

APPENDIX D

Economic appraisal

Introduction

In this section we present our assessment of the financial costs and benefits of the various options to identify those which offer the best return on our investment.

Appraisal of Costs

In accordance with Defra guidelines, a 60% Optimism Bias (OB) allowance has been applied to all costs. This is to allow for the fact that this strategy includes a broad appraisal of options. This inevitably means that when the outline design is completed there will be further associated permanent and temporary work items required to ensure the integrity of the preferred option, to comply with health and safety requirements and to meet local constraints.

Capital cost of works to linear defences

Capital works scheduled to be carried out more than 5 years hence have not been reviewed to the same level of detail as the Urgent Works. Instead, a decision has been made on the type of works required to secure each element based on a set of logic statements. These take the form:

IF the defence is already set back from the main river channel OR the defence is adjacent to the main river channel, but located in an area not under any stress from either regime or movement of the main-river or low-river channel THEN the defence is raised in-situ

ELSE the defence is realigned a nominal 30m back

Following the use of this decision tree, there were 3 types of work identified:

- Raise embankment in-situ
- Realign embankment
- Build new flood wall

Note that this list does not include riprap. The use of riprap is considered a short term solution used to buy time prior to major investment.

The cost of the identified works was estimated from linear interpolation of unit costs derived in 0.5m height increments. The cost of securing embankments was estimated based on schedules from actual costs from recent schemes and in the case of floodwalls, detailed cost estimates for similar types of construction for other projects. We have also compared with data collected nationally for out-turn costs. These estimates of cost are at the lower end of out-turn costs from projects nationally, but this reflects the intention to win spoil local to the site and the lack of site constraints. The estimated cost of these capital works including optimism bias are detailed in the following tables.

Unit Capital Cost of New Flood Walls

Defence Height	Cost used in this assessment (£/m)
0.5m	1600
1.0	2200
1.5m	2800
2.0m	3300
2.5m	3600

Unit Capital Cost of New Embankments

Defence Height	Cost used in this assessment £/m)
0.5m	-
1.0m	460
1.5m	610
2.0m	790
2.5m	1010
3.0m	1260
3.5m	1540

Capital Cost Of Works To Outfall Structures

Outfall structures are categorised as small, medium or large, based on culvert diameter. The estimated cost of replacement and renewal of these structures is detailed in the following table.

Size	Diameter (mm)	New (£k/item)	Refurbish (£k/item)
Small	0-400	75	37.5
Medium	400-900	160	80
large	900+	450	225

Where the linear defences are to be raised in-situ, the outfall structure will be “refurbished”. It is envisaged that this will include extending the culvert, refurbishment of flap valve etc. Refurbishment costs are assumed to be 50% of new-build costs.

Maintenance Costs

Future maintenance costs are based on estimates provided from Environment Agency records. These are detailed in the following table:

Maintenance Expenditure

Location	Length	£
Left bank, Bridgwater to Stert Point	18km	25,000
Right bank, Bridgwater to Huntspill Area	18km	21,000

Analysis of this data suggests that current expenditure is approximately £1.3/m/year. This figure has been used throughout the assessment to cover future maintenance costs.

Cost of Works Specific to Major Realignment

The capital cost of undertaking a significant realignment of the defences is built up from the items in the table below.

Capital Cost of Realignment

New flood bank	Included using the cost estimates detailed above
New outfall structures	Included using the cost estimates detailed above.
Demolish old bank and landscape	It is assumed that half of the old bank will be demolished to allow flow onto and off the realigned area. The cost of these works is included at £1.50/m ³ to cover excavation and landscaping. The demolition and removal of existing outfall structures is included at £10k per item.
Protect properties	There are a small number of properties located on high ground to the rear of proposed realigned areas that will still have safe access but may suffer some small increase to their flood risk. The cost of a low flood embankment to safeguard these properties is included in the assessment.
Compensation of landowners	The cost of purchasing land seaward of realigned defences is included at £10000/ha. An additional 10% is allowed for legal fees.
Compensation of property owners	A small number of properties will be located seaward of some of the proposed realignments. It is assumed that the current owners will be compensated at £150,000 per property. An additional 10% is again allowed for legal fees.
Provision of compensatory BAP habitat	The cost of providing compensatory BAP habitat to offset Coastal Grazing Marsh lost as a result of realignment has not been included in the assessment.
Secure pylons	Discussion with National Grid Transco suggests that the approximate cost of replacing 1km of standard circuit under emergency conditions would be £1M. However, towers that span the river are higher and replacing them, under the same conditions, would cost approximately £1M. This assessment has included the cost of rerouting pylons that will lie seaward of a realigned defence. The costs of these planned works are included in 1/3 rd the cost of undertaking the works under emergency conditions.

