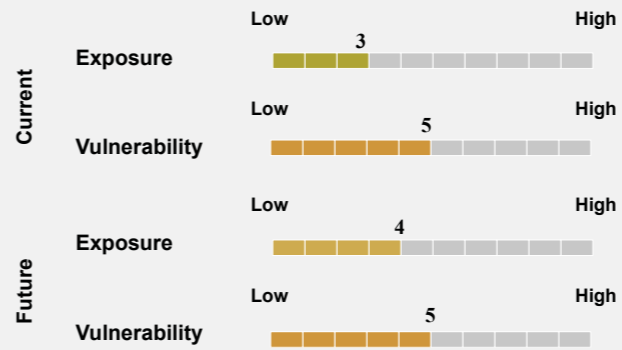
Figure 40: Scenario #07 © The Environmental Design Studio

Construction Process and Costs



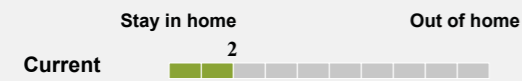
Flood Exposure vs Vulnerability Matrix

(90% Weighting)

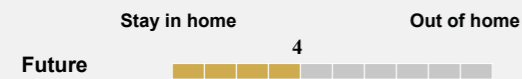


Consequences if Flooded

(90% Weighting)

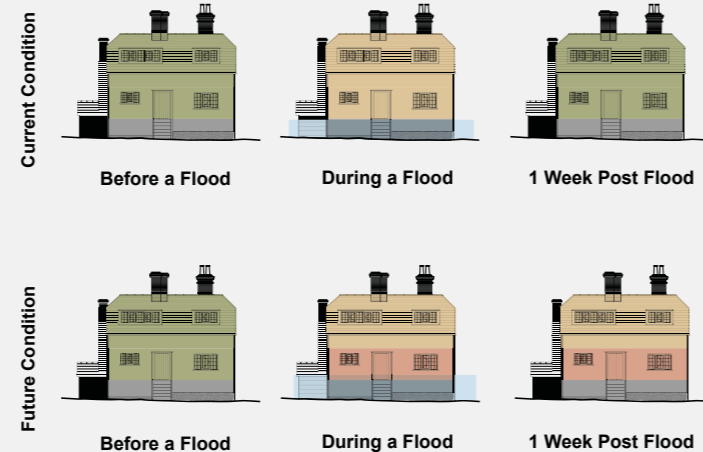


In this configuration the recovery time and requirements post flood would be minimal.

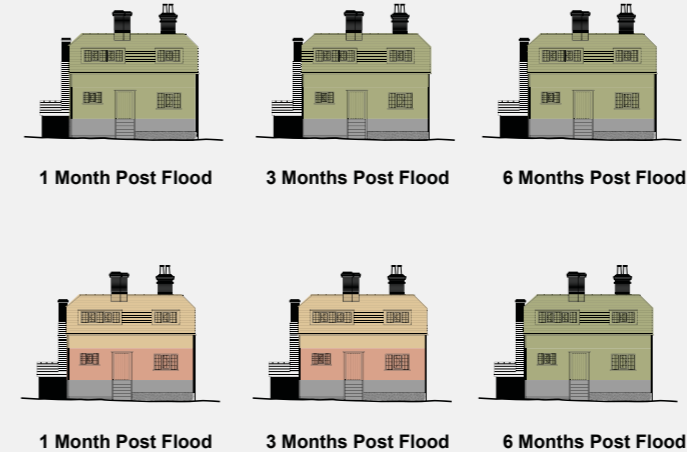


Minimal disruption caused by floods unless the depths are significant.

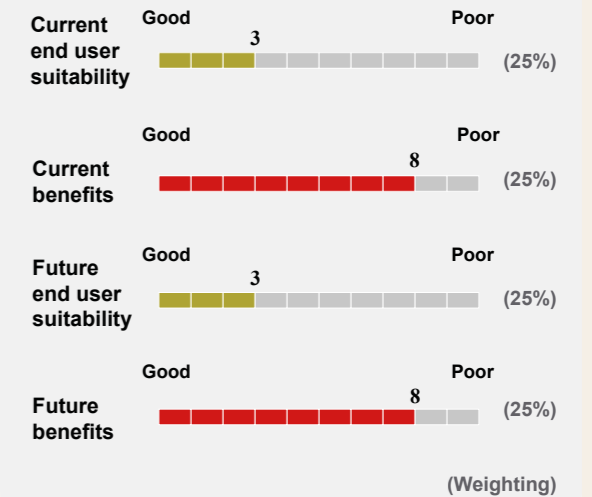
Occupancy



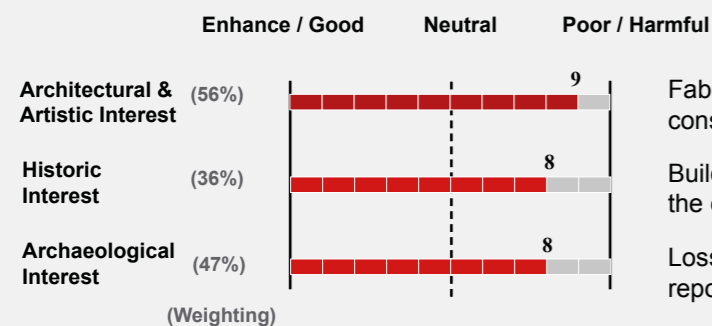
Fully Functional (Green), Non Functional (Red), Disrupted Functionality (Yellow), Non Habitable (Grey)



End User Suitability / Wider Benefits



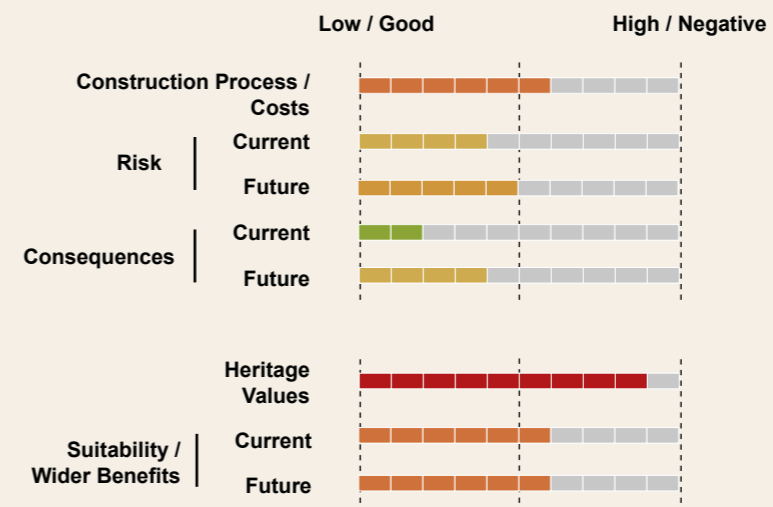
Heritage Values



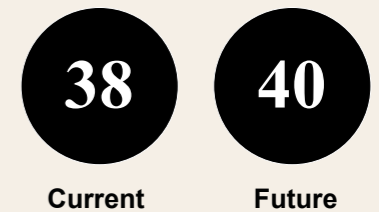
Fabric loss and appearance of the building will be considerable different.

Building continues to be used but visually different to the context in its setting.

Loss of considerable amount of internal features and repositioning of windows and doors.



MCA Score





Scenario #08

Add an Extra Storey

Figure 41: Scenario #08 © The Environmental Design Studio

Description of the strategy

The ground floor is adapted to be a garden room zone, living areas are moved to the first floor and an extra storey added to the building, with roof raised.

Pros:

- Retains volume of usable areas.
- Retain outline roof form.
- Chance to improve energy efficiency through the adaptation process.

Cons:

- Significant cost.
- New access would be required, or it would be via the non-habitable ground floor zone which would flood.
- Building reconfiguration required.
- Roof form would prove technically challenging to remove and refit.

Scenario 08

Add an extra storey

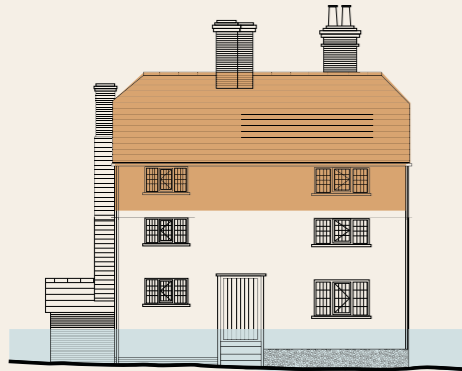
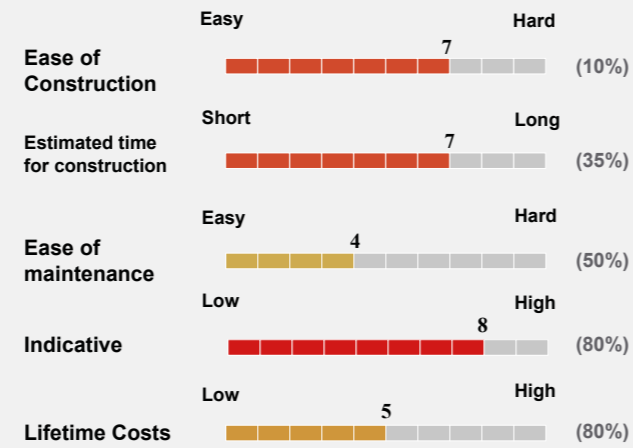


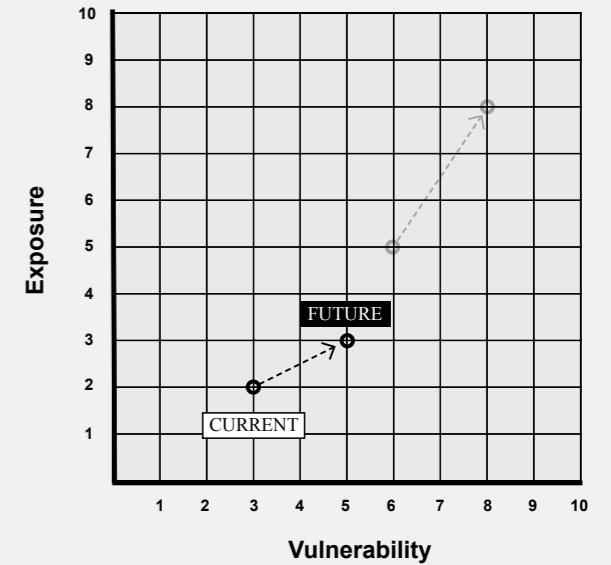
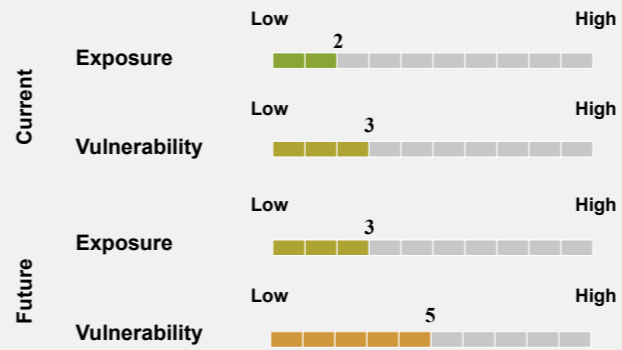
Figure 42: Scenario #08 © The Environmental Design Studio

Construction Process and Costs



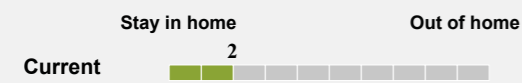
Flood Exposure vs Vulnerability Matrix

(90% Weighting)

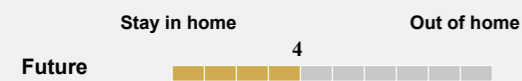


Consequences if Flooded

(90% Weighting)

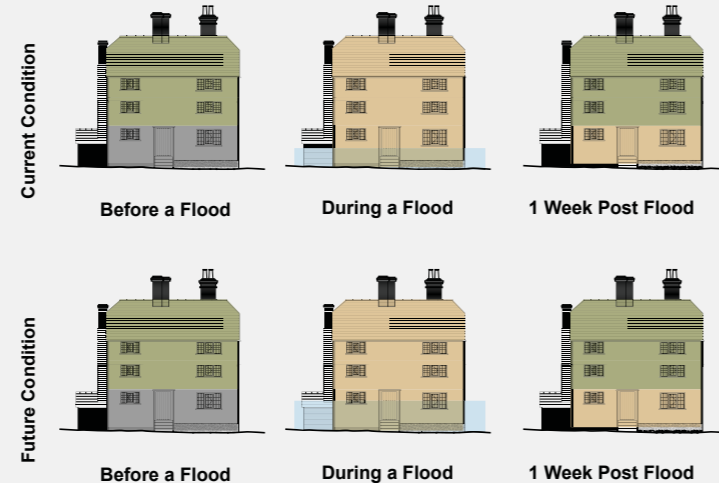


The non habitable ground floor zone would flood but living areas remain usable above it.

