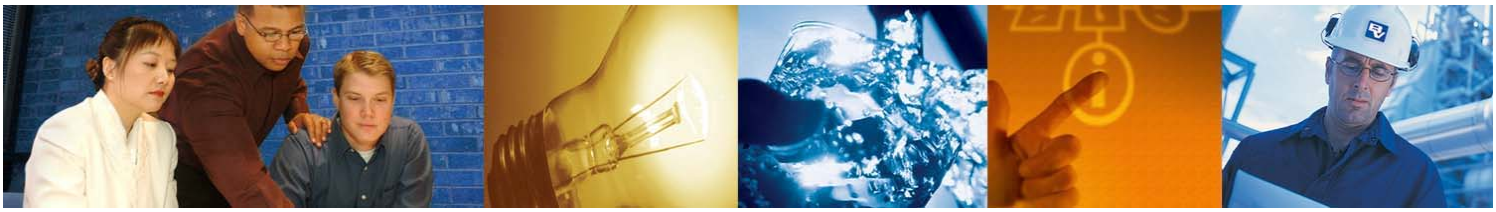

Bridgwater Strategic Flood Defence Infrastructure Planning

Final Report

June 2009

Bridgwater Strategic Flood Defence Infrastructure Planning

CONTENTS

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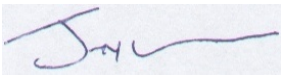
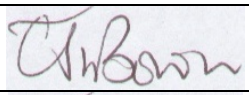
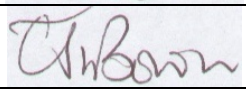
Prepared	Jack Mason		30 June 2009
Checked	Chris Bown		30 June 2009
Approved	Chris Bown		30 June 2009

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

Executive Summary

The sustainable regeneration of Bridgwater within the Local development Framework can only be achieved if flood risk is managed effectively and appropriate flood management infrastructure provided. This is supported by national, regional and local planning guidance.

The current flood defences in Bridgwater protect 8,400 households and 800 businesses from tidal flooding. The flood defences downstream of Bridgwater to the mouth of the River Parrett protect a further 2,500 households and 140 businesses.

Climate change is the predominant driver of increasing flood risk in the future as identified in the Strategic Flood Risk Assessment. With about a 1m increase in sea levels by 2108, severe tidal flooding of the Bridgwater town centre would occur, to a depth of 2m under extreme events over large areas.

Regionally and nationally important development (in particular the Severn Estuary Tidal Power opportunities) may have an impact on flood risk in Bridgwater.

There are a wide range of technical and environmental constraints and opportunities that must be considered when determining the long term flood management infrastructure required to protect the town.

Piecemeal protection of individual new regeneration sites is not a preferred approach to future flood risk. This approach would not be sustainable and ultimately safe access to many regeneration sites in the town could not be achieved during tidal flood events.

Continuing the previous approach to flood risk in the town by raising riverside flood defences is not the preferred option. Very high walls would be difficult and expensive to build, and would cause land drainage problems. The landscape implications of such an approach would be dramatic, essentially dividing the centre of the town up with 2m high walls. There would also be heritage issues with the loss of existing bridges which would have to rebuilt. High walls would also cause problems for the community in terms of accessibility as well as create a negative and defensive environment in the town centre which would be detrimental to the place and how it feels to live or invest in.

The preferred approach to flood risk in the town is to construct a new tidal barrier which would be raised when required to exclude high and dangerous tides. The approach is analogous to the approach taken in London with the use of the Thames Barrier. The new barrier would cost about £24.5 million, if constructed near the Bridgwater urban area. As the width of the estuary increases downstream of Bridgwater, costs would increase significantly if a barrier were located further downstream.

Whilst the barrier is seen as the central approach to flood risk management for Bridgwater in the long term, the current defences must be managed and maintained and future embankments will be required downstream of the barrier location. It is important that the barrier is seen as an important element of an overall flood management system. The Environment Agency are prepared to be responsible for maintaining and developing the wider system and future embankments.

The current predictions of sea level rise have been used by Defra for flood risk management purposes and these have been incorporated into Planning Policy Statement 25 (PPS25) which sets out Government policy on development and flood risk. Its aims are to ensure that flood risk is taken into account at all stages in the planning process. These allowances for sea level rise, combined with the expected deterioration of existing defences, mean that a barrier would be required between 2030 and 2050, the date being dependent on the actual rate of both measures over the next few years. Studies and planning would be required in advance, particularly to address issues such as the existing navigation.