Where capital works are carried out within 10 years of a major realignment that will render them obsolete, it is assumed that short term solutions, such as riprap, will be used. This is included as 25% of the cost of the long term solution developed in the Hold the Line Option.

Cost of Works Specific to Tidal Peak Attenuation

The capital costs of options that include Tidal Peak Attenuation are based on those derived for the Major Realignment Options with some additional items. These additional items are included in the table below.

Additional Costs Associated with Tidal Peak Attenuation Option

Secure seaward flood banks	<p>This option requires banks seaward of the realigned area to be maintained in a secure fashion throughout the life of the scheme. The cost of these works is based on those developed for the Hold the Line Option. However, it is assumed that some saving can be made using short-term solutions – acceptable because of the reduced consequence of breaching. The cost of the long-term solutions identified in the Hold the Line Option have been used at the following reduced rates</p> <p>Figure 1 Within 10 years of demolition – 25% of HTL cost</p> <p>Figure 2 10-20 years prior to planned demolition – 50% of HTL cost</p> <p>Figure 3 20+ years prior to demolition – 100% of HTL cost</p>
Engineering spillway	<p>The cost of a 1000m long spillway is included at twice the cost of a new 3m high bank of the same length. This is on the basis that construction is very similar, but the spillway has a shallower back slope and so much larger volumes of material will be involved.</p>
Water level management	<p>Included as £500,000 for two new structures to control water levels, and £50,000 per year for additional monitoring and maintenance works.</p>

Phasing

This assessment has considered the 100 year timeframe of the Strategy in 5 discrete periods:

- 0-5 years hence
- 5-10 years hence
- 10-25 years hence
- 25-50 years hence
- 50-100 years hence

The length of each period increases through time to reflect increased uncertainty.

Phasing of capital investment in the Hold the Line Option is driven by the output from the Risk-Response Matrix. This classifies the need for works as being “Negligible”, “Action” or “Urgent”. It is expected that works will be carried out when the necessary response is classified as “Action”. For simplification purposes, this assessment has spread the cost of works equally across the period (as defined above) in which the mid-year of the “Action” classification lies.

Appropriate phasing of Major Realignment options is key to minimising whole-life costs. This is because works carried out on banks that are later rendered obsolete through realignment are, to some extent, wasted. This assessment considered the economic consequence of each of the realignments in all years between 5 and 98 years hence. This allowed the most appropriate point of intervention to be chosen.

The capital cost of works associated with major realignment of defences is spread over the 3 years prior to scheme completion in the following manner:

Phasing of Capital Costs in Major Realignment Option

Year	% of Total Capital Cost
2 years prior to completion	20%
1 year prior to completion	40%
Year of scheme completion	40%

The approach to phasing of Tidal Peak Attenuation Option costs is outlined in the table below.

Phasing of Capital Costs in Tidal Peak Attenuation Options

Year	Item
2 years prior to completion	20% of new defence and compensation costs
1 year prior to completion	40% of new defence and compensation costs
Year of scheme completion	40% of new defence and compensation costs
During active period	Additional maintenance costs
Year of demolition	Cost of demolition and landscaping. Cost of securing any pylons

For simplification purposes, phasing of works to outfall structures (with the exception of the Urgent Works) are driven by works to the linear defences in which they are situated.

Appraisal of Benefits and Priority Score for FMUs

Mechanism of flood damage:

Direct damage to assets is caused by flow overtopping and ponding behind the defences. The situation is exacerbated if the existing embankments fail either due to structural failure (front or back slope slips or piping failure) or by erosion by overtopping.

Do Nothing Option

Do Nothing flood damages are based on the premise that eventually an un-repaired breach will develop. The probability that a breach occurs in any given year will increase through time as the defences deteriorate and sea levels rise. Following a breach, the land behind the defences will act as a reservoir; it will fill and drain on each tide. For the purposes of this study, extreme flood levels following a breach are assumed equal to tide levels at Burnham-on-Sea. The probability of a total failure of the defences is increased linearly from existing annual breach risk (FMU dependent) to unity in year 40.