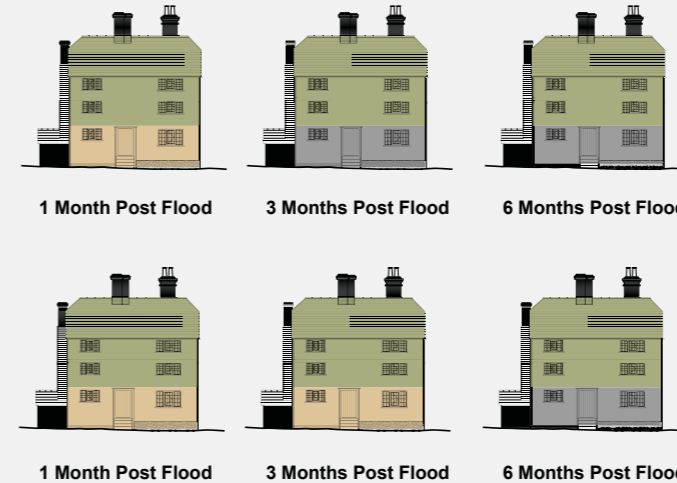


More severe/frequent floods would see the ground floor deteriorate and access through that space would prove challenging.

Occupancy



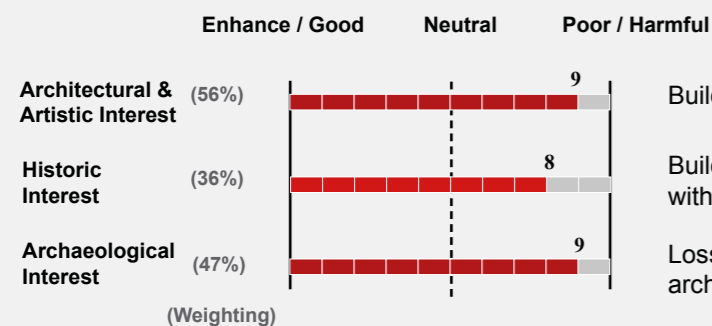
Fully Functional (Green), Non Functional (Red), Disrupted Functionality (Yellow), Non Habitable (Grey)



End User Suitability / Wider Benefits



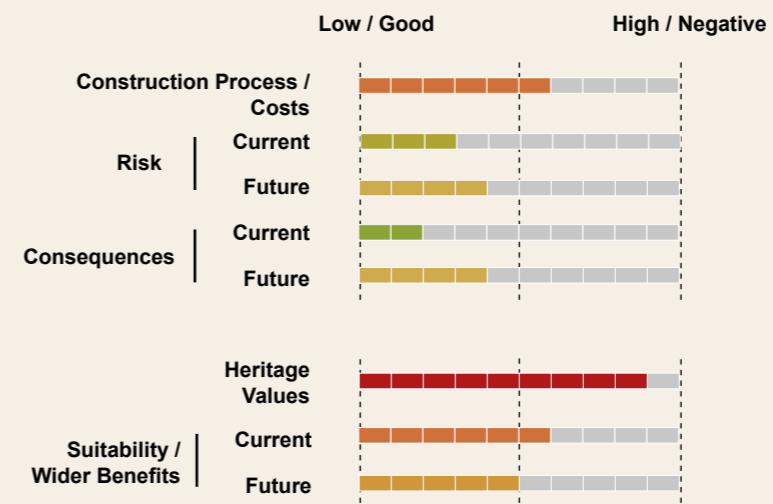
Heritage Values



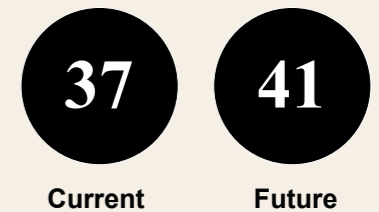
Building proportion will be drastically different.

Building continues to be used but will no longer fit in with other buildings in the area.

Loss of upper archaeology and impact to underground archaeology via underpinning



MCA Score





Scenario #09

Add an Extension

Figure 43: Scenario #09 © The Environmental Design Studio

Description of the strategy

A new construction would be built onto / alongside the existing structure. This would provide a safe haven and habitable area during a flood event and the recovery process.

Pros:

- This design helps ensure continuity of inhabitation.
- The new build would be more energy efficient than the existing cottage.
- There would be a safe and dry space for the family to reside.

Cons:

- New access would be required
- Planning could restrict the style, setup and design of the new build structure.
- The heritage building will still be impacted, damaged and vulnerable to flooding.
- There would still only be a portion of the total habitable area that remains usable during the recovery process.

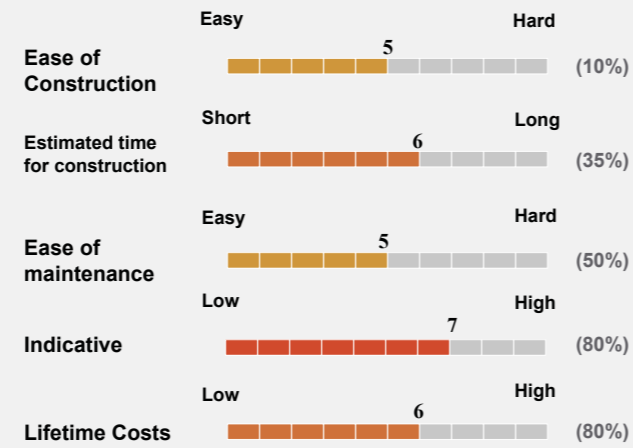
Scenario 09

Add an extension



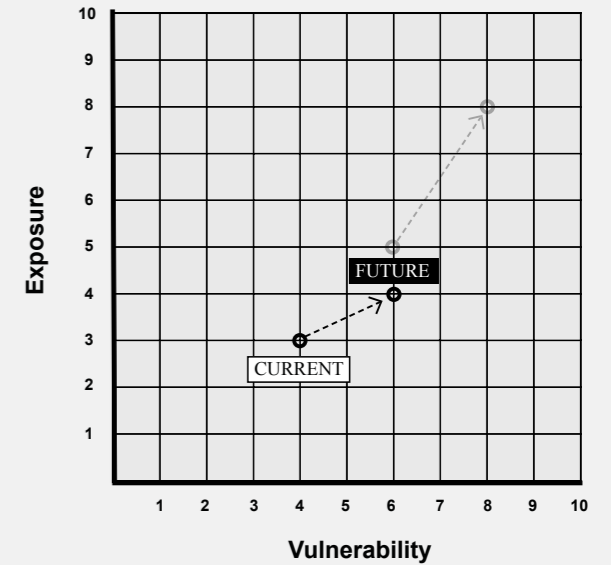
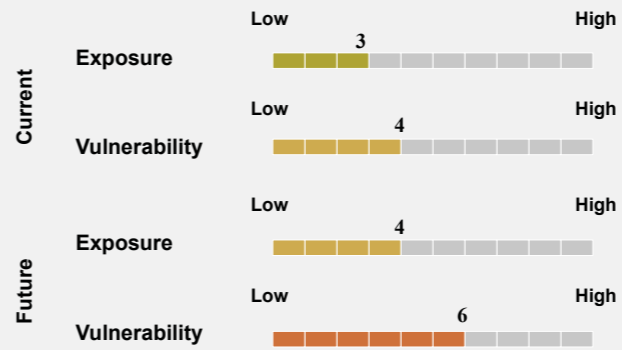
Figure 44: Scenario #9 © The Environmental Design Studio

Construction Process and Costs



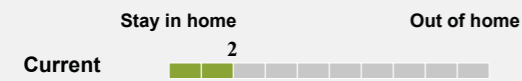
Flood Exposure vs Vulnerability Matrix

(90% Weighting)

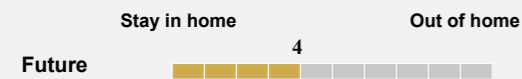


Consequences if Flooded

(90% Weighting)

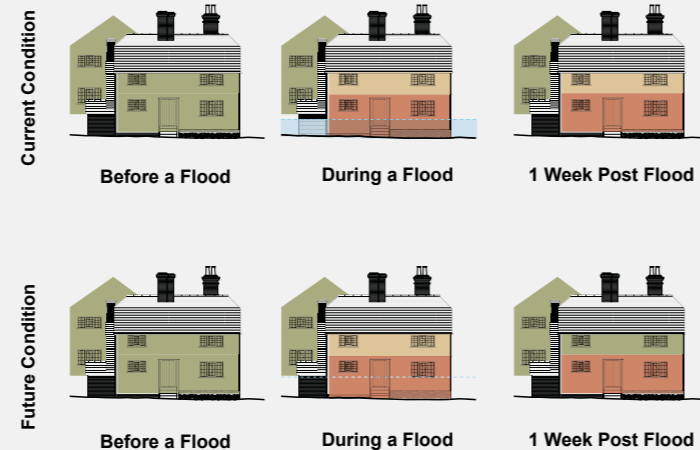


The cottage is flooded but the new build struture can be lived in during the recovery process.

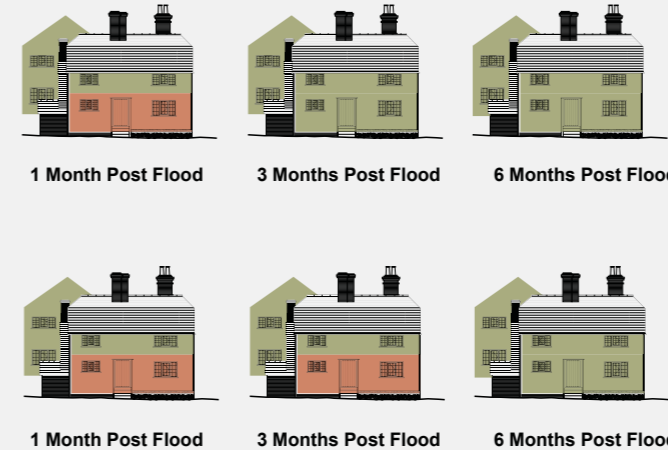


Frequent flooding makes the cottage hard to reinhabit and so the family reside primarily in the new build property.

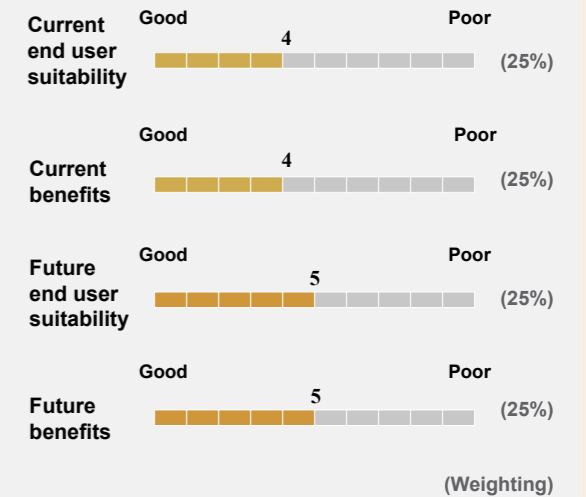
Occupancy



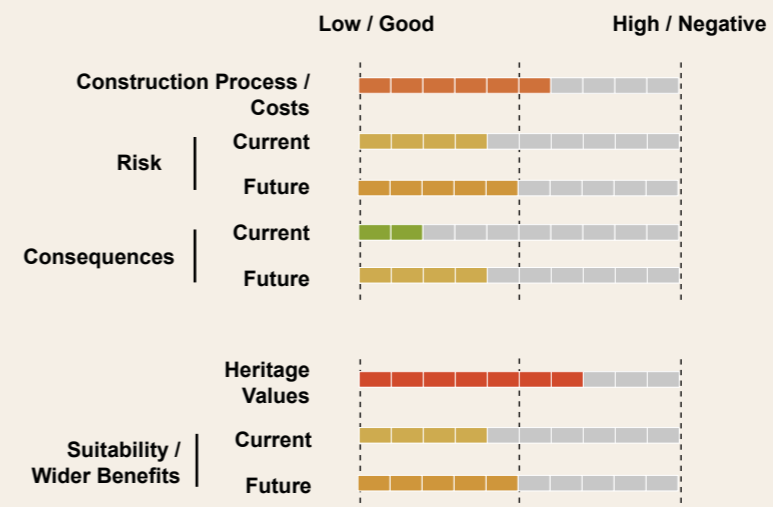
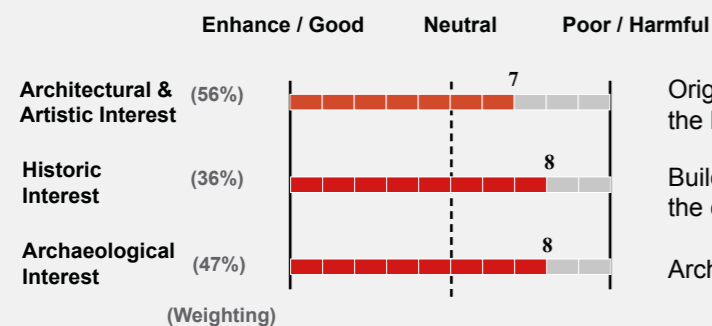
Fully Functional (Green), Non Functional (Red), Disrupted Functionality (Yellow), Non Habitable (Grey)



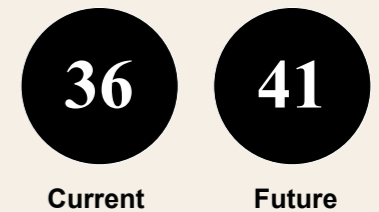
End User Suitability / Wider Benefits



Heritage Values



MCA Score





Scenario #10

Lift the Building, Add a Recoverable Ground Floor

Figure 45: Scenario #10 © The Environmental Design Studio

Description of the strategy

The building is lifted, and a new flood resilient ground floor is built. The new ground floor zone would be designed to be flood resistant and flood recoverable.