The barrier is therefore a key infrastructure need which will need to be integrated into the Local Development Framework (LDF) infrastructure plan. The core strategy will also need to have an appropriate policy and suitable mechanism to call on funds to contribute to this strategic infrastructure need. Given the long term date for the barrier to be provided, the current proposal, discussed with the Agency, Council and Government Office, is for contributions to be collected over two plan periods.

The infrastructure planning work for the LDF will scope out other infrastructure needs and also recommend priorities.

In the short term, prior to the core strategy being approved, the Council and the Agency have agreed to progress a Supplementary Planning Document, aligned with the Regional Spatial Strategy and existing strategic planning policy, which will enable contributions to the barrier, as a significant amount of the planned growth is likely to come forward early in the plan period. This is a pragmatic response which enables investment in the short term to buy into the strategic solution.

1. INTRODUCTION

This report confirms that the sustainable regeneration of Bridgwater can only be achieved if appropriate flood defence infrastructure is provided.

Sedgemoor District Council and the Environment Agency have jointly recognized the need to identify how flood management in Bridgwater should be addressed, taking into account the need for regeneration and increasing flood risk associated with future climate change. The need for a strategic approach to infrastructure is essential to inform the emerging Local Development Framework now being prepared by Sedgemoor District Council.

The report aims and structure is summarised below:

Section	Description
Section 2	Identifies the planning policy context, taking into account national, regional and local requirements
Section 3	Describes the past, present and future flood risks in the town
Section 4	Outlines the current studies and plans
Section 5	Considers the options available to manage flood risk and the constraints
Section 6	Outlines the environmental issues and how these influence the flood management options
Section 7	Identifies the preferred strategic approach to flood infrastructure provision in Bridgwater
Section 8	Provides further details of the preferred flood infrastructure and the expected programme
Section 9	Identifies methods of financing the preferred option and the expected cash flow
Section 10	Considers the delivery of the preferred solution and the associated risks
Section 11	Conclusions and Recommendations
Section 12	Bibliography

2. PLANNING CONTEXT

The statutory 'development plan' for an area guides decisions on new building and the use of land to help ensure there is a balance between development and conservation of the environment in the public interest. Within this context, development plans must consider all key constraints which may influence how development is planned in the future. Flood risk, including the increases associated with climate change is a key constraint and must be considered within all development plans.

In September 2004 the Government introduced significant changes to the development plan-making system through the Planning and Compulsory Purchase Act 2004. The general hierarchy of planning documents proposed through the 2004 act is summarised below:

Table 2.1 Planning Hierarchy

Tier	Name	Specific Flood Risk Relevant Documents
National	Planning Policy Statements (PPSs)	PPS1: Delivering Sustainable Development PPS25: Development and Flood Risk PPS12: Local Spatial Planning
Regional	Regional Spatial Strategies (RSS)	Regional Spatial Strategy for the South West
County	Minerals & waste Local Development Frameworks	Somerset Minerals and Waste Development Framework. (However little relevance to flood risk issues but included for completeness)
Local	Local Development Framework (LDF)	Sedgemoor Local Development Framework

Under the Act the 'development plan' for Sedgemoor will comprise of:

- The **Regional Spatial Strategy (RSS) for the South West** – currently being prepared by the South West Regional Assembly. This document sets out a broad spatial planning strategy for the region between 2006 and 2026. Climate change and associated flood risk issues are usually considered over longer periods than the RSS, which presents challenges when considering the response to flood risk in the longer term within a shorter planning horizon. This issue is discussed later in this report. The final Regional Spatial Strategy was due for publication in summer 2009 but there may be some delay. The assessment of the RSS within this document is based on the current draft RSS.
- The development plan documents (DPDs) of the **Sedgemoor Local Development Framework (LDF) -** a portfolio of policy documents prepared by the District Council – which will outline the spatial planning strategy for the local area.
- The development plan documents of the **Somerset Minerals and Waste Development Framework (MWDF)** –a folder of documents prepared by Somerset County Council – which will outline the spatial strategies and detailed land-use policies and proposals for the management of waste and extraction of minerals in the county. This has limited relevance to the flood risk issues discussed in this report.

