F Cost Benefit Analysis

This section discusses the economic appraisal carried out during this study. The methods of calculating the benefits and costs are outlined together with an assessment of the benefit-cost ratios for the flood storage options assessed.

Guidance on assessing the cost and benefits is provided in the Environment Agency's Flood and Coastal Erosion Risk Management - Appraisal Guidance[1] (FCERM-AG), supplemented by guidance and data from the following sources:

- The Benefits of Flood and Coastal Risk Management: A Manual of Assessment Techniques[2] (Multi-Coloured Manual or MCM);
- HM Treasury Green Book[3];
- Long Term Costing Tool[4]

Benefit-cost analysis looks at a flood risk management strategy or practice and compares all the benefits that will be gained by its implementation to all the costs that will be incurred during the lifetime of the project.

In accordance with the FCERM-AG, benefits are taken as annual average damages avoided, expressed as their present value using Treasury discount rates. These are compared with the whole life cost of the capital and maintenance costs of selected options, expressed as present value. If the benefits exceed the costs for the option, the scheme is deemed to be cost effective and worthwhile for promotion.

F.1 Cost of proposed flood risk management options

Cost estimated were required for each of the options under consideration. The outputs and tool from the Long Term Costing project (SC080039) were used for the purpose of this assessment. This project was undertaken by JBA and provided a range of cost 'evidence summary' reports and a long term costing estimation tool. The tool allows users to derive a range of costs for a portfolio of flood defence measures and is ideally suited to strategic level studies.

Whole life costs are generated by the tool for 4 key cost categories:

1. *Preliminaries*. These costs relate to the mobilisation and for the purpose of this project it is assumed to be 15% of the construction cost. These do not include land purchase costs, and later stages of assessment should seek to understand if this will be required before scheme progression
2. *Construction works.* These costs relate to the construction of the flood mitigation measures and include relevant costs such as project management, construction and materials, licences, administration and supervision. This does not include landscaping.
3. *Construction contingency:* Contingency costs should be budgeted to allow for unforeseen costs. For the purpose of this project it is assumed to be 10% of the construction cost.
4. *Design fees.:* These costs relate to the cost for the next stage of the assessment, including detailed design of the flood mitigation measures. For the purpose of this project it is assumed to be 10% of the construction cost.
5. *Optimism bias*. As the flood mitigation measures outlined in this report are very high level, an optimism bias is appropriate to account for the uncertainties at this stage. The FCERM-AG recommends a value of 60% for projects in an early stage of consideration and therefore, for the purpose of this project it is assumed to be 60% of the construction cost.

The options considered for Marden include a number of surface water management measures. The costing consideration for each flood mitigation measure is outlined in Table F-1 below.

1 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/481768/LIT_4909.pdf

2 Penning-Rowsell, *et al* (2013) The Benefits of Flood and Coastal Risk Management: A Manual of Assessment Techniques

3 HM Treasury (2011) The Green Book, Appraisal and Evaluation in Central Government.

4 Environment Agency and Defra (2015) Long term costing tool for flood and coastal risk management.

Table F-1: Indicative costs for typical flood mitigation measures

Option	Unit cost		Source
Wall	Height (m)	Cost (£/m)	Environment Agency Unit Cost Database (average length in database = 180 m)
	<1.2	1,419	
	1.2 - 2.1	2,905	
	2.1 - 5.3	3,577	
	>5.3	11,168,	
	All heights	2,984	
Embankment	Volume band (m^3)	Cost (£/m^3)	Environment Agency Unit Cost Database (average volume per meter length = 18m^3)
	<500	188	
	500 - 5,000	94	
	5,000 - 15,000	64	
	>15,000	33	
Swales	£10-£15 per m^2 swale area £18-£20 per m length using an excavator £12.5 per m^2		CIRIA, 2007 Stovin & Swan 2007 Environment Agency, 2007
Infiltration basin	£10-£15 per m^3 stored volume		CIRIA, 2007

The upper end costing has been used in all cases after advice from Kent County Council that overall costing was lower than expected based on the costs of schemes delivered in Kent.

F.1.1 Cost summary

A summary of the scheme costs is presented in the below. The costs present related only to scheme costs.