Pros:

- Adding floor area for the building (+33%).
- The ground floor zone can remain accessible so there would be a reduced need to raised access.
- The existing built form would remain intact, albeit raised.
- The majority of the historic fabric would not in contact with flood water and therefore less damaged over time.

Cons:

- Makes the building 3 storeys tall.
- The ground floor zone during a flood will still be disrupted.
- In future flood conditions the recoverable strategies (e.g. raised sockets) could still be inundated so there are limitations as to how future proof it would be.

Scenario 10

Lift the building, add a recoverable ground floor

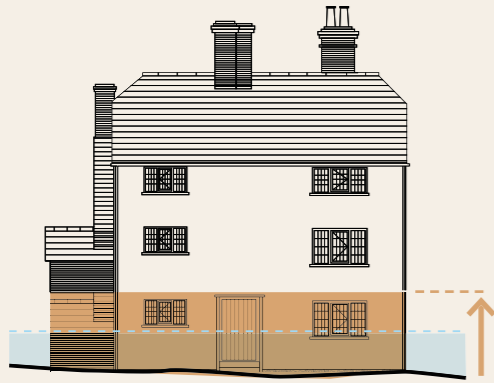
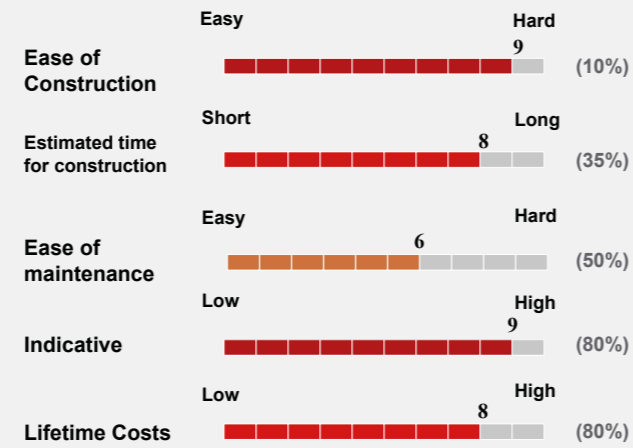
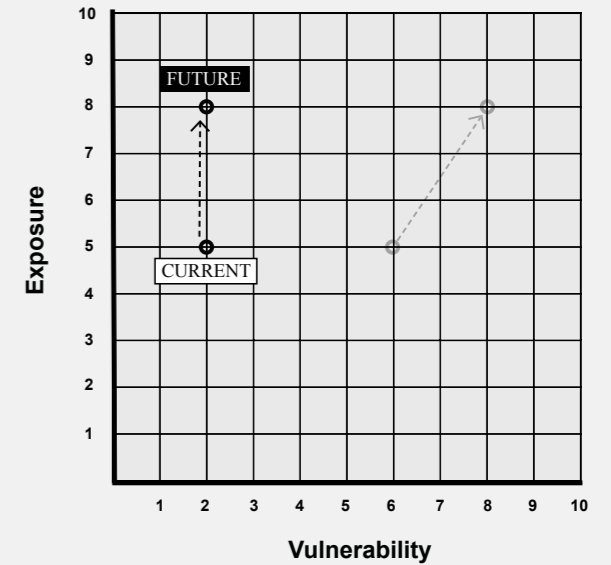
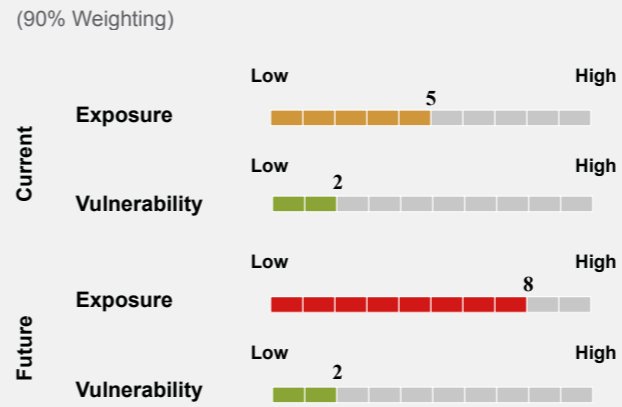


Figure 46: Scenario #10 © The Environmental Design Studio

Construction Process and Costs

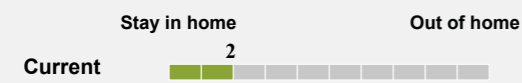


Flood Exposure vs Vulnerability Matrix

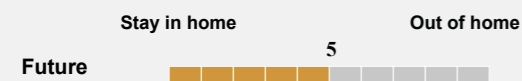


Consequences if Flooded

(90% Weighting)

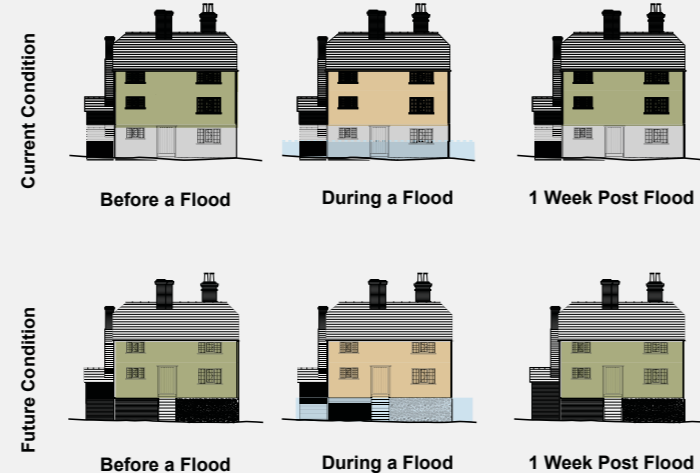


Flood resistance measures work well with the new ground floor structure and the building is flood recoverable.

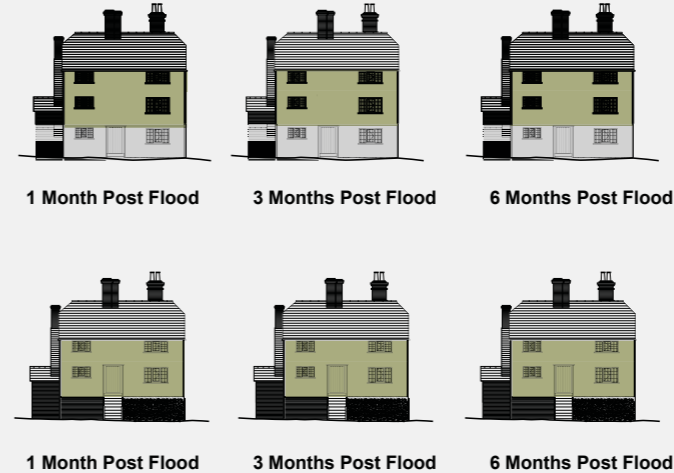


If flood waters are very deep the recoverable approaches could be undermined and the ground floor made unusable.

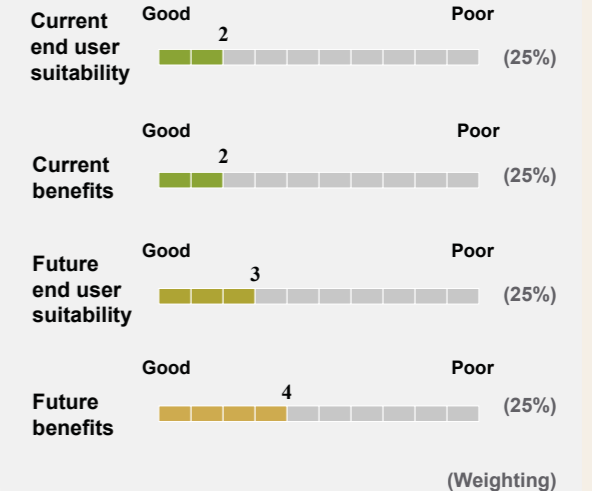
Occupancy



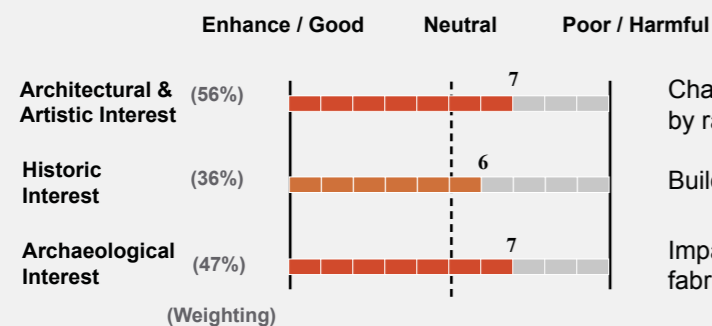
Fully Functional (Green), Non Functional (Red), Disrupted Functionality (Yellow), Non Habitable (Grey)



End User Suitability / Wider Benefits



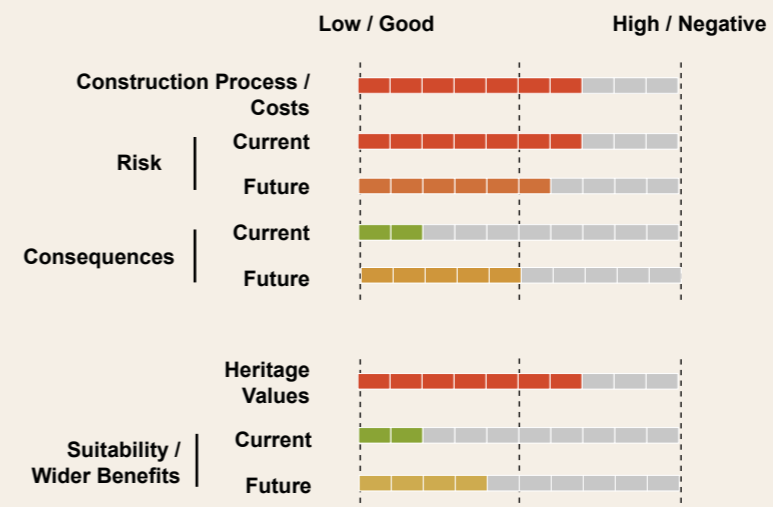
Heritage Values



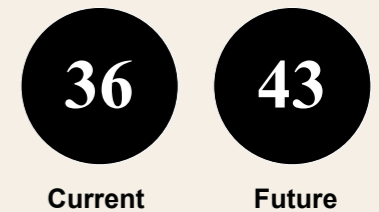
Change of visual appearance but this can be mitigated by raising fencing.

Building will remain in use in the community.

Impact to underground archaeology but the building fabric is not changed



MCA Score





Scenario #11

Make it Amphibious

Figure 47: Scenario #11 © The Environmental Design Studio

Description of the strategy

The building is retrofitted (in its current location) onto an amphibious deck whereby in normal conditions it would stay at its existing level. However, in the event of a flood, the building and its amphibious pontoon would rise up and remain up above from the flood water level. There would be flexible services and guide rails for the deck but these could be integrated into the landscaping / positioned to the rear of the property and away from the street and primary elevation.

Pros:

- The building can remain occupied and habitable before, during and after a flood event.
- The property would have a very high adaptive capacity.
- When in its rested position, access remains largely undisrupted.
- The form and ridge-line of the property would not be significantly affected.

Cons:

- Costs for adaptation could be high.
- Technical complexity to consider.
- The base of the building would need to be significantly adapted.
- Risk of debris getting stuck beneath the building so a hydraulic jack is required to ensure regular checks and tests.