Key to the successful preparation of the 'development plan' is the establishment of links and consistency between national, regional and local plans and strategies. Further details of the general progress of the preparation of the LDF by Sedgemoor District Council and the future programme is included in the Local Development Scheme Third Revision (available at http://www.sedgemoor.gov.uk/index.aspx?articleid=1918).

2.1 National Planning Policies

PPS1: Delivering Sustainable Communities stresses that '*Development plan policies should take account of environmental issues such as….the potential impact of the environment on the proposed developments by avoiding new development in areas of risk of flooding and sea-level rise, and as far as possible, by accommodating natural hazards and the impacts of climate change.'* (paragraph 20).

PPS25: Development and Flood Risk sets out Government policy on development and flood risk. Its aims are to ensure that flood risk is taken into account at all stages in the planning process to avoid inappropriate development in areas at risk of flooding, and to direct development away from areas of highest risk. The aims of PPS1 are further elaborated on within PPS25 '*Positive planning has an important role in helping deliver sustainable development and applying the Government's policy on flood risk management. It avoids reduces and manages flood risk by taking full account in decisions on plans and applications of:*

- *Present and future flood risk, involving both the statistical probability of a flood occurring and the scale of its potential consequences, whether inland or on the coast; and*
- *The wider implications for flood risk of development located outside flood risk areas.* (paragraph 4)

Paragraph 5 of PPS25 goes on to stress that '*Where new development is, exceptionally, necessary in areas at risk of flooding, policy aims to make it safe without increasing flood risk elsewhere and where possible, reducing flood risk overall.'* (paragraph 5, slightly truncated).

PPS12: Local Spatial Planning confirms that '*The core strategy* (of the Local Development Framework) *should be supported by evidence of what physical, social and green infrastructure is needed to enable the amount of development proposed for the area, taking account of its type and distribution. This evidence should cover who will provide the infrastructure and when it will be provided. The core strategy should draw on and in parallel influence any strategies and investment plans of the local authority and other organisations.'* (paragraph 4.8)

PPS12 further clarifies how good infrastructure planning is undertaken and what it should achieve '*Good infrastructure planning considers the infrastructure required to support development, costs, sources of funding, timescales for delivery and gaps in funding. This allows for the identified infrastructure to be prioritised in discussions with key local partners. This has been a major theme highlighted and considered via HM Treasury's CSR07 Policy Review on Supporting Housing Growth. The infrastructure planning process should identify, as far as possible:*

• *infrastructure needs and costs;*
• *phasing of development;*
• *funding source; and*
• *responsibilities for delivery.* (paragraph 4.9)

Within the national planning policy outlined above, this document aims to address the key needs for flood management within Bridgwater as identified in **PPS1: Delivering Sustainable Communities** and **PPS25: Development and Flood Risk**. The information provided in this report aims to help inform the Local Development Framework Core Strategy in accordance with the needs of **PPS12: Local Spatial Planning**.

This report builds upon previous studies and reports prepared regionally and locally and these sources are discussed further below.

2.2 Regional Planning Policies

Regional Planning Policy is defined within the emerging Regional Spatial Strategy for the South West. The draft polices are summarised below and have been obtained from the *The Draft Revised Regional Spatial Strategy for the South West Incorporating the Secretary of State's Proposed Changes – For Public Consultation July 2008.* Generally the RSS echoes the national policy recommendations. However it confirms the importance of flood risk to the regeneration of the town:

The Regional Flood Risk Assessment provides a broad overview of the source and significance of all types of flood risk across the region. It concludes that the areas which are subject to regionally significant flood risk are the Somerset Levels and Moors, Avonmouth, Weston-super-Mare, Exeter, Bridgwater, Taunton, Christchurch, Poole, Weymouth and Truro. At the local level, local planning authorities will prepare Strategic Flood Risk Assessments and will use the sequential test outlined in PPS25 to guide development away from current or future flood risk areas and flood plains. Flood risk will also be managed through the use of Sustainable Drainage Systems. (Paragraph 4.0.12).

Bridgwater will be regenerated, diversify its economy and increase self-containment, while reducing the risk of flooding, by providing for the re-use of redundant employment site improving the town centre (Bridgwater Strategically Significant City and Town)

Bridgwater is designated under the RSS as a Strategically Significant City and Town (SSCT) and is expected to accommodate high levels of growth. Currently there is a limit on the physical extent of the town, with development constrained by potentially high flood risk, particularly in the future due to climate change. To satisfy the Regional Spatial Strategy in terms of housing provision and employment, a long term flood management solution is needed to allow development of areas at risk of flooding, without which prospects of accommodating significant levels of growth are limited.