Flood Damage Calculation

Interest	Data availability	Methodology
Residential and commercial property	AddressPoint and National Property Database data currently held. LiDAR data used to estimate threshold level by adding 200mm.	<p>Property damaged based on standard depth damage data in the Multicoloured Manual. Land use codes taken, where available, from NPD data. Residential properties assumed to be a weighted average of all property in the UK.</p> <p>A level – damage relationship is derived for each property. This includes an allowance for emergency costs and activities carried out by emergency services, local councils and the Environment Agency equivalent to 10.7% of the total direct property damages. Additional allowance equivalent to 10% of the total direct property damages is included for costs associated with clean-up of utilities infrastructure. Additional allowance equivalent to 5% of the total direct property damages is included for costs associated with clean-up of gardens and outdoor space.</p> <p>Frequency and severity of flooding is based on risk assessment of defence failure driven by output from ISIS model.</p> <p>Damage in the Do Nothing Assessment is capped at write-off value of property, set equal to its market value. The market value of residential property is assumed to be £120k. This is based on a weighted average of property sold in Bridgwater between January and March 2004.</p> <p>The market value of commercial property is estimated, where possible, based on its rateable value. Where this is not possible, the value is nominally set to £120k. (i.e. the value of a residential property)</p>
Agriculture	Lower Parrett & Tone flood management strategy.	<p>Loss of agricultural productivity following flooding of farm land is included in accordance with the Multi-Coloured Manual. The flooding of agricultural land will not be a significant issue in terms of option selection.</p> <p>The market value of agricultural land should be set to £10k per ha.</p>
Roads		<p>Generally assumed negligible (roads that lead to permanently flooded areas are not required). There are few major through routes (except M5 which does not flood), so probably reasonable to ignore.</p> <p>Frequent flooding of roads is unlikely from tidal risk. Ignore unless high frequency of flooding is indicated</p>
Railways	Some information	Permanent diversion costs due to rerouting of trains capped by a maximum cost of rebuilding the railway

Interest	Data availability	Methodology
	from Network Rail available from Lower Parrett & Tone Flood Management Strategy	Diversion costs where railways affected plus railway embankment rebuild costs where appropriate.
Environment (particularly conservation benefits)		<p>Total value of area assumed to be area of SPA+SSSI multiplied by Tier 3 ESA value of £430/Ha/per annum. All assumed lost in do nothing (although other habitats would be created)</p> <p>All options will need to ensure that conservation requirements can be delivered. ‘Damages’ are therefore probably not permitted given conservation overrides. Therefore environmental benefits from the options on their own cannot be identified.</p> <p>Only conservation (Biodiversity/flora/fauna) benefits will be valued. Other environmental assets (e.g. water, soil, air, climate, etc) will not be included in the benefit/cost analysis.</p>

Detailed Points to Note

An additional 500mm of freeboard is included for the banks on the Parrett in the Huntspill FMU. This is to accommodate the additional wave action that they suffer.

The cost and phasing of works to upgrade defences through Bridgwater is taken from the assessment carried out for the Tidal Sluice Pre-Feasibility Study.

OPTION SELECTION

Bridgwater East & West FMU

Six options have been identified to manage flood risks in Bridgwater.

DN	Do Nothing
DM	Do Minimum
DM+FW	Do Minimum & Flood Warning
HTL	Hold the Line – raising flood defences along the existing alignment through Bridgwater
Ba	Barrier construction now
HTL/Ba	Hold the line followed by a barrier in approximately 2046

The table below summaries the benefit/cost analysis for Bridgwater:

	Strategy Option					
	DN	DM	DM+FW	HTL	Barrier	HTL + Barrier
PV Damages	1699.2	915.6	869.8	Neg	Neg	Neg
PV Damages Avoided		783.6	829.3	1699.2	1699.2	1699.2
PV Environmental Benefits		0.0	0.0	0.0	0.0	0.0
Total PV Benefits		783.6	829.3	1699.2	1699.2	1699.2
PV Costs		0.6	0.9	24.2	29.6	17.8
Net Present Value		782.9	828.4	1674.9	1669.6	1681.3
Benefit Cost Ratio		1251.68	876.67	70.11	57.44	95.38
Incremental Benefit/Cost ratio (over do minimum)			143.06	38.78	31.62	53.27

Notes:

All Figures are £million

PV: Present value

Environmental benefits = value of habitat created (£1200/Ha per annum)

Preferred option highlighted in **bold**

The decision making process is based on the approach taken in *Flood and Coastal Defence Project Appraisal Guidance: Economic Appraisal*. Within this context the following commentary is provided:

The *Do Nothing option* illustrates that in excess of £1.6 billion damage would be caused if the defences were abandoned, illustrating the importance of the defences to the future viability of Bridgwater.