Scenario 11

Make it amphibious

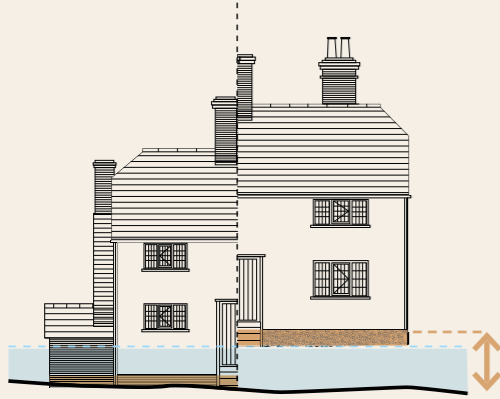
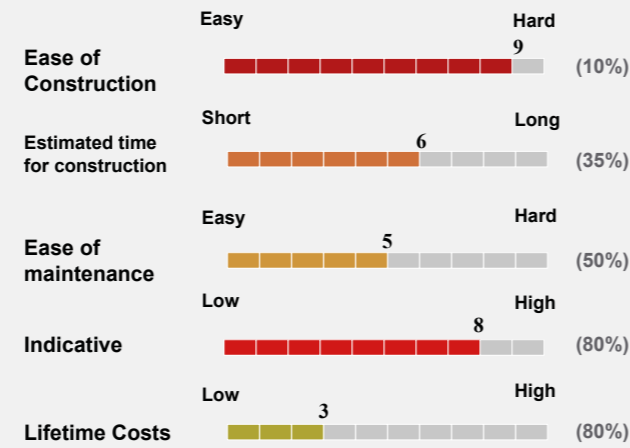
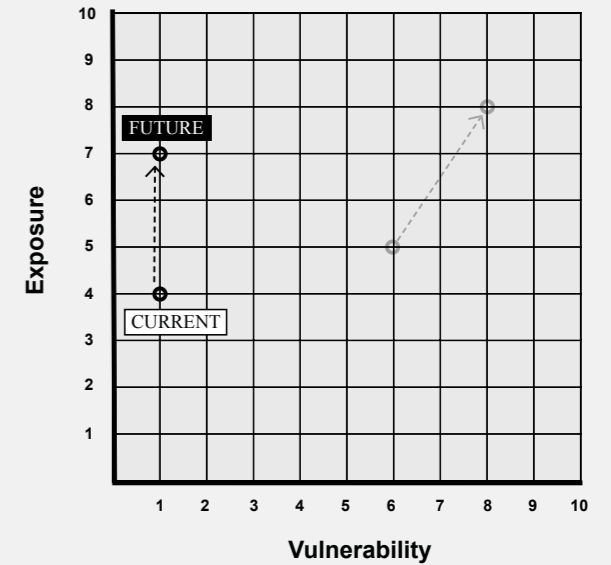
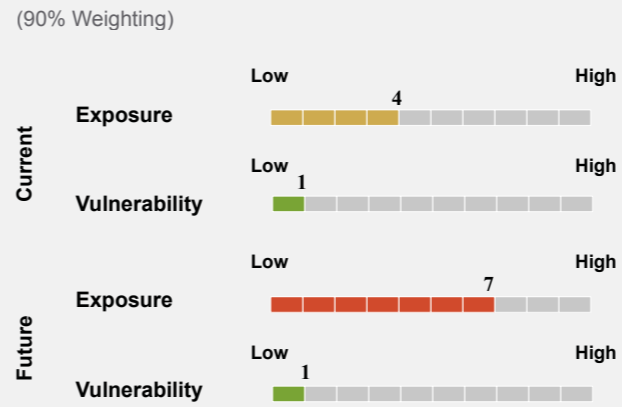


Figure 48: Scenario #11 © The Environmental Design Studio

Construction Process and Costs

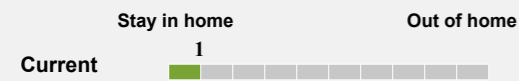


Flood Exposure vs Vulnerability Matrix

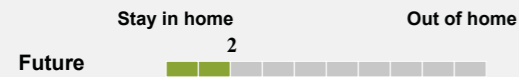


Consequences if Flooded

(90% Weighting)

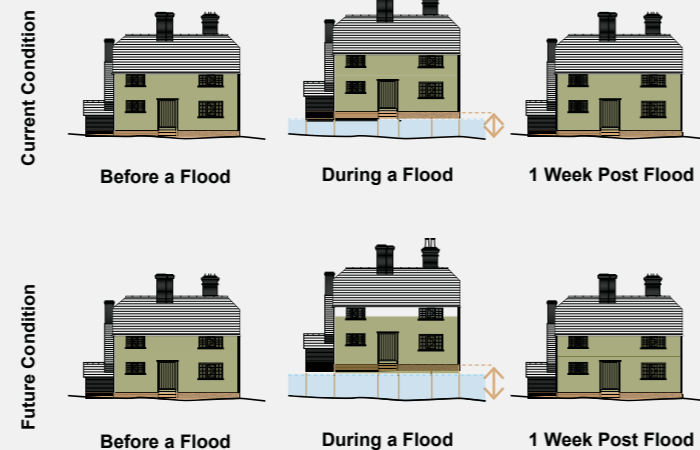


The building rises gradually and as the flood waters recede it returns to its previous level and location.

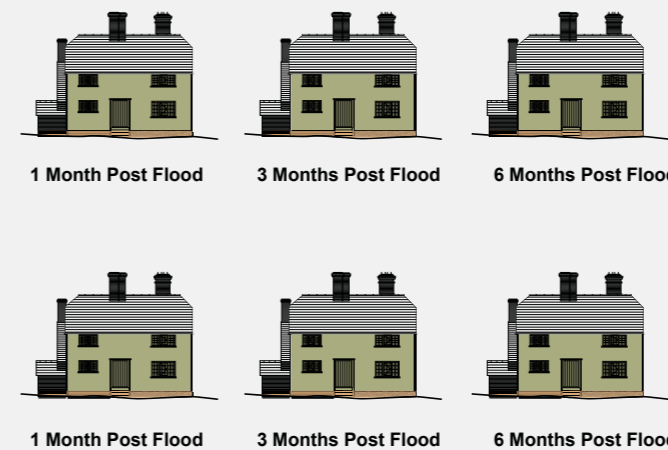


The building rises significantly, access could be disrupted for longer durations but post flood the building has returned to its previous position.

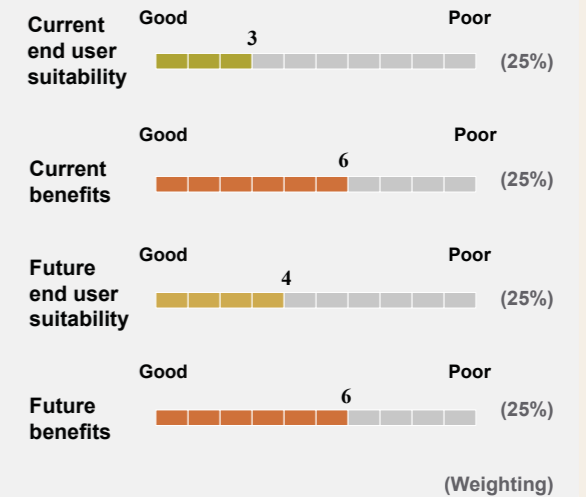
Occupancy



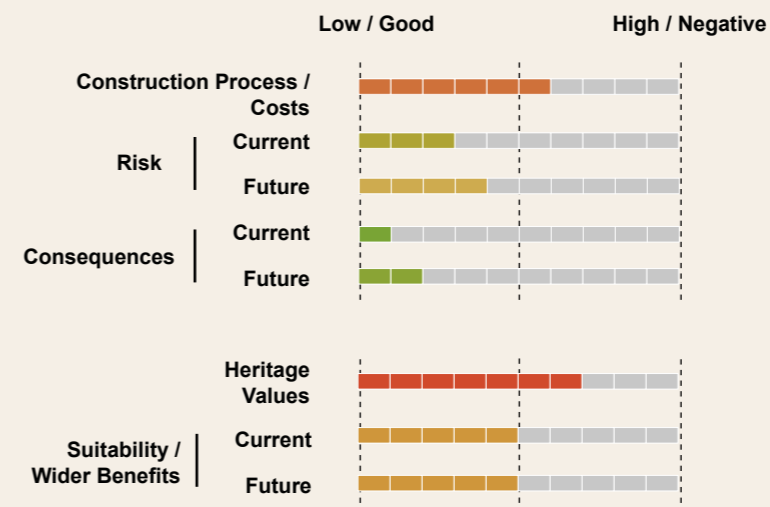
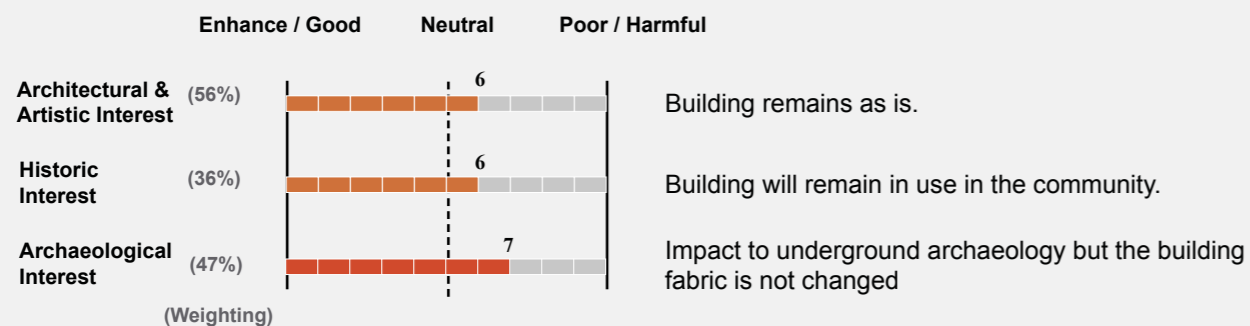
Fully Functional (Green), Non Functional (Red), Disrupted Functionality (Yellow), Non Habitable (Grey)



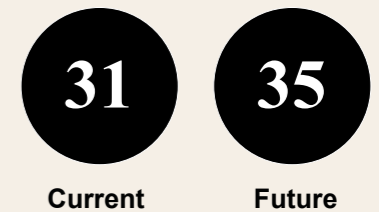
End User Suitability / Wider Benefits

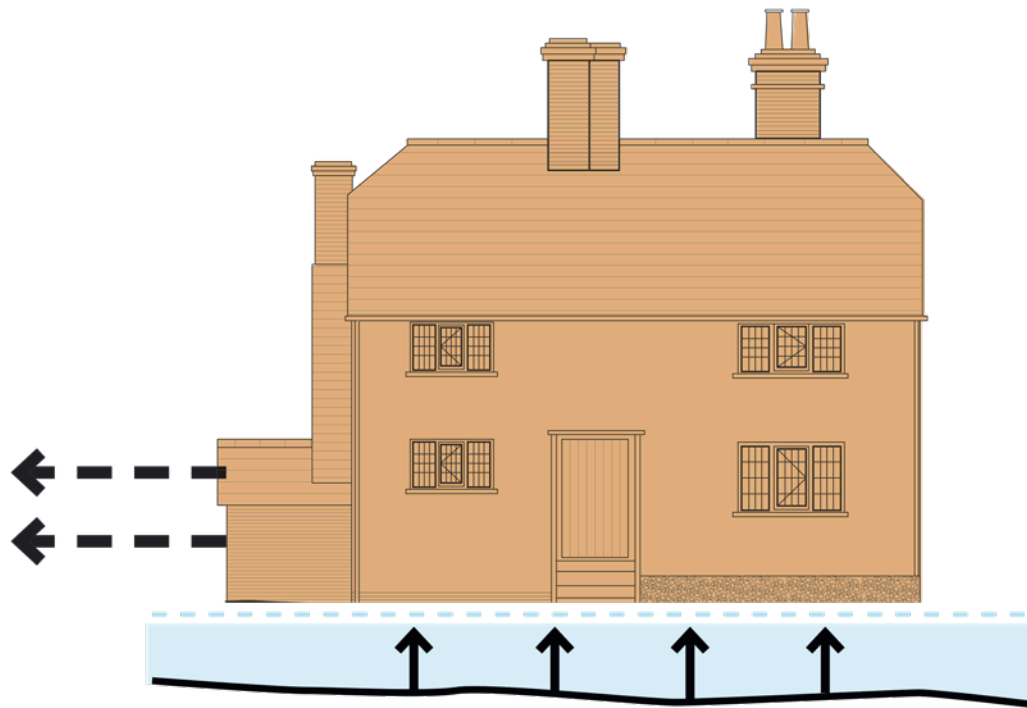


Heritage Values



MCA Score





Scenario #12

Lift / Move the Building to an Alternate Location

Figure 49: Scenario #12 © The Environmental Design Studio

Description of the strategy

The building is lifted and placed on a transport vehicle. It is then relocated to an alternate location with lower flood risk.

Pros:

- Moving the building allows it to be sited in an area of lower flood risk.
- The built form would remain largely undisrupted.
- The buildings historic fabric would not continue to be damaged by flood events.
- The family would experience less floods and therefore less stress and disruption to their lives from the chaos they bring.

Cons:

- Cost would be high.
- High degree of technical complexity involved in the lift and move.
- A new site / location is required.
- The homeowner does not want to leave the area / their plot.
- A historic building would be lost from the streetscape / community.

