



Bridgwater Strategic Flood Defence Infrastructure Planning

Technical Appendices

June 2009



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ANNEX A: PARRETT ESTUARY FLOOD MANAGEMENT STRATEGY: PREFERRED STRATEGY REPORT (JANUARY 2009) CD Only

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Report Status

This report has been completed in advance of other studies which are investigating the wider infrastructure requirements to support the regeneration of Bridgwater within the Sedgemoor District Council Local Development Framework.

This report should be read in conjunction with the other studies as they become available.



Bridgwater Strategic Flood Defence Infrastructure Planning

Summary of Technical Appendices

Appendix A provides details of the wide range of options considered to provide a sustainable flood management approach to the risks in the Parrett Estuary. Whilst the wider options are of interest, the critical options considered in this study relate primarily to Bridgwater.

Appendix B provides some further information on the basis for the economic appraisal, and the use of optimism bias.

Appendix C considers in more detail the approach adopted in considering the location of the barrier, and the proposed planning safeguarding area. This section considers environmental constraints, and related issues.

Appendix D outlines a range of funding options. This section considers how different sources of finance could be used to fund different elements of the work. At this stage the options are provided as options only without a final preferred option, for consideration by Sedgemoor District Council and the Environment Agency.

Appendix E Programme and climate change risks

Annex A includes the Parrett Estuary Flood Management Strategy: Preferred Strategy Report 2008 (available on CD only). This report was prepared by the Environment Agency to provide a strategic approach to flood management over the whole of the River Parrett Estuary including Bridgwater. The overall approach adopted in this strategy is consistent with the approach taken here. The Parrett Estuary Flood Management Strategy will be reviewed nationally by the Environment Agency during the summer of 2009.

A. STRATEGIC ESTUARY FLOOD MANAGEMENT OPTIONS

Table 7.1 in the main report summarises the short list of options considered to provide flood protection to Bridgwater. This short list has been derived from an extensive long list of options which should be considered, which is summarised in Table A1. The discussion of these wider options is discussed in Annex A Parrett Estuary Flood Risk Management Strategy (section 6).

Table A1: Long List of Options

Short List Ref	Name	Description
A	Do nothing	Undertake no further maintenance or construction work within the catchment. Included as a baseline for comparison during assessment.
B	Do Minimum	Carry out work to repair breaches as and when they occur and general maintenance, but otherwise allow the standard of defence to deteriorate in line with sea level rise and general “wear and tear”.
-	Off line flood storage	Contain flood waters within purpose built storage areas designed to fill at a certain water level in the estuary. Not effective in reducing flood levels of the most vulnerable properties.
-	On line flood storage/Attenuation	Contain floodwaters within the floodplain. Lowers lengths of the existing tidal embankment, maintain the existing banks, construct spillways and construct new embankments inland to contain the “ponded” floodwater. Not effective in reducing flood levels of the most vulnerable properties.
-	Optimise existing flood storage	Redirecting flood flows to low risk areas. This is a flood storage variation on options 3 and 4 above. Not effective in reducing flood levels of the most vulnerable properties.
F	Flood warning and flood awareness	Issue warnings to allow people to prepare for a flood
C	Re-engineer banks/Hold the line	Improve the exiting banks to either strengthen, or raise them, or both (includes minor realignment of up to 50m from their present position)
-	Bridge and weir modifications	Replace or modify bridges and weirs to reduce flow constraints. Hydraulic capacity is not a controlling factor. Not effective in reducing flood levels.
-	Land management	Change in land use to reduce run off and sediment delivery to the estuary. Runoff from the land is not the cause of flooding. Not effective in reducing flood levels.
-	Sustainable Urban Drainage System (SUDS)	Drainage systems that mimic natural processes, such as allowing water to soak into the ground. Runoff from the land is not the cause of flooding. Not effective in reducing flood levels.
-	Set back banks/Managed realignment	Reposition the defence line back from the estuary. Not practical in Bridgwater
D	Barrier	Construct a structure across the estuary

Short List Ref	Name	Description	
-	Dredging	Remove sediment from the river bed to increase the hydraulic capacity.	If the channel is widened or the depth increased the surface water level will largely remain unchanged in Bridgwater as it responds to the tide. Not effective in reducing flood levels.
-	Channel widening	Widen the channel to increase hydraulic capacity.	
Note 1	Development control	Prevent inappropriate development in the floodplain. Runoff from the land is not the cause of flooding. This is a partial solution to future problems not current issues.	
E Note 2	Individual property protection	Protect individual buildings or small groups of buildings with flood defences placed within the property boundary. Relates to a small number of properties and does not contribute to protection of infrastructure. Not a strategic solution. (At project level this should always be considered).	
-	Insurance	Compensate for flood damage. Moves risk costs and additional cost to nation in insurance fees. Therefore, not sustainable or justifiable.	
-	Hold the line then set back defences	Combined option to test optimum approach.	
D	Hold the line then install a surge barrier for Bridgwater	Combined option to test optimum approach.	