The *Do Minimum option* reduces the damages to just under £1 billion, however property damage is considerable and the approach effectively delays the considerable damage that will occur in the future (so reducing the present value). This option has the highest benefit/cost ratio but the approach provides a standard of protection below the indicative standard to the majority of properties.

The *Do Minimum and Flood Warning Option* provides some further reduction in damages but the overall impact is marginal, because flood warning will not address the loss of property in the future due to deterioration in defences and sea level rise. The incremental benefit/cost ratio of 143 illustrates the value of flood warning.

Hold the Line would involve the raising of walls and banks through the town. In many locations access is difficult and the cost of undertaking the works is high. Nevertheless this option provides an incremental benefit/cost ratio of 38 over the *Do Minimum* option.

A tidal barrier could be constructed in the near future and this is the basis of the *Barrier Construction now*. However the barrier is expensive and critically the construction of the barrier now increases operational and maintenance costs considerably. This option has an incremental benefit/cost ratio of 31 and compares poorly with the *Hold the Line* option.

The final option considers maintaining the current defences and building a tidal barrier in about 2046. This approach makes effective use of the current defences in Bridgwater which are in a reasonable condition and builds the barrier when it is needed. This approach is more cost effective than both the *Hold The Line* and *Barrier Construction Now*, and leads to an incremental benefit/cost ratio of 53. The *Hold The Line followed by a barrier in approximately 2046* option has a present value of costs of £17.8 million compared with £24.2 million for *Hold the Line* and £30.0 million for the construction of the barrier now.

Essentially the three main options are designed to undertake the same task and ensure that the tidal flood risks to Bridgwater are minimal. Each option has an incremental benefit/cost ratio above 30 over the *Do Minimum* option and a benefit/cost ratio in excess of 50. The most cost effective option is the *Hold The Line followed by a barrier in approximately 2046*. In accordance with PAG, this is the preferred option.

Cannington FMU

Seven options have been identified to manage flood risks in the Cannington.

DN	Do Nothing
DM	Do Minimum
DM+FW	Do Minimum & Flood Warning
HTL	Hold the Line
HTL/MR C1	Hold the Line & Managed Realignment C1
HTL/MR C2	Hold the Line & managed Realignment C2
HTL/MR C4	Hold the Line & managed Realignment C3

The table below summaries the benefit/cost analysis for the Cannington FMU:

	Strategy Option						
	DN	DM	DM+FW	HTL	HTL/ MR C1	HTL/ MR C2	HTL/ MR C3
PV Damages	357.3	285.0	270.7	14.7	15.6	15.0	19.5
PV Damages Avoided		72.3	86.6	342.6	341.7	342.3	337.8
PV Environmental Benefits		0.0	0.0	0.0	1.7	0.5	8.9
Total PV Benefits		72.3	86.6	342.6	343.4	342.8	346.7
PV Costs		0.8	1.1	29.0	29.2	29.3	32.3
Net Present Value		71.5	85.5	313.6	314.2	313.5	314.4
Benefit Cost Ratio		93.30	79.05	11.81	11.76	11.70	10.73
Incremental Benefit/Cost ratio (over do minimum)			44.53	9.57	9.53	9.48	8.70

Notes:

All Figures are £million

PV: Present value

Environmental benefits = value of habitat created (£1200/Ha per annum)

Preferred option highlighted in **bold**

The *Do Nothing option* illustrates that in excess of £350 million damages would be caused if the defences were abandoned, illustrating the importance of the defences.

The *Do Minimum option* reduces the damages to £285 million, however property damage is considerable and the approach effectively delays the considerable damage that will occur in the future slightly (so reducing the present value). This option has the

highest benefit/cost ratio but the approach provides a standard of service below the indicative standard to the majority of properties.