Table F-2: Details of the option model and associated scheme costs (£k)

Option	Preliminaries	Construction	Contingency	Design fees	Optimism bias
1 - The Cockpit	1	7	1	1	4
2 - Plain Road	113	754	75	75	452
3 - Howland Road	11	75	8	8	45
4 - Wheelbarrow Estate	3	17	2	2	10

F.2 Benefit assessment for floor risk management options

Benefits are assessed as the flood damages that will be avoided by the implementation of a project. Property counts and damage estimates have been calculated using Frism, JBA's in-house flood metrics software.

F.2.2 Baseline scenario

To calculate the benefits or a proposed scheme, it is necessary to assess the damages that are likely to occur under a baseline scenario, which represents the scenario in which no flood defence works are carried out. The baseline scenario assumes the current maintenance regime would continue. This would include periodic channel maintenance, removal of debris, maintenance and repair of assets but no new structures would be constructed or capital expenditure invested.

F.2.3 Options

Four flood risk management options were identified and taken forward for cost-benefit assessment. The economic appraisal was carried out for each of the options in isolation to understand the individual contribution.

F.2.4 Present value

Benefits have been calculated throughout the project life which is assumed to be 100 years. All benefits and costs have been assessed at a price base date of October 2015 with future benefits and costs being discounted to present value using a varying treasury discount rate. This is in line with Defra guidance4.

The MCM data is based on January 2013 prices, and was therefore brought up to date in order to more accurately compare the costs and benefits. The FCERM-AG recommends that this is carried out using the consumer price index (CPI). The current and January 2013 indices for the CPI are provided in Table 7-3. The MCM damages estimates have been factored against the current CPI in order to bring them up to present day prices representing an increase in damages of approximately 3%.

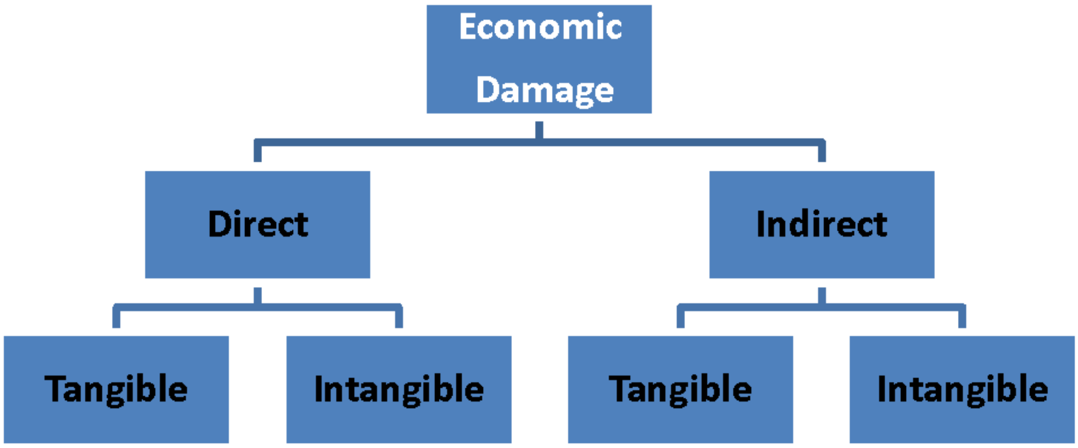
Table F-3: CPI adjustment factors (£k)

January 2013	October 2015	Adjustment factor
124.4	128.2	1.03

F.2.5 Methodology

Flood damage assessment can include direct, indirect, tangible and intangible aspects of flooding, as shown in Figure F-1 below. Direct damages are the most significant in monetary terms, although the MCM and additional research provide additional methodologies, recommendations and estimates to account for the indirect and intangible aspects of flood damage.

Figure F-1: Aspects of flood damage



Flood damage estimates have been derived for the following items:

- Direct damages to residential properties;
- Direct damages to commercial and industrial properties;
- Indirect damages (emergency services);
- Vehicle damages.
- Intangible damages associated with the impact of flooding;

The assumptions and additional data recorded below were used to improve and provide the necessary information to supplement the above datasets.