Notes

1. The Parrett Estuary Flood Risk Management Strategy did not focus on land use planning and development control specifically. This is an integral part of this new report and is not considered separately.
2. Individual property protection in the Parrett Estuary Flood Risk Management Strategy focussed on protecting existing property. In this Bridgwater Strategic Flood Defence Infrastructure Planning report the focus is on regeneration and this option becomes *Raising Ground Levels in Association with New Development* in Table 7.1

B. ECONOMIC APPRAISAL

B.1 Basis of Flood Damage Assessment in Bridgwater

Table B1 summarises the economic basis of the flood damage assessment in Bridgwater.

Table B1: Basis of Economic Flood Damage Assessment

Asset	Damage or Risk	Data Source(s)	Value(s)
Residential Property	Direct damage to property (including 10.7% allowance for emergency service costs)	The Benefits of Flood and Coastal Risk Management: A Manual of assessment Techniques (Multi-Coloured Manual)	0 to 0.3m depth £21,137 per property 0.3m to 1.5m depth £44,655 per property 1.5m to 3m depth £57,202
Residential property	Capped Value	Land registry	£190,122 (this value is used when direct flooding damage is greater than the market value of the property). In Bridgwater most properties currently protected by tidal defences would flood frequently in the future (without the construction of the tidal barrier), and the economic value would be capped at the value shown.
Non-residential property	Direct damage	Multi-Coloured Manual	The damage depends on the type of non-residential property. For a flood depth of up to 0.3m flood damage can vary from £30,000 for a basic warehouse up to £1,000,000 or more for large buildings such as supermarkets or secondary schools.
Risk to Life	Risk to life is strongly related to breach risks	Assessing and Valuing Risk to Life from Flooding for Use in Appraisal of Flood Risk management Measures (Defra 2008)	£1,450,000 value of providing protection for 1 life. Similar values are used in road safety projects. Estimates of the number of lives at risk during a major flood event are difficult to quantify, and depends on many factors. If no works were undertaken then the probability of overtopping and breaching of the defences would increase, leading to approximately 10 or more deaths in major events.

B.2 Barrier Cost Summary

Table B2 provides further details of the cost of the tidal barrier. This assessment assumes that the barrier is constructed near Bridgwater (approximately at location 5 in Figure 4 of the main report)

Table B2: Barrier Cost Breakdown

Item	Description	Typical Rate	Cost £
Cofferdam/Temporary Works	Cofferdam including:		£3,960,000
	Sheet Piles	£170/m2	
	Whalings		
	Struts		
Excavation	Dewatering	£1800/month	
	Excavation to foundation level within cofferdam	£50/m3	£499,000
	Disposal of excavated Material	£30/m3	
Fill	Imported granular fill	£50/m3	£156,000
Piling	Structural foundation piling to support concrete structure	£1900/m installed	£336,000
Concrete	Structural concrete	£150/m3	£2,828,000
Tide Gates	Fabricated steel gates	Sum	£525,000
Machinery	Powerpack	£45k	£466,000
	Rams	£150k	
	Pipework	£50k	
	Biodegradable oil	£8k	
	Controls	£15k	
	Standby generators	£35k	
	Power supply	£20k	
	Switchgear and transformers	£20k	
	Fire protection	£15k	
	CCTV/Web Camera	£18k	
	Miscellaneous	£90k	
Landscaping			£171,000
Other Construction	e.g.		£339,000
	Site Investigation		
	Access		
	Utilities		
Contractors On Costs			£2,810,000
Engineering Design	Design Fees		£1,485,000
	Client Administration		
Legal/Planning	Legal issues in connection with navigation		£1,713,000
	Other planning issues		
Sub Total			£15,288,000
Optimism Bias	60% Refer to section 9.4 for discussion of the optimism bias allowance. Section B.3 lists the main typical contributory factors which lead to optimism bias		£9,173,000
TOTAL			£24,461,000

B.3 Contributory Factors and Risks Which Lead to Optimism Bias

Optimism bias is discussed in section 9.4 of the main report. Optimism bias reflects the tendency for appraisers on all kinds of projects to be overly optimistic in their early estimate of project costs when compared with the final outturn cost.