Scenario 12

Lift / move the building to an alternate location

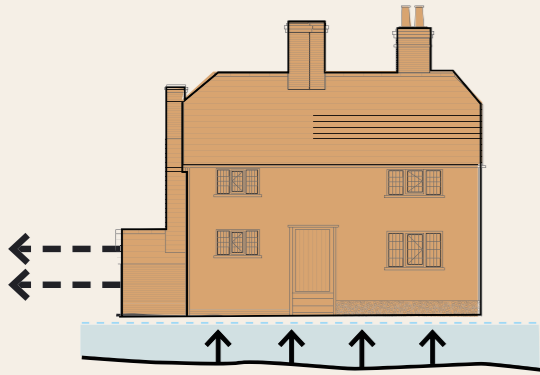
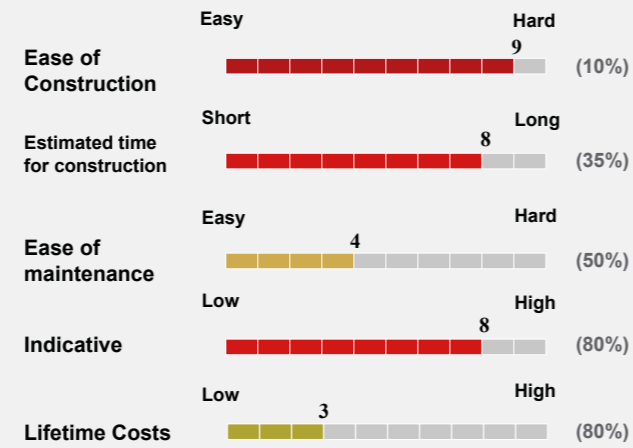
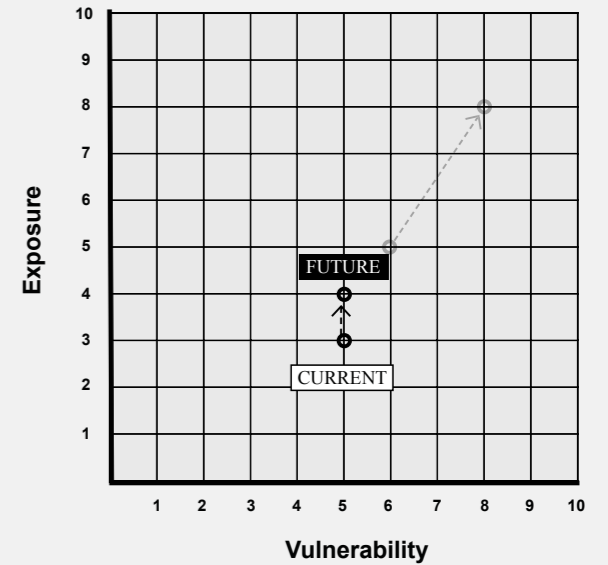
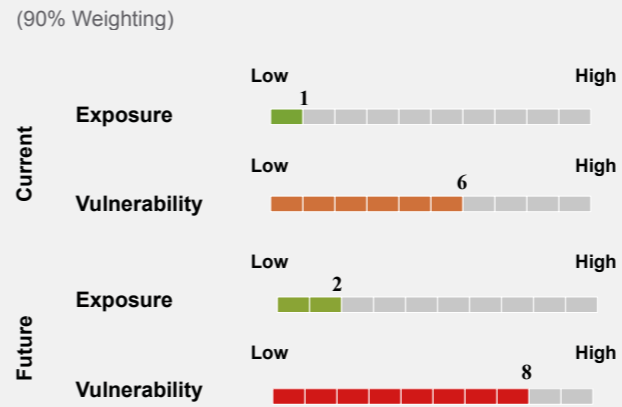


Figure 50: Scenario #12 © The Environmental Design Studio

Construction Process and Costs



Flood Exposure vs Vulnerability Matrix

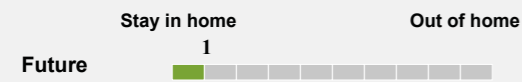


Consequences if Flooded

(90% Weighting)

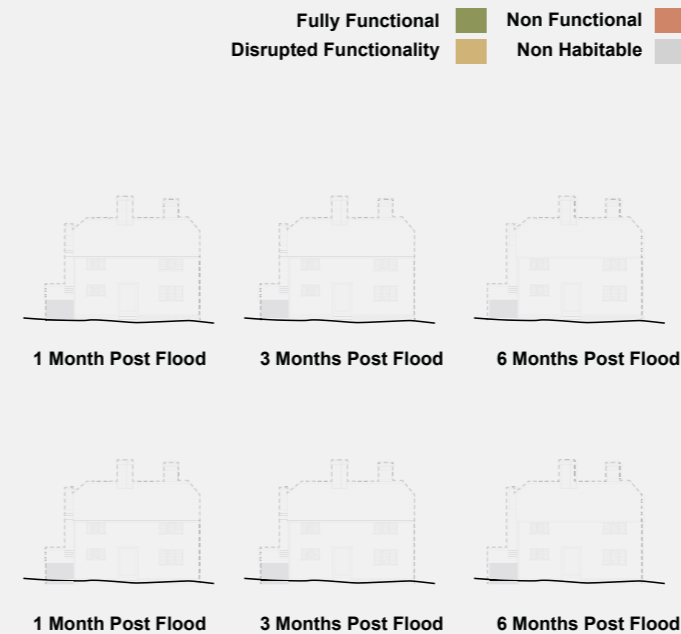
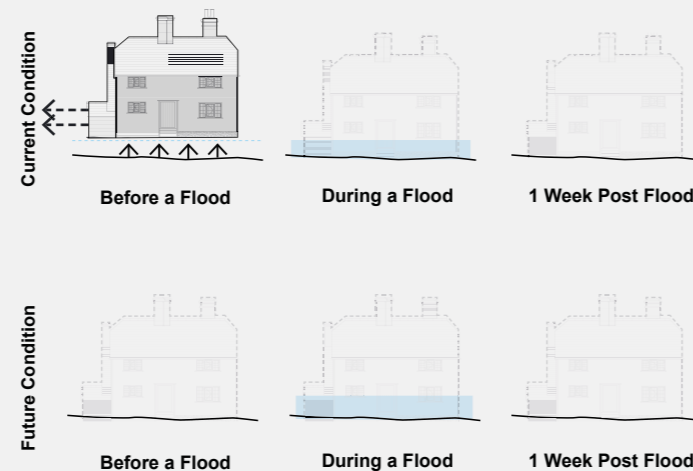


In the building's new location flood risk is low and the structure would be positioned at a level to avoid flood water entry.

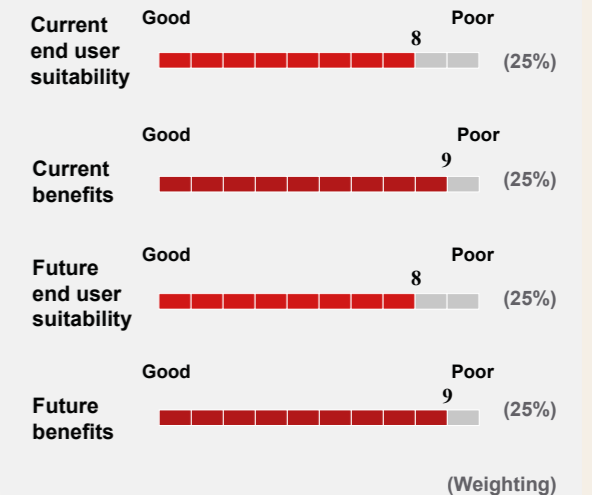


In the building's new location flood risk is low and the structure would be positioned at a level to avoid flood water entry.

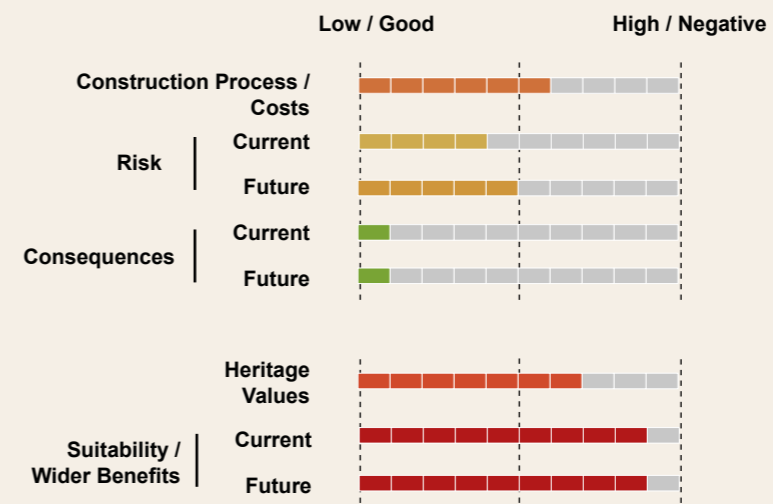
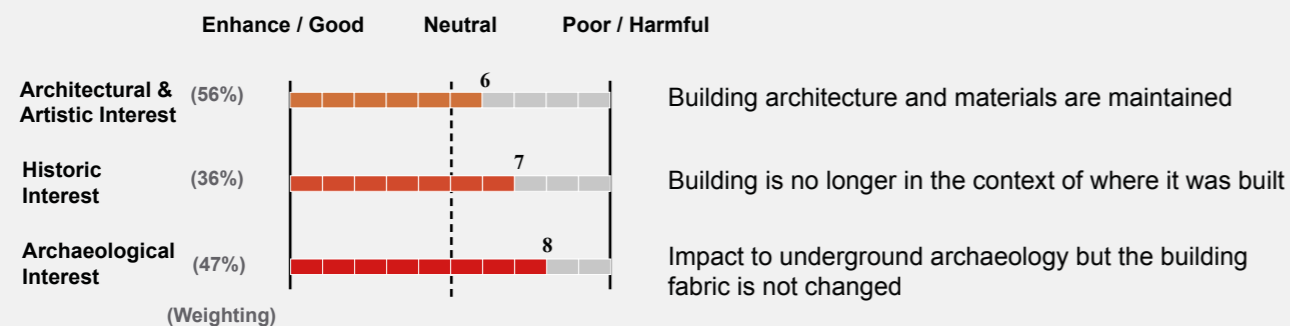
Occupancy



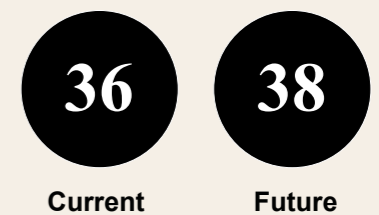
End User Suitability / Wider Benefits

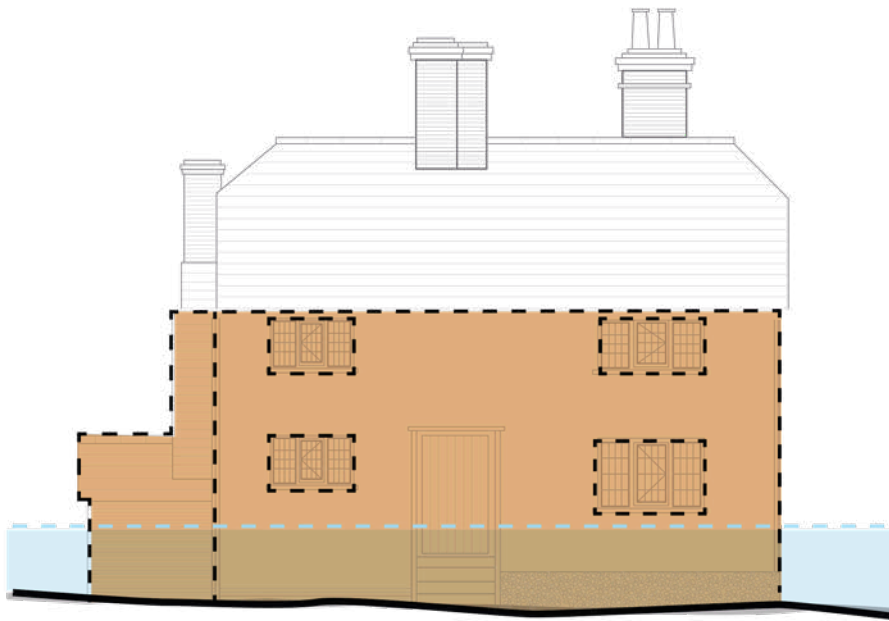


Heritage Values



MCA Score





Scenario #13

Dismantle / Rebuild in an Alternate Location

Figure 51: Scenario #13 © The Environmental Design Studio

Description of the strategy

The building is carefully deconstructed and catalogued. It would then be stored and rebuilt in an alternate location.

Pros:

- The built form can be moved to an area of lower flood risk.
- The buildings fabric can be documented and maintained more easily.
- The buildings historic fabric would not continue to be damaged by flood events.
- The family would experience less floods and therefore less stress and disruption to their lives from the chaos they bring.

Cons:

- Risk of damage to the building's fabric during the process of dismantling/ rebuilding.
- The removal of the building would dislocate it from its original location.
- Significant cost for removal and rebuild.
- The homeowner does not want to leave the area / their plot.
- A historic building would be lost from the streetscape / community.

