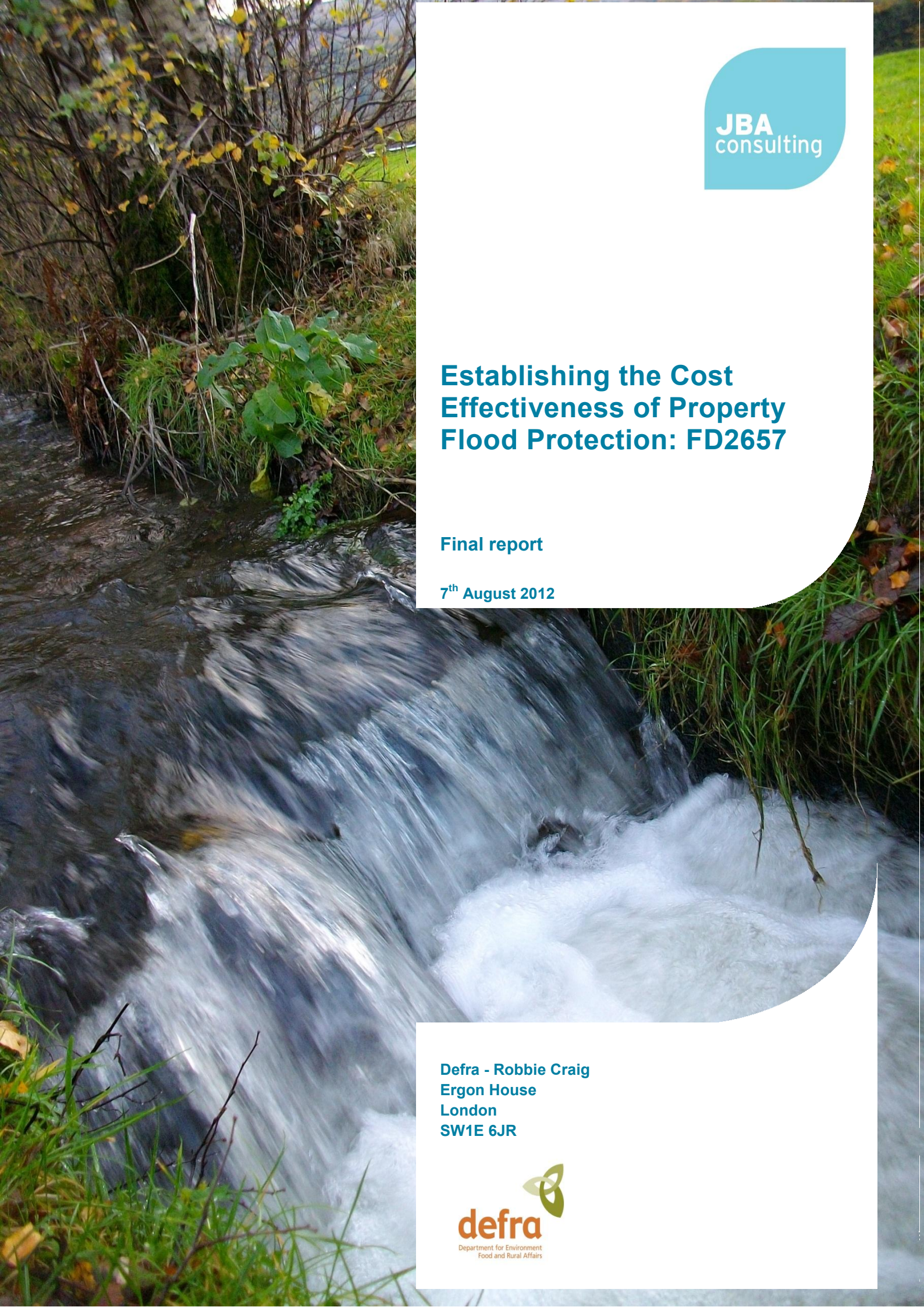

Establishing the Cost Effectiveness of Property Flood Protection: FD2657

Final report

7th August 2012

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Contract

This report describes work commissioned by Kerry Whitehouse, on behalf of Defra, by a letter dated 11th January 2012. Defra's representative for the contract was Robbie Craig in Flood and Coastal Erosion Risk Management. Peter May led this work on behalf of JBA Consulting in partnership with Dr. John Chatterton of J.B. Chatterton & Associates.

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Purpose

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Executive Summary

This report presents the evidence and findings from an economic and financial analysis of the cost of installing property-level flood protection. The study takes account of the findings from an evaluation of the 2 year Defra Property-level Flood Protection Grant Scheme as well as recent policy changes and the introduction of Partnership Funding.

A new and extended model has been developed that builds on the strengths of a previous study undertaken by Entec UK in 2007-08. It incorporates the latest data on the economic damages from flooding and the costs and benefits of a range of flood protection measures, updated to a 2011 price base perspective. The introduction of innovative, automatic (or passive) protection measures are compared to manually deployed measures. Factors such as the service life and reliability of such systems have also been addressed.

Assumptions on damage savings have been re-visited and improved, using the 2010 Multi-Coloured Manual data. Additional damage-saving categories have been incorporated, including emergency costs and the cost of electricity during the post-flood drying out process. The wider social impacts of flooding and the intangible health and well-being benefits and reduced levels of stress that can be gained from property-level flood protection are also considered. The introduction of such measures can help to reduce the severity of these losses compared to an unprotected property. It is also important to recognise that, unlike a traditional flood defence scheme these measures do not alter the likelihood of floodwater reaching the property. They do however aim to manage the consequences once this happens.

Financial and economic models have been developed to analyse the costs relative to the benefits of six packages of flood resistance and resilience measures. These have been applied to a wide range of property types, for various levels of social deprivation and for different thresholds of flooding. Improvements and extensive revisions have been made to the previous economic model developed in 2008, to provide for an interactive model that can be used to explore the impacts of altering a range of key variables. Further analytical tools have also been suggested that could provide a simple to use spreadsheet tool that could also contain spatial links using GIS to help local authority scheme appraisal decisions.

The analysis has been extended to explore the implications of applying the new Partnership Funding approach, to determine and make comparisons between over 22,000 possible scenario outcomes, made in terms of benefit cost ratios and typical Partnership Funding Outcome Scores. This has provided an assessment of cost effectiveness and the approaches that could qualify for government funding, together with the levels of contributions that might be necessary from developers or home owners for a scheme to proceed.

The study finds:

- Compelling evidence for the cost effectiveness of manually deployed flood resistance measures, with high benefit cost ratios and high Partnership Funding Outcome Scores for typical flood thresholds of up to 2.5% annual exceedance probability (1 in 40 year).
- The higher cost of Automatic Resistance measures results in lower benefit cost ratios but there are still significant cost effective opportunities for schemes with appropriate levels of contribution, but at typically lower flood thresholds of 5% annual exceedance probability (1 in 20 year).
- The high cost of resilience measures indicates that these are a less cost effective option for Government intervention, unless flooding of a property occurs at greater than a 20% annual exceedance probability (1 in 5 year).
- Manual Resistance measures are more than twice as cost beneficial as automatic measures, achieving some very high benefit cost ratios.
- The effects of reliability have been examined but found not to have significant impacts on the overall outcomes.

This analysis has assessed the new Partnership Funding arrangements and identified the range of scenarios that are cost effective. The study will help provide evidence to inform Government policy on mainstreaming property level protection within the flood protection budget, funded on a Partnership Funding basis. It will help confirm those elements of

property-level flood protection that are most cost effective and that provide an important new approach within the wider flood risk management hierarchy.

Approaches to the use of property-level protection across the UK as a means of managing flood risk have been reviewed. An early pilot grant scheme was launched by the Welsh Government in Wales back in 2004 and although this generated considerable interest and demand, few schemes were completed at the time (due perhaps to resource constraints). The scheme was discontinued although Environment Agency Wales has been providing measures free of charge to communities in some areas but retaining these as Agency assets which are then maintained and inspected annually by the Agency. The Welsh Government is considering adopting the approach once more, as part of the overall flood management strategy. Partnership Funding has not been adopted in Wales.

The approach for scheme delivery being followed in Scotland is different again, combining a facilitating and encouraging role of the Scottish Flood Forum with financial support provided by the local authority of 60%. An agreement is reached with residents to contribute the remaining 40%.

The Environment Agency's evaluation of the 2009 to 2011 Defra Grant Scheme suggested that there are inherent differences between community level flood protection and property level protection:

- Property-level protection schemes do not change or alter the actual likelihood of a flood that properties are exposed to; and
- There is a much lower capital investment required to implement these schemes and provide people the opportunity to manage the consequences of flooding in areas where costly flood defence schemes cannot be justified.

As a result of these important distinctions, it is considered that the two approaches offer quite different responses to managing flood risk and that this should be reflected in the appraisal process. Property-level protection provides lower standards of protection than a capital community defence scheme, but greatly improved standards than can be gained from just using sandbags alone. By focusing on managing the consequences once flood water has reached a property, residents still have the worry and stress of the impacts this could cause. This contrasts markedly with those communities who benefit from defence schemes that are designed to retain floodwater some distance away from the community and in so doing, reducing the likelihood and consequences of flooding. Residents therefore have to be prepared for flooding and must recognise that flood damage can still occur, but to lower levels than would be experienced with either sandbags or if there was no protection whatsoever.

Residents benefitting from property-level protection measures report increased 'peace of mind' from such schemes, which also help raise levels of flood awareness and local community cohesion. Such schemes help to encourage individuals and communities to take greater responsibility and to consider what actions they can take to reduce the damage and stress caused by flooding. This should also help to keep insurance premiums down in the future as well.

Property-level protection provides an effective and accepted new approach for managing flood risk in the hierarchy of management interventions.

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Abbreviations

ABI ..... Association of British Insurers
AEP ..... Annual Exceedance Probability
ASC ..... Adaptation Sub-Committee
BCA ..... Benefit Cost Appraisal
CCC ..... Committee on Climate Change
CIRIA ..... Construction Industry Research and Information Association
CPI ..... Consumer Price Index
ECLAC ..... Economic Commission for Latin America and the Caribbean
FHRC ..... Flood Hazard Research Centre
FPA ..... Flood Protection Association
GIS ..... Geographic Information System
MCM ..... Multi-Coloured Manual
NaFRA ..... National Flood Risk Assessment
NRD ..... National Receptor Database
NRV ..... Non-return Valve
OM ..... Outcome Score
PF ..... Partnership Funding
PFRA ..... Preliminary Flood Risk Assessment
PLP ..... Property-level Flood Protection
PV ..... Present Value
SME ..... Small and Medium Enterprise
SoP ..... Standard of Protection
WAAD ..... Weighted Annual Average Damages

1 Introduction

1.1 Purpose of Study

Defra commissioned JBA Consulting to undertake an analysis of the costs and benefits of providing property-level flood protection measures to existing residential properties. This study commenced in January 2012 and was required to inform the developing policy for property-level flood protection as this approach becomes an established option for managing local community flood risk.

The study updates and revises an earlier Defra research project completed in 2008[1] (FD2607) and follows directly on from the related evaluation of the Defra property-level flood protection Grant Scheme carried out by JBA Consulting for the Environment Agency (EA 25918[2]).

This research has been carried out alongside, and is closely associated with, a related project "Assessing the Economic Case for Property Level Measures in England" being undertaken for the Committee on Climate Change (CCC) Adaptation Sub-Committee (ASC) by Royal Haskoning. Since part of that project has also been considering the costs and benefits of property-level flood protection measures, care was taken to ensure effective communication and knowledge sharing between the two studies, to provide both consistencies and efficiencies in delivering these two research projects. In particular, consistent assumptions were made over the range of benefits assigned to property protection, as well as shared information over the costs and types of resistance and resilience measures. Both studies have benefitted from the fact that J. Chatterton Associates have had a direct involvement in developing property-level protection models for both research projects. They also helped develop the original 2008 model as well, thereby bringing experience and understanding as well as efficiencies to this research.

The Defra model (FD2607) was made available and is central to both projects whilst these have also built upon a further research report commissioned by the Adaptation Sub-Committee by Davis Langdon in 2011[3] to assess property-level measures.

The report presented here outlines the scope and programme of the cost effectiveness project, describes the objectives and approach that were adopted, presents the findings and output from the model and makes recommendations for future appraisal and property-level flood protection practice.

1.2 Objectives

The evaluation of the 2009 - 2011 "Property-level Flood Protection Defra Grant Scheme" has shown there is a need to undertake a more detailed and comprehensive benefit cost analysis of fitting property-level flood protection measures. Defra require a study that assesses the cost effectiveness of property protection measures for a range of residential property types exposed to different severities of flood risk

The study objectives are:

- To inform the mainstreaming of property-level flood protection into Government policy alongside Partnership Funding.
- To update the existing economic evidence base and review new evidence.
- To provide an independent economic appraisal from a national perspective and a financial appraisal from a householder's perspective and assess the full suite of direct

[1] Defra (2008) Developing the Evidence Base for Flood Resistance and Resilience: Entec.
[2] Environment Agency (2012) Evaluation of the Defra Property-level Flood Protection Grant Scheme: JBA Consulting.
[3] Committee on Climate Change Adaptation Sub-Committee (2011) Research to identify potential low-regrets adaptation options to climate change in the residential buildings sector: Davis Langdon.

and indirect benefits from different kinds of property resistance and resilience measures.

- To carry out an appraisal of intangible benefits arising from property-level protection schemes, such as reduced levels of stress arising from reduced flood risk, leading to improved health and well-being noting those that are particular to this approach.
- To analyse the costs relative to the benefits using established appraisal techniques, including when they are fully realised and the level of residual risk.
- To make recommendations about the risk of flooding, the level of local participation and the passive/active measures threshold that would represent best value for Government intervention.
- To review practice across the UK and assess the benefits of the property-level protection 'industry' to the UK economy.

The study has updated and revised the economic and financial models used in the earlier Defra Research and Development project FD2607 undertaken in 2008. It has also taken account of recent policy changes and provides evidence on costs and benefits to inform Defra's policy making, including how property-level protection is to be funded under the new Partnership Funding approach adopted in May 2011 and extended during 2012-2013.

The project provides an assessment of the role, effectiveness and the costs and benefits of property-level flood protection. The study has reviewed new evidence and updated the existing evidence base on the costs and benefits of property-level resistance and resilience measures and addresses a number of objectives, presenting:

- A full suite of benefits from different kinds of resistance and resilience measures and how these are captured in approaches to flood risk, including: reduced physical damage from floodwater; delayed time for water to enter property; reduced local authority emergency response and recovery costs; faster repair and return to property. This may affect property prices; availability of insurance and mortgages.
- An evaluation of intangible benefits arising from property-level protection schemes, using indicators such as reduced demands on family doctors and the overall health service as stress levels fall with increased levels of flood protection. Local community cohesion and wider health and well-being benefits from reduced damage and levels of anxiety caused by the threat of flooding are also explored.
- An analysis of the costs relative to the benefits, including when they are fully realised and the level of residual risk from the type of measures deployed and the consequences for the resident of failure to deploy.
- The analysis of property-level flood protection measures using economic appraisal techniques as set out in Defra's 2009 Policy Statement on Appraisal and the Environment Agency's 2010 Flood and Coastal Erosion Risk Management Appraisal Guidance.
- Recommendations about the risk or frequency of flooding (i.e. the level of risk at which different forms of property level protection may be cost beneficial) and level of local participation in such schemes in areas at flood risk, that would represent best value for Government intervention, from an economic perspective.

A particular emphasis is given to the review of the emerging product market, the development of innovative products such as automatic (or passive) measures and the role and impacts of the Kitemark scheme aimed at providing reassurance about quality and effectiveness. The risk threshold where such passive protection becomes more economic than measures requiring manual intervention by the householder is explored.

Property-level flood protection has increasingly been recognised as a means of addressing local flood risk and following the demonstration projects funded by Defra and the Environment Agency between 2009 and 2012, have been mainstreamed within the Flood and Coastal Risk Management budget. This study is designed to help inform future Government policy on providing property protection. It will contribute to the ongoing work to develop the roadmap towards 2013 when the current Statement of Principles agreement between Government and insurers expires.

1.3 Approach

The study has drawn upon the findings and evidence from the Defra Grant Scheme evaluation to explore in detail the costs and benefits of providing property-level protection schemes. The work builds upon and revises the FD2607 study updating and transforming the earlier model to produce individual property benefit cost characteristics and profiles for a wider range of property types. These account for a range of flood characteristics (depth, frequency and duration) and a range of protection and resilience measures (such as passive flood doors, manual barriers, pumps etc). Particular focus is given to assessing the more recent and innovative passive measures which although having higher initial capital costs, are recognised as being more reliable, hence offering the prospect of lower failure rates.

The assessment addresses the financial position (i.e. costs to fitters and returns to property owners) and the economic position (i.e. net costs and benefits to "UK plc" excluding tax transfers) as well as giving careful consideration to the implications for properties within socially deprived areas. Flood damage assessment with and without measures are analysed, along with a range of indirect and intangible losses. Those considered include reductions in stress levels from frequent flood risk exposure, leading to lower levels of health and general well-being. Indirect benefits include reduction in temporary accommodation, emergency services costs and absence from work.

There are inherent differences between community level flood defence schemes and property level protection:

- Property-level protection schemes do not change or alter the actual likelihood of a flood that properties are exposed to.
- There is a much lower capital investment required to implement these schemes and give people the opportunity to manage the consequences of flooding in areas where costly defence schemes cannot be justified.

As a result of these important distinctions, it is considered that the two approaches offer quite different responses to managing flood risk, leading to very different levels of anxiety over the risk of flooding between the two groups. Property-level protection provides lower standards of protection than a capital community defence scheme, albeit to greatly improved standards than can be gained from just using sandbags alone. By focusing on managing the consequences once flood water has reached a property, residents still have the worry and stress of the impacts this could cause. This contrasts markedly with those communities who benefit from defence schemes that are designed to retain floodwater some distance away from the community and in so doing, reducing the likelihood and consequences of flooding.

Residents with property-level protection measures must therefore be prepared for flooding and must recognise that flood damage can still occur, but to lower levels than would be experienced with either sandbags or if there was no protection whatsoever.

> ***"The risk of flooding is the first thing I think about in the day - and it's the last thing on my mind when I go to bed".***
>
> Typical interview response of residents without community flood defence schemes

The recent modelling undertaken by Davis Langdon in 2011 was reviewed. The links and efficiencies were also developed with the parallel work being undertaken by Royal Haskoning for the Commission for Climate Change. Whilst this latter work has looked to gross up the benefits and costs and considered property-level protection at an England scale, there has been a consistency of approach and good level of communication between the two projects. In particular, work on aggregating potential benefits from property protection to the National level has been used in this project to formulate "average" or "typical" benefits for use in Partnership Funding calculations.

The intention of the study was to produce a simple look-up matrix that will help characterise the individual benefit cost ratios and net present values for the range of property types installing the developing range of innovative protection products and measures. The project has also produced average or typical figures for cost and benefit of property protection

measures, as well as a comparison of costs and benefits for automatic (or passive) measures with products that need to be fitted manually.

The resistance and resilience state of the art costs from Davis Langdon and earlier sources such as the Association of British Insurers (ABI), Norwich Union etc. have been reviewed and updated with costs surveyed during the Defra Grant Scheme evaluation.

Six packages of flood resistance and resilience measures have been derived:

A: Automatic resistance.

B: Manual resistance.

C: Resilience without resilient flooring.

D: Resilience with resilient flooring.

E: Automatic resistance and resilience with resilient flooring.

F: Manual resistance and resilience without resilient flooring.

The model has been revised for both a financial and an economic perspective, so that any combination of residential property (e.g. type; type and age) can be easily slotted into the model to establish individual benefit cost ratios. The assumptions and data linkages were audited before creating bespoke models for detached, semi-detached, bungalows, terraced properties and flats characterised by age bands.

2 Methodology and Approach

2.1 Tasks

The key tasks for the cost effectiveness study:

- **Refine the FD2607 model into the characterisation layers using the Multi-Coloured Manual (2010) data.**
- **Agree the property-level protection characterisations and use data from Davis Langdon, ABI, insurers and other sources, such as direct scheme experience, to cost each package of measures.**
- **Update the Weighted Annual Average Damages (WAAD) values for:**
    - **Building Fabric**
    - **Inventory**
    - **Clean-up costs**
    - **Intangibles**
    - **Temporary accommodation**
    - **Absence from work**
    - **Emergency services**
- **Create a new financial and separate economic model.**
- **Undertake a reliability analysis of both manual and passive protection measures, converting potential benefits to actual benefits.**
- **Create a benefit cost appraisal matrix for the various flood and property characterisations.**
- **Maintain awareness of and review the Commission for Climate Change research that will aim to scale-up model data to produce national "heat maps" of where and what types of property-level protection can be cost beneficial.**
- **Assess practices elsewhere in the UK.**

In revising and updating the 2008 Entec model the same property-level protection characterisation packages have been generated for both this project and the Commission on Climate Change project. The Davis Langdon work has 4 residential property characterisations (Detached, Semi-detached, Terrace, Flat) and 2 Small and Medium Enterprise (SME) properties - 'High Street Shop' and 'Office') whilst the Entec model has 3 property characterisations (the 'Average Residential Property', the 'High Street Shop' and 'Office'). Including and updating SMEs was not part of the current brief.

It is proposed to adopt similar property protection packages as applied to the Entec model, combining a number of component measures, to avoid overly detailed and numerous individual measures. So, for each agreed property characterisation (see Section 2.3.2), a typical mix and match of resistance and resilience packages has been established.

A third variable is flood characterisation (i.e. which packages are likely to be more cost beneficial with respect to pre-scheme flood risk). For example, if a property is only in a "Moderate to Low" flood risk banding (as defined in the Partnership Funding calculator), basic manual resistance may be the pragmatic approach if no defences exist. If however the property is in a "Very Significant" category, then a more robust range - or combination - of resistance and resilience measures may be appropriate. The model has been used to explore these scenarios.

Scheme success will depend on appropriate levels of routine testing and maintenance. For all approaches, a reliability analysis has been carried out, to address the range of uncertainties and factors affecting the outcome. The actual costs for individual schemes were assessed, to accurately determine the theoretical potential cost benefit for any type of installation. The most cost effective solutions were then scrutinised for feedback to future schemes. Conversion from theoretical potential benefits (what might be achieved under market perfection) to actual potential (what can actually be achieved) is complicated by:

- The efficiency of installation based on response to warning.
- The design failure, driven by type of solution instigated.
- And the design exceedance probability.

A cost-benefit algorithm (fault tree) model was developed to explore these efficiency limitations as part of future input to Partnership Funding. The case studies examined in the Defra Grant Scheme evaluation gathered evidence for success but confidence in future investment must be risk based. Decisions to invest are not always based on economics or affordability but on actuarial principles, where insurance premiums and excesses reflect property flood risk, especially prior to events. These premiums may be tempered or reduced if local property protection measures are installed. Just like 5-lever locks or alarm systems, property-level protection may in time become a pre-requisite for continued insurance, irrespective of the residual risk. Thus in locations with a threshold of flooding of less than 2% annual exceedance probability (1:50 years), decisions to invest may be difficult to justify on cost-benefit grounds but may still be necessary as a result of:

- terms set by insurers; or
- as a way of reducing both event anxiety and the anxiety of potential future events, securing "peace of mind" for the homeowner.

The models were further tested to include reduction in insurance premiums and post event excesses currently levied by the insurance industry for many flood plain properties perceived to be at risk. We have also reflected the fact that local contributions for property protection should be measured against local or financial benefits. Conventional flood defence grant in aid evaluates economic or resource benefits (i.e. benefits to the nation). These cannot be applied where local authorities or property owners themselves are responsible for larger parts of the investment under the outcome-focused Partnership Funding approach. The Financial property-level protection model is appropriate in such circumstances, linking the benefits of locally funded protection to insurance losses, measured as financial losses (e.g. new goods for old).

It will be important to test the findings of the analysis with Government and those at flood risk, namely the residents and communities for whom the property-level protection schemes are being developed. We have considered this evidence through reference to the recent Defra Grant Scheme evaluation project; from our direct input to property-level protection schemes; and from the involvement, experience and critical appraisal of the National Flood Forum.