The *Supplementary Green Book Guidance: Optimism Bias* published by HM Treasury outlines some of the causes of optimism bias in past projects. The summary below is a modified version of the factors identified. It is a generic list and not all factors are relevant.

Text highlighted in red are considered particularly relevant to the construction of the barrier, and require careful management to minimise risks in the future.

Procurement

1. Complexity of Contract Structure

- Details of risk transfer had to be clarified
- Payment mechanism had to be defined
- Unforeseen amount of negotiation required on terms of contract

2. Late Contractor Involvement in Design

- Value management was necessary but contractor was not involved early enough to allow for it
- The design could not be built due to construction problems (e.g. access)
- Contractor provided design / construction feedback at a late stage resulting in a redesign

3. Poor Contractor Capabilities

- Contractor was inexperienced
- Site health and safety standards were not met
- Construction was not carried out to the necessary standards
- The contractor had insufficient resources

4. Government Guidelines

- No precedent or guideline had been developed to procure a leading edge Project

5. Dispute and Claims

- Dispute over interim payments
- Claims for changes in scope
- Claims for late release of information by other stakeholders

6. Information Management Systems

- The interfaces between the stakeholders were not managed efficiently resulting in information not being transferred effectively.

Project Specific

7. Design Complexity

- The design had to be built in difficult conditions e.g. within the river or landfill site

8. Degree of Innovation

- New generation design
- Unusual site conditions requiring innovative solutions e.g. soil contamination

9. Environmental Impact

- Contamination e.g. existing landfill site
- Noise pollution e.g. airports
- Impact on wildlife

Client Specific

10. Inadequacy of the Business Case

- Number of services were not anticipated
- Output specifications were not defined clearly
- Oversight in facilities required
- All stakeholders were not involved and so their needs were not defined and included in business case

11. Large Number of Stakeholders

- Different public sector parties having differing interests in the project
- Process of obtaining approval took longer than expected due to number of parties involved.

12. Funding availability

- Difficulties in obtaining financial backing for project
- Additional funding was made unexpectedly available later on in the project thus changing project scope

13. Project Management Team

- The project management team was inexperienced in delivering a project of this nature
- Inadequate review of drawings by the project manager before construction

14. Poor Project Intelligence

- Insufficient ground investigation
- The detailed design was based on insufficient site information
- Insufficient surveying of existing conditions

15. Public relations

- Opposition from the local community (with regards to traffic and construction noise and environmental impact)
- Environmental protests

16. Site Characteristics

- The presence of badger setts within construction site (and similar environmental issues)
- Underground stream requiring protection during construction
- Archaeological findings

17. Permits / Consents / Approval

- **Parliamentary Bill required for project initiation**
- Difficulties in obtaining planning permission, possibly resulting in an appeal to the Secretary of State

External Influences

18. Political

- Opposition by a major political party
- Impact on sensitive constituencies
- Lacks support from key political stakeholders

19. Economic

- **Change in market demand resulting in a change in funding priorities**
- **Crash in stock markets**

20. Legislation / Regulations

- **Change in required standards – particularly environmental and planning**

21. Technology

- Unanticipated technological advancements
- Computer virus
- Limits in technology

C. DETERMINATION OF BARRIER LOCATION

Section 8.1 of the main report discusses the barrier location, and the appropriate area to safeguard in the Local Development Framework. It is important to reiterate that the exact location of the barrier does not have to be determined at the present time. Equally the exact form of the barrier, in terms of the arrangement of gates etc does not have to be fully confirmed. It is also likely that how the barrier is managed and controlled may well change as technology advances.

Nevertheless it is essential that an area is safeguarded in the Local Development Framework to ensure that the barrier can be built in the future, and the costs of undertaking the work is minimised. Therefore it is essential not only to safeguard the footprint of the barrier but also the areas of potential access. This safeguarding area is shown in Figure 4 in the main report.