Sedgemoor District Council have taken forward the advice contained in PPS25 and the RSS, and have prepared a Strategic Flood Risk Assessments for Sedgemoor. This is discussed below in the Local Planning Policies section.

2.3 Local Planning Policies and Information

The purpose of this document is to inform the Sedgemoor LDF and, in particular, the emerging Core Strategy. However the Local Authority has commissioned a Strategic Flood Risk Assessment for the district, which provides significant information on the scale and severity of the flood risk in the town. The details of the flood risk identified in the SFRA are discussed in section 3. However the key policy messages from the SFRA for Bridgwater are summarised below.

Key Conclusions from the Sedgemoor District Council Strategic Flood Risk Assessment in relation to Bridgwater:

• Under present day conditions (i.e. no inclusion of climate change) tidal overtopping is not a significant constraint to development within Bridgwater;

• Sea level rise due to climate change is the predominant factor affecting future flood risk;

• Bridgwater experiences medium to high flood hazard under climate change conditions;

• The impacts of climate change illustrate the requirement for a strategic flood defence solution for the sustainable development of Bridgwater and surrounding area; and

• Where land is allocated for development, a site specific Flood Risk Assessment will be required building on the information provided within the Level 1 SFRA and this Level 2 SFRA report. This should incorporate additional information of mitigation of residual risk and emergency planning procedures to ensure safe access and egress for the lifetime of the development.

2.4 The role of the Environment Agency

The Department for Environment, Food and Rural Affairs (Defra) has overall *policy* responsibility for flood and coastal erosion risk in England. The Environment Agency is empowered under the Water Resources Act 1991 to manage flood risk arising from designated "main" rivers and the sea. The Agency is also responsible for exercising a general supervision over matters relating to flood defence. The Agency has permissive powers to undertake flood defence works. However it does not have a statutory duty to undertake new flood defence works, and generally only undertakes works where it is economically worthwhile from a national perspective, is consistent with other environmental objectives, and where national budgets permit.

Planning Policy Statement 25: Development and Flood Risk (PPS25) sets out national policy in this context. The aims of PPS25 are to ensure that flood risk is taken into account at all stages in the planning process to avoid inappropriate development in areas at risk of flooding, and to direct development away from areas of highest risk. The policy aims to make planned development safe, without increasing flood risk elsewhere, and where possible, reducing flood risk overall. Within this national policy, landowners have primary responsibility for safeguarding their land and property. Those proposing development are responsible for ensuring their development is safe (over the lifetime of the development) and ensuring flood risks to others are not increased.

The River Parrett flows through the centre of Bridgwater and is the principal flood risk to the town driven by peak tidal levels. Current defence against high tidal levels is provided by a combination of earth embankments and flood walls from the mouth of the Parrett Estuary, through the town and into the Somerset Levels and Moors to the South West. High water levels generated by surge tides in the Bristol Channel are the main risk, whilst high fluvial flows in the river spill out into the upstream floodplains before reaching the town. Typical photographs of the current defences in Bridgwater are shown below:

Flood Wall in front of Bridgwater Hospital

Bridge and Flood wall

Concrete Flood wall

Past, present and future emissions of greenhouse gases are expected to cause significant global climate change. This will lead to sea level rise, which will put increased pressure on the current tidal defences in the town. In accordance with PPS25, a new approach to flood management is required to maintain flood protection in Bridgwater for both existing properties and new development. This report outlines the options and how they should be delivered.

3. FLOOD RISKS PAST, PRESENT AND FUTURE

The Parrett Estuary embankments date back to the 14th century when the Somerset Levels and Moors were first reclaimed and protected from the sea. Since then in this area flood defences have been repaired and improved in reaction to flooding and population growth particularly during the 20th century. This approach continued into the late 1970's when flood risk management became more sophisticated and defences were built in readiness for anticipated tidal events. The tidal flood event of 1974 triggered the onset of the phased "Parrett in Bridgwater" scheme, which commenced in 1977 to improve the standard of the tidal defences protecting Bridgwater. Fortunately, the majority of the works phases were complete by the time of the December 1981 event, when a 1.45m tidal surge coincided with the peak of a modest spring tide, protecting the town from flooding which severely affected the majority of the Somerset coastal floodplain.