Scenario 13

Dismantle and rebuild in an alternate location

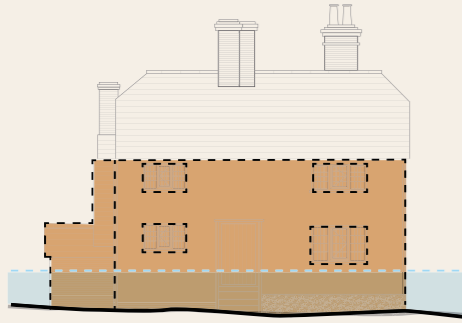
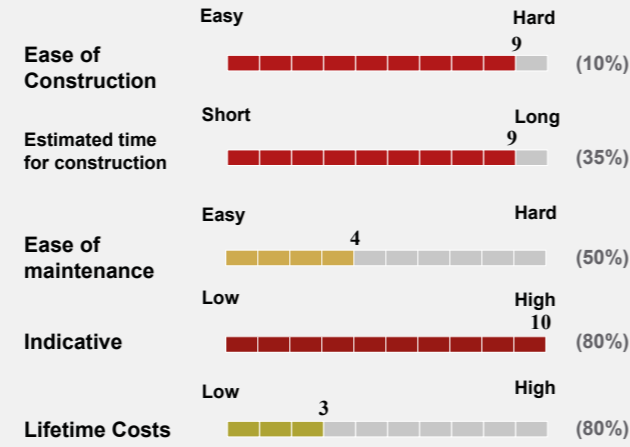
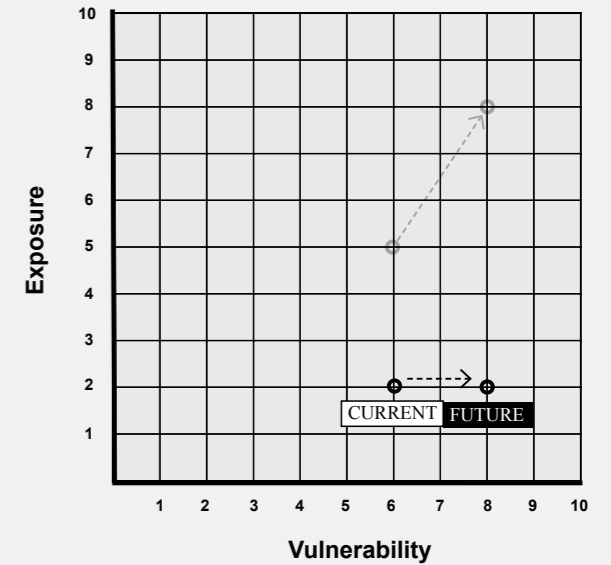
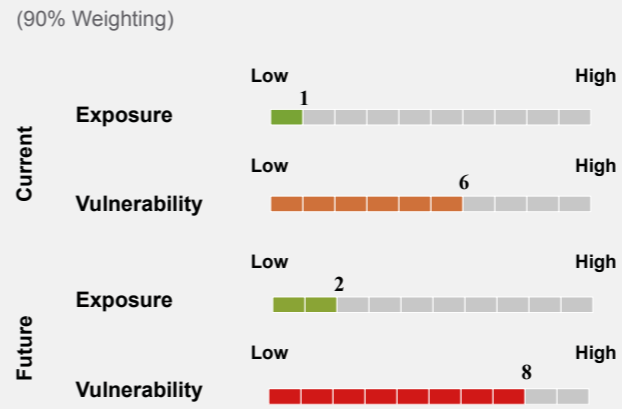


Figure 52: Scenario #13 © The Environmental Design Studio

Construction Process and Costs

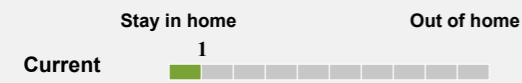


Flood Exposure vs Vulnerability Matrix

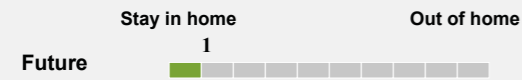


Consequences if Flooded

(90% Weighting)

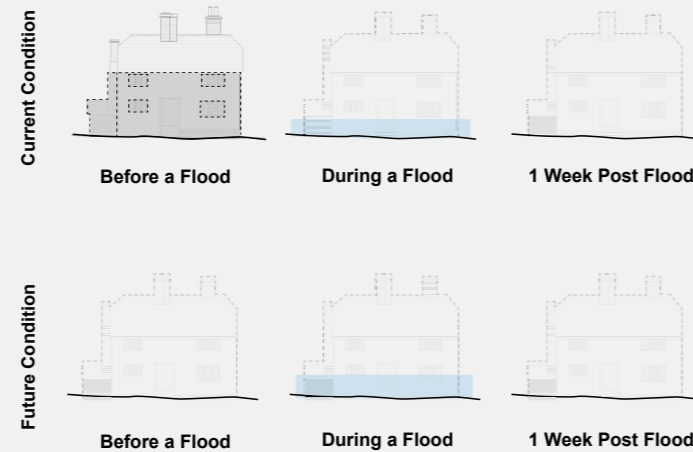


In the building's new location flood risk is low and the structure would be positioned at a level to avoid flood water entry.

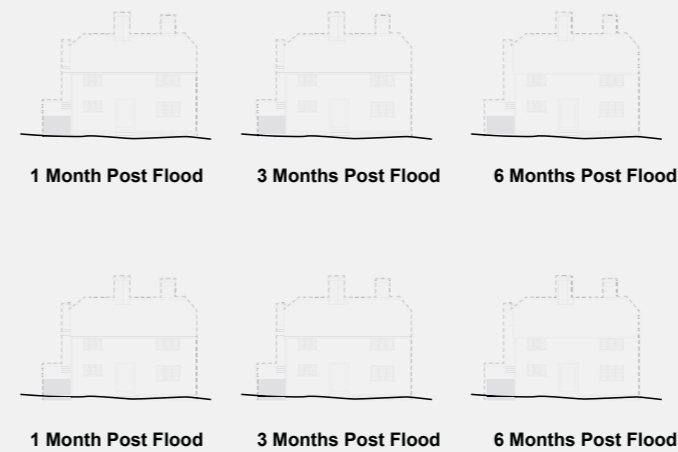


In the building's new location flood risk is low and the structure would be positioned at a level to avoid flood water entry.

Occupancy



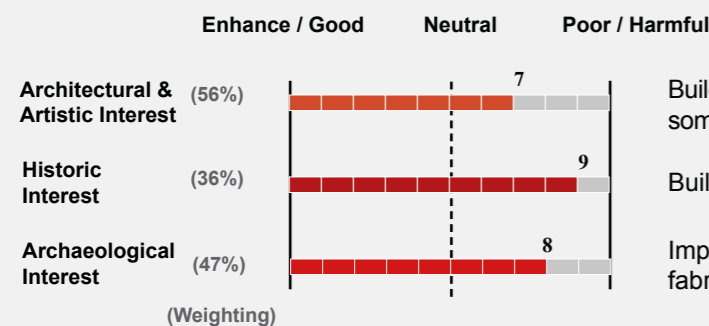
Fully Functional (Green), Non Functional (Red), Disrupted Functionality (Yellow), Non Habitable (Grey)



End User Suitability / Wider Benefits



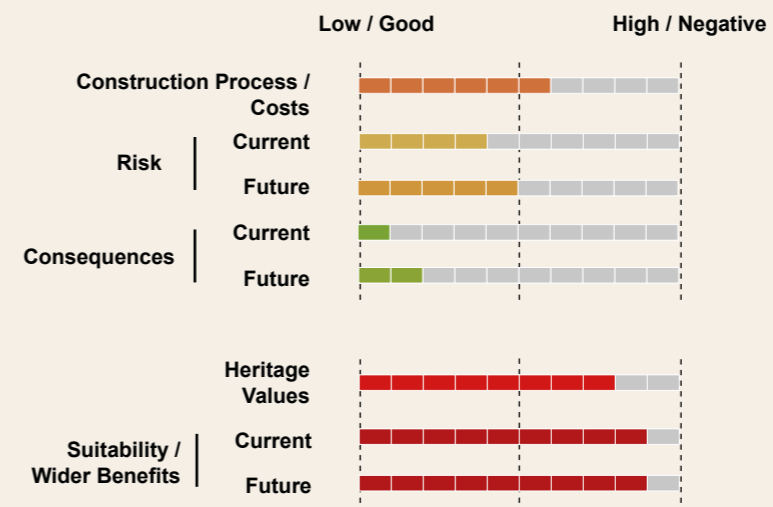
Heritage Values



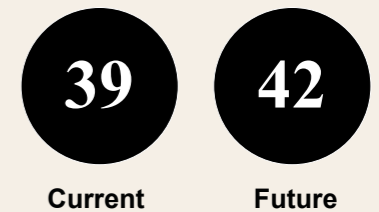
Building architecture and materials are maintained but likely some elements will be damaged or incorrectly rebuilt.

Building is no longer in the context of where it was built

Impact to underground archaeology but the building fabric is not changed



MCA Score





Scenario #14

Knock the Building Down

Figure 53: Scenario #14 © The Environmental Design Studio

Description of the strategy

The building is demolished and all hardstanding removed.

Pros:

- The homeowner does not have to live in a property that is exposed or vulnerable to flooding.
- Enhanced flood storage areas, flow paths and rates of infiltration.
- Cost/carbon associated with future recovery works avoided.

Cons:

- Substantial loss of heritage value.
- Homeowner must move elsewhere.
- Gap in streetscape.
- The homeowner does not want to leave the area / their plot.
- A historic building would be lost from the streetscape / community.

Scenario 14

Knock the building down

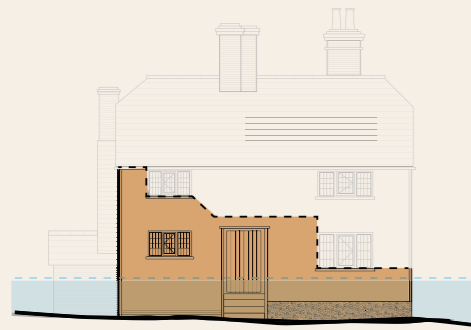
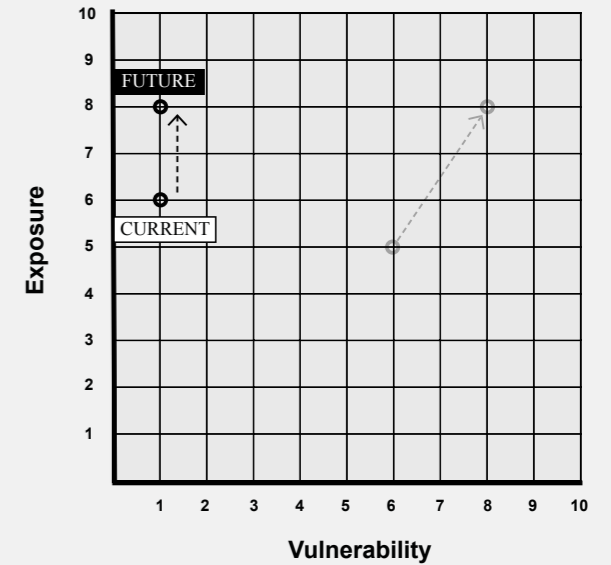
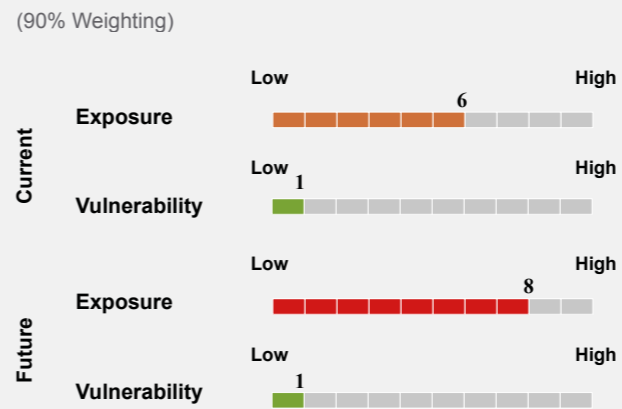


Figure 54: Scenario #14 © The Environmental Design Studio

Construction Process and Costs

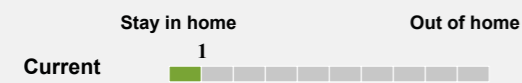


Flood Exposure vs Vulnerability Matrix

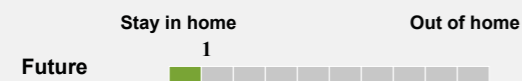


Consequences if Flooded

(90% Weighting)

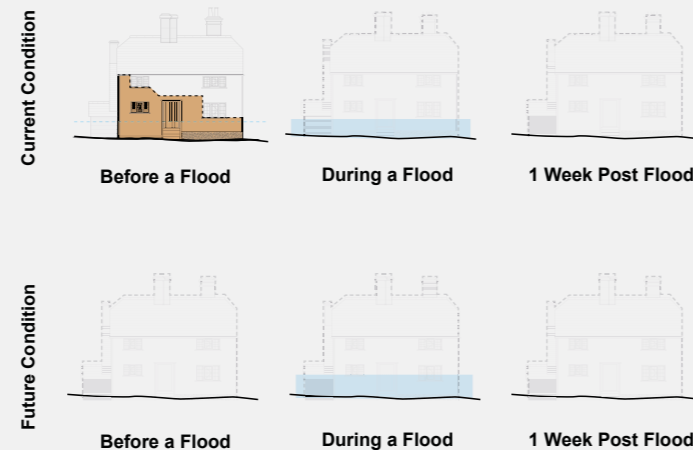


The building no longer exists, the homeowner is permanently out of this home.