Section 8.1 of the main report concluded that the environmental benefits/disbenefits of the 5 possible sites were broadly similar and there were no strong environmental reasons for adopting one site over another. The detailed analysis is shown below in Table C1, and Figure 4 from the main report is repeated for ease of use. Generally the options in Table C1 assume that the structure is built within the river (requiring careful phasing and temporary works to ensure that there is no flood risk from the works). There are other options:

- Building the structure remote from the river and then diverting the river through it
- Diverting the river temporarily, constructing the barrier on the line of the existing river and then diverting the river back to the original alignment

These options have not been considered in detail in this report. However there may be environmental and economic reasons to consider these options further during detailed design.

The most significant issue identified in the matrix is the impact on the landscape both during construction and operation. The conservative approach adopted in the assessment was to assume a large intrusive structure (including a significant overhead steel gantry for example). The design selected in the main report is significantly lower profile and the landscape impact would be considerably less.

Wider environmental impacts have also been considered including the 'carbon footprint' of the options. The carbon footprint calculation aims to assess the quantity of greenhouse gas (specifically CO₂) produced by construction activities. The primary aim of the carbon calculator is assist decision makers in selecting strategies, designs and materials which minimise the production of CO₂.

The carbon analysis was undertaken in the Parrett Estuary Flood Management Strategy, but has been extended in this study. It should be stressed that the analysis is simplistic and only assesses the main construction activities and it should be treated as a lower bound value. The assessment indicates that approximately 50% of the carbon footprint is derived from the use of steel (piles, gates, steel reinforcement etc), 33% from concrete, and the remainder from all other materials and activities (including transport). The summary in Table C2 confirms that the most upstream location (location 5) is preferred from a greenhouse gas perspective.

Table C2: Barrier Carbon Footprint Summary

Barrier Site	Estimated Cost £m	Barrier Carbon Footprint t CO2
1	68.0	23000
2	68.0	23000
3	51.3	17000
4	29.0	9500
5	24.5	8000

Table C1: Environmental Review of Alternative Barrier Locations

Receptor	Key Receptor	Bridgwater Strategic Flood Defence Infrastructure Planning									
		Surge Barrier 1		Surge Barrier 2		Surge Barrier 3		Surge Barrier 4		Surge Barrier 5	
		Construction	Operation	Construction	Operation	Construction	Operation	Construction	Operation	Construction	Operation
Humans	Communities	No Impact	Additional flood protection to residential properties within Bridgwater.	No Impact	Additional flood protection to residential properties within Bridgwater.	No Impact	Additional flood protection to residential properties in the Bridgwater area.	Minor disturbance to communities in north Bridgwater.	Additional flood protection to residential properties within Bridgwater. Potential for barrier to become feature within Bridgwater.	Disturbance to communities in north Bridgwater. Best practice during construction may reduce some disturbance.	Additional flood protection to residential properties within Bridgwater. Potential for barrier to become feature within Bridgwater.
	Public Rights of Way	Temporary closure/diversion of the PRoW on both banks.	Enhanced erosion protection of PRoW further upstream.	Temporary closure/diversion of the PRoW on both banks.	Enhanced erosion protection of PRoW further upstream.	Temporary closure/diversion of the PRoW on the right bank.	Enhanced erosion protection of PRoW further upstream.	Temporary closure/diversion of the PRoW on the right bank.	Enhanced erosion protection of PRoW further upstream.	Temporary closure/diversion of the PRoW on both banks.	Enhanced erosion protection of PRoW further upstream.
Flora & Fauna	Severn Estuary cSAC, SPA, Ramsar and Bridgwater Bay SSSI	Noise and increased sedimentation could affect downstream sites and associated species. Mitigation would include timing of works and pollution control measures.	No Impact	Noise and increased sedimentation could affect status of downstream site.	No Impact	Sedimentation could affect status of downstream site.	No Impact	Sedimentation could affect status of downstream site.	No Impact	Sedimentation could affect status of downstream site.	No Impact
	County Wildlife Site (CWS)	No Impact	Increased flood protection to upstream CWS	No Impact	Increased flood protection to upstream CWS	No Impact	Increased flood protection to upstream CWS	Noise may disturb species within the CWS.	No Impact	No Impact	No Impact
	Protected Species e.g. otter, badger, water vole	Potential for temporary disturbance or habitat loss of protected species. Protected species surveys and associated mitigation could avoid/minimise effects.	Increased flood protection to protected species habitats upstream of barrier.	Disturbance to protected species (records of which exist close by).	Increased flood protection to protected species habitat upstream of barrier.	Disturbance to protected species.	Increased flood protection to protected species habitat upstream of barrier.	Disturbance to protected species (records of which exist close by).	Increased flood protection to protected species habitat upstream of barrier.	Disturbance to protected species (records of which exist close by).	Increased flood protection to protected species habitat upstream of barrier.
	BAP Habitats	Footprint of barrier would result in the loss of small amount of intertidal mudflat and grazing marsh.	Footprint of barrier would result in the loss of intertidal mudflat and grazing marsh.	Footprint of barrier across wide channel would result in the loss of intertidal mudflat.	No Impact	Footprint of barrier would result in the loss of intertidal mudflat and grazing marsh.	No Impact	Footprint of barrier would result in the loss of intertidal mudflat and grazing marsh.	No Impact	Footprint of barrier would result in the loss of intertidal mudflat and grazing marsh.	No Impact
	Migrating Fish	Sedimentation or pollution could indirectly effect migratory fish by impacting on water quality, although would be minimised through construction best practice. Some potential disturbance from noise and vibration.	Fish/ elver passage would only be limited during extreme tidal events (when surge barrier is closed). Otherwise there is no obstruction to passage.	Sedimentation could indirectly effect migratory fish by impacting on water quality.	Fish/ elver passage may be limited during extreme tidal events (when surge barrier is closed).	Sedimentation could indirectly effect migratory fish by impacting on water quality.	Fish/ elver passage may be limited during extreme tidal events (when surge barrier is closed).	Sedimentation could indirectly effect migratory fish by impacting on water quality.	Fish/ elver passage may be limited during extreme tidal events (when surge barrier is closed).	Sedimentation could indirectly effect migratory fish by impacting on water quality.	Fish/ elver passage may be limited during extreme tidal events (when surge barrier is closed).
	Birds	Potential to disturb migratory and non-migratory wader and waterfowl bird	No Impact	Potential to disturb migratory and non-migratory wader and waterfowl bird	No Impact	Potential to disturb migratory and non-migratory wader and waterfowl bird	No Impact	Potential to disturb migratory and non-migratory wader and waterfowl bird	No Impact	Potential to disturb migratory and non-migratory wader and waterfowl bird	No Impact