Data and assumptions

The Multi-Coloured Manual provides standard flood depth/direct damage datasets for a range of property types, both residential and commercial. This standard depth/damage data for direct and indirect damages has been utilised in this study to assess the potential damages that could occur under each of the options. Flood depths within each property have been calculated from the 2D hydraulic modelling by comparing predicted water depths at each property to the ground level implemented with the hydraulic model, which are informed from filtered LIDAR data.

A mean, minimum and maximum flood depth within each property footprint is derived by JBA's in-house FRISM tool. Only the mean flood damages have been presented. A key assumption with the flood damage calculations is that a given property threshold levels is present across all properties.

An assumed threshold value of 150mm (property thresholds assumed to be 150mm above the model ground levels) was assumed across the study area. Clearly such an assumption can have large implications on the damages predicted within the study area and more detailed assessment into FRM options should seek to better understand threshold levels within the study area, and ideally have property threshold levels surveyed which would provide much greater clarity on predicted flood depths within properties.

The assumptions presented in were used to generate direct flood damage estimates.

Table F-4: Direct flood damage assumptions

Data type	Data and any assumptions used
Depth damage data	Multi-Coloured Manual used
Flood depths	Mean flood depths for each property extracted for: 50%, 10%, 5%, 3.33%, 2%, 1.33%, 1%, and 0.1% AEP events
Threshold level	No threshold values surveyed. 150mm above modelled ground levels adopted across the study area.
Residential property types	Defined by property types (Detached, Semi-Detached, Terraced, Flat, Bungalow).
Upper floor flats	Upper floor flats have been removed from the flood damage estimates. Whilst homeowners may be affected it is assumed that no direct flood damages are applicable.
Non-residential property types	MCM property types defined using national receptor dataset.
Property areas	Defined by OS MasterMap data.
Capping of property damages	Property market values have not been used for capping. Capping has not been completed.
Updating of MCM damage data	Consumer Price Index to October 2015 used.

Errors and limitations

The approach to estimation of flood damages assumed the mean flood depth is applicable across the entire building footprint. This is not always true, particularly where localised surface water ponding is predicted. Within large property boundaries this can significantly over estimate the likely damages and is most noticeable in the non-residential results as it particularly impacts warehouse buildings with large footprints. A more thorough analysis using surveyed threshold levels would help to correct these inconsistencies in the future.

Indirect damages

The Multi Coloured Manual provides guidance on the assessment of indirect damages. It recommends that a value equal to 5.6% of the direct property damages is used to represent emergency costs and have been accounted for in the Frism outputs. These include the response and recovery costs incurred by organisations such as the emergency services, local authorities and the Environment Agency.

Guidance and standard costs are also provided in the Multi-Coloured Manual for the assessment of additional costs incurred by property owners as a result of flooding. These include rental costs for alternative accommodation, additional heating and electricity costs required to dry out a flooded property. These have not been included in the analysis at this stage.

Intangibles

Current guidance indicates that the value of avoiding health impacts of fluvial flooding is of the order of £290 per year per household. This value is equivalent to the reduction in damages associated with moving from a Baseline scenario to an option with an annual flood probability of 1% (100-year standard).

Vehicular damages

The Multi Coloured Manual provides guidance on the assessment of vehicular damages. It is recommended for project appraisals to use an average loss value of £3,600 per residential property in the risk area. This is accounted for flood depth greater than 0.35m above bare ground levels (not above property threshold level) at each property.

F.2.6 Baseline flood damage results

The number of properties (residential and non-residential) flooded in the design events simulated is summarised in Table F-5.

Table F-5: Counts of ground floor residential and non-residential properties intersect the predicted flood extent (baseline case)

Flood Event Return Interval	Residential Properties Flooded	Non Residential Properties Flooded
50% AEP event	31	27
10% AEP event	60	79
5% AEP event	70	94
3.33% AEP event	83	100
2% AEP event	89	116
1.33% AEP event	94	132
1% AEP event	98	138
0.1% AEP event	137	206

The damages predicted at each design event simulated are summarised in Table F-6. These account for direct and indirect damages, including emergency cost and vehicular damages.