We have reviewed and included the intangible benefits such as health and well-being; peace of mind; community cohesion etc. These factors, as has been described above, take on greater importance and significance for residents relying on property-level protection as compared to those benefitting from flood defence schemes. They in turn have knock-on benefits to local authorities who have lower emergency response, recovery and re-housing costs. It could also be anticipated that there would be a lower burden on family doctors and the health service, responding to fewer stress and mental health issues brought on by flooding and flood risk. These wider social benefits arising from fewer family breakdowns caused by the stress of flooding have been factored into the analysis.

A benefit cost appraisal matrix has been produced for each combination of flood and property type, with summary statistics on which combination of property, flood and social deprivation characterisations lead to a cost beneficial outcome and which characterisations stand out with the largest economic and financial worth in terms of benefit-cost ratios and net present values.

Benefit cost ratios were calculated by measuring whole life costs against whole life benefits. Damage savings for the 34 residential property types defined within the 2010 Multi-Coloured Manual (detailed in Section 2.3.2) were estimated for each of the 6 property protection packages. Property-level protection does not change the threshold or likelihood of flooding to a property but avoids some damage, depending on the approach adopted. Beyond the effectiveness of the measures installed, *'No Measures'* levels of damages will be incurred. The Weighted Annual Average Damages for *'No Measures'* and for the 6 property-level protection packages (detailed in Table 2.4) were selected and modelled for each Multi-Coloured Manual property type and age combination. Different thresholds of the onset of flooding are assumed, from 50% annual exceedance probability (1 in 2 years) to 0.05% annual exceedance probability (1 in 200 years). The benefit of installing the measures is the difference between the flood damage with 'No Measures' and the flood damage for each

successive property-level protection package. Although a detailed benefit cost appraisal can only be carried out by reliably knowing the pre-scheme flood threshold, determined as part of a field based study of the actual property to be protected, this research provides a generic benefit cost appraisal matrix to apply to specific case studies, such as those analysed in the previous Grant Scheme Evaluation project for the Environment Agency and Defra.

The Committee for Climate Change project had access to threshold probability values for every 50m by 50m impact cell, linked to the Environment Agency's 2008 National Flood Risk Assessment (NaFRA) database and their National Receptor Database (NRD) properties for each cell. The basic model used by both projects was therefore extended to scale up for the number of properties potentially benefiting from each of the 6 resistance and resilience packages.

2.2 Costs of Property-level Flood Protection

The 6 measures packages in the 2008 FD2607 model were replaced with 6 new combinations of resistance, resilience and combinations of both resistance and resilience measures. These measures packages are labelled 'A' to 'F' and are detailed in Section 2.2.1, 2.2.2 and 2.2.3.

For property characterisation Davis Langdon used:-

- Type – detached; semi-detached; flats; and bungalows (50:50 detached and semi-detached).
- Age – pre-1919; 1919-1980; 1980-2010; and new (for incorporation of resilience as new build).
- Household size.

The cost model adopted was for application of measures to the main types of residential property available from the National Receptor Dataset: these are detached, semi-detached, terraced and flat. In addition, provision was made to also include bungalow, while the model can be adjusted to assess any property type-age combination for which flood damage data is available from the Multi-Coloured Manual. Non-residential properties have not been included in the study.

The model allows for a 'High, Mid and Low' cost range for each package of measures. The combinations of property type and installation scenario have also been assessed from both an economic (society based) and financial (individual household) perspective.

- The economic model assesses the benefits and costs from the perspective of the national UK economy. A discount rate of 3.5% has been used for calculating present value costs and benefits over a 20 year period, as recommended in the 2003 HM Treasury Green Book. Inventory damage and some building fabric repairs were assumed to be 50% of the cost of replacement, to avoid betterment. The costs and benefits of the packages have been developed with VAT (20%) excluded.
- The financial model assesses the benefits and costs from the perspective of the individual household. A discount rate of 8% has not been used for calculating present value costs and benefits over a 20 year period, in line with the Adaptation Sub-Committee's approach to financial assessments from a perspective of individual investment. The 3.5% Treasury test discount was retained in the financial analysis as using 8% as for the Davis Langdon study will negate the value of betterment to flood damaged properties. Damages were assumed as "new for old" in line with insurance payments. VAT (20%) was included in all costs and benefits used in the model.

2.2.1 Costs of Resistance and Resilience Packages

To assess the cost of the measures packages developed for the model, unit costs for the individual resistance and resilience elements have been obtained from as many available sources as possible, including the Defra Grant Scheme, subsequent Environment Agency schemes, the Davis Langdon study and JBA case studies.

The average resistance measures cost per property in the Defra Grant Scheme evaluation was £4,832. This comprised £3,646 for the installation of measures, £452 for the survey and

£734 for administration costs. The Davis Langdon work assessed the measures on an individual basis rather than as packages of measures.

Unit cost databases have been developed for the installation scenarios being considered by reviewing the available information and determining appropriate costs. Greater weight has been given to more recent cost information as the industry has developed significantly in since 2008 and costs have changed as a result. The costs used by Davis Langdon are far lower than the Defra Grant Scheme costs and based on the practical experience of the Grant Scheme are underestimated. It may be expected that costs have increased due to inflation although it might also be expected that a maturing market might also result in reductions due to competition. The Davis Langdon modelling provided for 1.0m high resistance above the property threshold, whereas the Defra schemes and this research only modelled to a height of 0.6m, which should be less expensive.

An upper, lower and mid estimate of the cost has been developed to allow the variability in cost of the measures to be assessed. These are summarised in Table 2.1 below. All costs have been updated to 2011 prices using the Consumer Price Index (CPI). The cost of resilience measures is based upon 2003 Association of British Insurers data which gives financial costs of resilience for the three installation scenarios. These costs have also been updated to 2011 prices.

The various components of the resistance and resilience packages are summarised in Tables 2.2, 2.3 and 2.4, for the resistance, resilience and combination packages respectively.

Measures	2011 Cost (£)		
Resistance Property Level Measures:	**Lower**	**Mid**	**Upper**
Demountable Door Guards	500	700	900
Demountable Window Guards	500	700	900
Airbrick Cover	20	30	40
Sewerage Bung	30	40	50
Toilet Pan Seal	60	70	80
Sump Pump	400	500	600
Re-pointing external walls with water resistant mortar	150	200	250
Silicone gel around openings for cables etc.	80	100	120
Repair mortar	80	100	120
Waterproof external walls	200	300	400
Automatic Door Guards	1000	1500	2000
Automatic Window Guards	0	0	0
Self-closing airbrick	50	70	90
Non-return valves 110mm soil waste pipe	550	600	650
NRV 40mm utility waste pipe	80	100	120
NRV 12mm overflow pipe	70	90	110
Garage/Driveway Barrier	2000	2500	3000
Measures	**2011 Cost (£)**		
Resilience Property Level Measures:	**Lower**	**Mid**	**Upper**
Replace sand-cement screeds on solid concrete slabs (with dense screed)	670	700	740
Replace chipboard flooring with treated timber floorboards	920	970	1020
Replace floor including joists with treated timber to make it water resilient	3490	3670	3850
Replace timber floor with solid concrete	8210	8640	9070
Raise floor above most likely flood level	33640	35410	37180
Replace mineral insulation within walls with closed cell insulation	720	760	800
Replace gypsum plaster with water resistant material, such as lime	4280	4510	4740
Install chemical damp-proof course below joist level	6250	6580	6910
Replace doors, windows, frames with water-resistant alternatives	11840	12460	13080
Mount boilers on wall	1080	1140	1200
Move washing machine to first floor	0	0	0
Replace ovens with raised, built-under type	700	740	780
Move electrics well above likely flood level	760	800	840
Move service meters above likely flood level	1620	1710	1800
Replace chipboard kitchen/bathroom units with plastic units	5000	5260	5520
Survey	400	450	500

Table 2.1 Unit Costs of Resistance and Resilience Measures.

Resistance Packages

Property Level Measures Package	Components
A - Automatic Resistance	Automatic door guards. Self-closing airbricks. Non-return valves on utility and sewer pipes. Re-pointing external walls up to 0.6m above ground level with water resistant mortar. Silicone sealant around service and cable entry points. Sump pump. Waterproof external walls.
B - Manual Resistance	Demountable door barriers. Manual airbrick and vent covers. Sewerage bungs and toilet pan seals. Re-pointing external walls up to 0.6m above ground level with water resistant mortar. Silicone sealant around service and cable entry points. Sump pump. Waterproof external walls.

Table 2.2 Components of Property Resistance Packages.

The new model includes two packages that are broadly similar to those used by Davis Langdon with some additional elements. These are termed *Automatic Resistance* and *Manual Resistance*. The elements of these various packages that are commonly installed and were proposed for the new model are highlighted in the tables below. The term *'fit and forget'* has been dropped as this implies that once installed these measures require no further consideration, such as maintenance, which is not the case.

Within the new packages it is assumed that protection is provided up to a flood depth of 0.6m above the threshold of the property, rather than 1.0m used by Davis Langdon. This limiting depth has increasingly become the industry standard. This is due to concerns that for any higher flood levels, there is a risk that brick and concrete block walls could fail due to the hydrostatic loading of flood water. The recently completed Defra Grant Scheme and the subsequent Environment Agency Grant Scheme for property-level protection measures included this assumption.

Resilience Packages

Property Level Measures Package	Components
C - Resilience with resilient flooring	Resilient plaster up to 1m, resilient doors, windows and frames, resilient kitchen, raised electrics and appliances, and concrete/sealed floors.
D - Resilience without resilient flooring	Resilient plaster up to 1m, resilient doors, windows and frames, resilient kitchen, raised electrics and appliances.

Table 2.3 Components of Property Resilience Packages.

The model assumes that if resilience measures are introduced, then for depths to 0.6m:

- All plumbing and electrical damages are saved.
- All floor damages are saved if resilience to floors is included, otherwise not saved.
- All damage to plasterwork is saved.
- Damage to interior decoration remains.
- Clean up (evaluated separately) remains but is reduced as assumptions in Table 2.6.

Combination Packages

Property Level Measures Package	Components
E - Automatic Resistance and Resilience with Resilient Flooring	All measures in packages A and C plus: • Automatic door guards. • Self-closing airbricks. • Non-return valves on sewer pipes. • Re-pointing external walls up to 0.6m above ground level with water resistant mortar. • Silicone gel sealant around service and cable entry points. • Sump pump. • Resilient plaster up to 1m; resilient doors; windows and frames; resilient kitchen; raised electrics and appliances; and concrete/sealed floors.
Property Level Measures Package	**Components**
F - Manual Resistance and Resilience without Resilient Flooring	All measures in packages Band D plus: • Demountable Door Guards. • Manual Airbrick Covers. • Sewerage bungs/toilet pan seals. • Re-pointing external walls up to 0.6m above ground level with water resistant mortar. • Silicone gel sealant around service and cable entry points. • Sump pump. • Resilient plaster up to 1m; resilient doors; windows and frames; resilient kitchen; raised electrics and appliances.

Table 2.4 Components of Combined Resistance and Resilience Packages.

2.3 Direct and Indirect Benefits of Property-level Flood Protection

2.3.1 Previous Models

The Entec model (2008) for property-level measures used flood damages data from the 2005 Flood Hazard Research Centre (FHRC) Multi-Coloured Manual, which was the best available source of flood damage data for the UK. This data has been updated since this model was developed. Therefore the flood damages component of the model in this study has used the updated Multi-Coloured Manual data released in 2010. The Entec model also incorporated both a financial and an economic analysis of the benefits of property level measures and this has been updated in the new model.

2.3.2 Benefit Calculation

The benefits of the 6 property-level protection packages are calculated as being the level of damages from flooding averted, as a result of successful installation of the measures, when compared with the damages to an unprotected property. The damages have been assessed using the Weighted Annual Average Damage (WAAD) approach that is the industry standard detailed in the Environment Agency's 2010 Flood and Coastal Risk Management Appraisal Guidance and the 2010 Multi-Coloured Manual. Weighted Annual Average Damages are applied where the depth-frequency relationships of flooding for a property are not known. A statistical average of the percentage of properties flooded to successively greater depths is presented using evidence derived from empirical research, for a range of flood return periods. The value decreases as the threshold of property flooding increases.

Comprehensive datasets of the damages for different types of property are provided in the updated 2010 Multi-Coloured Manual. The data for the 34 residential property type and age profiles have been selected to be representative of the majority of house types:

- Detached;
- Semi-detached;
- Terraced;
- Flat;
- Bungalow.

Each with 7 age bands, representing size and building material/construction variances:

- Pre-1919;
- 1919-1944;
- 1944-64;
- 1965-74;
- 1975-85;
- 1975-85 Utility (except Bungalow) - ground floor not used as main living area;
- Post-1985.

Weighted damage values for direct damages are divided into three components:

- Building fabric;
- Building inventory;
- Clean-up costs.

Weighted damage values for indirect damages are divided into three further components:

- Temporary accommodation;
- Emergency services and recovery costs;
- Absence from work.

Weighted Annual Average Damage values were also calculated for intangible losses to largely reflect the reduced costs in treating anxiety and stress.

The model assesses the impact of the property-level protection packages on reducing these damages to determine the benefits associated with each package. Because Property-level protection as a flood risk management tool is in its infancy, there is little evidence, either statistical or anecdotal on the actual level of damages that could be saved by their introduction. Considered assumptions have therefore been made for each of the listed components above which are outlined in the following sections.

Section 2.5 considers reliability and the effects of seepage or leakage should the measures not function to manufacturer's specification. Under ideal conditions, there will be no leakage or seepage associated with either manual or automatic resistance measures. In these circumstances, whilst the measures are in place there will be no internal damage or clean-up required, no recourse to temporary accommodation, limited emergency services support, only minor stress or anxiety and a minimal requirement for absence from work. For resistance measures with a working tolerance of 600mm internal depth, damages will occur where flood levels are higher. These damages are termed the *'residual damages*'. However, seepage is permitted under the Kitemark scheme and leakage is sometimes inevitable, so further assumptions are made as to the damage characteristics associated with these issues, largely as a result of mismanagement of the equipment either before or during fitting. For some components of damage, data is provided for long (>12 hours) and short (<12 hours) duration floods with separate assumptions made for these two situations and averaged to give the overall picture of potential damage reduction. Building fabric comprises elements of the actual property including the external walls, internal plasterwork, floors, joinery, internal decorations, plumbing, central heating and electrics. The assumptions made for building fabric and inventory (household contents) damages and clean-up are outlined in Tables 2.5 to 2.8. Assumptions made for temporary accommodation and absence from work are outlined in Tables 2.9 to 2.10. Emergency services costs are taken as 5.6% of the direct damages and clean-up costs associated with both 'No Measures' and each property protection package.

Property-level Package	Building fabric assumptions		
	No Seepage/leakage Resistance measures only	**With Seepage/leakage (resistance measures only) Short Duration**	**With Seepage/leakage (resistance measures only) Long Duration**
A - Automatic Resistance	Damage to external buildings and garden areas as for *No Measures*. No internal damages to 600mm	No damage to internal building fabric up to 600mm, damage to external building fabric as for *No Measures*. Damages above 600mm as for *No Measures*	Up to 600mm internal building fabric damage is 20% of the damage incurred for a 5mm flood; Internal damage below 5mm is 20% of *No Measures* damages. Damages above 600mm are as for *No Measures*
B – Manual Resistance	Damage to external buildings and garden areas as for *No Measures.* No internal damages to 600mm	Up to 600mm internal building fabric damage is 20% of a 5mm flood; internal damages below 5mm are 20% of *No Measures;* damages to external building fabric as for *No Measures*	Up to 600mm internal building fabric damage is as for a 5mm flood; damages to external building fabric as for *'No Measures'*
C – Resilience without resilient flooring		All plumbing and electrical damage saved to 900mm; no damage to plasterwork to 900mm; no damage to joinery; full damage to decorations	All plumbing and electrical damage saved to 900mm; no damage to plasterwork to 900mm; 25% damage to joinery through water saturation and warping; full damage to decorations
D – Resilience with resilient flooring		All plumbing and electrical damage saved to 900mm; no damage to plasterwork to 900mm; no damage to joinery; full damage to decorations; no damage to flooring.	All plumbing and electrical damage saved to 900mm; no damage to plasterwork to 900mm; 25% damage to joinery through water saturation and warping; full damage to decorations; No damage to flooring
E- Automatic resistance and resilience with resilient flooring		Minimum damage values of Packages A and D	Minimum damage values of Packages A and D
F- Manual resistance and resilience without resilient flooring		Minimum damage values of Packages B and C	Minimum damage values of Packages B and C

Table 2.5 Damage Assumptions for Building Fabric.

Property-level Package	Building fabric assumptions		
	No Seepage/leakage Resistance measures only	**With Seepage/leakage (resistance measures only) Short Duration**	**With Seepage/leakage (resistance measures only) Long Duration**
A - Automatic Resistance	No damage to internal inventory to 600mm; damage to DIY/Leisure equipment (external inventory) as No Measures; damage above 600mm as *No Measures*	No damage to internal inventory to 600mm; damage to DIY/Leisure equipment as No Measures; damage above 600mm *as No Measures*	Up to 600mm internal inventory incurs 20% of damage for a 5mm flood; below 5mm damages are 20% of *No Measures* damage; damage above 600mm as *No Measures*
B – Manual Resistance	No damage to internal inventory to 600mm; damage to DIY/Leisure equipment as No Measures; damage above 600mm as *No Measures*	Up to 600mm internal inventory incurs 20% damages for a 5mm flood; damages to external inventory as *No Measures*	Up to 600mm internal inventory incurs damage for a 5mm flood; damages to external inventory as No measures; damage above 600mm as *No Measures*
C – Resilience without resilient flooring		Inventory Damage as *No Measures* except domestic appliance damage reduced by 40% to 1200mm to allow for raising washing machine to first floor and replace oven with raised built under type. Domestic appliances damage reduced by 20% above 1200mm to allow for raising washing machine to first floor	Inventory Damage as No Measures except domestic appliance damage reduced by 40% to 1200mm to allow for raising washing machine to first floor and replace oven with raised built under type. Domestic appliances damage reduced by 20% above 1200mm to allow for raising washing machine to first floor
D – Resilience with resilient flooring		Flooring damage reduced to zero with same assumptions for *Package C* for domestic appliances	Flooring damage reduced to zero with same assumptions for *Package C* for domestic appliances
E- Automatic resistance and resilience with resilient flooring		Minimum damage values of Packages A and D	Minimum damage values of Packages A and D
F- Manual resistance and resilience without resilient flooring		Minimum damage values of *Packages B and C*	Minimum damage values of *Packages B and C*

Table 2.6 Damage Assumptions for Inventory.

Property-level Package	Building fabric assumptions		
	No Seepage/leakage Resistance measures only	**With Seepage/leakage (resistance measures only) Short Duration**	**With Seepage/leakage (resistance measures only) Long Duration**
A - Automatic Resistance	No Clean up costs	Clean up costs are 20% of <100mm values; Full clean up costs are assumed above 600mm and *No Measures*	
B – Manual Resistance	No Clean up costs	Clean up costs are 40% of <100mm values; Full clean up costs are assumed above 600mm and *No Measures*	
C – Resilience without resilient flooring		Flood resilient materials reduce drying and associated costs by 50%. Items reduced are Storage cabin, air blower, air mover, dehumidifier, and maintenance and labour costs	
D – Resilience with resilient flooring		Standard floorings and floor coverings are replaced by resilient floor products so as well as Package C savings, labour costs for removing flooring material and carpets are also saved	
E- Automatic resistance and resilience with resilient flooring		Minimum damage values of Packages A and D	Minimum damage values of Packages A and D
F- Manual resistance and resilience without resilient flooring		Minimum damage values of Packages B and C	Minimum damage values of Packages B and C

Table 2.7 Damage Assumptions for Clean-up.

The clean-up costs have been derived from the Flood Hazards Research Centre's 2010 Multi Coloured Manual, as evaluated by The National Flood School (see the updated MCM table 4.11). These values exclude VAT so for the financial models, 20% has been added. The values (example below) have been applied equally to both long and short duration flooding.

Clean-up component	Unit Cost	No. of units	No.of days	Other costs	Total cost
Pressure Washer	50	1	1		£50
Aquavac and transformer	34	1	1		£34
Decontamination	2	65			£130
Skip (6yd)	185	1	7		£185
Storage cabin or off site storage	256	1	28	£504	£760
**Blower heater	6	2	21	£454	£706
**Air Mover	7	4	21	£907	£1495
**Dehumidifier	11	3	21	£680	£1373
labour Costs					
Pressure Washer	126		0.5		£63
Aquavac	126		0.5		£63
Decontamination	203		2		£406
Carpet Removal	126		2		£252
Moving contents to storage	126		2		£252
Flooring Removal	126		2		£252
Skip loading	126		2		£252
Dehumidifier maintenance	30		5		£150
TOTAL inc VAT					**£6,423**
CPI update - November 2011		**120%**	**@**	**20%**	**£8,166**

**Use 3kw per hour of electricity usage (£0.15/kw hr ex VAT). Blower heaters, air movers and dehumidifiers incur substantial electricity costs.

Storage cabin costs based on £504 delivery and collection.

Table 2.8 Average Clean-up Costs - assuming no measures in place. (updated by the National Flood School)

Property-level Package	Building fabric assumptions		
	No Seepage/leakage Resistance measures only	**With Seepage/leakage (resistance measures only) Short Duration**	**With Seepage/leakage (resistance measures only) Long Duration**
A - Automatic Resistance	No Temporary accommodation costs	The 10 percentile of the 2007 flood data (£2,043 ex VAT) was assumed up to 600mm. £5,698 ex VAT was assumed (as *No Measures*) above 600mm.	
B – Manual Resistance	No Temporary accommodation costs	The 25 percentile of the 2007 flood data (£887 ex VAT) was assumed up to 600mm. £5,698 ex VAT was assumed (as *No Measures*) above 600mm.	
C – Resilience without resilient flooring		The 25 percentile of the 2007 flood data (£887 ex VAT) was assumed up to 900mm, to reflect damage to flooring but reduced drying out cost. £5,698 ex VAT was assumed (as *No Measures*) above 900mm.	
D – Resilience with resilient flooring		The 10 percentile of the 2007 flood data (£2,043 ex VAT) was assumed up to 900mm, to reflect improved resilience to property with resilient flooring. £5,698 ex VAT was assumed (as *No Measures*) above 900mm.	
E- Automatic resistance and resilience with resilient flooring		Minimum damage values of *Packages A and D*	Minimum damage values of *Packages A and D*
F- Manual resistance and resilience without resilient flooring		Minimum damage values of *Packages B and C*	Minimum damage values of *Packages B and C*

Table 2.9 Assumptions for Temporary Accommodation Costs

The cost of temporary accommodation has been based on evidence from the 2007 major flood event across England (ref. "The costs of the Summer 2007 Floods in England - Project: SC070039/R1 for EA January 2010). Weathernet insurance data (Chatterton et al, 2010) showed that for a subset of 5,800 households in temporary accommodation in 2007, a mean cost was paid out of £6,695 (£5,698 excluding VAT). The cost of temporary accommodation is often not flood depth related but is more dependent on the vagaries of the market repair chain. Assumptions were therefore made regarding the impact of property-level protection on the time spent in temporary accommodation. No distinction was made between long and short duration floods.

Property-level Package	Building fabric assumptions		
	No Seepage/leakage Resistance measures only	**With Seepage/leakage (resistance measures only) Short Duration**	**With Seepage/leakage (resistance measures only) Long Duration**
A - Automatic Resistance	No absence from work costs	The costs are pro rate to the costs of temporary accommodation. The £3,149 figure for No Measures is proportionately increased or reduced depending on the severity of flooding. The *No Measures* figure is used above 600mm	
B – Manual Resistance	No absence from work costs	Ditto	
C – Resilience without resilient flooring		Ditto	
D – Resilience with resilient flooring		Ditto	
E- Automatic resistance and resilience with resilient flooring		Minimum damage values of Packages A and D	Minimum damage values of Packages A and D
F- Manual resistance and resilience without resilient flooring		Minimum damage values of Packages B and C	Minimum damage values of Packages B and C

Table 2.10 Assumptions for absence from work

The mean time of absence from work after suffering flood inundation is assumed at 26 days, as derived from work for the Scottish Executive, 2007 '*Exploring Social Impacts of Flood Risk and Flooding in Scotland*'. The UK mean weekly wage (National Office of Statistics, Annual Survey of Hours and Earnings, 2011) is £606, giving an average total loss due to absence from work of £3,149.