Although the new defences kept the damages to isolated locations in Bridgwater, wave action caused structural damage where defences were exposed to open fetches in the Severn Estuary. A large volume of tidal water overtopped the defences and filled the majority of the tidal floodplain of the River Parrett. The seawater flowed back to the M5 motorway, flooding communities and hundreds of hectares of agricultural land. Hundreds of livestock drowned both in open fields and in stock houses, but miraculously no people died during the event. The Parrett Estuary was sheltered from wave action, which otherwise might have led to catastrophic failure.

The event of 1981 serves as a reminder of the potential risks if flood defences along the River Parrett are not maintained. Figure 1 shows the tidal flood plain which would be realised, if the defences along the River Parrett were removed. This plan is based on data provided in the Sedgemoor Strategic Flood Risk Assessment (August 2008), and shows the area assessed as having a 1 in 200 or greater probability of flooding in any one year, if the defences were not in place. The town as we know it today would not be viable without the extensive flood banks and walls that protect the town. Figure 1 shows the floodplain on the eastern side of Bridgwater extending across to the M5 motorway. The M5 which is on an embankment would act to contain floodwater in this way as occurred in 1981.

In summary the current defences in Bridgwater protect 8,400 households and 800 businesses. The flood defences downstream of Bridgwater to the mouth of the River Parrett protect a further 2,500 households and 140 businesses.

3.1 Climate Change and Future Flood Risk

In the future flood risk pressures to Bridgwater will increase for a number of reasons. In particular:

- Sea level rise associated with climate change
- The rate of deterioration of the existing defences (which is a function of structure type, age and river hydraulics)
- Changes in land use (further urban development increases the *potential* to put further development at risk)

These issues are discussed below:

Sea Level Rise

Sea levels are rising and the rate of rise is predicted to increase. Climate change will modify weather patterns. This could mean changes to the frequency, duration and severity of storms across the UK.

Sea levels
Sea levels are rising as a result of melting ice caps and thermal expansion of the sea water. Current Defra guidelines recommend allowances for sea level rise shown in Table 3.1 below.

Table 3.1: South West net sea level rise allowances

Administrative or Devolved Region	*Net Sea-Level Rise (mm/yr)*			
	1990- 2025	*2025- 2055*	*2055- 2085*	*2085- 2115*
South West and Wales	3.5	8.0	11.5	14.5

http://www.defra.gov.uk/environ/fcd/pubs/pagn/climatechangeupdate.pdf

In Bridgwater sea levels would rise by 978mm by 2108 above today's sea levels. The standard of defence provided by the defences will reduce dramatically as a consequence. Some illustrative levels are summarised below.

Table 3.2: Illustrative Flood and Ground Levels

Description	Level m AOD	Comment
Current 1 in 200 year flood level[Note 1] in River Parrett adjacent to Bridgwater town centre	8.3	
Current typical ground level in Bridgwater Town Centre	7.2	Without defences Bridgwater Town centre would be flooded by about 1m.
Current typical flood defence level protecting Bridgwater town centre	8.4	The current defences provide over a 1 in 200 year standard of service.
Future 1 in 200 year flood level in Bridgwater town centre in 2108	9.3	With about a 1m increase in sea levels, flood levels in the River Parrett would flood the town centre to a depth of about 2m if no improvements were undertaken

Note 1: The 1 in 200 year flood event level is more accurately described as the level having a 1 in 200 annual probability of occurring. In accordance with PPS25: Development and Flood Risk, areas which flood more frequently than once in 200 years are considered at high risk of flooding.

The UK Climate Impacts Programme1 (UKCIP) co-ordinates research on climate change and summarises how it might impact at regional and national levels. Their predictions for sea level rise have been incorporated into the Defra allowances. Additionally UKCIP predicts that the UK's climate will become increasingly variable with higher intensity storms becoming more common. The defences in Bridgwater are some way upstream and sheltered from the open coast and therefore, increased wave action is not a prime concern. However, increased storminess is likely to increase the frequency of major tidal surges, which present the greatest flood risk in the area. How the frequency of major surge tides will increase in the future is uncertain at present. This will be reviewed at appropriate intervals as more data becomes available from the increasingly sophisticated climate models being run worldwide.
Surface water

On a smaller scale, due to increased storminess more local 'flash' flooding may be experienced due to the local surface water system not coping with the sudden volume of surface runoff from heavy storms. This aspect is of secondary importance in comparison with the tidal flood risk and is outside the scope of this study.