Receptor	Key Receptor	Bridgwater Strategic Flood Defence Infrastructure Planning									
		Surge Barrier 1		Surge Barrier 2		Surge Barrier 3		Surge Barrier 4		Surge Barrier 5	
		Construction	Operation	Construction	Operation	Construction	Operation	Construction	Operation	Construction	Operation
		species. Timing of works could help minimise disturbance.		species.		species.		species.		species.	
Water	Surface Water and Groundwater Quality	Increased sedimentation or pollution could affect water quality. Construction best practice would minimize effect. Subsurface construction could affect local groundwater regime and levels.	Reduced risk of inundation upstream will reduce risk of mobility of contaminants from agricultural, STWs and discharge sources	Increased sedimentation or pollution could affect water quality. Construction best practice would minimize effect.	Reduced risk of inundation upstream will reduce risk of mobility of contaminants from agricultural, STWs and discharge sources	Increased sedimentation or pollution could affect water quality. Construction best practice would minimize effect.	Reduced risk of inundation upstream will reduce risk of mobility of contaminants from agricultural, STWs and discharge sources	Increased sedimentation or pollution could affect water quality. Construction best practice would minimize effect.	Reduced risk of inundation upstream will reduce risk of mobility of contaminants from agricultural, STWs and discharge sources	Increased sedimentation or pollution could affect water quality. Construction best practice would minimize effect.	Reduced risk of inundation upstream will reduce risk of mobility of contaminants from agricultural, STWs and discharge sources
	Discharge Points	No Impact	No Impact	No Impact	No Impact	No Impact	No Impact	No Impact	No Impact	Raising of flood embankment downstream could affect discharge point.	No Impact
Landscape & Visual Amenity	'Green Wedge'	No Impact	No Impact	No Impact	No Impact	Major impact of construction on 'Green Wedge' landscape designation.	Broad visual and character impact on the local landscape within the 'Green Wedge'.	Major impact of construction on 'Green Wedge' landscape designation.	Broad visual and character impact on the local landscape and townscape of Bridgwater within the 'Green Wedge'.	Major impact of construction on 'Green Wedge' landscape designation.	Broad visual and character impact on the local landscape and townscape of Bridgwater within the 'Green Wedge'.
	Landscape Character Area	Temporary visual intrusion of construction on local flat landscape.	Structure is likely to have a broad visual and character impact on the flat landscape.	Nearby industrial development would reduce impact of construction on visual character.	Impact of structure on landscape character would be reduced by nearby industrial development.	Significant impact of construction on local flat landscape.	Structure is likely to have a broad visual and character impact on the flat landscape.	Significant impact of construction on local flat landscape.	Structure is likely to have a broad visual and character impact on the flat landscape.	Major impact of construction on local landscape and surrounding townscape of Bridgwater.	Structure is likely to have a broad visual and character impact on the flat landscape.
Archaeology & Cultural Heritage	Scheduled Monument	No Impact	Increased flood and erosion protection to the nearby Scheduled Monument upstream	No Impact	Increased flood and erosion protection to upstream Scheduled Monuments.	No Impact	Increased flood and erosion protection to upstream Scheduled Monuments.	No Impact	Increased flood and erosion protection to upstream Scheduled Monuments.	No Impact	Increased flood and erosion protection to upstream Scheduled Monuments.
	Listed Buildings & Historic Environment Records	No Impact	Increased flood and erosion protection to Listed Buildings and Historic Records further upstream.	Impact of barrier footprint on nearby Historic Record.	Increased flood and erosion protection to Listed Buildings and Historic Records further upstream.	Impact of barrier footprint on Historic Record along flood embankment.	Increased flood and erosion protection to Listed Buildings and Historic Records further upstream.	Impact of barrier footprint on Historic Record along flood embankment.	Increased flood and erosion protection to Listed Buildings and Historic Records further upstream.	Impact of barrier footprint on Historic Record along flood embankment.	Increased flood and erosion protection to Listed Buildings and Historic Records further upstream.
	Unknown archaeology, including Parrett Banks	Potential to disturb/destroy non-designated or unknown sites.	No Impact	Potential to disturb/destroy non-designated or unknown sites.	No Impact	Potential to disturb/destroy non-designated or unknown sites.	No Impact	Potential to disturb/destroy non-designated or unknown sites.	No Impact	Potential to disturb/destroy non-designated or currently unknown sites.	No Impact
Infrastructure	Transport links including Road (M5 & A38) and Rail	Increased construction traffic.	Increased protection of transport links within Bridgwater.	Increased construction traffic.	Increased protection of transport links within Bridgwater.	Increased construction traffic.	Increased protection of transport links within Bridgwater.	Increased construction traffic.	Increased protection of transport links within Bridgwater.	Increased construction traffic.	Increased protection of transport links within Bridgwater.
	Navigation Channel & Dunball Wharf	Regular temporary restrictions of navigation to Dunball Wharf.	Navigation to Dunball Wharf would only be restricted during times that the surge barrier is closed	Regular temporary restrictions of navigation to Dunball Wharf.	Navigation to Dunball Wharf would be restricted during times that the surge barrier is closed.	No Impact	Navigation to Dunball Wharf would be unrestricted.	No Impact	Navigation to Dunball Wharf would be unrestricted.	No Impact	Navigation to Dunball Wharf would be unrestricted.