2.4 Intangible Benefits

2.4.1 Overview

In assessing and updating the costs and benefits of property-level flood protection, a brief review of the intangible benefits of installing such measures has also been undertaken. Communities seeking to promote such schemes are often those most at risk from the highest frequency of flooding, but who in the past have been unable to justify and secure funding for a permanent alleviation scheme. Interviews with many residents as part of the Environment Agency Defra Grant Scheme evaluation revealed that this ever present risk of flooding can often combine with a feeling of being abandoned and being left to manage without support, resulting in potentially very high levels of stress for the people involved.

The different levels of stress discussed above between residents behind a major flood defence scheme compared those with property-level protection measures are also likely to remain after a flood event. This reflects the unchanged degree of likelihood that a house with measures will inevitably experience direct contact with floodwater again in the future, unlike the property behind a major scheme. This explains why many residents stated in the Scheme evaluation that they are unable to stop worrying that flooding will happen again.

One of the clear findings from the survey carried out as part of the evaluation of the Grant Scheme was how appreciative the recipients of measures were for the support provided and the increased level of protection provided.

Differing levels of stress and well-being

- ***The thought and fear of flooding for people involved in property-level flood protection probably rarely leaves their minds.***
- ***In contrast, many people behind a multi-million pound flood wall or embankment are probably unaware of their flood risk.***

The sense of well-being between people protected by community level and property level protection is very different, as is the level of flood awareness.

- Many of those hoping to be included in property-level protection schemes (and those recently included) have flooded so often that many report that they cannot live normal lives: the ever-present risk can result in a permanent and chronic level of stress. As studies have shown, continuously high stress levels can eventually cause even more serious illness, family breakdowns and mental ill-health.
- In contrast to this group of people who can rarely forget about flood risk, the National Flood Forum's experience suggests that many people living behind a long established community flood defence may well have no idea that the wall or bank is for flood defence. Their awareness of flood risk is quite possibly low and their stress levels likewise pretty much unaffected by the low flood risk.

This factor emphasises the importance of accounting for the intangible benefits when considering property-level protection. Residents and communities involved in property-level protection however could quite possibly be required in the future to install measures themselves under insurance policy conditions: infact some residents interviewed for the Grant Scheme evaluation reported that they already are required to install measures if vacating the property for more than 48 hours.

The assumptions made for stress and mental health costs are summarised in Table 2.11 below.

Property-level Package	Building fabric assumptions		
	No Seepage/leakage Resistance measures only	**With Seepage/leakage (resistance measures only) Short Duration**	**With Seepage/leakage (resistance measures only) Long Duration**
A - Automatic Resistance	No Stress or mental health costs	The costs are pro rata to the costs of temporary accommodation as flood recovery and the necessity of spells in alternative accommodation are main catalysts for undue stress and deterioration in mental health. Full costs are assumed above 600mm and for *No Measures*	
B – Manual Resistance	No Stress or mental health costs	The costs are pro rata to the costs of temporary accommodation as flood recovery and the necessity of spells in alternative accommodation are main catalysts for undue stress and deterioration in mental health. Full costs are assumed above 600mm and for *No Measures*	
C – Resilience without resilient flooring		Ditto	
D – Resilience with resilient flooring		Ditto	
E- Automatic resistance and resilience with resilient flooring		Minimum damage values of Packages A and D	Minimum damage values of Packages A and D
F- Manual resistance and resilience without resilient flooring		Minimum damage values of Packages B and C	Minimum damage values of Packages B and C

Table 2.11 Assumptions for Stress and Effects on Mental Health Costs.

The impacts of flooding on property and possessions can result in extensive and costly damage. The impacts on the people (adults and children alike) and communities (homeowners and business owners) experiencing the flooding can be devastating. Those at very significant flood risk may well have suffered repeat flooding and can expect to experience yet more events in the future.

The following comments in Table 2.12 below capture some of the feelings and experiences of people who have had to deal with significant flood risk.

"Some days I just felt like jumping off the Humber Bridge. It's been that low, it's been that bad, except I'm not brave enough to do it. But the state of mind you've been in – some days I've just sat in here and just sobbed and sobbed and sobbed."
(Leanne, interview)

"When I go home, the first thing I do if it's been raining or is raining, is stop and check the level of the drain. The last thing before I leave is check the level of the drain just to make sure that I'm aware of its current state… There is a lot of anxiety if the weather is going to be bad. As we move more into winter… the anxiety, I think, will rise and it's affecting people. I think the main one is sleep patterns because a lot of us have said we are not sleeping through it and a lot of us are waking up and we've dreamt it's been raining through the night because that's on our mind all the time."
(Amy, interview)

"When it rains I suppose, yes, I feel quite depressed … it maybe just triggers something in my brain. Yesterday it rained quite bad and I was coming in and the drain at the front is blocked and that was starting to fill and do you know, when you think - I just walk away and I don't know what I'd do, I'd rather just set fire to the house, walk away and just never come back I think. I couldn't do it again."
(Abby, interview)

"You get very fraught marriage-wise. We've had lots of arguments and lots of discussions and lots of "I'm leaving you when this is all done!" and "That's it, the house is going up for sale!" Because there's nobody to help you – if my husband is working away during the week and he comes home on a weekend and we are in here, and it's like all the stress I've had in the week goes straight on him, and all the stress he's had in the week goes onto me…"
(Debbie, interview)

Table 2.12 The Human Impacts of Flooding - Excerpts from "The Ongoing Experience of Recovery for Households in Hull" 2008: Lancaster University and Collingwood Environmental Planning.

Feelings of anxiety can continue to be experienced long after repairs have been completed and the person has returned to their home. Periods of bad weather, in particular, can be particularly stressful, as people fear a return of the flooding and are reminded of the emotions and hardships that they faced at the time

Householders also describe the strain on their family relationships, for example with an increase in arguments. In some cases, the stresses on relationships can be amplified by the type of accommodation used during the recovery process. Those living in caravans or moving in with relatives while their home is being repaired often describe their stress and irritability as a result of having no personal space. However, relationships can also struggle in cases where the temporary accommodation is more adequate, as people struggle to deal with their feelings of anger, tiredness and frustration.

Diarists recording the recovery process In Hull following the Summer 2007 floods also note concerns about their physical health. For example, some with long-term health problems, such as angina and arthritis, say that the flooding has made it harder for them to manage their condition, while other participants report suffering from coughs, colds, flu, stomach upsets and increased blood pressure, in addition to more generalised feelings of malaise and lethargy.

These impacts can be long term too, exacerbated by the knowledge that flooding, unlike other forms of "natural" disaster can, and often does, strike more than once ("The Effects of Flooding on Mental Health" Health Protection Agency, December 2011). The National Flood Forum frequently receives comments such as "the recovery was far worse than the flood itself" and "I can't sleep at night for fear that it will happen all over again". The long term impacts are

potentially far more acute for communities reliant on property-level protection measures as compared to those behind permanent flood defence schemes. Whilst measures can alleviate some of the worst anxieties and stress there is a considerable element of residual risk: both from knowing that such measures are designed to limit, not stop, damage; and that one day they are likely to be overwhelmed by a bigger flood than their design height.

Given these impacts, it is not surprising that those communities who have been involved in the property protection schemes have reported such relief and appreciation. Whilst measuring 'peace of mind' is of course difficult, it is important that such intangible benefits are adequately reflected in future scheme appraisals.

2.4.2 Valuation Review

The recently published Defra report "UK Climate Change Risk Assessment – Health Report" (2012) provides some relevant information on valuing such intangible health and stress benefits (see Section 5.14.2).

The total per-case treatment and labour opportunity costs for cognitive behaviour therapy and non-directive therapy identified in Table 5.25 of that report are rounded and define a range to be applied to the mid-depression end-point, within which the general practitioner care cost is found. A central value is derived by taking the simple mean of these three values. This equates to £970.

Resource use costs at 4 months	GP care	Cognitive behaviour therapy	Non-directive counselling
Direct costs (£):			
Primary care	103	64	60
Drugs	21	8	11
Outpatient services	156	51	38
Inpatient services	104	3	63
Protocol therapy	0	212	228
Travel costs	4	5	11
Total	388	342	409
Total indirect costs	611	455	707
Total societal costs	1000	800	1115

Table 2.13 Mean Costs of Treating Depression (source - Bower et al, 2000)

This illustrates a typical market value where the impact is measured in terms of the cost of the services delivered.

A revised figure of £1065 per person was used to adjust for an increased intangible benefit figure that aims to account for the mental stress of flooding and fear of further flooding data. The benefits of property-level protection due to the avoidance of stress and other mental health issues are based upon a value of £2,513 per household per event based on future climate change metrics (Defra, 2012). The value relates to a figure of £1,065 per person and the assumption that there are 2.36 persons per house, from the 2001 census. The figure of £1,065 is made up of the existing approximate £225 value used by Defra (2008) as the willingness to pay, per household per year, to avoid stress caused by flooding; and £970 as a central value of medical and productivity costs for an average four months; these are a blend of general practitioner care, cognitive behaviour therapy and non-direct counselling (see Table 2.13 above).

There are also 'intangible' damages caused by flooding. These include stress-related health impacts and loss of, or damage to, irreplaceable personal possessions (e.g. family photos, diaries etc.) and manifest themselves as the value of lost utility because of restricted activities,

pain and suffering, anxiety about the future and concern and inconvenience to family members and others. These costs are not reflected in actual markets and hence cannot be estimated using actual market data. Generating evidence that such costs exist and producing initial estimates of their magnitude was the focus of a study entitled "The Appraisal of Human Related Intangible Impacts of Flooding" 2005, Defra Research and Development Technical Report. This particular study produced a sum for these damages of “about £225” through a willingness to pay to prevent flooding exercise. In essence, this research attempted to value all of these intangibles through a single measure.

Recent academic research and government policy has promoted a multi-criteria approach to the valuation of intangible impacts. New practical tools and existing valuation evidence mean there is increasing scope to value environmental impacts in policy appraisal. Valuation can help demonstrate the significance of environmental impacts by translating into terms that highlight the importance of these impacts to society.

Peace of mind - priceless!

"Three solid weeks were spent trying to obtain house insurance after being informed we were living in the highest risk flood zone. We began to fear the worst. Our property was uninsurable. We were devastated.

A chance meeting about flood barriers with our builder led to further discussions with a specialist insurance broker. Within days, not only were we given a very reasonable quote with full flood cover at the sight of a letter confirming flood defences in place on our property, but the policy being offered to us had a minimal excess on flood claims. Alleluia! Peace of mind is priceless!"

Resident in Rothbury

2.5 Reliability Factors

Unlike traditional flood defence approaches using structurally engineered schemes, there is a strong human element to the success of the property-level protection approach. A key feature in using resistance measures is the requirement for individuals to install and maintain the products and measures in an effective and timely manner. There is also a key requirement for thorough and continuing community engagement to maintain levels of awareness and preparedness. Product life assumptions must also be considered.

The evaluation of the Defra Grant Scheme highlighted how successful schemes will rely on effective local flood warning and effective ongoing maintenance and emergency plan arrangements. It is evident from experiences of scheme delivery that property-level protection scheme communities are far more flood-aware: they are at significant levels of flood risk and motivated to use the protection measures to limit the damaging effects of frequent flooding. However, where human actions are required, there is the possibility that measures will, for some reason, be less than completely reliable. An assessment has therefore been undertaken using a simple fault-tree analysis to investigate the impact and effect that reduced reliability has on the model results.

2.5.1 Service Life of Measures

Consultation with product manufacturers has generally confirmed the consensus opinion that the product life of flood resistance measures should be taken as 20 years. This figure continues to be applied by the Environment Agency in the Partnership Funding Calculator and was also endorsed during workshop discussions held as part of the Defra Grant Scheme evaluation.

2.5.2 Reliability of Resistance Measures

For resistance measures, a distinction can be made between automatic measures (Package A) and those requiring manual deployment and intervention (Package B). One of the driving market forces in developing automatic measures is that they clearly offer advantages over

manual measures in removing or limiting the degree of human intervention required for maintenance and deployment. They can be expected to operate as planned regardless of the local flood warning arrangements that manual measures depend upon.

There are several factors which affect the reliability of the measures being deployed correctly. Each of these has been assigned a likelihood of success and an overall reliability factor calculated by multiplying these together.

The factors used and the overall reliability factors derived are shown in Table 2.14 below.

Factor	A - Automatic Measures	B - Manual Measures
Equipment not lost or misplaced	**N/A**	**95%**
Products in good working order - well maintained and correctly stored	**90%**	**95%**
Flood warning received	**N/A**	**90%**
Measures installed correctly	**N/A**	**95%**
Probability factor	**90%**	**77%**

Table 2.14 Reliability Assessment of Property-level Protection Resistant Measures.

The factors affecting the reliability assessment are presented in further detail for automatic measures in Figure 2-1 and for manual measures in Figure 2-2 below.

The higher reliability of automatic measures reflects the fact that:

- They do not require prior flood warning to function.
- They are already fixed permanently in place, so can't be misplaced or installed incorrectly.

Measures such as automatic flood doors however are in constant daily use. They are therefore exposed to much higher levels of wear and tear and need greater maintenance when compared to manual measures (see Table 2.14 above). In contrast, manual measures can be lost or misplaced; might be installed incorrectly; or if there is no flood warning of any sort, not installed at all. As already noted, they also require regular maintenance to ensure they are in good working order, although are considered to be less prone to wear and tear as automatic measures such as flood doors.

The overall reliability factors of 90% and 77% derived for Automatic and Manual Resistance measures have therefore been applied directly to reduce the benefits of the packages. This has generated two further sets of scenarios, termed "Total Reliability" and "Reduced Reliability" and these have been factored in to the analysis to assess the effect on the results.

This assessment has been made in consultation with a range of industry experts, including manufacturers, academics and property and flood survey specialists (including Royal Haskoning as part of the CCC work). However, the model has been developed to allow other reliability factors to be applied if considered appropriate, so that changes can reflect local conditions. As is illustrated in this study however, there is only a modest impact from varying reliability values on the overall cost effectiveness outcome.

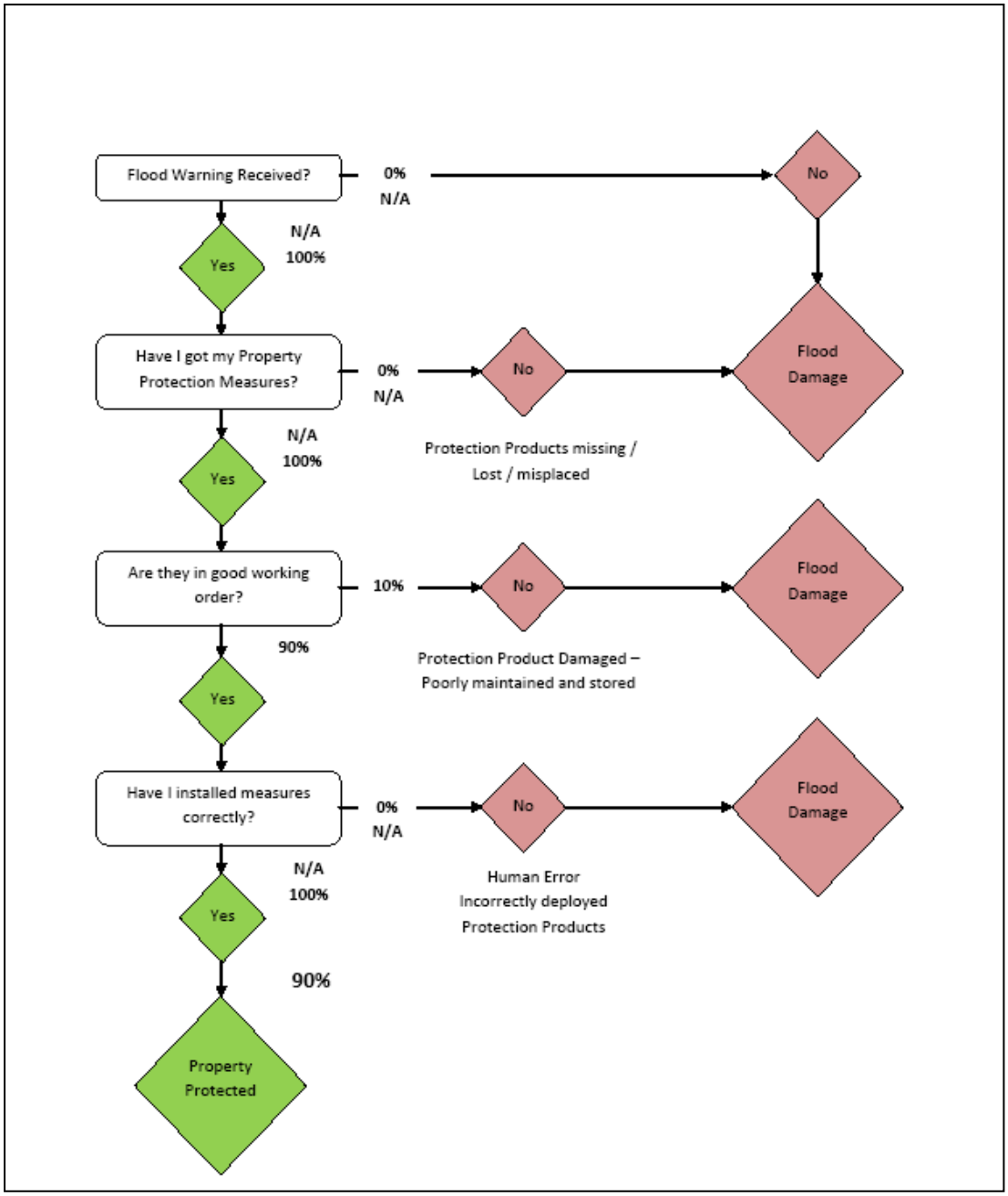


Figure 2.1 Reliability Assessment for Automatic Property-level Protection Measures.

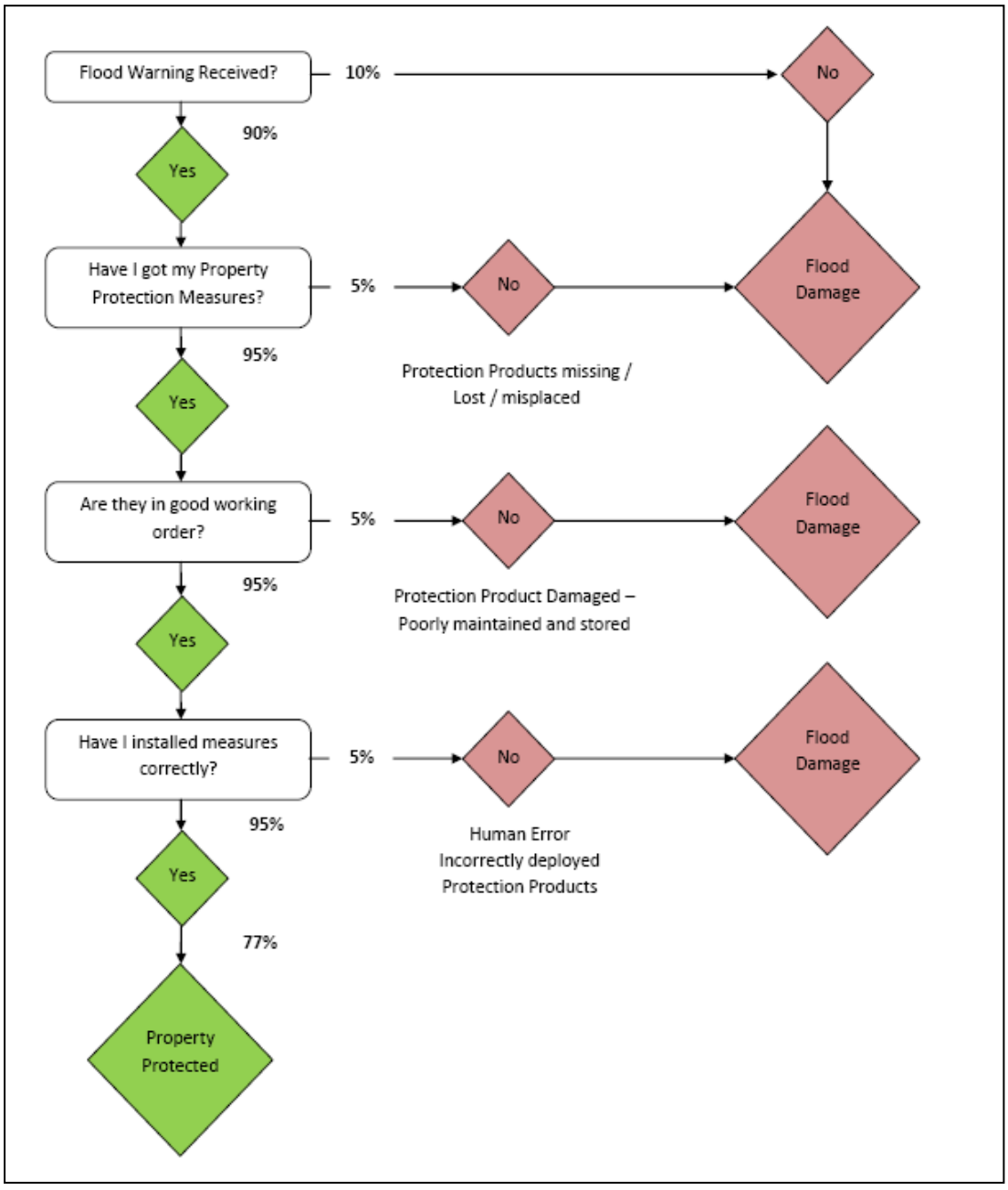


Figure 2.2 Reliability Assessment for Manual Property-level Protection Measures.

2.5.3 Product Performance and Leakage

The 2008 Entec model assumed that there was a small degree of leakage causing an internal flood depth of 0.05m and associated levels of damage to the building fabric. This was assumed to occur up to the design depths of 0.60m. The previous model also made a distinction in leakage rates between Automatic and Manual Resistance measures: for Automatic Resistance this value using 0.05m up to a depth of 0.60m was taken as 20% of the 0.05m value at all depths. Again this is supposition and part of uncertainty.

In this current review and model update, it has been determined that such leakage would only be likely in cases of faulty installation. Kitemarked products are tested to certain small leakage rates but allowing for internal flood damage to a depth of 0.05m is considered to be inappropriate. Furthermore, the distinction between the types of measures has been removed: both should perform satisfactorily so there is no difference assumed between automatic or manual measures up to the 0.60m depth.

This view has been checked and confirmed by product manufacturers, who agree there should be no reason to assume a difference in performance. Providing measures are correctly installed, manual measures should not leak more than the automatic or passive measures. The difference is that automatic measures are considered to offer higher overall reliability.

2.6 Residual Damages

Once the reliability of property-level protection measures is reduced and/or the design characteristics of the measures are exceeded, the property will be exposed to residual damage. Thus if resistance measures are designed to limit flood damage to 600mm but the depth of the flood exceeds this, it will result in the same level of damages as if there has been *No Measures* in place. These are residual damages. In these circumstances, some Resilience measures (e.g. resilient plasterwork) will continue to be effective in reducing residual damages.

Weighted Annual Average Damage (WAAD) values for both *'No Measures'* and the property protection measures package are therefore residual annualised damages that a property is exposed to, depending on the threshold of property flooding or risk exposure (sometimes referred to in the model as *'Standard of Protection'*). The analysis compares benefits associated with the costs of the 6 property-level protection packages against the baseline '*No Measures*' assumption and is therefore the difference in these residual damages.

2.7 Partnership Funding Approach

2.7.1 Outline

Defra introduced the new system of funding flood and coastal risk management schemes, known as "flood and coastal resilience partnership funding" in May 2011. Property-level flood protection schemes are now funded using this system and are considered for funding alongside community scale projects.

The amount of central Government funding eligible for each project (known as Flood Defence Grant in Aid) is calculated by multiplying the value of benefits for householders as a result of flood or coastal erosion risks being reduced by a set of payment rates. Payment rates for protection of households are higher in deprived areas so that schemes in these areas are more likely to be fully funded by Government. This was because households in these areas are less likely to be insured, can need more help to recover after a flood and may be less able to make a contribution. Deprived areas are identified using the Social Deprivation Index, which is published by the Department for Communities and Local Government.