Deterioration of Defences

The flood defences through Bridgwater are significant engineering structures. The present defences were predominately built in the early 1980s. Whilst the defences have performed well to date they will gradually deteriorate even with appropriate normal maintenance. Realistically the current defences have a further life of about 25 to 40 years. Maintenance work is undertaken both on the tidal embankments and walls to ensure that the defences work as designed, and to maximise the life of the system.

Changes in Land use

By allowing further urban development, more development is *potentially* at risk of flooding (there are more potential 'receptors'). However PPS25 aims to ensure that all new development is not at a high risk of flooding over the lifetime of the development. In more rural areas there may be the potential to remove development from flood risk by either rebuilding it or relocating it elsewhere. In Bridgwater this option is often not practical or desirable in spatial planning terms.

4. CURRENT STUDIES AND PLANS

Under their general supervisory role the Environment Agency has undertaken a range of flood risk management studies within the Parrett catchment, Parrett Estuary and the Somerset coast, which provide the basis for sustainable flood management in Bridgwater. Sedgemoor District Council are currently preparing the Local Development Framework which will provide the basis for planning in the district, and will ultimately direct development to appropriate locations taking into account all key planning objectives including flood risk. The key current and emerging studies which inform this report are summarised in Schematic 1 below.

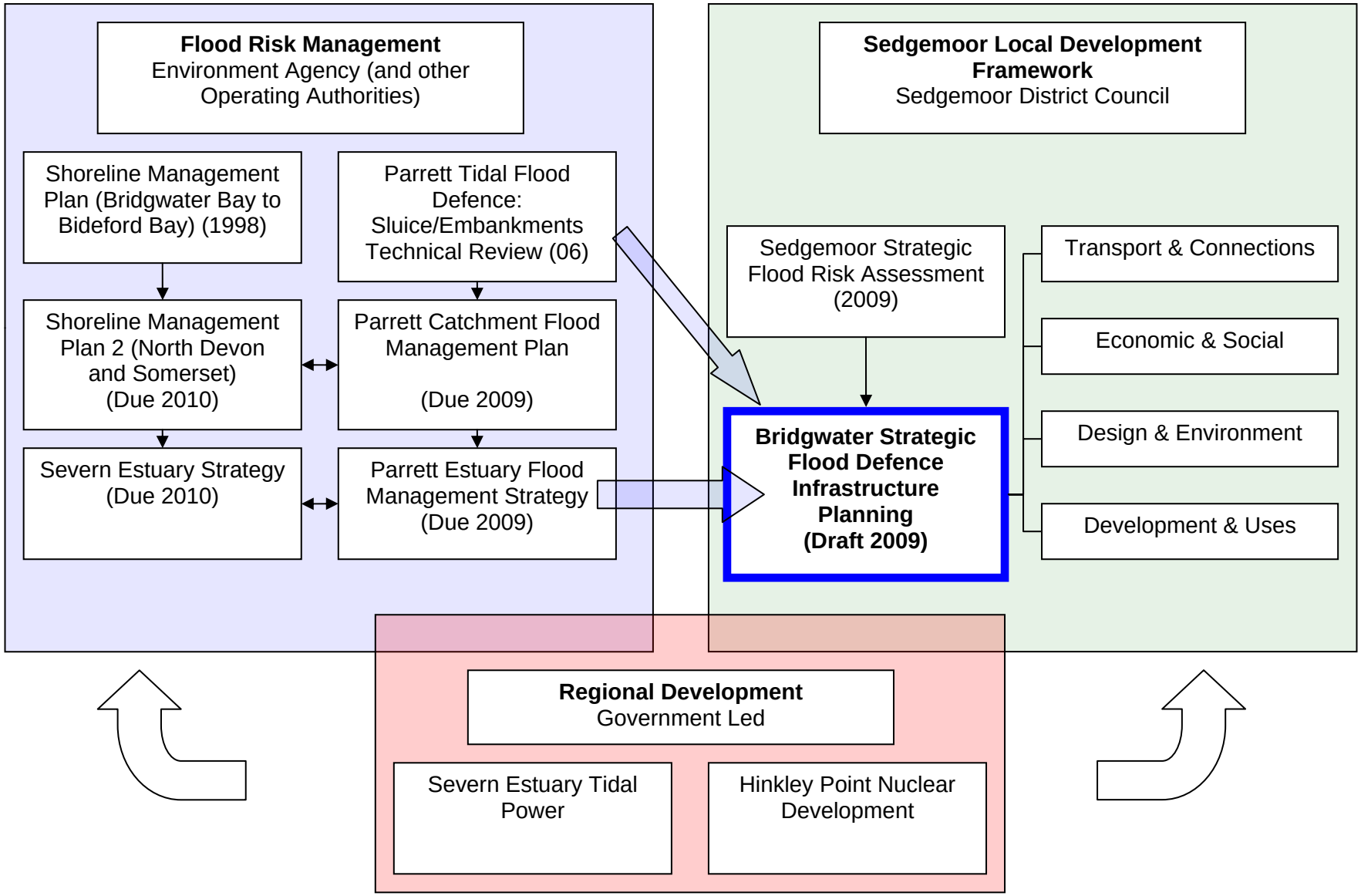
The key conclusions of the *Sedgemoor Strategic Flood Risk Assessment* are included in section 2.3. The principal conclusion from this work is that current flood risks in Bridgwater are low but that climate change will increase flood risks significantly.