Receptor	Key Receptor	Bridgwater Strategic Flood Defence Infrastructure Planning									
		Surge Barrier 1		Surge Barrier 2		Surge Barrier 3		Surge Barrier 4		Surge Barrier 5	
		Construction	Operation	Construction	Operation	Construction	Operation	Construction	Operation	Construction	Operation
			(extreme tidal events).								
Land Use	Agricultural Land Classification	No Impact	Reduced risk of saline inundation of agricultural land upstream of barrier.	No Impact	Reduced risk of saline inundation of agricultural land upstream of barrier.	No Impact	Reduced risk of saline inundation of agricultural land upstream of barrier.	No Impact	Reduced risk of saline inundation of agricultural land upstream of barrier.	No Impact	Reduced risk of saline inundation of agricultural land upstream of barrier.

Key – Orange = Major Negative

Yellow = Minor Negative

White = No impact

Light Green = Minor Positive

Bright Green = Major Positive

D. FUNDING MODELS

There are a wide range of potential funding models available. The sources of funding include:

- Environment Agency (using permissive powers and GiA)
- Developers (to ultimately achieve the requirements of PPS25: Development and Flood Risk)
- Local Authority
- Regional development (e.g. from Severn Tidal Power/ Hinkley Point or other)
- UK Government (Infrastructure/regeneration related funds)

The report assumes that Sedgemoor District Council will identify and utilize all available UK Government funding opportunities. However, this appendix assumes that no UK Government infrastructure funding can be identified and that the flood management funding will have to be derived from the Environment Agency, Local Government, Regional Development or Developers.