Under the Partnership Funding approach, projects achieving a Partnership Funding score of more than 100% (or more than a pre-determined percentage) are eligible for full funding from Flood Defence Grant in Aid. Schemes can, however, still go ahead where the Partnership Funding score is less than the threshold: if the costs are reduced; if contributions are made available from elsewhere (for example, from such sources as Local Levy, Local Authority funding or from private individuals); or from a combination of the two.

The partnership approach means that Government can potentially pay for a share of the costs of any worthwhile scheme. Defra's contribution is based on paying a share of the benefits (this is typically a fifth for benefits to households but could be more for schemes that will benefit deprived areas). From previous experience, projects typically deliver benefits worth at least five times the costs involved so in many cases schemes will continue to be 100% funded through Defra budgets.

The average cost benefit ratio from the case study projects examined in the Defra Grant Scheme evaluation project was 4.8 to 1, which was just below the target figure. This means that for every pound spent, estimated flood damages of £4.80 were avoided, representing good value for money. Defra sets an overall benefit cost target to ensure flood and coastal risk management projects provide value for money. Projects funded by the Flood Defence Grant in Aid programme typically achieve an overall benefit cost ratio of 5 to 1. This means for every £1 spent, £5 of benefits (money saved in flood damages) are achieved. Under the new Partnership Funding arrangements it may be possible to exceed the threshold but with the benefit cost ratio lower than 5:1 (for example if the scheme is in a socially deprived band and flood risk is reduced from Very Significant to Moderate). Thus any worthwhile scheme with a positive benefit cost ratio (i.e.>1:1) can be progressed if the level of contributions can bring the funding level above the relevant threshold for approval. In addition, Regional flood and Coastal Committees have the discretion to use Local Levy funds and prioritise local schemes within their approved investment programmes.

Put into context of the flood and coastal risk management capital programme (community scale schemes) the cost benefit ratio was 8.2 to 1 between 2008/09 to 2010/11, which is nearly double that achieved by the case study projects. Although community scale projects have a higher benefit cost ratio, the property-level schemes can still represent good overall value for money as well, given their significant advantage in terms of entry cost over a community defence scheme. They also help to realise a range of intangible benefits by addressing those locations experiencing very significant and repeated flooding:

- Reduced stress and anxiety levels for those living in fear of very frequent flooding;
- Increased community cohesion as people work together to manage their property-level protection measures scheme (one of the aims of Partnership Funding);
- Building capacity and flood risk awareness in the local authority organisations delivering the schemes; and
- Raising the general level of flood awareness and preparedness in communities prompted by the need for timely installation of measures.

2.7.2 Partnership Funding Calculator

The model output has been applied to the Partnership Funding calculator using a range of measures packages and assumptions, to determine Outcome Scores and likely levels of flood defence grant-in-aid funding. These include assessing benefits for:

- Economic and financial benefits.
- Both 'Total Reliability' and 'Reduced Reliability' assumptions.
- 34 different property type and age combinations.
- 6 different flood risk exposure or 'standards of protection' bands.
- 3 social deprivation bands: (20% most deprived; 21% - 40% most deprived; 60% least deprived)
- Lower, Mid and Upper Cost assumptions

The Partnership Funding Calculator uses the following fixed risk band assumptions:

Very Significant	**5% AEP - 1 in 20 year chance**
Significant	**2.5% AEP - 1 in 40 year chance**
Moderate	**1% AEP - 1 in 100 year chance**

For example, the benefits of property-level protection for properties with a *'Very Significant'* flooding threshold uses the 5% AEP (1 in 20 year) property flooding threshold *'No Measures'* damage value. If property protection reduces this to '*Significant*' then this assumes that measures are only effective to 2.5% AEP (1 in 40 year), the mean value used in the calculator. The benefits are therefore the damage value for the 5% AEP (1 in 20 year) threshold, minus the damage value for 2.5% AEP (1 in 40 year) for the measure selected. In other words, the benefits of the measures ultimately become ineffective at the 'Significant' risk band level and

residual damages above this threshold are deducted from the benefits. If the measures move the flood risk banding to 'Moderate' there are less residual damages to deduct.

Table 2.15 summarises the flood risk exposure band change assumptions made.

	Risk Exposure Benefit	Remaining Risk
1	Very Significant (10% AEP / 1 in 10 year)	Moderate (1% AEP / 1 in 100 year)
2	Very Significant (5% AEP / 1 in 20 year)	Moderate (1% AEP / 1 in 100 year)
3	Very Significant (10% AEP / 1 in 10 year)	Significant (2.5% AEP / 1 in 40 year)
4	Very Significant (5% AEP / 1 in 20 year)	Significant (2.5% AEP / 1 in 40 year)
5	Significant (2.5% AEP / 1 in 40 year)	Moderate (1% AEP / 1 in 100 year)
6	Significant (1.3% AEP / 1 in 75 year)	Moderate (1% AEP / 1 in 100 year)

Table 2.15 Risk Exposure Band Changes Assumed in the Analysis

In summary, protection measures are designed to largely reduce the damage to depths of up to 0.60m, rather than change and reduce the actual flood threshold frequency. For any individual risk band threshold, the benefits are the *'No Measures'* damage value minus the *'Measures'* damage value. Damages are calculated to the Multi-Coloured Manual upper limit of 3 metres (or first floor ceiling). Above 600mm, either *'No Measures'* damages return or resilience scenarios are reduced, as determined by underlying assumptions.

2.8 Summary of Model Revisions

The main updates, revisions and changes made from the Entec 2008 model to the current JBA 2012 model are summarised in Table 2.16.

Feature	Entec (2008)	JBA (2012)
Property characteristics	All residential no breakdown by type and age; shop, office also included	5 core types; detached, semi detached, terrace, flat bungalow 34 Type and age combinations (see Section 2.3.2).
Property Type, Type/age selection	N/A	Automatic selection from option menu avoids errors in data management .
Model	Financial and Economic VAT @ 17.5%	Financial and Economic VAT @ 20% (see Section 2.2).
Property-level Protection Measures	6 Standard and Premium Resistance and Resilience with Standard and Premium combinations	6 - Automatic separated from Manual Resistance with up to date costs for automatic resistance; Resilience with and without resilient flooring; and combinations. (see Table 2.2 to 2.4).
Cost ranges	Low – Mid –Upper estimates rather than from evidence	Low – Mid –Upper updated from wider evidence of installation (see Table 2.1).
Annual maintenance	Fixed @ 1%	Variable; for Automatic and Manual separately
Direct Damage Data (Building Fabric and Inventory)	MCM 2005 data updated to 2007	MCM 2010 data updated to 2011
Reliability (seepage and leakage)	Included in data input assumptions	Separated from data input assumptions and Variable % input on option menu (see Table 2.14; Figure 2.1 and Figure 2.2).
Reliability (Flood Warning)	100% reliable	Variable % input in option menu (see Table 2.14).

Reliability (Measures not Lost)	Assumed always available	Variable % input in option menu (see Table 2.14).
Clean-Up costs	MCM 2005 data	MCM 2010 data from National Flood School data (see Table 2.7).
Clean-Up costs (Electricity)	Not included	Included for air blowers, air movers and de-humidifiers @ 15p per Kw hour (plus VAT) (see Table 2.8).
Temporary Accommodation	Scottish Executive data 2005	Data from 2007 floods in England (see Table 2.9).
Absence from Work	Scottish Executive data 2005	Scottish Executive data 2005 updated to 2010 (see Table 2.10).
Emergency Recovery Costs	Not included	5.6% of direct costs from 2007 foods in England data
Stress and Mental Health	£225 per household per year	"UK Climate Change Risk Assessment – Health Report" 2012: £2,513 per property (see Table 2.11).
Life of Scheme	Fixed	Variable with 20 year default
Discount Rate	3.5%	Variable with 3.5% default (see Section 2.2).
Annual Average Damage calculations	Weighted Annual Average Damages(WAAD) algorithm	Weighted Annual Average Damages(WAAD) algorithm unchanged

Table 2.16 Summary of Revisions and Differences between the Entec 2008 and JBA 2012 Models.

3 Model Results

3.1 Introduction

The 2008 Entec model has been completely overhauled and updated to include the cost, damage and benefit assumptions detailed in Section 2. This is a prime deliverable of this research. There are 2 models: one from a national, economic perspective; and the other from a householder, or financial perspective. The model is designed to be wholly interactive, by selecting appropriate variables on the 'Option' worksheet as follows:

- Property Type - either 34 Type and Age combinations or 5 'Core Type' groups (detached, semi detached, terrace, bungalow and flat)
- Reliability assumptions
- Percentage allocated to annual maintenance
- Discount rate
- Effective life of property-level protection measures

3.1.1 Economic

The economic model assesses the benefits and costs from the perspective of the national UK economy. As a default, a discount rate of 3.5% has been used for calculating present value costs and benefits over a 20 year period, as recommended by the Treasury Green Book (HM Treasury, 2003). The costs of the packages have been developed with VAT (20%) excluded. Damages also exclude 'betterment' by assuming damage to particular inventory items and internal decoration is about 50% of damage to new items (30% for video and audio equipment which are replaced much more frequently). This is contrary to insurance policy terms for 'new for old' replacement on damage, but more fairly represents economic resource costs.

3.1.2 Financial

The financial model assesses the benefits and costs from the perspective of the individual household. The Entec 2008 (FD2607) report states "Financial analysis includes provisions for VAT……and provides an indication of the expected annual per property savings for an uninsured individual homeowner or insurance company". VAT (20%) was included in all costs and damages/losses used in the model. Total replacement to reflect betterment was also assumed. In the Royal Haskoning Commission for Climate Change financial model, a financial rate of 8% has been used, in line with the Adaptation Sub-Committee's approach to financial assessments. The Defra model however retains 3.5% as using 8% would negate the effects of full replacement damages.

For the financial model for all the property types, the following cost adjustments for damages were made:

- Add VAT;
- Add 50% for betterment (see MCM p62);
- All inventory 50% except audio video @ +30%;
- All building fabric no betterment assumed (see bullet 1 of Table 4.7);
- Internal Decoration +50%;
- Clean-up, add VAT;
- Temporary accommodation, add VAT.

3.2 Analysis of Results

It is not proposed to show the detailed results for all the multiple scenarios of property type, thresholds of protection and reliability assumptions using both financial and economic models here. The detailed figures are attached as Excel worksheets.

- The narrative is presented in a series of steps, to demonstrate the the modelling process.

- 2 selected property types are presented as to illustrate damage and damage savings and benefit cost scenarios.
- The examples are a post-1985 modern detached property and a pre-1919 terraced property, with reduced reliability assumptions are made for both (see Section 2.5.3).
- The headline results are then presented for the all 5 core property types in Section 3.2.2 (see page 12 for core property types).

3.2.1 Converting Damages to Benefit Cost Ratios

For any selected property type the model generates a progression of data until benefit cost ratios and net present values are calculated. The following sequence of 7 steps demonstrates the process used to generate the benefit cost ratios for the various packages of measures.

STEP 1
The property-level protection model first generates depth/damage curves associated with *'No Measures'* and for each of the 6 packages of measures.

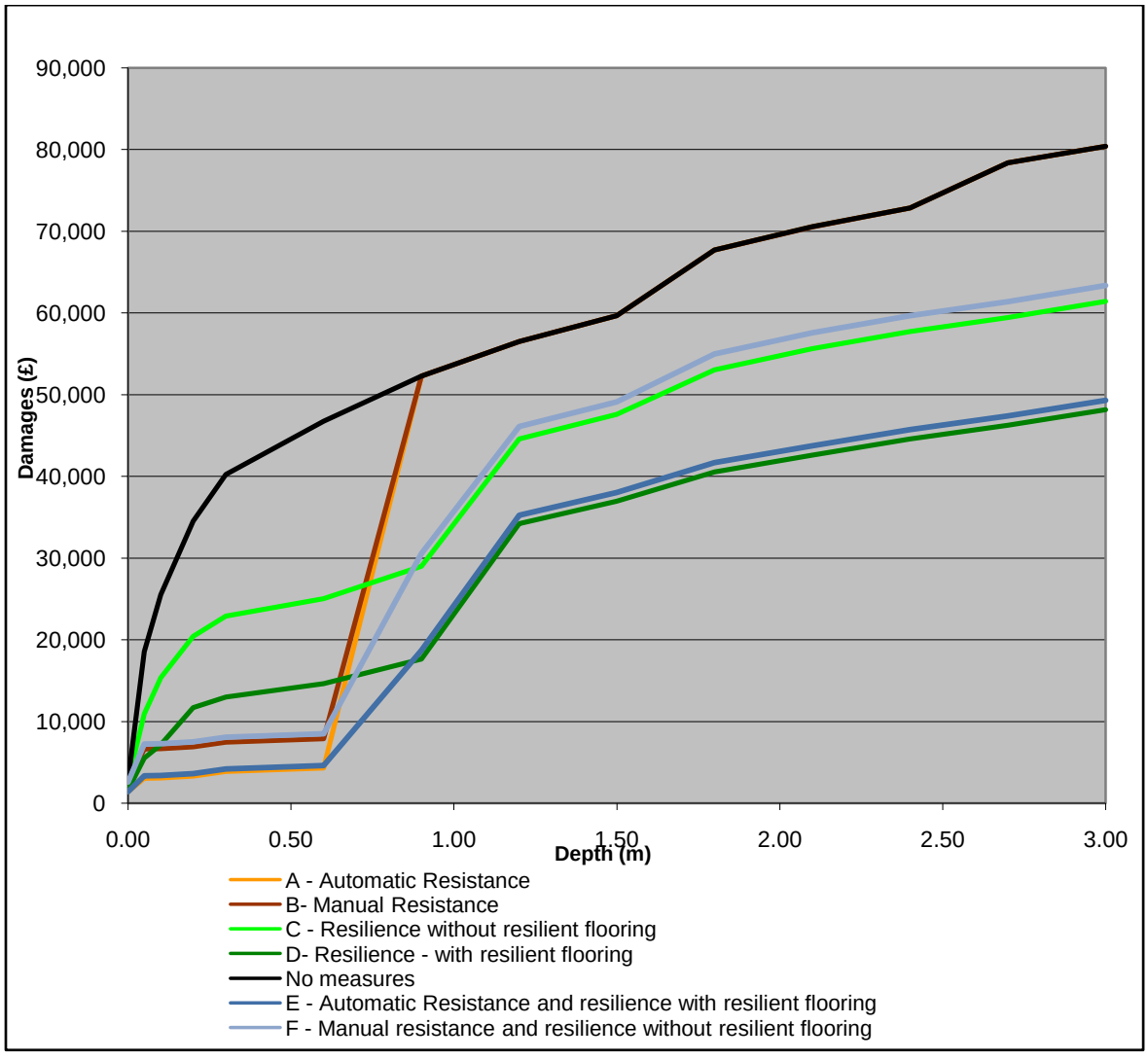


Figure 3.1 'No Measures' and Property-level Protection Measures Damages for Post-1985 Detached with Short Duration Flooding.

STEP 2
Damages avoided by each property-level protection measure become the savings, again by depth.

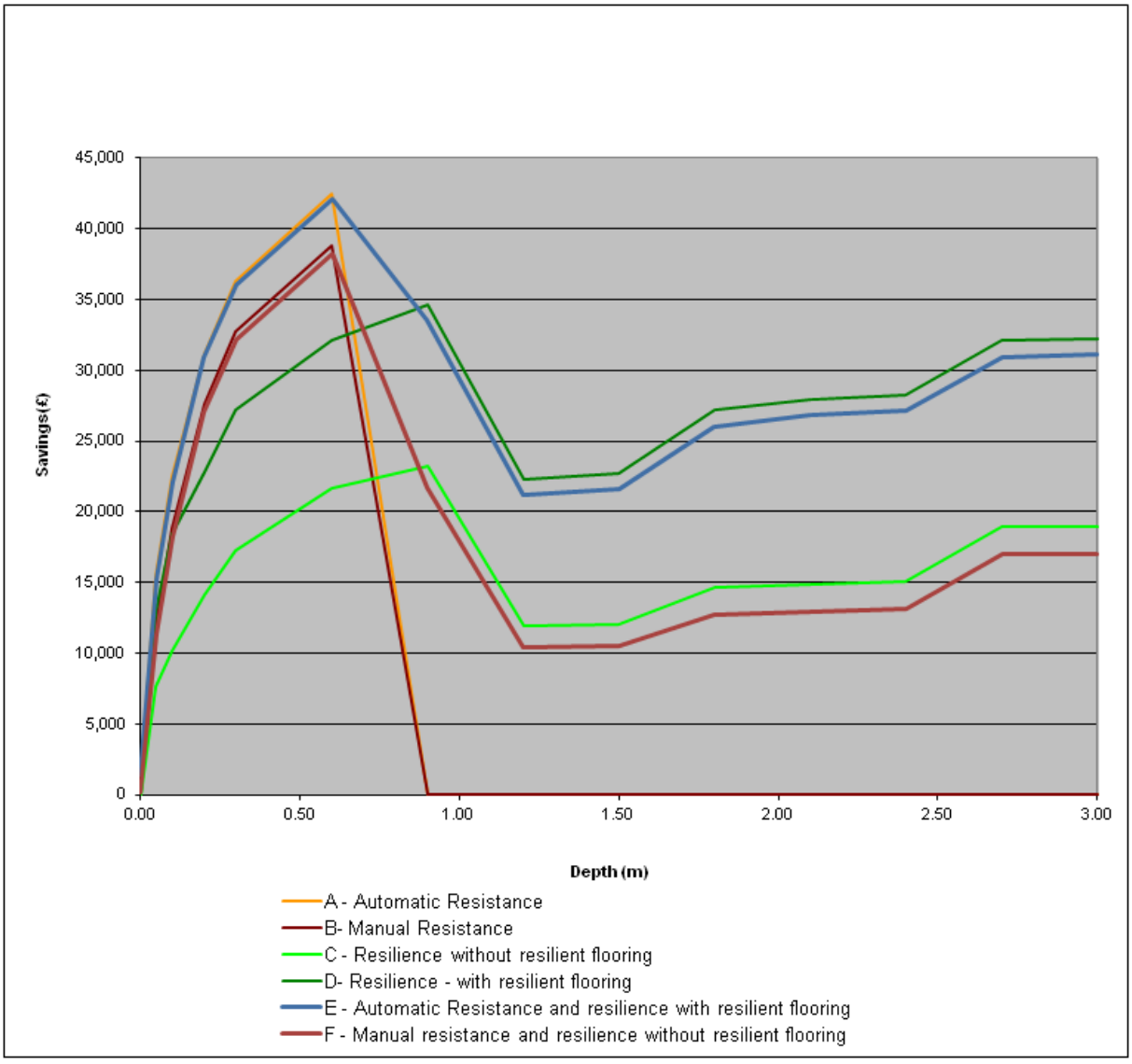


Figure 3.2 Property-level Protection Measures Savings for Post-1985 Detached House with Short Duration Flooding (including building fabric, inventory, clean-up, emergency services and temporary accommodation).

Figure 3.2 illustrates significant savings for resistance measures up to 0.6m with no savings above this depth but savings for resilience measures well beyond the 0.6m cut off for the efficacy of resistance measures.

STEP 3
The Weighted Annual Average Damages calculation converts the damages for each depth for a combination of long and short duration flooding into annual average damages assuming different frequency thresholds of flooding.

Figure 3.3 shows the value of Weighted Annual Average Damages (WAAD) for successive standards of protection thresholds, comparing *'No Measures'* with 4 packages of property-level protection measures.

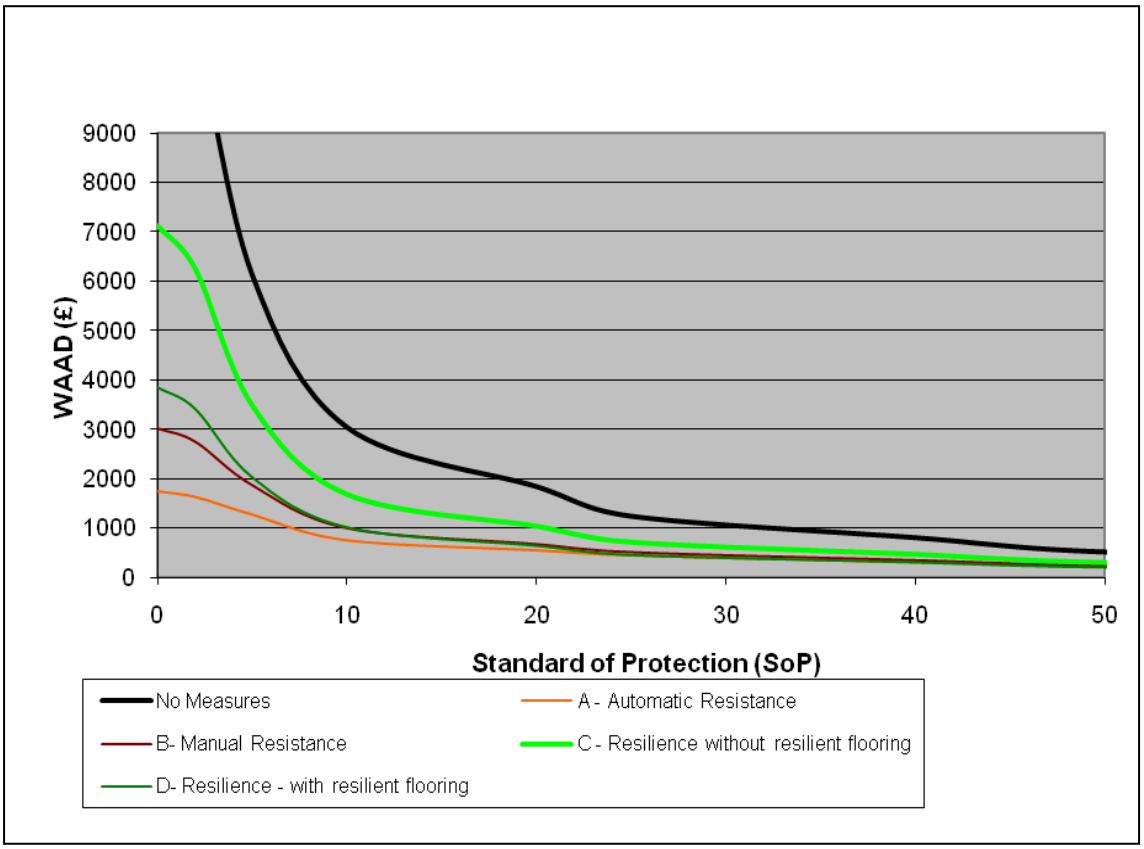


Figure 3.3 Weighted Annual Average Damage (WAAD) values for post-1985 detached house.

STEP 4
The difference between the *'No Measures'* Weighted Annual Average Damages value and the property-level protection measures Weighted Annual Average Damages value becomes the Annual Average Benefits.

(NB no graph)

STEP 5
The present value of costs is calculated for each package of property-level protection measure, including an allowance for maintenance.

Cost Band		A - Automatic Resistance	B - Manual Resistance	C - Resilience without resilient flooring	D - Resilience with resilient flooring
High Cost	Capital cost	£6,351	£3,349	£20,060	£26,620
	Annual maintenance	£318	£67	£401	£532
	Total discounted cost	£10,864	£4,301	£25,762	£34,187
Mid Cost	Capital cost	£5,037	£2,713	£19,070	£25,320
	Annual maintenance	£252	£54	£381	£506
	Total discounted cost	£8,616	£3,484	£24,491	£32,517
Low Cost	Capital cost	£3,727	£2,030	£18,080	£24,020
	Annual maintenance	£186	£41	£362	£480
	Total discounted cost	£6,375	£2,606	£23,219	£30,848

Table 3.1 Costs of 4 Packages of Property-level Protection Measures for 3 Cost Bandings for a pre-1919 Terraced Property.

STEP 6
The present value of benefits for each package of property-level protection measure is calculated.

Standard of Protection	A-Automatic Resistance	B-Manual Resistance	C-Resilience without resilient flooring	D-Resilience with resilient flooring	E-Automatic Resistance and resilience with resilient flooring	F - Manual Resistance and resilience without resilient flooring
0 year	£134,856	£116,383	£73,817	£111,085	£111,085	£73,817
2 year	£117,147	£101,154	£64,989	£97,407	£97,407	£64,989
5 year	£59,751	£50,982	£34,956	£51,702	£51,702	£34,956
10 year	£28,632	£24,958	£18,241	£26,008	£26,008	£18,241
20 year	£16,081	£14,158	£10,645	£15,303	£15,303	£10,645
25 year	£9,810	£8,758	£6,846	£9,950	£9,950	£6,846
40 year	£6,165	£5,549	£4,412	£6,409	£6,409	£4,412
50 year	£3,735	£3,410	£2,789	£4,049	£4,049	£2,789
75 year	£2,410	£2,206	£1,818	£2,606	£2,606	£1,818
100 year	£934	£853	£697	£1,012	£1,012	£697
200 year	£467	£426	£349	£506	£506	£349

Table 3.2 Present Value of Benefits for Successive Standards of Protection Thresholds for 6 Packages of Property-level Protection Measures for a pre-1919 Terraced Property.