Table F-6: Damages of residential and non-residential properties

Flood Event Return Interval	Residential (£)	Commercial (£)
50% AEP event	332,000	2,694,000
10% AEP event	689,000	3,628,000
5% AEP event	886,000	3,846,000
3.33% AEP event	985,000	4,133,000
2% AEP event	1,132,000	4,352,000
1.33% AEP event	1,286,000	4,799,000
1% AEP event	1,363,000	4,985,000
0.1% AEP event	2,153,000	4,982,000

F.2.7 Option flood damage results

To assess the impact of the options, the damages for the baseline and options were calculated using a reporting unit just covering the area of impact. The estimated damages (residential and non-residential) flooded in the design events simulated is summarised in Tables F7- F10.

Table F-7: Damages of ground floor residential and non-residential properties in the Cockpit (£k)

AEP event	Residential properties at risk		Non-residential properties at risk	
	Base	Option	Base	Option
10	15	0	0	0
2	20	11	0	0
1	23	12	0	0

Table F-8: Damages of ground floor residential and non-residential properties in Plain Road(£k)

AEP event	Residential properties at risk		Non-residential properties at risk	
	Base	Option	Base	Option
10	9	9	0	0
2	13	11	0	0
1	15	12	0	0

Table F-9: Damages of ground floor residential and non-residential properties in Howland Road (£k)

AEP event	Residential properties at risk		Non-residential properties at risk	
	Base	Option	Base	Option
10	7	0	0	0
2	8	7	0	0
1	9	8	0	0

Table F-10: Damages of ground floor residential and non-residential properties in Wheelbarrow Estate (£k)

AEP event	Residential properties at risk		Non-residential properties at risk	
	Base	Option	Base	Option
10	0	0	0	0
2	0	0	8	2
1	0	0	12	10

F.3 Benefit-cost results

The benefit-cost ratio compares the benefits of each option to the costs of that option and can be used to compare different engineering options.

F.3.8 Option 1: The Cockpit

The results showed that an infiltration basin at the Cockpit is an affective measure to trap overland flows and prevent £11,000 of damages to residential properties. However, the cost of an infiltration basin was over twice as high as the benefits predicted to be brought about. During the options workshop KCC raised concerns that an infiltration basin in this impermeable catchment is likely to take a long time to drain down and would reduce the amenity value of the green space. As a result, a positively drained solution was sought. However, there was no option to discharge directly to the Cockpit Drain due to the location of housing and Southern Water and KCC highways do not take land drainage. Therefore, it is considered that this option is neither cost beneficial or practicable at this time.

F.3.9 Option 2: Plain Road

Options were tested to retain access to Marden via The Plain during a 1% AEP event. The testing concluded that if the highway remained at the present level, the storage required to maintain access would be impractically large. Therefore, storage was considered in combination with highway raising. The construction of a raised highway embankment is hugely expensive but no benefit was predicted to properties at risk. As a result, the costs outweighed the benefits at a ratio of 135:1. Therefore this option is not cost beneficial. In addition, access to Marden can be achieved via alternative routes. Therefore, the closure of The Plain is an inconvenience rather than a health and safety risk to residents.

F.3.10 Option 3: Howland Road

The option appraisal of Howland Road found the most affective opportunity to manage surface water was to combine the swale behind properties and the attenuation basin upstream of the railway culvert. However, the predicted flood damages were only reduced from £9,000 to £8,000 under this option because rainfall continued to pond directly on properties. As a result, the estimated costs of the SuDS outweighed the flood damage benefits at 52:1. Therefore this option is not cost beneficial. However, the swale and attenuation basin SuDS features should be considered as part of the drainage design if the Howland Road development progresses.

F.3.11 Option 4: Wheelbarrow

Under the current conditions £14,000 of flood damages was predicted during a 1% AEP rainfall event at the Wheelbarrow Estate. This is reduced to £10,000 if an exceedance route is implemented. However, the estimated cost is lowering the private road is three times greater than the predicted benefits. Therefore, this option is not cost beneficial. In addition, these properties are predicted to flood from the Lesser Teise at a 20% AEP fluvial event, and an exceedance route would not protect these properties from this flood risk. As a result, the exceedance route is not a sustainable use of public resources as the properties would remain at frequent flood risk.