The funding available can be directed to various elements:

- Maintenance of existing flood defences in Bridgwater
- Design and planning of the barrier
- Construction of the barrier (the construction could be split between main civil construction work and then later flood gates and mechanical equipment)
- Maintenance of the barrier

Therefore there are many combinations of funding sources and elements to fund. Table D1 summarises some of the more likely funding options.

At the time of writing the wider infrastructure requirements to support the regeneration of Bridgwater within the Local Development Framework have not been fully defined.

The funding options identified in Table D1 are not the only options available and funding should be considered within the context of all the infrastructure requirements.

It is assumed that the Environment Agency will fund all other flood management works in the Parrett Estuary (i.e. downstream of the barrier location). Once the barrier is constructed flood management work on the defences upstream of the barrier location in Bridgwater are not required.

Other funding combinations are possible and part funding of elements from different sources can be considered within the options shown.

Funding of the operation of the barrier (OPEX) is not discussed above but is estimated as £200k per annum once the barrier is operational.

TABLE D1: FUNDING OPTIONS

Option Ref	Title	Description	Flood Management Element						Financial Contribution Summary		Advantages	Disadvantages
			Walls & Embankments			Barrier			Environment Agency Permissive Powers	Development Contributions		
			Element Provided (Funding Source)	Programme	Cost £	Element Provided (Funding Source)	Programme	Cost £				
1	EA Funded Scheme	All works funded by the EA (GiA)	All (EA)	All works until construction of the barrier	£8m	All (EA)	Construction of barrier between 2030-2050	£24.5m	All	None	No financial burden on Bridgwater development sites	All investment met by public funds Development cannot guarantee that EA permissive powers will be used. Therefore Requirements of PPS25 not met Construction of barrier must wait until economically justified
2	EA Funded Barrier 2030-2050 (with development contribution for barrier design)	All walls and banks funded by the EA. Development contributes to design of the barrier	All (EA)	All works until construction of the barrier funded by the EA	£8m	Design & Planning funded by development during LDF plan period Construction by EA	To 2026 Between 2030-2050	£5m £19.5m	Walls and construction of barrier	Design and planning of barrier	Some contribution by development in accordance with PPS25	Investment substantially met by public funds Development cannot guarantee that EA permissive powers will be used. Therefore Requirements of PPS25 not met Construction of barrier must wait until economically justified
3	Development Funded Barrier 2030-2050	All walls and banks funded by the EA Development funds barrier	All (EA)	All works until construction of the barrier funded by the EA	£8m	All (Development)	Construction of barrier 2030-2050 or earlier if desired	£24.5m	Walls	Barrier	Substantial investment met from private funds Requirements of PPS25 broadly met	Financial viability of development uncertain due to level of contribution Uncertainty that development can fund barrier outside of LDF period

Option Ref	Title	Description	Flood Management Element						Financial Contribution Summary		Advantages	Disadvantages
			Walls & Embankments			Barrier			Environment Agency Permissive Powers	Development Contributions		
			Element Provided (Funding Source)	Programme	Cost £	Element Provided (Funding Source)	Programme	Cost £				
4	Development Funded Walls Present-2026	Development funds maintenance of walls between present day and end of the LDF period. Future barrier met by EA or with future development contributions	All (Development)	All works to 2026	£8m	All (EA)	Construction of barrier 2030-2050	£24.5m	Barrier	Walls	Work to walls will be required prior to 2026, within LDF period Some contribution by development in accordance with PPS25	Financial viability of development uncertain due to level of contribution
5	Barrier civil engineering works constructed from development contributions	Development funds construction of barrier civil engineering works prior to 2026. Barrier completed between 2030-2050 by EA as required	All (EA)	All works before construction of the barrier	£8m	Design of works and civil engineering (Development) MEICA (gates, hydraulics, controls etc) construction and management (EA)	To 2026 2030-2050	£21.5m £3m	Walls and MEICA element of barrier	Design and civil engineering of barrier	Substantial investment met from private funds Requirements of PPS25 broadly met Development funded works within LDF period	Financial viability of development uncertain due to level of contribution Construction of civil engineering works only may be considered unsatisfactory and hard to justify because benefits of the barrier are only realised once the structure is complete.
6	Barrier funded by external contribution	EA funds wall maintenance until construction of barrier between 2030 and 2050. Cost of barrier met from contribution in connection with Hinkley Point and/or Severn Tidal Power project	All (EA)	All works before construction of the barrier	£8m	All (Regional Infrastructure Development)	2030-2050	£24.5m	Walls	Regional infrastructure development funds barrier Bridgwater development could fund part of walls work to 2026	Regional infrastructure funds large component of work. Restrictions related to LDF period presumably not relevant Considerable uncertainty regarding options and programme of regional development	Clear logic for funding of barrier would need to be established. Some infrastructure options (such as the Bridgwater Bay Tidal Lagoon) will show this clear linkage Development cannot guarantee that EA permissive powers will be used. Therefore Requirements of PPS25 not met. However since funding is met