Figure 3.4 shows the contribution to total benefits of each benefit component. Note the inclusion of health and stress, absence from work, temporary accommodation and clean-up losses, as well as physical damages to the property and losses.

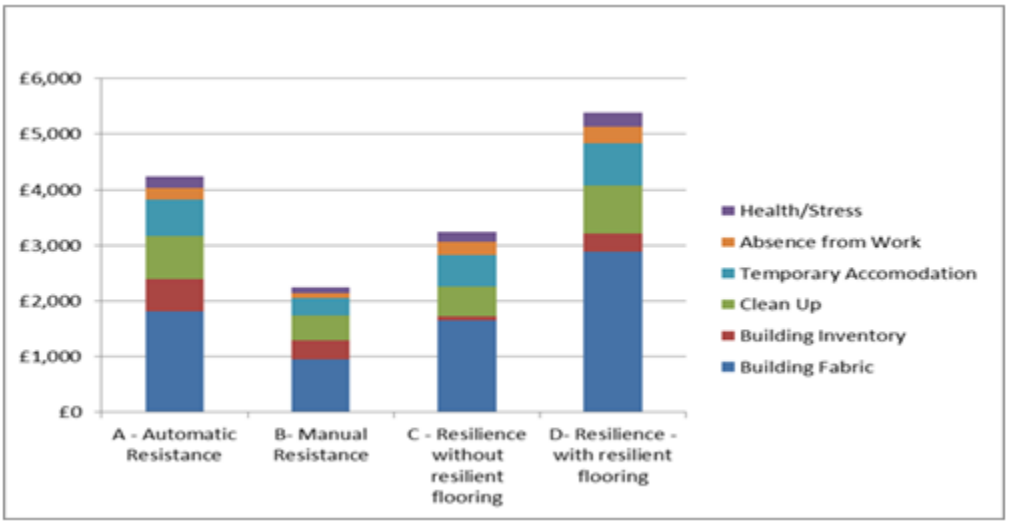


Figure 3.4 Benefit Breakdown for a Detached Property and 2% AEP (50 year) Flooding Threshold.

STEP 7
Combining present value of costs with present value of benefits allows the benefit cost ratios and net present values to be calculated, with two examples shown below - a post-1985 detached and a pre-1919 terraced property.

Discounted Values (costs and benefits) are the total values discounted at the Test Discount rate (3.5%) over the life time of the property-level protection measures (with 20 years as a default). *Net Present Values* are the differences between the whole life costs and whole life benefits. A positive value indicates the selected measure has a benefit cost ratio greater than unity.

Cost Band	Flood Risk Exposure Band	Annual Exceedance Probability (AEP)	A-Automatic Resistance	B-Manual Resistance	C-Resilience without resilient flooring	D-Resilience with resilient flooring	E-Automatic Resistance and resilience with resilient flooring	F - Manual Resistance and resilience without resilient flooring
High Cost	Flood Threshold		8.7	25.7	2.4	2.8	1.6	2.1
	2 year	50% AEP	7.6	22.3	2.1	2.5	1.4	1.8
	5 year	20% AEP	3.9	11.4	1.1	1.3	0.8	1.0
	10 year	10% AEP	1.8	5.5	0.6	0.7	0.4	0.5
	20 year	5% AEP	1.0	3.1	0.3	0.4	0.2	0.3
	25 year	4% AEP	0.6	2.0	0.2	0.3	0.1	0.2
	40 year	2,5% AEP	0.4	1.3	0.1	0.2	0.1	0.1
	50 year	2% AEP	0.2	0.8	0.1	0.1	0.1	0.1
	75 year	1.33% AEP	0.2	0.5	0.1	0.1	0.0	0.1
	100 year	1% AEP	0.1	0.2	0.0	0.0	0.0	0.0
	200 year	0.5% AEP	0.0	0.1	0.0	0.0	0.0	0.0
Mid Cost	Flood Threshold		11.0	31.9	2.5	2.9	1.8	2.2
	2 year	50% AEP	9.6	27.7	2.2	2.6	1.6	1.9
	5 year	20% AEP	4.9	14.2	1.2	1.4	0.8	1.1
	10 year	10% AEP	2.3	6.8	0.6	0.7	0.4	0.5
	20 year	5% AEP	1.3	3.9	0.4	0.4	0.2	0.3
	25 year	4% AEP	0.8	2.5	0.2	0.3	0.2	0.2
	40 year	2,5% AEP	0.5	1.6	0.2	0.2	0.1	0.1
	50 year	2% AEP	0.3	1.0	0.1	0.1	0.1	0.1
	75 year	1.33% AEP	0.2	0.6	0.1	0.1	0.0	0.1
	100 year	1% AEP	0.1	0.2	0.0	0.0	0.0	0.0
	200 year	0.5% AEP	0.0	0.1	0.0	0.0	0.0	0.0
Low Cost	Flood Threshold		14.8	43.6	2.6	3.1	2.0	2.4
	2 year	50% AEP	12.9	37.8	2.3	2.7	1.7	2.1
	5 year	20% AEP	6.6	19.4	1.3	1.5	0.9	1.2
	10 year	10% AEP	3.1	9.3	0.6	0.7	0.5	0.6
	20 year	5% AEP	1.8	5.3	0.4	0.4	0.3	0.4
	25 year	4% AEP	1.1	3.3	0.3	0.3	0.2	0.2
	40 year	2,5% AEP	0.7	2.1	0.2	0.2	0.1	0.1
	50 year	2% AEP	0.4	1.3	0.1	0.1	0.1	0.1
	75 year	1.33% AEP	0.3	0.8	0.1	0.1	0.0	0.1
	100 year	1% AEP	0.1	0.3	0.0	0.0	0.0	0.0
	200 year	0.5% AEP	0.1	0.2	0.0	0.0	0.0	0.0

Table 3.3 Benefit Cost Ratios for 3 Cost Bands and 6 Packages of Property-level Protection Measures for a post-1985 Detached Property.

Key:
Green - Benefit cost ratio >5;
Amber - Benefit cost ratio >1<5;
Red - Benefit cost ratio <1.

Cost Band	Flood Risk Exposure Band	Annual Exceedance Probability (AEP)	A-Automatic Resistance	B-Manual Resistance	C-Resilience without resilient flooring	D-Resilience with resilient flooring	E-Automatic Resistance and resilience with resilient flooring	F - Manual Resistance and resilience without resilient flooring
High Cost	Flood Threshold		12.4	27.1	2.9	3.2	2.0	2.5
	2 year	50% AEP	10.8	23.5	2.5	2.8	1.8	2.2
	5 year	20% AEP	5.5	11.9	1.4	1.5	0.9	1.2
	10 year	10% AEP	2.6	5.8	0.7	0.8	0.5	0.6
	20 year	5% AEP	1.5	3.3	0.4	0.4	0.3	0.4
	25 year	4% AEP	0.9	2.0	0.3	0.3	0.2	0.2
	40 year	2,5% AEP	0.6	1.3	0.2	0.2	0.1	0.1
	50 year	2% AEP	0.3	0.8	0.1	0.1	0.1	0.1
	75 year	1.33% AEP	0.2	0.5	0.1	0.1	0.0	0.1
	100 year	1% AEP	0.1	0.2	0.0	0.0	0.0	0.0
	200 year	0.5% AEP	0.0	0.1	0.0	0.0	0.0	0.0
Mid Cost	Flood Threshold		15.7	33.4	3.0	3.4	2.2	2.7
	2 year	50% AEP	13.6	29.0	2.7	3.0	1.9	2.4
	5 year	20% AEP	6.9	14.6	1.4	1.6	1.0	1.3
	10 year	10% AEP	3.3	7.2	0.7	0.8	0.5	0.7
	20 year	5% AEP	1.9	4.1	0.4	0.5	0.3	0.4
	25 year	4% AEP	1.1	2.5	0.3	0.3	0.2	0.2
	40 year	2,5% AEP	0.7	1.6	0.2	0.2	0.1	0.2
	50 year	2% AEP	0.4	1.0	0.1	0.1	0.1	0.1
	75 year	1.33% AEP	0.3	0.6	0.1	0.1	0.1	0.1
	100 year	1% AEP	0.1	0.2	0.0	0.0	0.0	0.0
	200 year	0.5% AEP	0.1	0.1	0.0	0.0	0.0	0.0
Low Cost	Flood Threshold		21.2	44.7	3.2	3.6	2.4	2.9
	2 year	50% AEP	18.4	38.8	2.8	3.2	2.1	2.6
	5 year	20% AEP	9.4	19.6	1.5	1.7	1.1	1.4
	10 year	10% AEP	4.5	9.6	0.8	0.8	0.6	0.7
	20 year	5% AEP	2.5	5.4	0.5	0.5	0.3	0.4
	25 year	4% AEP	1.5	3.4	0.3	0.3	0.2	0.3
	40 year	2,5% AEP	1.0	2.1	0.2	0.2	0.1	0.2
	50 year	2% AEP	0.6	1.3	0.1	0.1	0.1	0.1
	75 year	1.33% AEP	0.4	0.8	0.1	0.1	0.1	0.1
	100 year	1% AEP	0.1	0.3	0.0	0.0	0.0	0.0
	200 year	0.5% AEP	0.1	0.2	0.0	0.0	0.0	0.0

Table 3.4 Benefit Cost Ratios for 3 Cost Bands and 6 Packages of Property-level Protection Measures for a pre-1919 Terraced Property.

Key:
Green - Benefit cost ratio >5;
Amber - Benefit cost ratio >1<5;
Red - Benefit cost ratio <1.

The traffic light shading in Tables 3.3 and 3.4 above has been used to illustrate which combinations of property-level protection measures and cost bandings for selected property threshold AEPs provide cost beneficial solutions, using the economic model (with reduced reliability scenarios):

- The green shading highlights those packages of measures (for low, mid and high cost scenarios) that have benefit cost ratios in excess of 5 and are likely to need lower contributions or be fully funded under partnership funding;
- Amber shading highlights the scenarios with benefit cost ratios in excess of 1 (but less than 5); and
- Red shading highlights those scenarios that have benefit cost ratios of 1 or less and will require higher levels of contributions under Partnership Funding.

As can be seen on both the detached and the terraced property examples above, both automatic and manual resistance measures have benefit cost ratios in excess of 5 for the higher frequency flooding scenarios. However, manual measures are more than twice as cost beneficial as automatic measures and achieve some very high benefit cost ratios.

Measures involving resilience do not achieve any (green shaded) scenarios in excess of 5 and are only exceeding benefit cost ratios of 1 at the very highest flood risk bands (more frequent than 20% AEP (or 1:5 chance in any year). This pattern is consistent across 34 property type and age combinations, with manual resistance giving positive benefit cost ratios for property with flood thresholds up to around 40 years (2.5% AEP). Automatic resistance measures have positive benefit cost ratios for property with flood thresholds up to around 25 years (4% AEP).

All 34 property type scenarios show a similar pattern with benefit cost ratios greater than 5:1 restricted to properties experiencing very frequent flooding. Resilience measures are only cost beneficial where thresholds of flooding are 5 years (20% AEP) or even more frequent. This is primarily because although some savings are possible for flooding of considerable depth within the property, costs are considerably higher than either automatic or manual resistance measures yet the present value of benefits is similar.

The model output can also be illustrated in terms of Net Present Value (i.e. the differences between the *whole life costs* and *whole life benefits*). Table 3.5 below illustrates net present values for all scenarios and highlights in green just where benefits exceed costs, in this instance for a post-1985 detached property. This pattern is typical of all the output for other properties, with only minor variations for all type and age combinations.

Cost Band	Flood Risk Exposure Band	A-Automatic Resistance	B-Manual Resistance	C-Resilience without resilient flooring	D-Resilience with resilient flooring	E-Automatic Resistance and resilience with resilient flooring	F - Manual Resistance and resilience without resilient flooring
High Cost	Flood Threshold	£146906	£140,611	£48,284	£86,119	£52,117	£43,273
	2 year	£125330	£121,414	£38,295	£69,512	£35,510	£33,248
	5 year	£55249	£59,337	£4,778	£15,021	-£18,981	-£269
	10 year	£16100	£25,576	-£14,902	-£16,632	-£50,634	-£19,949
	20 year	£915	£12,231	-£23,398	-£29,268	-£63,270	-£28,445
	25 year	-£6677	£5,558	-£27,646	-£35,586	-£69,588	-£32,693
	40 year	-£11247	£1,435	-£30,503	-£39,917	-£73,919	-£35,550
	50 year	-£14294	-£1,314	-£32,407	-£42,804	-£76,806	-£37,454
	75 year	-£15942	-£2,843	-£33,536	-£44,566	-£78,568	-£38,583
	100 year	-£17814	-£4,595	-£34,888	-£46,551	-£80,553	-£39,935
	200 year	-£18401	-£5,142	-£35,301	-£47,175	-£81,177	-£40,349
Mid Cost	Flood Threshold	£150798	£141,716	£50,031	£88,444	£59,019	£46,024
	2 year	£129221	£122,519	£40,041	£71,837	£42,413	£36,035
	5 year	£59140	£60,442	£6,525	£17,346	-£12,078	£2,518
	10 year	£19992	£26,681	-£13,156	-£14,308	-£43,732	-£17,163
	20 year	£4807	£13,336	-£21,652	-£26,943	-£56,368	-£25,659
	25 year	-£2785	£6,663	-£25,900	-£33,261	-£62,686	-£29,906
	40 year	-£7355	£2,540	-£28,756	-£37,592	-£67,017	-£32,763
	50 year	-£10402	-£209	-£30,660	-£40,480	-£69,904	-£34,667
	75 year	-£12051	-£1,738	-£31,789	-£42,241	-£71,666	-£35,796
	100 year	-£13923	-£3,491	-£33,141	-£44,226	-£73,651	-£37,148
	200 year	-£14509	-£4,038	-£33,555	-£44,851	-£74,275	-£37,562
Low Cost	Flood Threshold	£154681	£142,942	£51,777	£90,768	£65,913	£48,933
	2 year	£133105	£123,745	£41,788	£74,161	£49,306	£38,943
	5 year	£63023	£61,668	£8,271	£19,670	-£5,184	£5,427
	10 year	£23875	£27,907	-£11,409	-£11,983	-£36,838	-£14,254
	20 year	£8690	£14,562	-£19,905	-£24,619	-£49,474	-£22,750
	25 year	£1098	£7,889	-£24,153	-£30,937	-£55,792	-£26,998
	40 year	-£3472	£3,766	-£27,009	-£35,268	-£60,123	-£29,854
	50 year	-£6519	£1,017	-£28,914	-£38,155	-£63,010	-£31,758
	75 year	-£8168	-£512	-£30,043	-£39,917	-£64,772	-£32,887
	100 year	-£10040	-£2,264	-£31,395	-£41,902	-£66,757	-£34,239
	200 year	-£10626	-£2,811	-£31,808	-£42,526	-£67,381	-£34,653

Table 3.5 Net Present Values for 3 Cost Bands and 6 Packages of Property-level Protection Measures for a post-1985 Detached Property.

Key:
Green - Positive values.
Red - Negative vales.

3.2.2 Headline Results for Core Property Types

These results have been used to further assess the influence of property type on benefit cost outcome. To carry out this analysis, the 10% AEP (10 year) and 2.5% AEP (40 year) standard of protection thresholds are used in a comparison of results for the 5 core types (detached, semi-detached, terraced, bungalow and flat) for 4 selected model and reliability scenarios. Each of the 4 scenarios have been restricted to mid-cost assumptions for the 10% AEP (1 in 10 year) and 2.5% AEP (1 in 40 year) thresholds of flooding.

The 4 scenarios used to compare results for the core property types are:

- Totally reliable property-level protection measures, using the Economic Model.
- Totally reliable property-level protection measures, using the Financial Model.
- Reduced reliability, in line with assumptions in Section 2.5.2, using the Economic Model.
- Reduced reliability, in line with assumptions in Section 2.5.2, using the Financial Model.

In view of the fact that reliability assumptions make little significant difference to the outcome, Figures 3.5 and 3.6 illustrate the model findings for the 'Reduced Reliability' scenarios for both the Financial and the Economic perspective respectively. The main points are summarised below. All 4 scenarios show an emerging pattern where:

- Benefit cost ratios for Manual Resistance measures are significantly greater than 5:1 for all core property types exposed to flooding with a 10% AEP (1 in 10 year) threshold.
- Manual Resistance measures for all core property types also achieve benefit cost ratios greater than 1:1 for the lower frequency flooding threshold of 2.5% AEP (1 in 40 year) threshold.
- Automatic Resistance measures generally exceed a benefit cost ratio of 2:1, but never reach 4:1, for the higher frequency 10% AEP (1 in 10 year) flood threshold.
- Automatic Resistance measures are not cost beneficial for lower frequency flooding thresholds of 40 years.
- Bungalows are always less cost beneficial because property-level protection measures cost more, since the ground floor property footprints are larger.
- For all scenarios, benefit cost ratios are marginally improved from a financial perspective compared to an economic one.
- 'Reduced Reliability' only marginally lowers benefit cost ratios and the core type benefit cost ratios remain consistent with other selected scenarios.

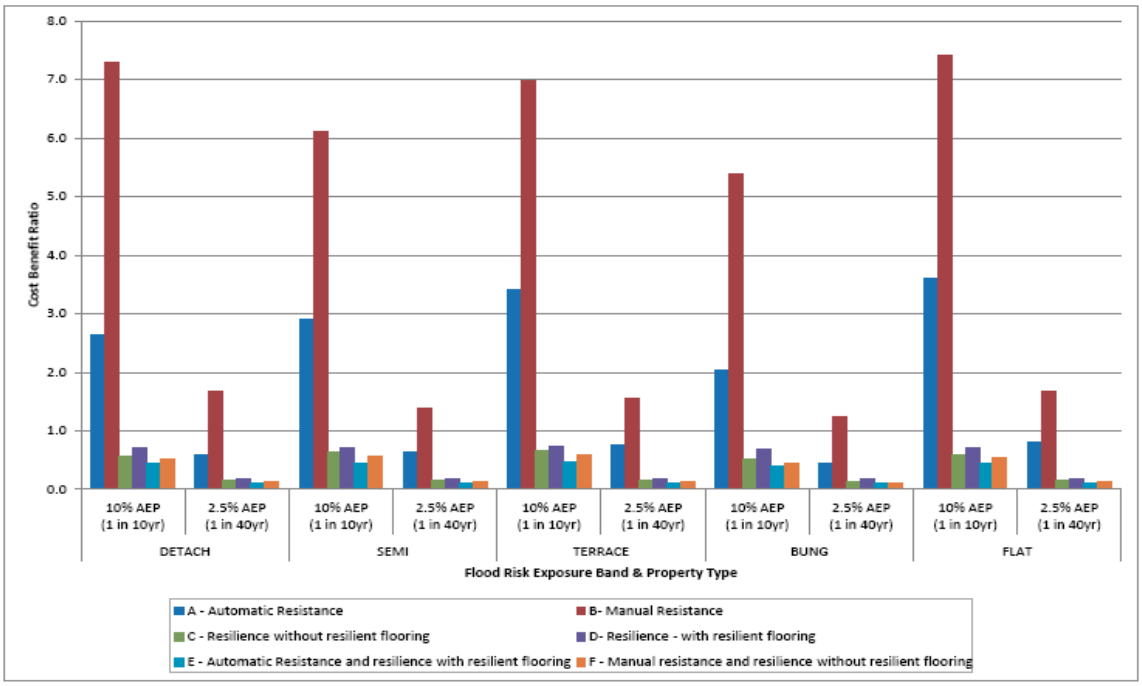


Figure 3.5 Scenario 1: The Effects of Property Type and Flood Threshold on Benefit Cost Ratios for Reduced Reliability Modelled from a Financial Perspective

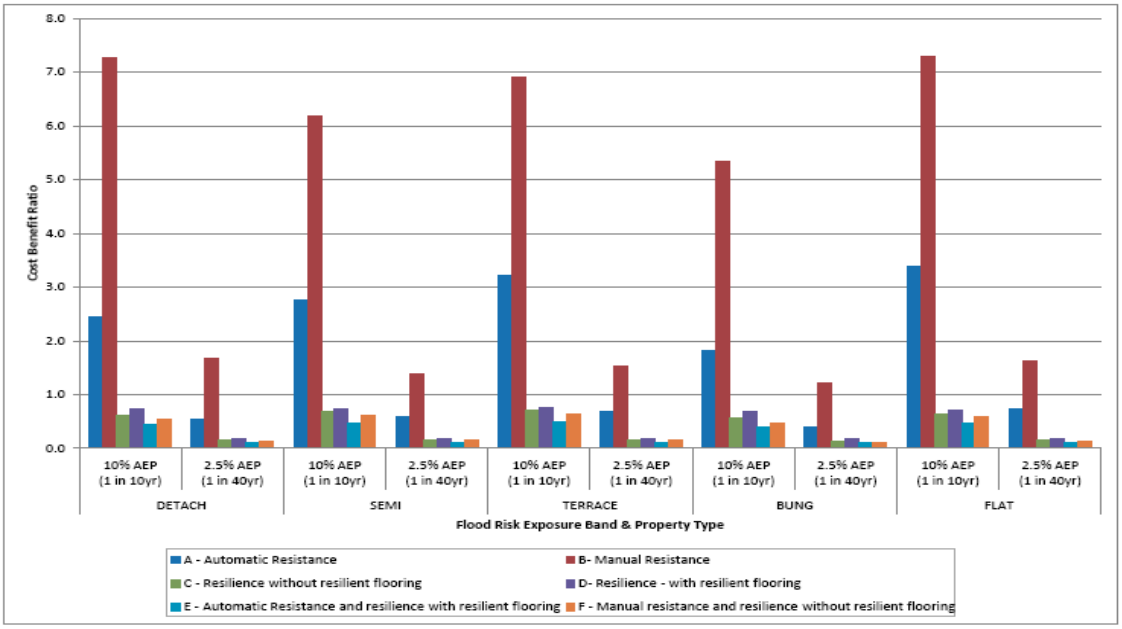


Figure 3.6 Scenario 2: The Effects of Property Type and Flood Threshold on Benefit Cost Ratios for Reduced Reliability Modelled from an Economic Perspective

3.3 Partnership Funding Output

3.3.1 Overview

Defra introduced the new system of Partnership Funding for flood and coastal risk management schemes in May 2011. Property-level flood protection schemes are now funded using this system and are considered for funding alongside community scale projects. The benefit cost model has therefore been extended to take account of these recent policy changes and to investigate the effects on cost effectiveness.

3.3.2 Partnership Funding Scenario Building

The property-level protection benefit cost model was extended to 'scenario build' based on the multiple parameters which will affect either the Outcome Measures score or the benefit cost ratio of the property/flood scenario under investigation. This will assist in identifying the contribution anticipated for specific properties with different levels of flood risk and social deprivation.

Table 3.6 lists the various factors that were investigated and the range of variants within each parameter that have been considered.

Parameter	Variant
Property Type	Detached
	Semi-detached
	Terraced
	Bungalow
	Flat
Model	Financial
	Economic
Social Deprivation	20% Most Deprived
	21-40% Most Deprived
	60% Least Deprived
Cost Band	High
	Mid range
	Low
Property-level Protection Measures Package	A - Automatic Resistance
	B - Manual Resistance
	C - Resilience without resilient flooring
	D - Resilience with resilient flooring
	E - Measures Package A plus D
	F - Measures Package B plus C
Flood Risk Exposure Band	Very Significant (10% AEP/1 in 10) to Moderate (1% AEP/1 in 100)
	Very Significant (5% AEP/1 in 20) to Moderate (1% AEP/1 in 100)
	Very Significant (10% AEP/1 in 10) to Significant (2.5% AEP/1 in 40)
	Very Significant (5% AEP/1 in 20) to Significant (2.5% AEP/1 in 40)
	Significant (2.5% AEP/1 in 40) to Moderate (1% AEP/1 in 100)
	Significant (1.3% AEP/1 in 75) to Moderate (1% AEP/1 in 100)
Reliability Assumption	Total Reliability
	Reduced Reliability

Table 3.6 Summary of the Multiple Parameters and Variants used to Analyse Benefit Cost and Partnership Funding Outcome Scores.