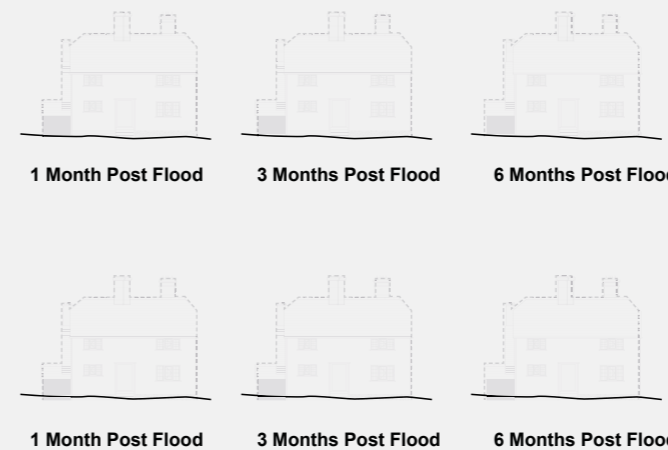


The building no longer exists, the homeowner is permanently out of this home.

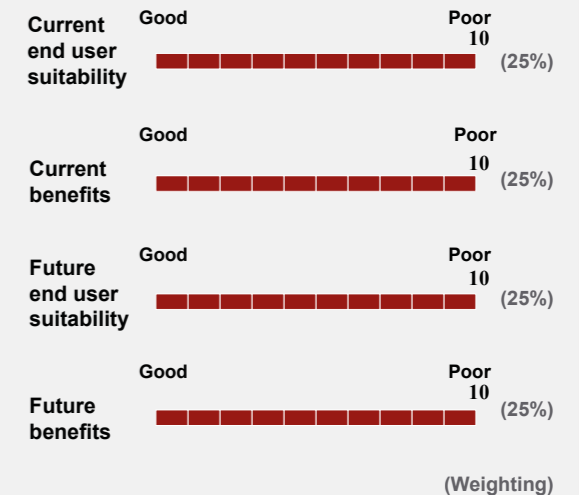
Occupancy



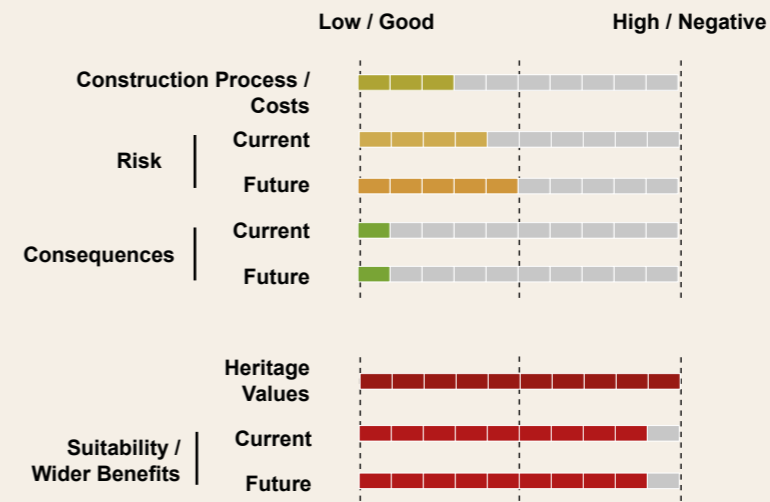
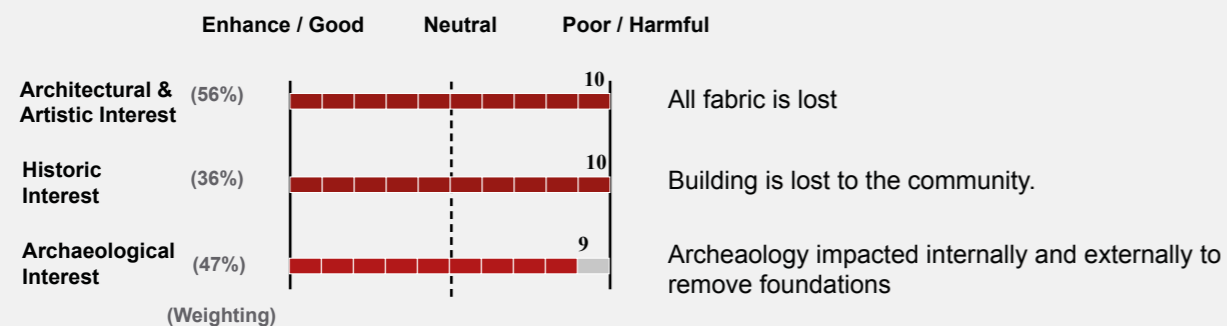
Fully Functional (Green), Non Functional (Red), Disrupted Functionality (Yellow), Non Habitable (Grey)



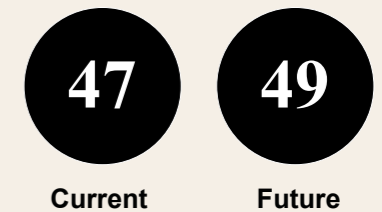
End User Suitability / Wider Benefits



Heritage Values



MCA Score



The Results

The dashboards shown in the proceeding section provide insight on an individual basis, but the full comparisons of scenarios shown in Figure 55 is where the value of this approach and methodology is most evident. What it allows for is a cross comparison between options and strategies. Figure 55 shows the resulting MCDA scores of each scenario for current and future conditions. It is important to remember that these scores have weightings added to them and the results are not decisive but rather enable a more informed position from which is discuss and consider which strategy or strategies to take forward and explore in more detail.

It should be noted that in this context, a low MCDA score is better than a high one. For example, we can see that the future condition of Scenario 4 which looked at 'perimeter protection' scored 50. It was deemed that this intervention would not only have a significant upfront cost (as it would also need to protect adjacent properties) but dire consequences would ensue if the barrier overtopped

and it would have a detrimental impact on heritage values. In contrast, some of the more substantial interventions that relate to vertical adaptation (e.g. Scenarios 6 & 8) have low (good) MCDA scores both now and in the future.

What is particularly interesting to note is the more traditional barrier/resistance and ground floor recoverable based approaches to PFR shown in scenarios 2, 3 and 4 score poorly when it comes to future conditions. That reveals a limitation in the lifespan of those approaches for this specific context, and this provides a useful insight to inform decision making moving forward, particularly in when considering cost, carbon and time and the damage to the heritage asset.

The scores shown in Figure 55 should however not be considered in isolation. When considered in relation to specific criteria such as heritage values or consequences, the results are even more revealing.

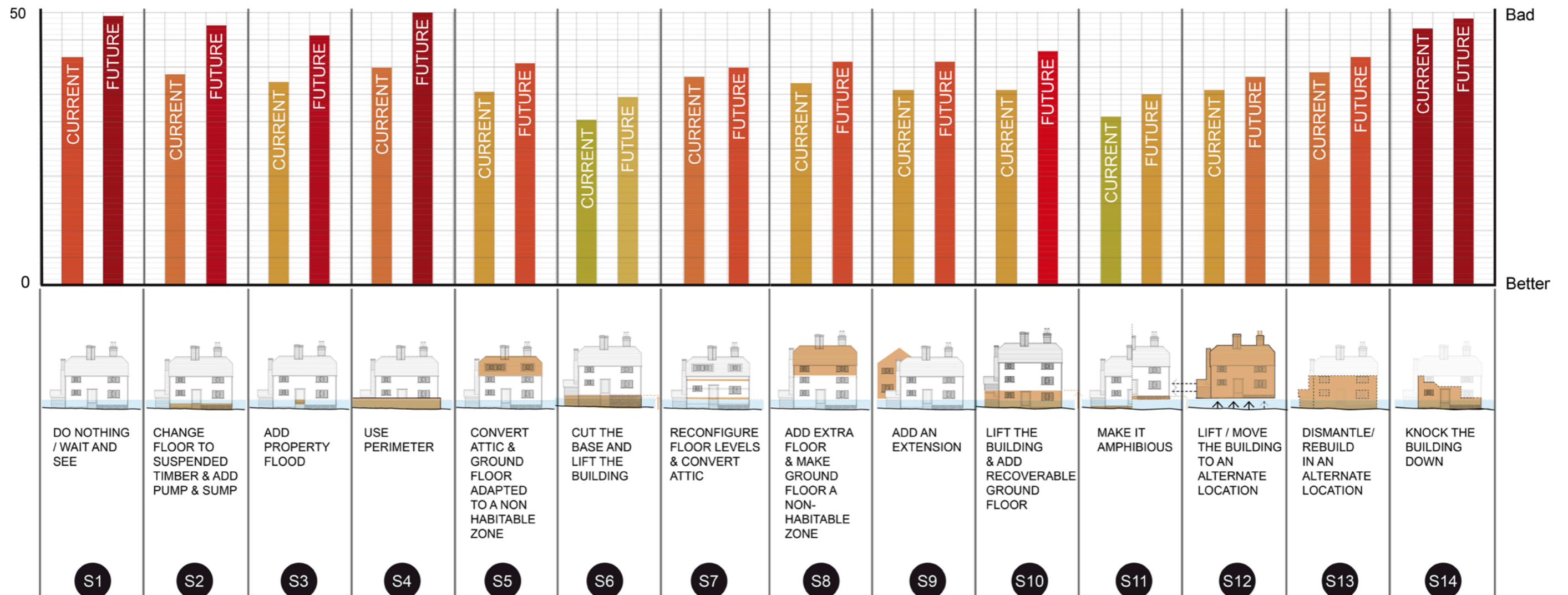


Figure 55: MCA scenarios scores © The Environmental Design Studio

Consequences

Consequences are also a useful criterion for cross comparison between interventions. Scenarios 3 for example (fit resistance-based approaches) may be deemed as having minimal impact on heritage value and be quick / cheap to construct, but in the long term the consequences for the homeowner could be severe and include months out of their home and a perpetual cycle of recovery and reinstatement. This is not what the owner of Lees Cottage, Geraldine had wanted. Conversely, Scenario 4 (Lift the building), would have a larger upfront cost but in the event of a flood either now or in the future the habitable areas of the property would remain in use and the consequences as a result be less severe and long lasting. This scenario also scored well in terms of its MCDA and impact on heritage values as the building's form and fabric would be largely unharmed. Access has however been noted as an issue and would be explored more in future stages of this research.

There are scenarios in which the current consequences are low to medium in severity, but under future climate conditions there could be severe impacts if/when a flood occurs. Scenario 4 is an example of this, a flood wall around the building/site would protect against small to medium floods but if overtopped by a severe flood event the consequences would be dire and flood water trapped inside that space. It is interesting to consider how an adaptation pathways approach would be applied to the selection of these options. There could be a sequence and process of adaptation that makes sense to work through, or it may prove effective to undertake large scale changes sooner rather than later to save lifetime costs, time and disruption.

For scenarios 12, 13 and 14 which show a relocation/removal of the building score low in the consequence as the building is no longer there to flood. They have been set to grey as the considering consequence in these cases is distinctly different. The family would have moved and whilst there may be reduced risk of flooding in the new location, but ultimately the consequence has been relocation.