Option Ref	Title	Description	Flood Management Element						Financial Contribution Summary		Advantages	Disadvantages
			Walls & Embankments			Barrier			Environment Agency Permissive Powers	Development Contributions		
			Element Provided (Funding Source)	Programme	Cost £	Element Provided (Funding Source)	Programme	Cost £				
											externally this appears to be a low risk	
7	Barrier construction combined with new Hinkley Point power station access road	Potential exists to construct combined access bridge and barrier structure	All (EA)	All works before construction of the barrier	£8m	All (Hinkley Point Development)	TBC 2013	£68m	Walls	Barrier (£68m in this location)	<p>Regional infrastructure funds large component of work.</p> <p>Restrictions related to LDF period presumably not relevant</p> <p>Considerable uncertainty regarding options and programme of regional development</p>	<p>Cost of barrier much higher due to location of new road and much wider estuary. Savings identified in combining structures would be negligible.</p> <p>Clear logic for funding of barrier would need to be established.</p> <p>Development cannot guarantee that EA permissive powers will be used. Therefore Requirements of PPS25 not met. However since funding is met externally this appears to be a low risk</p>

Option Ref	Title	Description	Flood Management Element						Financial Contribution Summary		Advantages	Disadvantages
			Walls & Embankments			Barrier			Environment Agency Permissive Powers	Development Contributions		
			Element Provided (Funding Source)	Programme	Cost £	Element Provided (Funding Source)	Programme	Cost £				
8	Barrier funded from Local Government Resources	EA funds wall maintenance until construction of barrier between 2030 and 2050 (or earlier if desired). Cost of barrier met from Local Government funding.	All (EA)	All works before construction of the barrier	£8m	All (Local Government funding) Alternative funding mechanisms could be investigated (e.g. PFI/PPP)	2030-2050 or earlier if desired	£24.5m	Walls	Local Government Funded Barrier	No financial burden on Bridgwater development sites Potential flexibility of timing of barrier construction (depends on local government investment regulations)	All investment met from public funds (local government) Resources unlikely to be available from local government Development cannot guarantee that EA permissive powers will be used. Therefore Requirements of PPS25 not met

E. PROGRAMME

The likely programme of works required is summarised in Table 8.2 of the main report. Further details of the likely programme will be provided in supporting documents once the overall funding approach is agreed, in conjunction with other infrastructure requirements.

Risks

The principal risks to the programme are discussed in table 10.2 of the main report and are summarised below:

- Identification of Incorrect Solution
- Funding Risks
- Unknown Environmental Issue
- Rate of Change of Sea Levels
- Regeneration in Bridgwater delayed

The scale of the risk is generally discussed in Table 10.2. Some further details are discussed below.

Rate of Change of Sea Levels

The rate of sea level rise is uncertain, and the assessment used in this study is derived from *Flood and Coastal Defence Appraisal Guidance, FCDPAG3, Supplementary Note to Operating Authorities – Climate Change Impacts October 2006* published by DEFRA. This is the standard document under which all publicly funded flood defence schemes are promoted.

The UK Climate Impacts Programme (www.ukcip.org.uk) published on the 18 June 2009 the new report on climate change scenarios for the UK which has the full title of *UK Climate Projections* and are known as UKCP09. This data is provided in a probabilistic model. It is likely that this data will be considered by Defra and new advice on the rate of sea level rise issued in due course. Whilst it is very unlikely that any changes in sea level rise estimates would change the overall flood management approach, the programme of the response may well change. It is essential that this is understood in relation to any contributions policy to support the construction of the barrier.