This matrix of variables results in a total of 22,032 possible outcomes, with 11,016 Financial and Economic scenarios for each reliability assumption. A scenario testing model was developed whereby selecting from the menus of variants for each parameter, a benefit cost ratio, outcome measure score and contribution is calculated. An early example of JBA's inital model menu selection screen is shown below in Figure 3.7. Defra extended the research scope to further develop a prototype scheme appraisal tool, to provide a fully interactive analytical support tool to help Lead Local Flood Authorities assess and prioritise potential

schemes. This allows for any combination and type of potential property-level protection scheme and can be further enhanced with a GIS data input option.

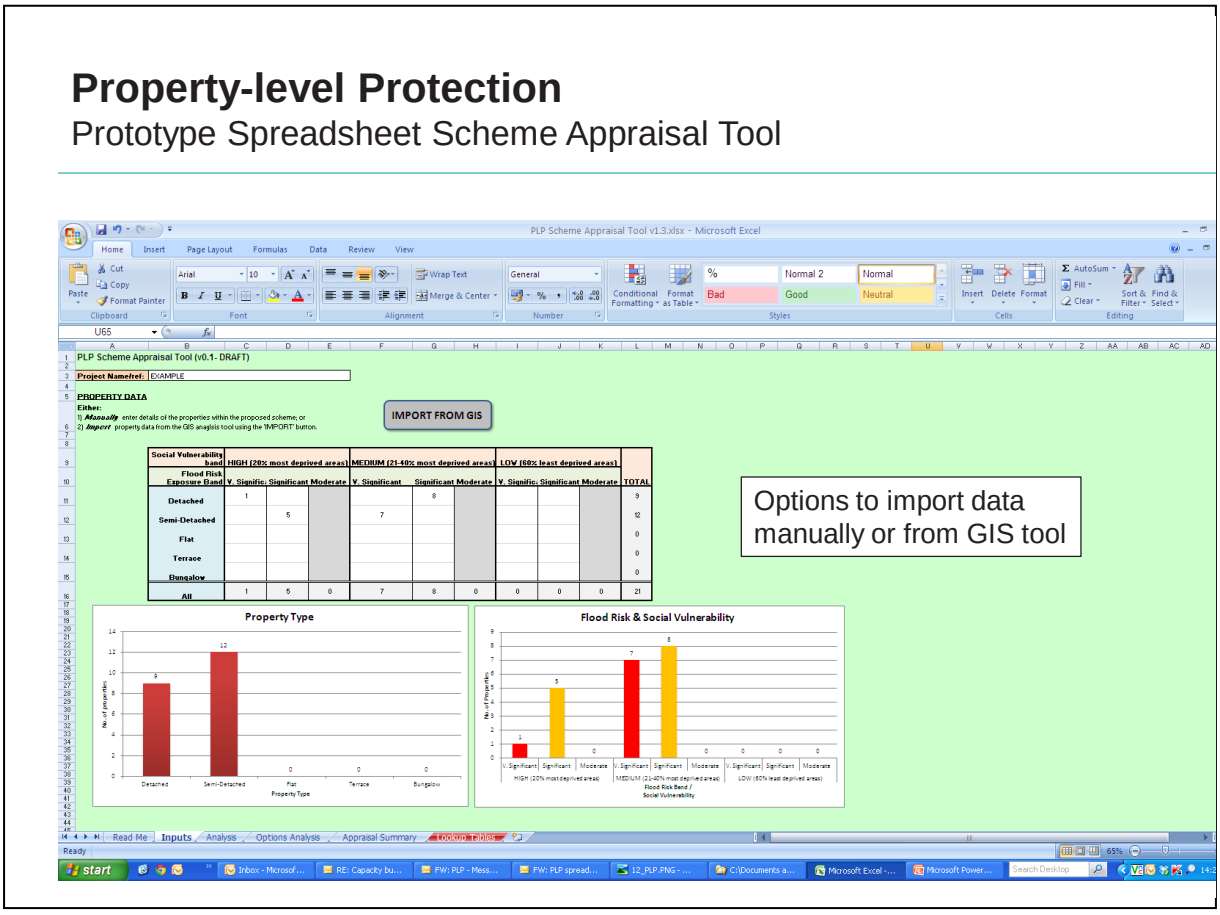


Figure 3.7 Development Stage of Possible Interactive Scheme Appraisal Tool.

Using a 'Reduced Reliability' scenario and holding each other parameter constant in turn, a summary of the percentage of scenarios was derived where:

- Outcome Measure Scores are greater than 100%;
- Where benefit cost ratios are more than 1:1; and
- Where benefit cost ratios are more than 5:1.

For example, 14% of all property scenarios have benefit cost ratios greater than 5:1 where the flood threshold was 10% AEP (1 in 10 years and property protection measures would reduce flood risk from Very Significant to Moderate (with Moderate taken as 1:100 years, from the Partnership Funding Calculator range of 75 to 200 years).

The following Table 3.7 summarises the results whilst the subsequent graphs in Figures 3.8 to 3.13 illustrate the findings. The analysis shows how resistance measures are most cost effective, with no resilience package exceeding 0% for Outcome Scores or benefit cost. Of the resistance measures, both Automatic and Manual packages substantially exceed a 1:1 benefit cost ratio (54% and 79% of scenarios respectively), but only Manual Resistance measures attain benefit cost ratios of 5:1 or more.

The same outcome can be seen for Outcome Score, with Manual Resistance attaining 100% or more in 35% of scenarios, whereas Automatic Resistance reach the 100% threshold in only 2% of scenarios.

Parameter Held Constant	Variable	Outcome Measure > 100%	Benefit Cost Ratio > 1	Benefit Cost Ratio > 5
Property Type (34 Type & Age Comb-inations)	Detached	4 to 7%	16 to 26%	3 to 7%
	Semi	5 to 6%	18 to 23%	1 to 3%
	Terrace	8%	21 to 25%	1 to 6%
	Bungalow	3%	19 to 20%	1 to 3%
	Flat	7 to 9%	20 to 25%	1 to 7%
Model	Financial	5.2%	22%	3.7%
	Economic	3.6%	22%	3.7%
Social Deprivation	20% most	10.7%	22%	3.7%
	21-40% most	5.8%	22%	3.7%
	60% least	1.9%	22%	3.7%
Cost band	High	3%	20%	1%
	Mid	5%	22%	4%
	Low	10%	24%	6%
Property Protection Measures Package	A - Automatic Resistance	2%	54%	0%
	B - Manual Resistance	35%	79%	22%
	C - Resilience without resilient flooring	0%	0%	0%
	D - Resilience with resilient flooring	0%	0%	0%
	E - Measures Package A plus D	0%	0%	0%
	F - Measures Package B plus C	0%	0%	0%
Flood Risk Exposure Band	Very Significant (10% AEP/1 in 10) to Moderate (1% AEP/1 in 100)	14%	34%	13%
	Very Significant (5% AEP/1 in 20) to Moderate (1% AEP/1 in 100)	11%	30%	2%
	Very Significant (10% AEP/1 in 10) to Significant (2.5% AEP/1 in 40)	7%	33%	8%
	Very Significant (5% AEP/1 in 20) to Significant (2.5% AEP/1 in 40)	4%	24%	0%
	Significant (2.5% AEP/1 in 40) to Moderate (1% AEP/1 in 100)	0%	12%	0%
	Significant (1.3% AEP/1 in 75) to Moderate (1% AEP/1 in 100)	0%	0%	0%

Table 3.7 Percentage of Scenarios for each parameter/variable where Outcome Measures are greater than 100% and Benefit Cost Ratio is greater than 1 and 5 respectively.

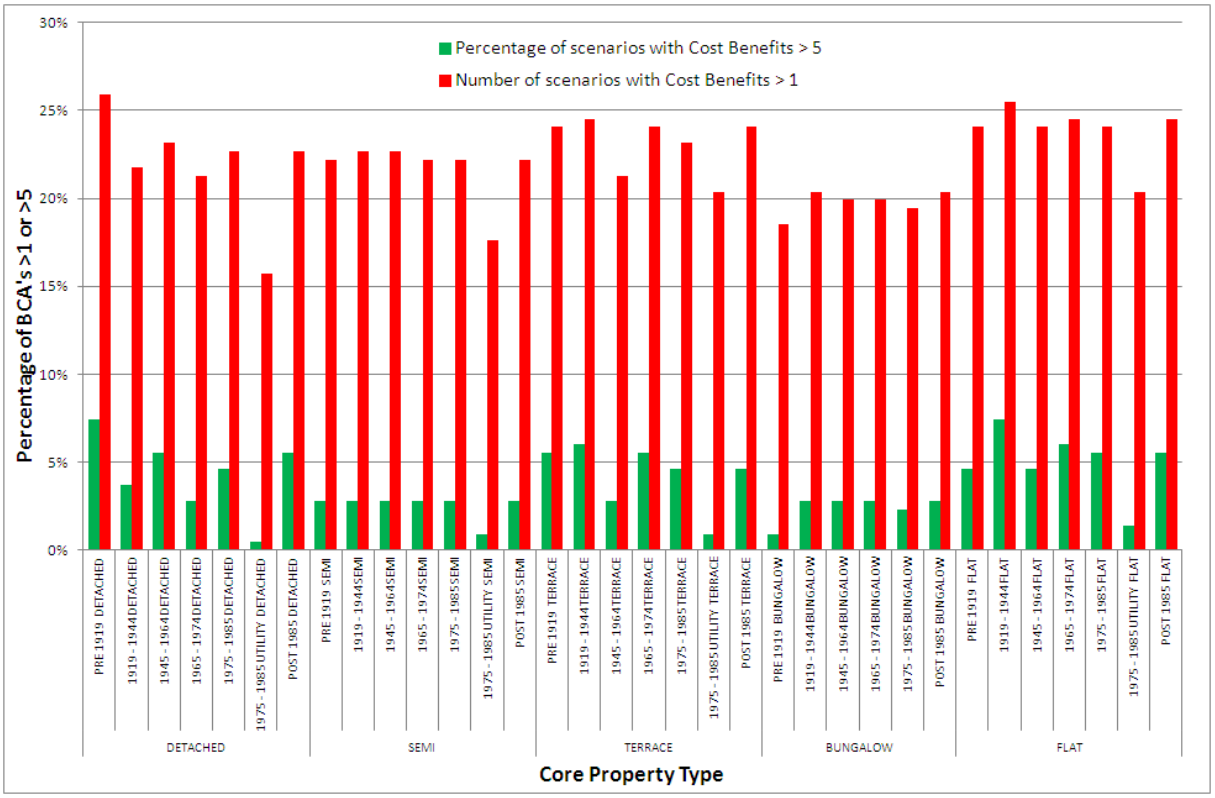


Figure 3.8 Percentage of Scenarios where Benefit Cost Ratios are Greater than 1 and Greater than 5 for Different Property Types.

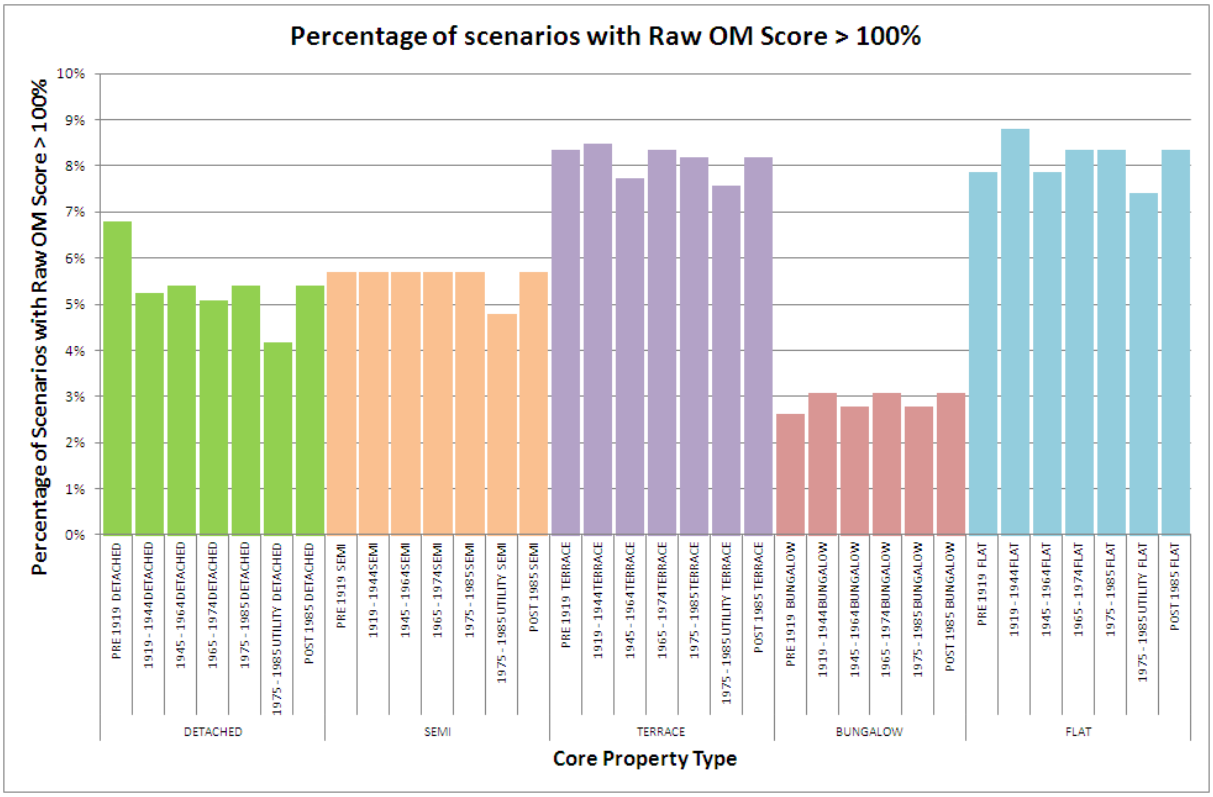


Figure 3.9 Percentage of Scenarios for Different Property Types where Outcome Measures Score is Greater than 100%.

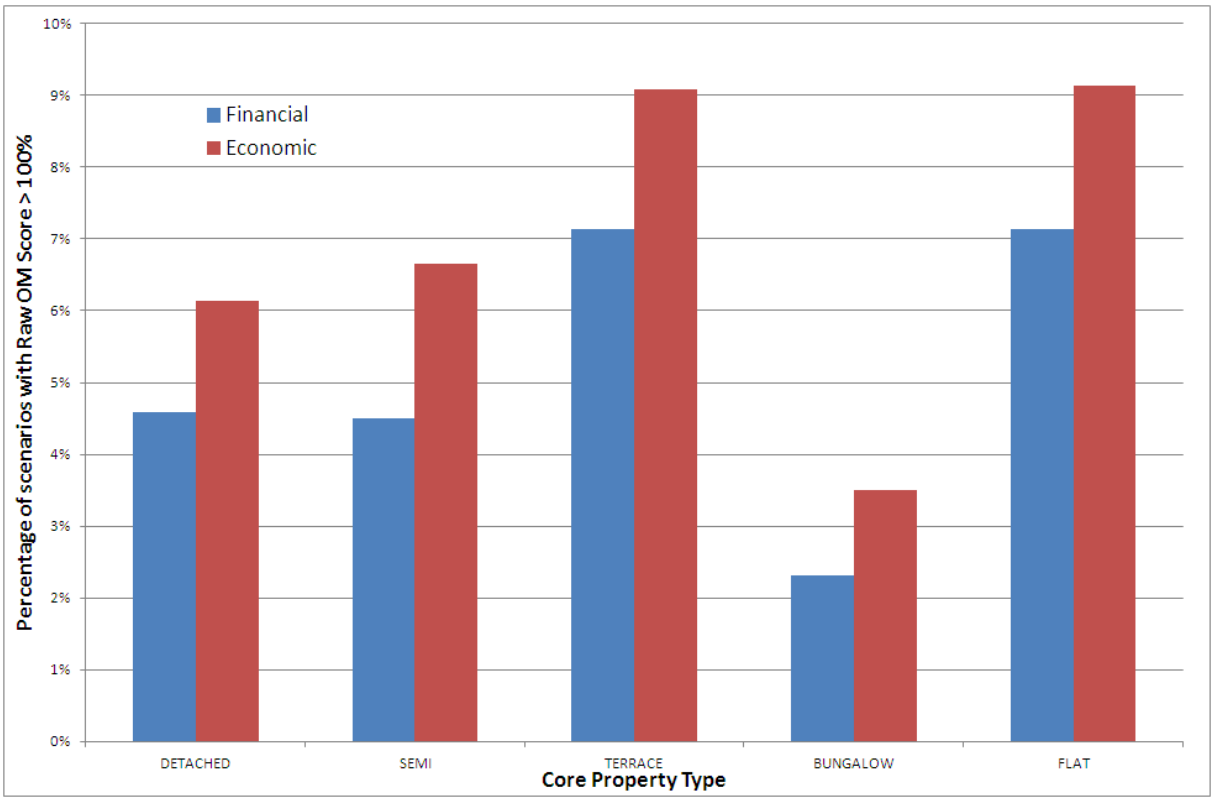


Figure 3.10 Percentage of Scenarios where Economic and Financial Model Raw Outcome Measures Scores are greater than 100%.

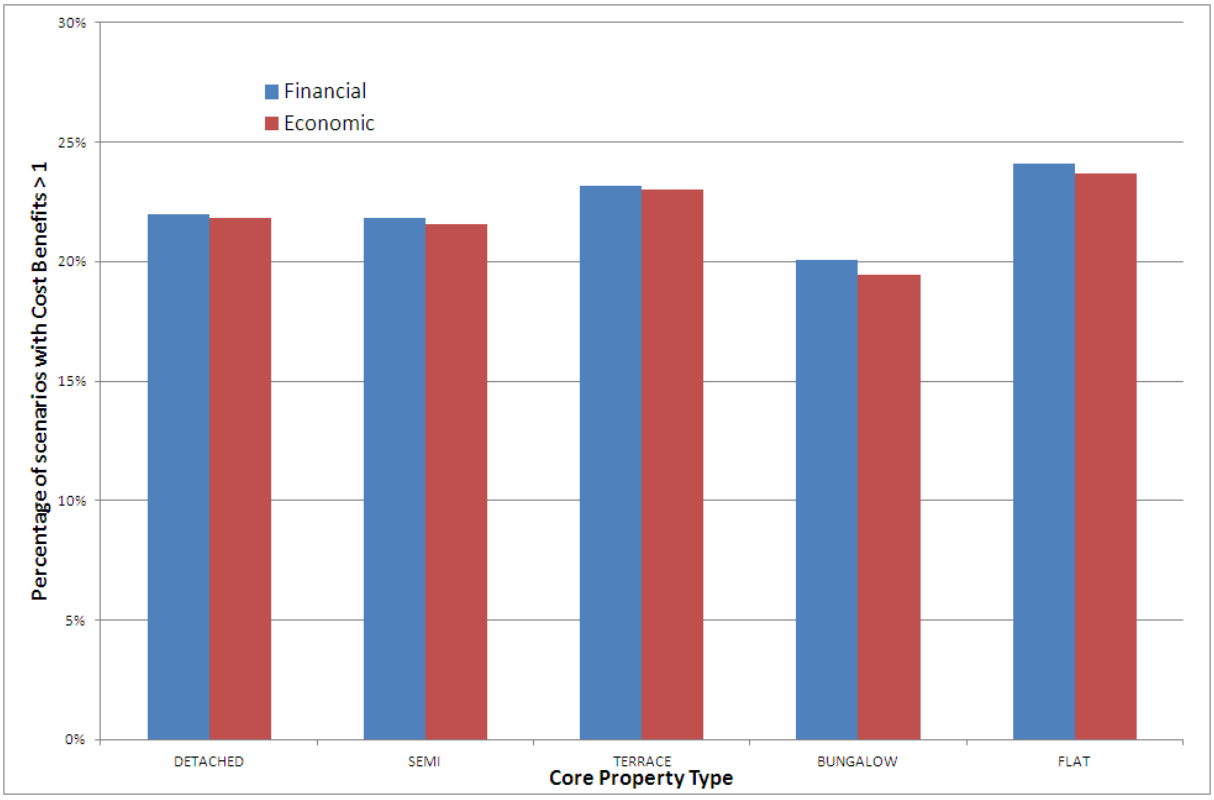


Figure 3.11 Percentage of Scenarios where Economic and Financial Model Benefit Cost Ratios are greater than 1.

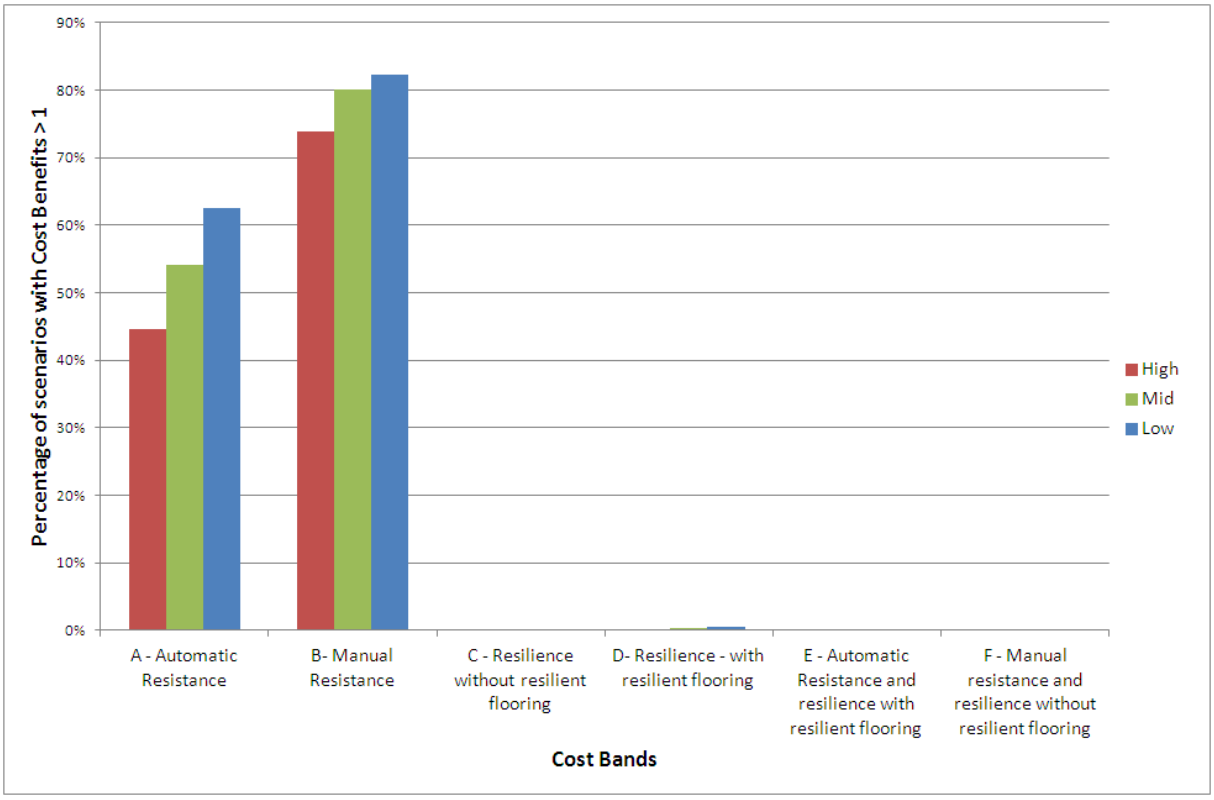


Figure 3.12 Percentage of Scenarios for Different Packages of Measures with Benefit Cost Ratios Greater than 1 for Differing Cost Bands.