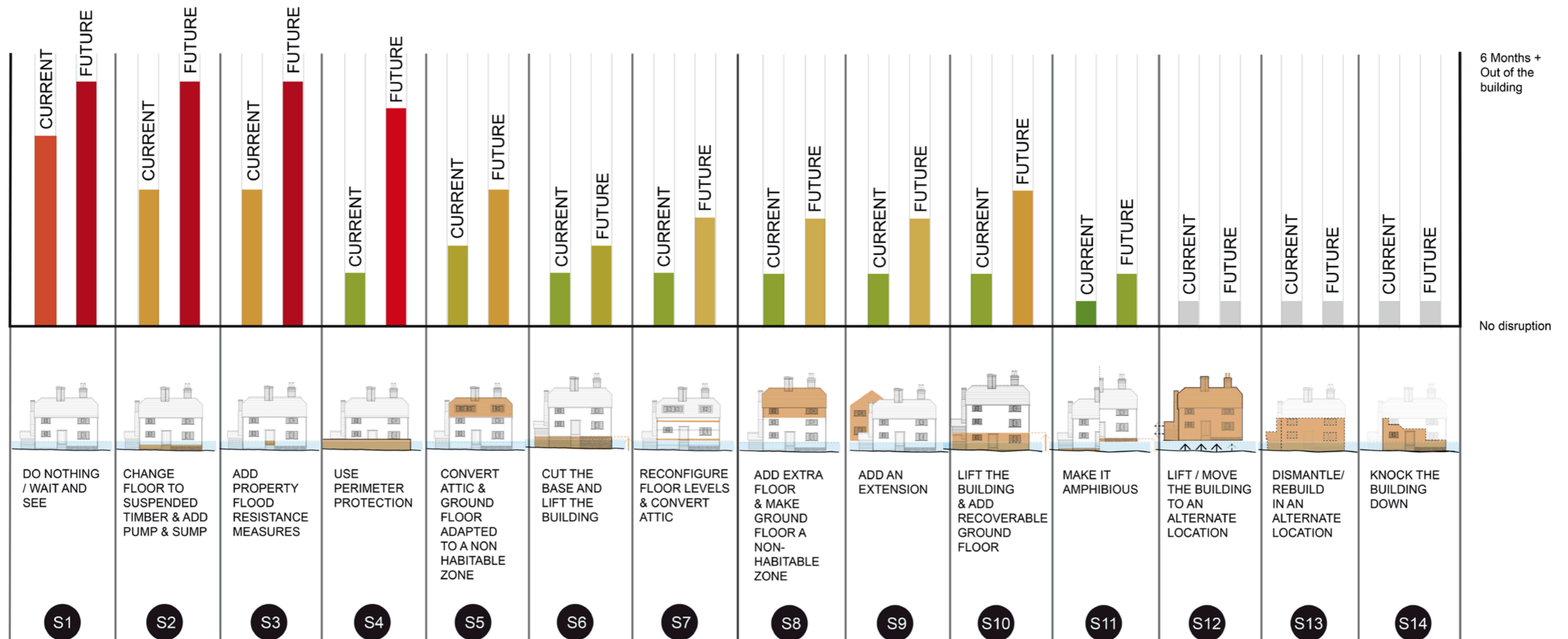


Figure 56: Comparison of scenario consequence scores © The Environmental Design Studio

Heritage Values

In line with the NPPF section 16 (NPPF, 2023) on conserving and enhancing the historic environment, all the scenarios were assessed against three heritage interests; Historic, Archaeological, Architectural & Artistic. The expert panels reviewed the scenarios and assessed the impact on significance as if these were real proposals. What was identified early on was that a historic survey of the property as well as a site visit would have been beneficial. It was noted that it would have been easier to assess the impact to the building via the original conservation

principles used pre-2019. Furthermore, no scenario resulted in a positive change to the building's heritage interests from its current state, but many did improve the situation it would be in under future climate conditions if the 'do nothing' approach continued.

A strategy such as scenario 5 (convert the attic) scored well in the overall MCDA ratings but is shown in its score to be more harmful in terms of the impact on significance and heritage values as it would require a major change to the built form and its historic setup. This approach for cross-comparison of factors opens a dialogue to help us consider these often-disparate topics and themes.

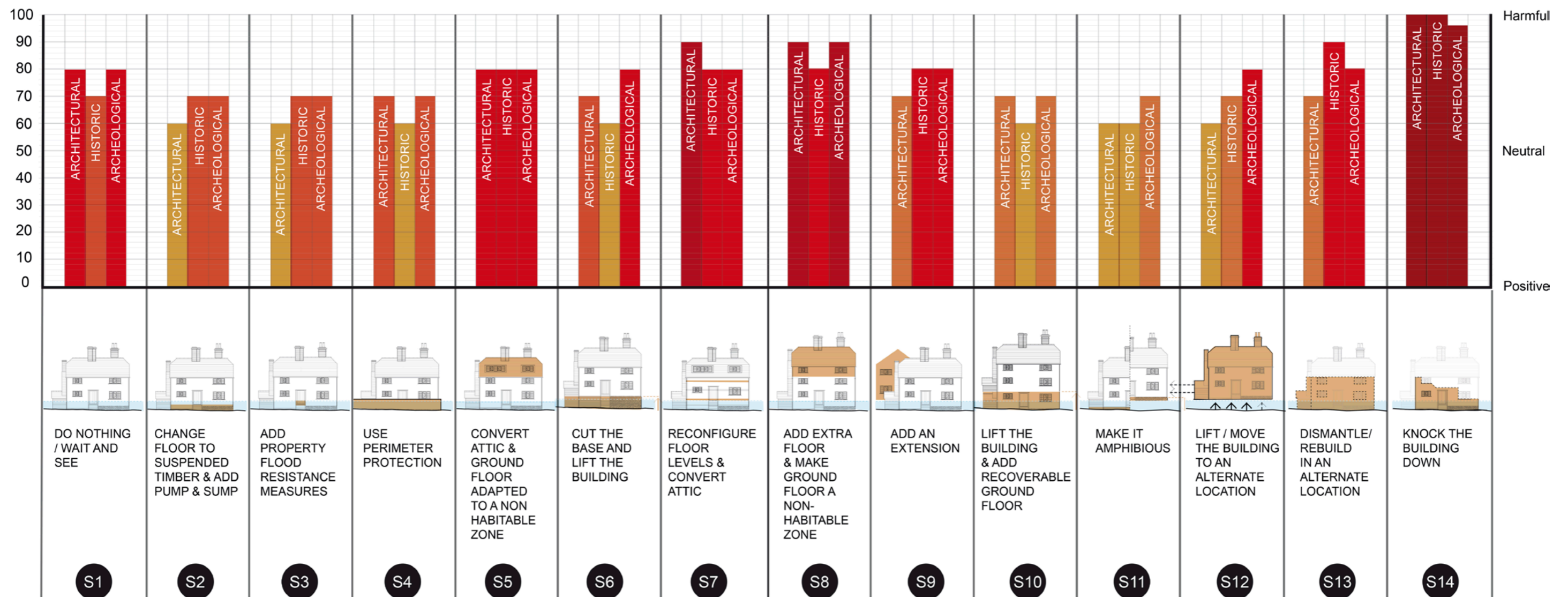


Figure 57: Comparison of scenario heritage value scores © The Environmental Design Studio

Limitations of the study

Within this study, none of the options have been specifically assessed against structural capacity/ capabilities, or the impact of force from flood and debris to the design, which then links into the building's lifetime expectancy and maintenance cost.

Scoring and weighting was found to be harder when adopting the more recent NPPF definitions rather than using conservation principals. For example, the new weighting made it more difficult to separate the impact of above and below archaeology, thus the weighting and scoring may have been different all together using the previous four principles.

A further limitation with scoring was the lack of information about the building's history and whether modern or original materials are present and where they were.

Subsequent studies would include a review of the building's materials and history in more detail and a site visit by the expert panel who helped scored the impact on significance of each scenario.

Key Findings

The value of this approach

This study has been propositional and experimented with new and novel approaches for design research in this field. The trans-disciplinary team and methodology has proved highly effective, and the study extremely well received when presented at the Historic England Technical Tuesday event and at Flood and Coast 2023.

The research methodology that has been developed has enabled multiple factors influencing and approaches to PFR to be considered. Exploring a more diverse range of spatial has revealed that there are options to consider beyond the standard off the shelf, business as usual product-based approaches to PFR, and that these changes can in specific circumstances be beneficial choices to explore.

The design research methodology used throughout this study has proved effective in not only drawing out the key themes and information from the stakeholders and location, but it has also brought together professionals from different sectors and backgrounds to discuss and consider climate change will impact a heritage building and how it could be adapted.

Barrier to adaptation

Knowledge gaps

A knowledge gap that became evident through the semi-structured interviews was that the conservation officer who reviewed the case file, was not a flood specialist and conversely the flood specialist was not a building professional with a specific knowledge of conservation principles or heritage properties. This disjoint led to problems during the selection and specification of PFR measures for Lees Cottage during the Middle Medway Flood Resilience scheme and for many other properties in Yalding. If prevalent elsewhere, this is a major issue limiting appropriate and contextual adaptation. Materials like tanking are being specified for use on a traditionally constructed building, which is often not appropriate. This is a broader issue than just heritage buildings.

The suggestion is that those professionals undertaking either flood risk assessments or property surveys must have training in working with historic buildings and conversely, the conservation officers must be trained in PFR.

Scope of strategies

The PFR approaches considered in the Middle Medway Flood Resilience scheme were primary 'product' and 'resistance' based (e.g. flood barriers). However, the results of this, the PFR Outliers Study show the value and need for further exploration of more holistic, whole house, building scale approaches to PFR. In this specific context, many of the avoidance-based approaches to PFR had a lesser impact on the significance of the building and reduced consequences should a flood occur (both now and in the future). The flood water depths that have affected (and will affect) Lees Cottage are significant (1m+) and that has certainly meant the results are more favourable when it comes to avoidance-based approaches. Deployable flood barriers are however often 60cm tall, and flood skirts 120cm. We can make properties more flood recoverable, but when water levels inside a building begins to exceed 1-1.5m+ there are limitations as to how much things can be raised and made resilient. It is in these instances that avoidance-based approaches can come to the fore as they provide a larger margin of safety and enable greater adaptive capacity. Further research should look to include analysis, case studies and costs for structural lifting, the use of pre-fab loft conversions for vertical adaptation and the ways in which a variety of property typologies can be reconfigured to be more future flood proof.

Behaviour Change

When it comes to adapting the built environment to be more flood resilient, it is important to understand the full suite of possible options and not just discount a building as 'impossible to adapt' or save because of its construction material or listed status. Behaviour and mindset change is needed in the way in which we work with heritage properties and buildings of traditional construction. It is important to recognise that many listed and historic buildings have been adapted over the years in order to cater for changing cultural and climatic conditions as well as its user's preferences. Lees Cottage has had a 50% extension to its eastern elevation and would not have previously had heating and electricity within it. The building itself is raised on a plinth and signals to an awareness of the risk posed by the rivers that run through the village. The timing of when to adapt is important to consider. The upheaval and disruption caused by construction works is never normally convenient, but this an issue but happens anyway when floods occur. If plans for PFR can be discussed and considered pre-emptively then there will be less time needed post flood to react to the situation and make difficult decisions at a time of crisis. For many properties there is a need to improve their energy efficiency and PFR should go hand in hand with the planning and timing of these changes.

Funding

It is excellent that in the UK, 'Build Back Better' exists (via Flood Re) and up to £10,000 can be used to make a property more flood resilient post flood, but this mechanism is still reactive rather than proactive. In the case of Lees Cottage, it costs £75k to reinstate the building (in a vulnerable way) after the first flood and £85k after the second. Therefore, £160k was spent without significant and long-lasting improvement to its flood resilience setup. Those two floods occurred within 10 years and if that repeated itself over the coming decade then it would be yet another £160k for reinstatement post flood. If even £70k was proactively spent on adapting the building to be significantly more flood resilient (by for example enacting scenario 4) then the consequences and reinstatement cost after each flood would be minimal, the house price could improve and crucially there would have been less stress and disruption caused by floods on Geraldine and her family.

Conclusions

The scenarios developed through this study showcase the wide range of ways that this specific heritage building (Lees Cottage) could be made more flood resilient. As the scores and commentary throughout this report show, not all of them are appropriate and in every situation context is key. It is never appropriate to simply copy and paste a strategy or idea from one place to another. It must suit the people and the place.

As mentioned previously, if commissioned, subsequent phases of the study could explore:

- Cost – Employ a MRICS Quantity Surveyor to accurately calculate the cost of different adaptation measures to identify what are financially realistic options.
- Carbon – Employ someone with the experience of the RICS Whole Life Carbon Assessment to calculate the amount of carbon emitted and used for each of the proposed adaptation scenarios. Whilst also considering the embodied carbon of the existing building.

This research has provided Historic England with a methodology that could work in identifying and assessing different approaches to historic buildings against different climate change risks.

Special thanks

A special thanks goes to Geraldine and Ken for welcoming the project team into their home and sharing their story with us. What this study has shown is that the situation they are in at Lees Cottage (with regards to its flood risk) is not insurmountable. There are ways in which the building can be adapted to have minimal flood damage, remain habitable for the long term without drastically impacting the significance of the building.



Historic England's Research Reports

We are the public body that helps people care for, enjoy and celebrate England's historic environment.

We carry out and fund applied research to support the protection and management of the historic environment. Our research programme is wide-ranging and both national and local in scope, with projects that highlight new discoveries and provide greater understanding, appreciation and enjoyment of our historic places.

More information on our research strategy and agenda is available at HistoricEngland.org.uk/research/agenda.

The Research Report Series replaces the former Centre for Archaeology Reports Series, the Archaeological Investigation Report Series, the Architectural Investigation Report Series, and the Research Department Report Series.

All reports are available at HistoricEngland.org.uk/research/results/reports. There are over 7,000 reports going back over 50 years. You can find out more about the scope of the Series here: HistoricEngland.org.uk/research/results/about-the-research-reports-database

Keep in touch with our research through our digital magazine Historic England Research HistoricEngland.org.uk/whats-new/research