The *Do Minimum and Flood Warning Option* provides some further reduction in damages but the overall impact is marginal, because flood warning will not address the loss of property in the future due to deterioration in defences and sea level rise. The incremental benefit/cost ratio of 44 illustrates the value of flood warning.

Hold the Line would involve the raising of existing embankments along their current alignments. The work would be phased to ensure that the full value of the defences is realised by only rebuilding the defences at the end of their lives.

The final 3 options involve realignment of defences. These options are selected to reduce costs in the future by reducing the length of bank to be raised and rebuilt. However there are additional costs in constructing new defences (rather than raising existing defences) and there are also costs associated with loss of agricultural land. Each of the main options (including *Hold the Line*) have a benefit cost ratio of between 10 and 12. The incremental benefit cost ratio over the *Do Minimum* option varies between 8.7 and 9.57.

The present value of the costs range from £29m for the *Hold the Line* option to £32.3m for the large realignment (HTL/MR C4) i.e. the major realignment is only 11% higher than the *Hold the Line* option. Based on the decision rule the *Hold the Line* option is just preferred (this option has the highest incremental benefit cost ratio).

The difference in costs between the major options is very small, hence the choice of preferred option will be sensitive to future changes in costs and other parameters.

The value of the habitat created exceeds the additional cost of creating it in all potential realignment options. If it was necessary to provide further salt marsh habitat in the future for any reason beyond the scope of this strategy, the net costs involved would be relatively small in this location, such that good value could be achieved. This might be sufficient to change the choice of preferred option in the future.

Huntspill and Pawlett FMU

Five options have been identified to manage flood risks in the Huntspill and Pawlett FMU.

DN	Do Nothing
DM	Do Minimum
DM+FW	Do Minimum & Flood Warning
HTL	Hold the Line
HTL/MR	Hold the Line followed by managed realignment

The table below summaries the benefit/cost analysis for the Huntspill and Pawlett FMU:

	Strategy Option				
	DN	DM	DM+FW	HTL	HTL/MR
PV Damages	184.6	135.1	128.3	2.5	4.4
PV Damages Avoided		49.6	56.3	182.1	180.2
PV Environmental Benefits		0.0	0.0	0.0	3.8
Total PV Benefits		49.6	56.3	182.1	184.0
PV Costs		1.0	1.3	33.3	32.6
Net Present Value		48.6	55.0	148.8	151.4
Benefit Cost Ratio		51.9	44.2	5.5	5.6
Incremental Benefit/Cost ratio (over do minimum)			21.10	4.10	4.24

Notes:

All Figures are £million

PV: Present value

Environmental benefits = value of habitat created (£1200/Ha per annum)

Preferred option highlighted in **bold**

The *Do Nothing option* illustrates that in excess of £184 million damages would be caused if the defences were abandoned, illustrating the importance of the defences.

The *Do Minimum option* reduces the damages to £135 million, however property damage is considerable and the approach effectively delays the considerable damage that will occur in the future slightly (so reducing the present value). This option has the highest benefit/cost ratio but the approach provides a standard of service below the indicative standard to the majority of properties.

The *Do Minimum and Flood Warning Option* provides some further reduction in damages but the overall impact is marginal, because flood warning will not address the loss of property in the future due to deterioration in defences and sea level rise. The incremental benefit/cost ratio of 21 illustrates the value of flood warning.

Hold the Line would involve the raising of existing embankments along their current alignments. The work would be phased to ensure that the full value of the defences is realised by only rebuilding the defences at the end of their lives.

The final option involves partial realignment of defences in the future. This option is selected to reduce costs in the future by reducing the length of bank to be raised and rebuilt. However there are additional costs in constructing new defences (rather than raising). The option selected is the most economically efficient by reducing the length of the long meander by realigning the bank inland as shown in Figure 6.1.

The present value of the costs range from £33m for the *Hold the Line* option to £32.6m for the realignment. The partial realignment option provides some additional environmental benefit. Based on the decision rule the realignment option is just preferred (this option has the highest incremental benefit cost ratio).

Programme of expenditure

Cash flow forecast for the preferred option, assuming prices are set at today's prices and not discounted to present value.

Period	Cannington £k	Pawlett/Huntspill £k	Bridgwater £k
2008 - 2020	22,000	24,000	9,000
2046 - 2081	21,000	21,000	26,000
2081 - 2108	22,000	24,000	6,000