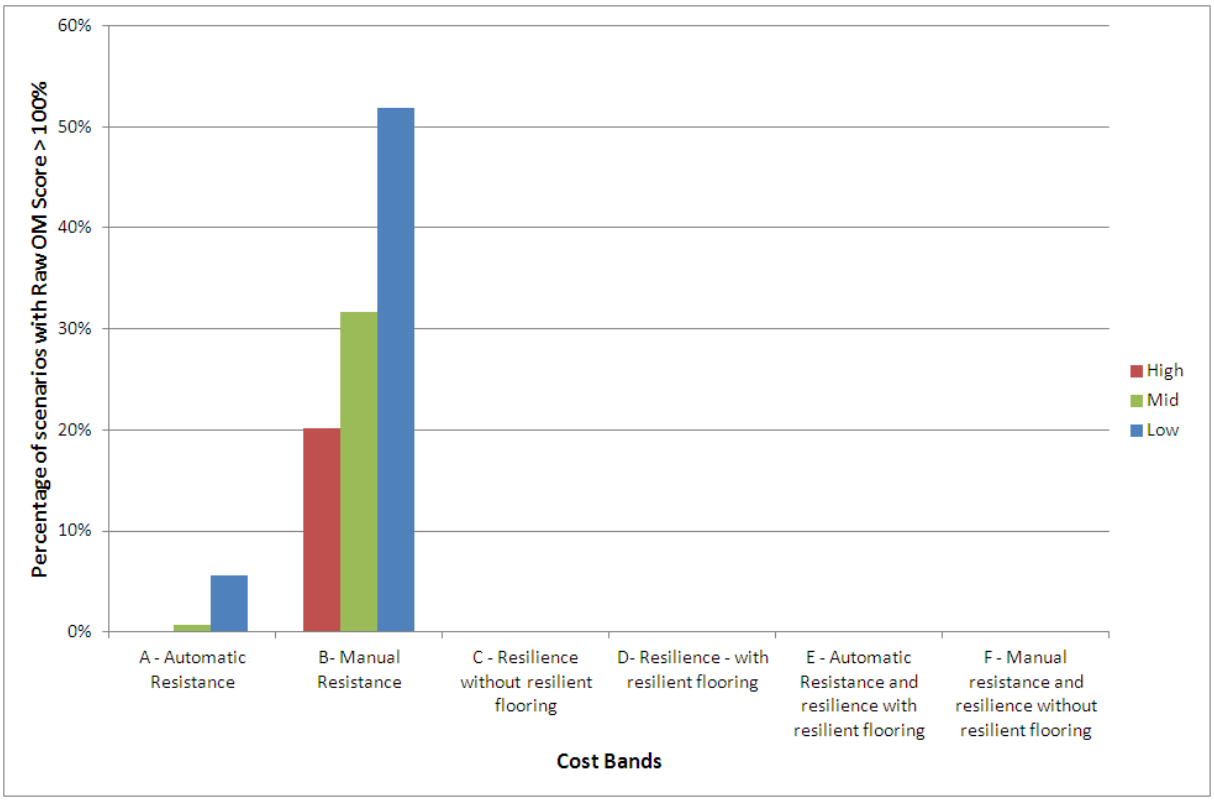


Figure 3.13 Percentage of Scenarios for Different Packages of Measures with Raw Outcome Measure Scores Greater than 100% for Differing Cost Bands.

Whilst benefits are standardised using the industry standard Multi-coloured Manual data, costs are more specific to individual property and market circumstances. Driving costs down will increase raw outcome measures scores and raise the benefit cost ratio. This will assist in promotion of both manual and automatic property-level protection measures. Table 3.8 illustrates the impact of cost, by holding both costs and measures constant:

Property-level Protection Measure	Cost Band	Outcome Measure > 100%	Benefit Cost Ratio > 1
Automatic Resistance	High	0%	45%
Manual Resistance	High	20%	74%
Automatic Resistance	Medium	1%	54%
Manual Resistance	Medium	32%	80%
Automatic Resistance	Low	6%	63%
Manual Resistance	Low	52%	82%
Resilience with Resilient Flooring	Mid	0%	0%
Resilience with Resilient Flooring	Low	0%	0%

Table 3.8 Percentage of Scenarios when Property-level Protection Measure and Costs are held constant where Outcome Measure Scores are Greater than 100% and Benefit Cost Ratios Greater than 1.

Table 3.8 clearly illustrates the sensitivity and impacts of cost on automatic and manual property-level protection measures. The lower the costs the more property type scenarios have Outcome Measures scores greater than 100% and benefit cost ratios greater than 1. In summary:

- For the Low Cost Manual Resistance measures example, over half of the scenarios could qualify for higher levels of Flood Defence Grant-in-Aid funding contributions.
- Four out of five mid-cost Manual Resistance scenarios attract a benefit cost ratio in excess of 1.
- Half of mid-cost Automatic Resistance scenarios exceed a benefit cost ratio of 1.
- Around half of Automatic Resistance measures make for cost effective schemes but have lower Outcome Measure Scores due to their higher expense. This implies that such examples could be considered but will need substantial contributions (e.g. from Local Levy or residents).
- The higher expense of resilience make these measures cost ineffective as a means of Government intervention.

Impact of Reliability

The impacts of factoring in reliability are also illustrated in Figure 3.14 and 3.15, which compare both the Total Reliability and Reduced Reliability scenarios for the 5 core property types. These confirm that despite making an allowance for the need for human intervention - and the likelihood that deployment of measures won't always be successful - there is in fact very little difference between the two scenarios. Reduced Reliability decreases the percentage of Outcome Measure Scores that exceed 100% by only 0.5% or less. Likewise

the number of scenarios where the benefit cost ratios are greater than 1 are also only marginally reduced when accounting for Reduced Reliability.

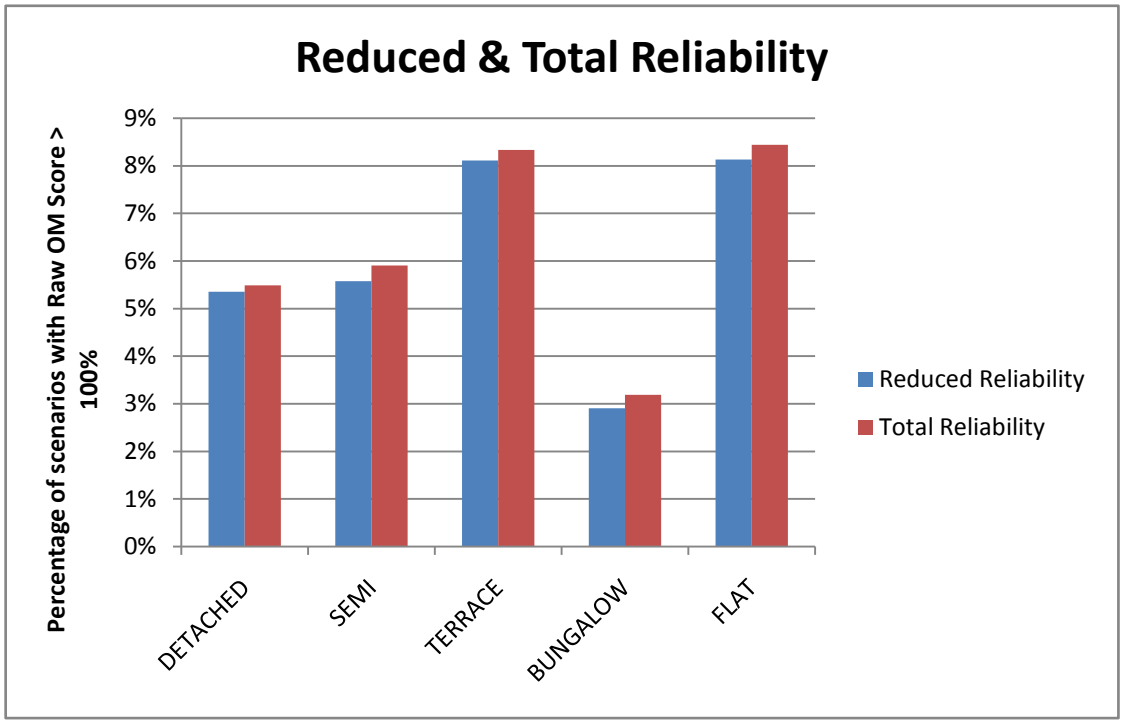


Figure 3.14 Reliability Assessment and the Impact on Outcome Measure Scores.

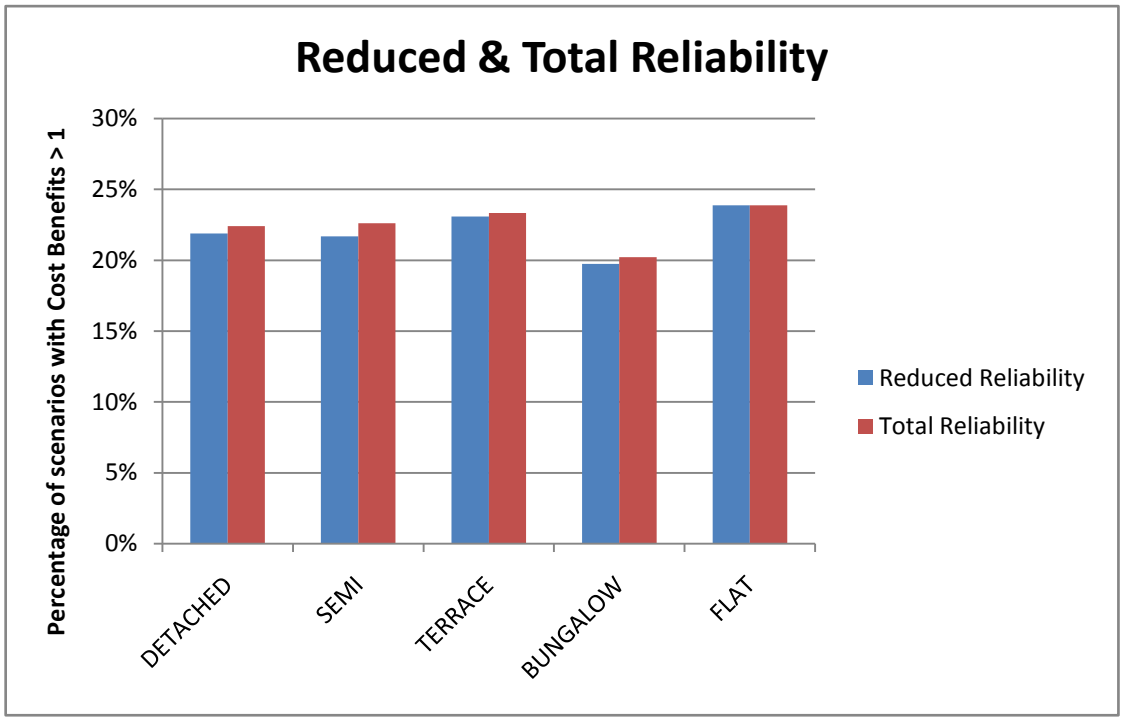


Figure 3.15 Reliability Assessment and the Impact on Scenarios with Benefit Cost Ratios Greater than 1.

4 Summary of Findings

4.1 Study Findings

Significant improvements and updates have been made to the earlier 2008 FD2607 property-level protection model. Through the comprehensive scenario testing analysis, a matrix of 22,032 variables was generated, resulting in the following findings and main conclusions:

FINDINGS

Manual Resistance measures provide by far the most cost effective property-level protection option, regardless of property type. They are cost beneficial (i.e. with a benefit cost ratio >1) for typical flood thresholds of 2.5% AEP (1:40 years) or more frequent. They also provide even higher benefit cost ratios of >5:1 for the more frequent flood thresholds of 10% AEP (1:10 year) or more (see Table 3.3 and 3.4).

Automatic Resistance measures are the second most cost effective option behind manual measures. Benefit cost ratios are in excess of 1 for flood thresholds of around 5% AEP (1:20 year) but only the more frequent flood thresholds of 20% AEP (1:5 year) or more attain benefit cost ratios of >5:1 (see Table 3.3 and 3.4).

Property-level protection packages that include resilience measures are only cost effective (i.e. exceed a benefit cost ratio of 1:1) for the most frequent flood thresholds of 20% AEP (1:5 year).

No resilience package generates benefit cost ratios in excess of 5:1 reflecting their higher investment costs.

22% of all scenarios exceed a benefit cost ratio of 1:1 but only 3.7% exceed a ratio of 5:1. This masks the big difference between resistance and resilience measures: 79% of Manual Resistance mid-cost scenarios have a benefit cost ratio greater then 1:1 and 22% greater than 5:1, compared to 0% for resilience measures.

All 34 property types show very similar and consistent patterns of cost effectiveness. This confirms that the 5 core property types can be considered as representative of the wider variety considered in the Multi-Coloured Manual.

However, of the 5 core types, bungalows are always marginally less cost beneficial because protection measures cost more, due to the larger ground floor property footprint.

Benefit cost ratios for Manual Resistance measures are significantly greater than 5:1 for all core property types exposed to flooding with a 10% AEP (1:10 year) threshold.

Manual Resistance measures for all core property types achieve benefit cost ratios more than 1:1 for the lower frequency flooding threshold of 2.5% AEP (1:40 years).

Automatic Resistance measures generally exceed a benefit cost ratio of 2:1, but never reach 4:1, for the higher frequency 10% AEP (1:10 year) flood threshold.

Automatic Resistance measures are not cost beneficial for lower frequency flooding thresholds of 4% AEP (1:25 years) or less.

FINDINGS Cont/d

Property-level protection of any sort is generally not cost effective for the lower frequency floods with thresholds of 2% AEP (1:50 year) or lower.

Benefit cost ratios are virtually identical (marginally improved) from a financial perspective compared to an economic one (see Figure 3.13).

A reliability assessment considered the implications of lost, misplaced or incorrectly deployed resistance measures, as well as possible deficiencies in flood warning. This confirmed that Automatic measures are more reliable, with probability factors for success being assigned of 90% for Automatic Resistance measures and 77% for Manual Resistance measures.

The findings reveal that reliability has very little effect on the outcomes and cost effectiveness of property-level protection. Reduced reliability reduces, as might be expected, the benefit cost ratios but the core type benefit cost ratios remain consistent with other selected scenarios. The percentage of all scenarios that exceed a benefit cost ratio of >1 are reduced by 0.75% or less; and those with an Outcome Measure score of >100% are reduced by only 0.5% or less. There are only small reductions of 1% or less for specific property types.

There is clear evidence of the effects of enhanced support for cases with greater levels of social deprivation, resulting in a higher percentage of scenarios exceeding the 100% Outcome Measure score. Nearly 6 times as many scenarios exceed the 100% threshold in the 20% 'Most Deprived' band as compared to the 60% 'Least Deprived' band (10.7% compared to only 1.9% in the 'Least Deprived' band).

The analysis defines the outcome sensitivity to the costs of the actual automatic and manual protection measures. The lower the costs the more property type scenarios have Outcome Measures scores greater than 100% and benefit cost ratios greater than 1. For the Low Cost Manual Measures for example, over half of all the scenarios would qualify for full Flood Defence Grant-in-Aid funding contributions, with four out of five scenarios resulting in a benefit cost ratio in excess of 1.

Intangible benefits, such as lower levels of stress and improved health and well-being, have been briefly reviewed and updated in light of current research. Modest increases have been applied to the model to better reflect the true benefits of flood protection to those undefended communities at highest risk experiencing repeated flooding.

Property-level protection measures do not reduce the likelihood of a flood to which a property is exposed. They do however help manage the consequences by avoiding some of the damage that would otherwise occur if the measures (resilience and resistance) were not in place.

Although traditional flood defence schemes have a higher benefit cost ratio, property level schemes can still represent good overall value for money, achieving reductions in flood risk and generating other wider intangible benefits (such as greater flood awareness, community cohesion and building local authority capacity) which are not included in the cost benefit analysis.

5 Conclusions

5.1 Study Outcomes

The model review, update and analysis have resulted in a number of recommendations that are made and summarised below for further consideration.

5.1.1 The Property-level Protection Approach

Property-level protection is an effective and accepted new approach for managing flood risk in the hierarchy of management interventions. This analysis has assessed and identified the range of scenarios that are cost effective and has also factored the new Partnership Funding arrangements into the analysis.

The Defra Grant Scheme evaluation suggested that while property-level protection should sit alongside traditional flood defence schemes, there are inherent differences between the two approaches that may mean they should be treated differently.

This further study emphasises the important distinction that should be made between community level flood defence schemes and property-level protection:

- Unlike traditional and permanent flood defence works, property-level protection schemes do not change or alter the actual likelihood of a flood that properties are exposed to.
- They simply provide residents with the option to manage the consequences of flooding, such that damages are reduced for the more frequent, lower threshold level floods.
- There is a much lower capital investment required to implement property-level protection schemes and give people the opportunity to manage the consequences of flooding in areas where costly defence schemes cannot be justified.

As a result of these important distinctions, it is considered that the two approaches offer quite different responses to managing flood risk, leading to very different levels of anxiety over the risk of flooding between the two groups. Property-level protection provides lower standards of protection than a capital community defence scheme but far superior to reliance simply on sandbags alone. By focusing on managing the consequences once flood water has reached a property, residents still have the worry and stress of the impacts this can cause. Residents with property-level protection measures must therefore still be prepared for flooding and must recognise that flood damage can still occur. This contrasts markedly with those communities who benefit from flood defence schemes that are designed to retain much larger flood events some distance away from the community and, in so doing, reducing both the likelihood and consequences of flooding.

The study has confirmed that manual resistance measures provide by far the most cost effective property-level protection option, with benefit cost ratios in excess of 5:1 for the more frequent flood thresholds (10% AEP or 1:10 year chance). They remain cost effective (i.e. a benefit cost ratio >1) for flood thresholds of 2.5% AEP (1:40 years chance), with 80% of the scenarios for mid-cost Manual Resistance measures exceeding this threshold.

The more costly automatic resistance measures only attain benefit cost ratios in excess of 5:1 for the most frequent flood events of 20% AEP (1 in 5 years) or more frequent. Benefit cost ratios are in excess of 1 for flood thresholds of around 5% AEP (1:20 year) and also account for 54% of all scenarios for medium cost Automatic Resistance measures (see Table 3.8).

The much more expensive resilience measures scenarios do not achieve positive benefit cost ratios or reach a 10% Outcome Measure threshold.

5.1.2 Raising Awareness

The Defra Grant Scheme evaluation highlighted how property-level flood protection schemes have helped raise awareness of the approach amongst communities and the respective operating authorities. This applies equally to understanding cost effectiveness and the new Partnership Funding arrangements. There remains more to be done before there is a much

wider and more general uptake of property-level flood protection. The existing flood awareness work of the Lead Local Flood Authorities and the Environment Agency should aim to describe the hierarchical relationship of property-level protection in context with community-level schemes and as part of other strategic flood or surface water management measures and integrate property-level flood protection options and benefits. This requires accompanying national policy and clear guidance, to explain to stakeholders and communities the options and benefits provided by property-level flood protection. Emphasis is also needed on the importance and need for ongoing long-term maintenance and routine testing of the measures provided under a scheme. This could for example involve suppliers offering annual maintenance agreements to homeowners which might then become a requirement of future insurance policy renewals.

The analysis highlights the considerable scope that exists for a far wider use of the approach, but that this will also require significant levels of contribution if the cost-effective schemes are to be progressed. The role of the Regional Flood & Coastal Committees in bringing forward property-level flood protection schemes within the Medium Term Plan will be important in driving a wider uptake. This in turn links into the improving understanding of spatial flood risk informed by recent and on-going planning work on Catchment Flood Management Plans, Strategic Flood Risk Assessments, Surface Water Management Plans, Preliminary Flood Risk Assessments and the National and emerging Local Flood and Coastal Risk Management Strategies. Property-level flood protection goes to the heart of achieving many of the objectives and local actions to manage flood risk. The Environment Agency also has a key role in continuing to promote, provide advice and encourage the use of property-level flood protection using its strategic overview role to best achieve these aims.

The approach for scheme delivery being followed in Scotland combines a facilitating and encouraging role of the Scottish Flood Forum with financial support provided by the local authority of 60%. An agreement is reached with residents to contribute the remaining 40%. This grant support scheme offers a useful model that is consistent with the principles of Partnership Funding and it is recommended this model be considered for delivery in England. This would see a greater role for the National Flood Forum and subtle changes in terminology such that the emphasis is placed on the grant support available, rather than the contributions that are necessary for a scheme to proceed.

5.1.3 Standards of Protection

The Defra Grant Scheme evaluation confirmed that residents were very grateful for the support and accepted that although the measures should be effective for the most frequent and smaller floods, they would still remain at risk from the rarer but much larger flood. In other words, the scheme has its limits and that inevitably residual risk must continue to be managed.

This study shows property-level protection is not cost effective for the larger, rarer flood events (e.g. less than say the 2.5% AEP (1: 40 year)) flood. This has important implications for the residents, who must guard against becoming complacent or believing they are fully protected and to also remain vigilant and prepared for property inundation in the event of a larger flood.

It is recommended that this important message around expectation management and preparedness be always clearly explained and emphasised in scheme guidance and in communication events with communities.

The Defra Grant Scheme evaluation recommended that better data are needed on levels of flood risk before and after schemes. The challenge, however, remains in identifying reliable levels of initial flood risk exposure and then in assessing the standards of protection provided by the property-level protection measures. This was recognised in both the Defra and Environment Agency Grant Scheme Guidance and in assumptions made in the Partnership Funding Calculator. The guidance requires candidate properties to have an actual flood history that meets pre-defined levels (e.g. twice in the last 10 years etc) whilst the calculator assumes a 'Very Significant' starting flood risk exposure, moving down to 'Significant' after the scheme completion.

5.1.4 Levels of Social Deprivation

There is clear evidence of the effects of enhanced support for cases with greater levels of social deprivation, resulting in a higher percentage of scenarios exceeding the 100% Outcome Measure score. Nearly 6 times as many scenarios exceed the 100% threshold in the 20% 'Most Deprived' band as compared to the 60% 'Least Deprived' band (10.7% compared to only 1.9% in the 'Least Deprived' band)..

5.1.5 Market Considerations

The Defra Grant Scheme evaluation made the following observations and recommendations regarding the state of the property protection product market:

- The Flood Protection Association (FPA) should encourage further improvements in scheme delivery, through support to residents with product operation instructions and ongoing aftercare and maintenance.
- Suppliers should continue to innovate and develop new measures, including passive “fit and forget” measures, to widen customer choice and help match the most appropriate product for each individual property and resident’s needs.
- All product suppliers and manufacturers should aim to expand their sales and markets through partnership working and a greater willingness to cooperate.
- Ensure the Kitemark scheme keeps pace with innovative new products and agreed performance standards set for non-return valves.
- The property-level flood protection market is still an emerging sector that would benefit from continued government support, to provide more time to raise awareness and demonstrate the benefits of the approach.

This further economic analysis has highlighted the approaches that are most cost effective (manual resistance measures) and defined the risk threshold where the more expensive but more reliable passive or automatic measures are cost effective. It highlights the extent and effects of the sensitivity to product costs and the inevitable conclusion that driving the cost of measures down will have a significant impact on cost effectiveness. Lower scheme costs will in turn allow a greater volume of candidate schemes to be considered and to stand a greater chance of meeting appraisal thresholds for benefit cost and Outcome Measures score. This will also encourage bigger contributions from residents in the future, again unlocking a larger potential market. The wider uptake of the property protection approach and evidence of schemes operating successfully during flood events will, in turn, encourage the more specialist insurance companies and brokers to consider offering more favourable policy terms in recognition of the steps taken to limit the damages caused by frequent flooding.

5.2 Further Development

5.2.1 Extended Data Analysis

Further data analysis and presentation is being explored to enable the development of a potentially valuable scheme assessment tool for use by local authorities considering candidate property-level protection schemes. The analysis and modelling carried out to assess the cost effectiveness of property-level protection required extensive data collation and scenario assessment, resulting in the generation of over 22,000 possible outcomes. The graphs and tables presented in this report have helped describe and illustrate the main findings. However there is potential to extend this analysis to make full use of such a valuable data resource, to develop a simple to use appraisal tool that Defra, Environment Agency and Local Authority officials could use to identify and prioritise potential property-level protection schemes. This is being progressed by Defra in the form of a Spreadsheet Assessment Tool and a Property-level Protection GIS Tool.

Property-level Protection Scheme Assessment - Spreadsheet Tool

The spreadsheet tool (Property-level Protection Scheme Assessment Tool) would be the property-level protection equivalent of the Flood Defence Grant-in-Aid calculator. At its core would be the 22,032 pre-calculated scenarios that have now been generated from the property-level protection model and Partnership Funding calculator. This would aim to keep

things simple by putting some distance between the complexities of the model calculations, making best use of the wealth of data already generated.

The Property-level Protection Scheme Assessment Tool would allow local authority engineers for example to input potential scheme details (numbers and types of property, social deprivation etc) and calculate the potential costs, benefit cost ratios, Outcome Measure Scores and Flood Defence Grant-in-Aid and other contributions. The Property-level Protection Scheme Assessment Tool is envisaged as having its own suite of charting tools (along the lines of the charting tool illustrated in Figure 3.9) to assess the input assumptions such as costs (high, mid, low) and type of measures for varying standards of protection.

Property-level Protection Scheme Assessment Tool – GIS Tool

In addition to the spreadsheet tool, there is huge potential to make the connection between the property-level protection data generated to analyse and present the information for this report and with using GIS tools. Local Authority GIS departments have the capability and experience to make the most of what GIS can offer, providing the ideal environment for property-level protection scheme appraisal. It is recommended to develop a prototype GIS tool in ArcGIS that can be used to estimate benefit and cost ratios and Partnership funding Outcome Scores and the potential that property-level protection might have for any particular community. A GIS tool would allow the user to draw a boundary around a proposed protection scheme area, automatically interrogate the relevant datasets (e.g. deprivation data, the Environment Agency's National Flood Risk Assessment (NaFRA) data - or surface water equivalent - and property type), and calculate and present the assessment through an easy to use graphical interface.

It is envisaged that the Scheme Assessment Tool would very likely require the following datasets:

- Index of Multiple Deprivation, available freely from the Office of National Statistic.
- National Flood Risk Assessment, available to Lead Local Flood Authorities through the Environment Agency's GeoStore.
- The Flood Map for Surface Water, available to Lead Local Flood Authorities through the Environment Agency's GeoStore.
- National Receptors Dataset, available to Lead Local Flood Authorities through the Environment Agency's GeoStore.

Some of this data will require a degree of pre-processing outside of the prototype tool, although ultimately we would expect any final tool to do all the necessary processing required. Following the prototyping stage, it would be a reasonably simple step to generate the national scale outputs which could be supplied to the likes of Magic Map, Lead Local Flood Authorities, public and civic groups. It is suggested that the prototype tool and a pilot area would help determine the type of outputs which would be most useful for this application.

Appendices

A Appendix - Defra Grant Scheme Summary Facts

Property-level Protection: Key Scheme Facts

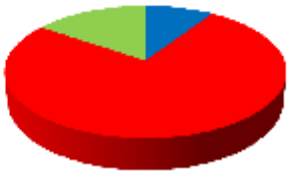
- £5.2m of Defra Grant awarded to Local Authorities
- Delivered in 2 phases from 2009 to 2011
- 1,109 properties were protected in 83 communities

This evaluation used:

- 40 Local Authority post-scheme evaluation reports
- 80 attendees at 2 Stakeholder Workshops
- 9 Scheme Case Studies for more detailed assessment
- Flood Group meetings and one to one meetings with residents
- 58 Telephone interviews with residents

Costs and Benefits

	Average	Minimum	Max
Cost / Property	£4,832	£618	£6,264
Survey	£452	£40	£868
Measures	£3,646	£479	£5,127
Administration	£734	£179	£1,800
Properties No.	19	1	77



Cost Benefit ratio of case studies: 4.8 to 1

- Local flood warning critical
- Some excellent examples of community emergency plans
- More positive response from insurers will help uptake
- Measures installed have yet to be tested by a flood event

- High levels of participation: 93% scheme uptake
- Effective engagement is key; initial awareness low
- 92.5% of Local Authorities used independent surveyors
- Schemes need more time

- Some residents need more support with installation and maintenance
- Evidence of good practice with cooperation between suppliers
- Communities working together supporting each other
- Tight deadlines during winter months caused some delays

- Over 60% of Local Authorities appointed a single supplier
- Householders however prefer a choice of products
- Excellent products, including 'fit and forget' now available
- Scheme administration was time consuming; frameworks can help

TAKING PROPERTY PROTECTION FORWARD

1. More time for *Engagement* to raise awareness
2. Further *Examples* will maintain impetus
3. These will provide *Evidence* in future floods
4. This will help to *Encourage* wider take-up

B Appendix - Property-level Protection Evaluation

B.1 Approaches to Property-level Protection

B.1.1 Defra Grant Scheme in England

The overall objective of the two year Defra Property-level Flood Protection Grant Scheme was to promote the use of flood protection measures in communities at high flood risk across England, where conventional community defences were unviable. The funding provided an average £5,700 per property to schemes which met the eligibility criteria from a ring-fenced grant of £5.2 million. Feedback reports from 40 local authorities involved in scheme delivery were assessed while workshops gave stakeholders the opportunity to identify the elements that went well and those areas where improvements can be made. The opinions of residents were also obtained from a series of telephone interviews held with householders involved in a selection of scheme case studies, as well as from attendance at a flood group meeting.

The overall scheme objectives were successfully met. It has helped:

- to provide support to communities that experience frequent flooding where traditional solutions are unviable;
- to raise flood awareness and encourage self-help and effective action;
- to encourage partnership working and local engagement; and
- to stimulate the market to provide quality flood surveys and innovative flood protection products.

The high levels of demand were in excess of the available grant support. The schemes provided improved levels of flood protection for 1,109 families where previously it has been uneconomic to defend using traditional methods.

In May 2011 Flood and Coastal Resilience Partnership Funding was introduced and property-level flood protection schemes will now funded using this system and be considered for funding alongside community scale projects. Six case studies were examined from projects funded through the Grant Scheme to understand whether the projects would have:

- been funded to the same extent under the Partnership Funding approach;
- delivered value for money in terms of cost benefit ratio and in context with the Environment Agency's Flood and Coastal Erosion Risk Management capital programme.

This was achieved at an average cost per property of £4,832 with the case study analysis indicating good value for money, with an average benefit cost ratio of 4.8. Under the Partnership Funding approach, 3 of the case study projects achieved a Partnership Funding Outcome Score of more than 100% and would have been eligible for Flood Defence Grant in Aid. The other case study projects would have had to reduce costs, find contributions or a combination of the two. The average cost benefit ratio from the case study projects was 4.8 to 1, which is just below the target figure. This means that for every pound spent, estimated flood damages of £4.80 are avoided, representing good value for money.

Although the primary objectives have been met, an informed and objective evaluation of the evidence was needed to identify the barriers as well as the success factors. The feedback reports and views of residents informed the selection of a number of case studies identified for more detailed analysis. These helped assess the scheme costs and benefits and to draw out the key messages to suggest how property-level protection could be delivered most successfully alongside the new Partnership Funding arrangements in the future.

The findings of the case study economic analysis are summarised below in Table B.1.

SCHEME	RISK ASSUMPTION		*Social Deprivation	Partnership Funding (PF) Score	Contribution required from local sources for scheme to proceed under PF	Benefit Cost Ratio
	PRE-PLP	POST-PLP				
TOLL BAR	Very Significant	Significant	20% Most	139%	n/a	7.23
ASHDON	Very Significant	Moderate	60% Least	105%	n/a	8.14
LEEDS OLD CLOSE	Very Significant	Moderate	20% Most	120%	n/a	4.68
LEEDS THORNER	Significant	Moderate	60% least	27%	£58,000	1.45
LEEDS WEST GARFORTH	Very Significant	Moderate	60% Least	74%	£21,000	5.75
WALLINGTON VILLAGE FAREHAM	Significant	Moderate	60% Least	32%	£152,100	1.73

Table B-1: Summary of Case Study Cost Benefit and Partnership Funding Analysis.

*** PF score = >100% scheme eligible for full funding under Flood Defence Grant in Aid.**

PF score = <100% scheme can still go ahead if costs are reduced, contribution is available, or a combination of the two.

Put into context of the flood and coastal risk management capital programme (community scale schemes), between 2008/09 to 2010/11, the cost benefit ratio was 8.2 to 1 which is double that achieved by the case study projects. Defra sets a cost benefit target to ensure flood and coastal risk management projects provide value for money. Projects funded by Flood Defence Grant in Aid must achieve a cost benefit ratio of 5 to 1. This means for every £1 spent, £5 of benefits (money saved in flood damages) must be achieved.

Although community scale projects have a higher benefit cost ratio, the property level schemes still represents good overall value for money, achieving reductions in flood risk. The qualitative analysis of people's views indicated that they generated other benefits which are not part of the cost benefit analysis. These include reducing stress and anxiety for those living in fear of flooding, bringing communities together to decide how to manage their flood risk and raising the general level of flood awareness and preparedness in communities.

Interviews with residents confirmed that the grant scheme prompted actions that would not have otherwise taken place. It was noted that the schemes brought local communities together, encouraging people to look out for their neighbours and others who need more support. The schemes were widely praised by appreciative communities and many stated that they now feel safer in their homes as a result. The schemes have still to prove themselves in an actual flood has however limited the wider confidence levels of homeowners and insurers alike. It has also limited the extent of this evaluation since it has not been possible to calculate actual damage losses. Local Environment Agency staff and authorities will need to report on all future flood events, to assess the response and impacts following scheme completion and to share lessons and experiences.

The results highlights that the key to achieving high up-take of measures is the degree of community engagement. Residents have been very keen to take up the offer of assistance but overall awareness is low and independent guidance and advice was needed to help people make informed judgements over suitable products. The majority of residents stated that they would not have paid for such products on their own, despite the clear benefits in terms of reducing the damage and stress from repeated flooding. More time is needed for wider promotion amongst householder and professional so that property level protection to ensure that it is recognised as a viable approach in the flood risk management portfolio. It is often only those who have suffered more frequent and repeated flooding who have either installed measures of their own or might be prepared to contribute towards the cost. Others maintain it is the responsibility of government or the local authorities.

There is also a perceived lack of benefit by many residents in terms of access to improved insurance policies. Thus far there are few examples where insurers have recognised and responded to the installation of property protection measures. This is due in part to a number of factors:

- none of the schemes have been called upon by an actual flood event, although there is much hope as the installations follow recognised good practice;
- there is currently no evidence of effective performance and reduced damages;
- there is a paucity of flood risk data to confirm the levels of risk reduction achieved by the measures and hence most make informed judgements; and
- there remain concerns that operation and successful deployment of the measures depends upon timely warning and manual intervention.

The rapidly emerging property protection sector continues to see the development of new and innovative approaches, in particular the provision of passive measures such as flood resistant doors, non-return valves and automatically sealing airbricks. Such passive products were in their infancy during these earlier Round 1 and 2 schemes but are now becoming more widely used. Although more costly and currently unsuitable for listed buildings and properties in conservation areas, they have the great advantage of removing the need for manual installation ahead of a flood.

The one year grant scheme timetable was too constrained and more time is needed to deliver property protection schemes. If necessary these should be spread over two successive years. There will be benefits from separating early engagement, scheme appraisal and survey from any subsequent installation of measures on those schemes that qualify for Partnership Funding. This will also serve to separate the two distinctly different appraisal and installation surveys. The property protection sector is still an emerging market in which all suppliers and manufacturers need to show more inclination to work in partnership for the good of the resident.

The property protection market has developed significantly in light of the experiences of these initial schemes and is maturing rapidly. Excellent products are available and manufacturers are responding with innovative solutions to challenging problems. Communities now have more options for reducing the impacts of the most frequent floods. It is important to ensure that future delivery is both justifiable and appropriate to the scale of investment. This should adequately reflect the needs of residents in high flood risk areas as well as the wider benefits and contributions that property protection can deliver. The Grant Scheme evaluation and this current study into costs and benefits of property-level protection will help inform policy options and encourage best practice in property protection delivery.

B.1.2 Further Developments

Following the success of the 2 year Defra Grant Scheme a further round of funded schemes were announced by the Environment Agency for 2011-2012. The first phase of direct grants was provided in the Spring of 2011 while the second phase in Autumn 2011 adopted the Partnership Funding model. The scheme guidance was modified slightly and relaxed to allow, for example, the inclusion of measures a little way from the property rather than just within the 2 metre curtilage area. This allowed the inclusion of garden walls or perhaps temporary free-standing barriers for example, if this was deemed appropriate. The overall timescales were however still very tight (completion within the year) and the budget allowances were reduced a little.

The Environment Agency is now taking the recommendations forward in an Action Plan that is helping to inform a further revision to guidance for Partnership Funding. In what was a transitional year there were only 8 bids, amounting to £0.5m approved in the current year.

The marked drop-off in the number and volume of property-level protection schemes principally reflects the ending of the grant support process. It is also apparent that there is some element of confusion and a lack of understanding about the Partnership Funding arrangements which could also be limiting the number of schemes coming forward.

The grant mechanism served to effectively showcase the approach and helped encourage a wider awareness, greater local community cohesion and wider uptake of such measures. The industry has duly responded with the rapid development of a wide range of effective and mostly Kitemarked products including the further development of innovative automatic passive measures. Similarly the expanding market has seen the establishment of a number of experienced and high quality survey companies to support the overall process.

Few residents have been able to confirm a positive response from their house insurance companies as yet, although some more specialist companies have considered individual examples and reduced excess figures and premiums. The National Flood Forum is examining this in a separate study.

The rapid drop-off in schemes has caused concern amongst many of the product manufacturers as they have expanded rapidly, taking more people on to meet the demand and to develop new products. It remains to be seen how this current imbalance between supply and demand develops but this study confirms how cost effective resistance measures can be and this should help endorse and confirm the wider adoption of the overall approach.

It has been noticeable that the Environment Agency's National Capital Programme Management Service is making more use of property-level protection, in conjunction with larger flood defence schemes. It is anticipated longer-term that demand will rise once again as Regional Flood and Coastal Committees look to include property-level protection in many of their regional Local Levy funded programmes.

Further support has also been provided by Defra and the Environment Agency to raise awareness of property-level protection with local authorities through the Building Capacity programme. A series of 9 workshops in England and 2 in Wales have been delivered and an accompanying e-learning module has been launched on the Environment Agency's website and linked from the Local Government Association's site. Further material will be added over the coming months to provide a useful learning and reference resource.

B.1.3 Wales

An early version of the property-level protection grant scheme was introduced in Wales by the Welsh Government back in 2004. This sought to identify candidate schemes that could be managed by local authorities and grant reclaimed from the government. Whilst there was extensive interest generated, with over 500 applications received, the initiative didn't progress as had been hoped for, due perhaps to inadequate levels of funding at the time. The Defra scheme has highlighted the significant investment required, with over £5m being provided to local authorities in England during the two year scheme.

Since these early days, there has been no follow-up in Wales of this local authority grant although Environment Agency Wales has provided measures for some communities in South-west and North Wales. These have been fully funded by the Agency and the measures adopted as Agency-owned assets that are then inspected and maintained by the Agency.

The Welsh Government is again considering the role and potential of property-level protection as part of the National Flood and Coastal Risk Management Strategy. It will also be reviewed as part of the changes associated with the creation of a Single Body and the capital funding programme review in Wales. The Partnership Funding approach in England has not been adopted in Wales.

B.1.4 Scotland

In Scotland, property-level protection has been encouraged by the Scottish Flood Forum and adopted by a number of local authorities as a practical and effective strategy for managing local flood risk. This was particularly driven as part of a strategic and operational response following severe flooding during November 2009 throughout Dumfries and Galloway. The

model developed there then served to inform similar approaches across many other Scottish local authority areas.

The Dumfries and Galloway property-level protection model involved the Council and the Scottish Flood Forum working extensively in partnership with many of the flood affected communities. The initial 3 months of engagement not only provided immediate and ongoing support to those who were affected by the flooding, but also began to cultivate relationships with those persons and properties identified as vulnerable and defined as 'at risk' properties. The move to adopt property protection came from the recognition that during recovery there was not just an urgent need to provide knowledge, information and advice to property owners in repairing their homes, but also to minimise the risk of flooding should a similar event happen again in the future. As with the schemes developed in England, many properties did not qualify for traditional hard engineering solutions (the area is largely rural) which left several hundred properties requiring property-level protection.

A series of exhibitions were held throughout the affected community areas to identify public preferences and property suitability for protection measures. This element of indirect collaboration meant that the partners were able to build on previous contacts and visits made during the recovery programme and gain important and relevant feedback. This was followed up through newsletters and then the offer of a free property flood protection assessment to owners of approximately 120 properties. Although quite time intensive, one major asset was the value of face-to-face contact to answer questions and concerns and to encourage people to take up property-level protection. It was identified that for this area, the biggest barrier to take-up was one of cost. This was tackled through a direct subsidy from the Council to reduce the cost of measures to 60% below cost price, with the difference being funded by the property owner.

This scheme was so effective that a similar approach, involving local authority subsidy and owner contributions, was adopted and continues to be offered in many other regions across Scotland during the last 2 years:

- Aberdeenshire Council – Stonehaven (130 properties) and Huntly (80 properties).
- Perth and Kinross – Perth and isolated communities depending on vulnerability.
- Scottish Borders – existing scheme in place, some products provided free of charge.
- Highland Council – provision of subsidised support to individual properties not covered by the proposed engineered flood defence scheme.
- North Ayrshire Council – 100 council properties included in two stages, with additional properties identified.
- West Dumbarton – 80 properties with additional properties identified.
- Clackmannanshire – 40 properties included under a Scottish Water scheme.
- East Dumbarton – total numbers not currently available with recovery still in progress.
- Lothian (Edinburgh) Council – total numbers not available at this time.
- Stirling Council – at consultation stage.
- East Lothian - numbers not available at this time.

B.2 Insurance Considerations

After underwriting huge damages in the last decade in the UK, in excess of £3 billion for 2007 alone, (ref http://www.bbc.co.uk/news/uk-16342911) properties that have flooded are often subjected to large excesses on future claims. The Association of British Insurers has estimated that the average flood insurance claim in 2007 was around £30,000 for contents and building fabric alone. Those 'living in flood plains' as defined by Flood Risk maps provided by the Environment Agency to the insurance industry are also subjected to increases in annual premiums for house insurance. Some insurers are withdrawing from the market and there is increasing anecdotal evidence that premiums are rising faster for people in these areas. It is important to emphasise however that the insurance industry's understanding of flood risk is driven by their own products and information, not necessarily by the Environment Agency's flood maps and that rates are set with reference to the business model of the individual insurance company. It is also important to recognise that flood maps chiefly focus

on main river and tidal flood risk rather than the surface water flood risk property-level protection can help address. .

The National Flood Forum suggests that annual premium increases of £3,000 per annum are not uncommon for properties deemed to be at flood risk, when compared with properties not at flood risk. Excesses on claims of between £5,000 and £10,000 have been reported for properties with a history of flood claims. With the cautious approach to flood insurance likely to continue, there is a risk that home owners may not be able to get flood insurance, or may be blighted during the sales and mortgage application process, with a consequent negative impact on property value and access to mortgages.

This research shows clearly there are reductions in the level of losses for properties at very significant risk of flooding by investment in property protection measures. This in turn may lead to a retraction of the increases in insurance policy premiums and excesses. However, this study also indicates that there is value in owners of properties that have not flooded in high risk flood areas to consider basic property protection and to engage the insurance industry when negotiating annual premiums.

B.2.1 Insurance Premium Savings

A discount rate of 8% is used when discounting private financial costs and benefits for households and companies, as used in the 2011 Davis Langdon study commissioned by the Adaptation Sub-Committee.

Property-level protection measures are considered effective for 20 years with present value of costs, for a semi-detached house including maintenance (Low band – financial model) of £3,560. Table 4.2 below gives the savings assuming £3,000 or £1000 per year.

Insurance Savings		
	Premium	
Premium	**High**	**Low**
	£3,000	£1,000
Present Value (@ 8%)	£29,460	£9,820

Table B.2 Insurance Premium Savings.

Thus for high savings the benefit cost ratio is 8.3:1 and for low savings is 2.8:1. Residual flooding beyond the efficacy of the measures would expose the insurer to small residual risks. These have not been accounted for but the figures illustrate how property protection measures act as an insurance against significant risk and may be an inducement to insurance companies to reduce premium supplements. Further work is required to indicate how introduction of basic property protection measures could act as market inducement to minimise increases in premiums for property perceived to be at flood risk but without a history of flooding. This issue is sensitive as many homeowners fear that the introduction of property protection measures may not only affect property sale prices but encourage mortgage lenders to support the purchase of property where significant flood risk has been addressed.

B.2.2 Reduction in excesses

For properties that have flooded, installation of property protection measures may be the best way to reduce the large excesses from insurance cover. As there is always the potential for residual risk, a formula is required (using the Weighted Annual Average Damage WAAD approach) to calculate the benefits depending on existing property risk and post-property protection measures installation risk.

Table 4.3 produces Weighted Annual Average Damage (WAAD) values for excess insurance payments for both £5,000 and £10,000 excesses for successive threshold standards of protection:

WAAD	Excess (£)		PV over 20 years @ 8% Discount rate	
	5000	10000	£5,000	£10,000
2 year protection	2475	4950	£24,305	£48,609
5 year threshold	975	1950	£9,575	£19,149
10 year threshold	475	950	£4,665	£9,329
25 year threshold	175	350	£1,719	£3,437
50 year threshold	75	150	£737	£1,473
100 year threshold	25	50	£246	£491

Table B.3 Damage Values for Excess Insurance Payments for Differing Standards of Protection.

Thus with a 10 year flood threshold a home owner would be expected to pay, in Present Value terms, £9,329 with a £10,000 excess.

As there will always be residual risk, the excess will be applied, though infrequently, where flooding exceeds the property-level protection efficacy. Table 4.4 illustrates the discounted savings in excess payments which exclude payments made for residual flooding.

Present value of savings in Excess Payments						
£5,000 excess	**Post-property protection Measures Threshold**					
Pre-property protection Measures Threshold	2 year threshold	5 year threshold	10 year threshold	25 year threshold	50 year threshold	100 year threshold
2 year threshold		£14,730	£19,640	£22,586	£23,568	£24,059
5 year threshold			£4,910	£7,856	£8,838	£9,329
10 year threshold				£2,946	£3,928	£4,419
25 year threshold					£982	£1,473
50 year threshold						£491
Present value of savings in Excess payments						
£10,000 excess	**Post-property protection Measures Threshold**					
Pre-property protection Measures Threshold	2 year threshold	5 year threshold	10 year threshold	25 year threshold	50 year threshold	100 year threshold
2 year threshold		£29,460	£39,280	£45,172	£47,136	£48,118
5 year threshold			£9,820	£15,712	£17,676	£18,658
10 year threshold				£5,892	£7,856	£8,838
25 year threshold					£1,964	£2,946
50 year threshold						£982

Table B.4 Present Values of Savings in Excess Payments.

Thus for an excess of £5,000 with a current 5 year flooding threshold moving to a reduction in damages equivalent to a 25 year threshold then the present value of savings will be £7,856 (highlighted yellow in Table 4.4 above). Taking the present value of mid-cost financial Manual Resistance measures for a semi-detached house as £4,802 gives a benefit cost of excess savings over cost as follows:

Benefit Cost ratio of savings in excess payments against Manual Resistance for a Semi Detached Property						
£5,000 excess	**Post-property protection Measures Threshold**					
Pre-property protection Measures Threshold	2 year threshold	2 year threshold	5 year threshold	10 year threshold	25 year threshold	50 year threshold
2 year threshold		3.07	4.09	4.70	4.91	5.01
2 year threshold			1.02	1.64	1.84	1.94
10 year threshold				0.61	0.82	0.92
25 year threshold					0.20	0.31
50 year threshold						0.10
Benefit Cost ratio of savings in excess payments against Manual Resistance for a Semi Detached Property						
£10,000 excess	**Post-property protection Measures Threshold**					
Pre-property protection Measures Threshold	2 year threshold	2 year threshold	5 year threshold	10 year threshold	25 year threshold	50 year threshold
2 year threshold		6.13	8.18	9.41	9.82	10.02
2 year threshold			2.04	3.27	3.68	3.89
10 year threshold				1.23	1.64	1.84
25 year threshold					0.41	0.61
50 year threshold						0.20

Table B.5 Benefit Cost Ratio of Savings in Excess Payments for Manual Resistance Measures to a Semi-detached Property.

Appreciation of these savings should be reflected in the insurers' willingness to accept a reduction in excess with an understanding that flooding from infrequent, major flood events is a reality that cannot be avoided by property protection measures.

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