The *Parrett Tidal Flood Defence: Sluice/ Embankments Technical Review* was undertaken in 2003. This report focussed on the technical options (excluding environmental considerations), rather than the wider delivery, planning and environmental issues which is the focus of this report. Since 2003 there have been significant changes to the expected rate of sea level rise, and how the economics of flood management studies is considered.

The *Parrett Catchment Flood Management Plan* (CFMP) is a high level document which provides an overview of the present and future flood risks and the high level response. The overall flood management policy for Bridgwater from the CFMP is *'Policy option 4. Take further action to sustain current scale of flood risk into the future (responding to the potential increases in flood risk from urban development, land use change and climate change).*' The CFMP also states that *'The protection to Bridgwater will be the single largest investment in the Parrett Catchment over the next 50 years. Planning for such an investment is essential.*'

The *Parrett Estuary Flood Management Strategy* is being undertaken to provide an overall approach to flooding in the Parrett Estuary. Information from this emerging strategy has informed this study. Because of the importance of this study, the Preferred Strategy Report is included in Annex A. This report aims to avoid duplication of work which has been undertakenin the Parrett Estuary Flood Management Strategy.

Schematic 1: Current and Emerging Studies



5. OPTION CONSTRAINTS AND OPPORTUNITIES

5.1 Future Development in Bridgwater

Proposed development in Bridgwater is set to transform the town dramatically with new commercial and residential sites located throughout the area to deliver the regional growth plans. Full details of the development plans for Bridgwater are available in the emerging LDF documents, and are not repeated in detail in this study. However the key points are summarised below, and are shown in Figure 2.

Bridgwater Challenge is the partnership process which is developing a spatial strategy and vision for the town to shape the delivery of the planned growth. The vision extends to 2060 and during this period flood risks in Bridgwater must be addressed.

New residential developments will provide an additional 7,700 homes including affordable housing (over the LDF period to 2026) with over 7500 new jobs in the Bridgwater Travel to Work Area and about 54ha of additional employment land in Bridgwater. It is generally accepted that there is an imbalance in the employment opportunities within the town, and this is one aspect the new LDF will aim to address.

Retail outlets in the town centre will be improved to encourage people to shop in the area. It is essential that flood defence options are consistent with general urban landscape enhancements if the town is to be an attractive place to live and work.

Building Schools for the Future (BSF) is the biggest ever schools investment programme nationwide, with plans to rebuild or nearly re-build every secondary school in the country to act as a catalyst to improved levels of education. It is planned that six schools in Bridgwater will be redeveloped, raising aspirations and creating widespread social regeneration and community cohesion. Presently, strategies are being developed with key partners including Sport England, Somerset Primary Care Trust, Avon and Somerset Police, Sedgemoor District Council, Bridgwater College and arts organizations to maximize the benefit from these works in the area. New flood defence structures will contribute to maintaining the levels of flood protection for some of these schools.

Enhanced infrastructure will be required to cope with the planned expansion of the town. Somerset County Council Bridgwater Transport Strategy aims to provide a transport system that accommodates the planned expansion of Bridgwater and assist economic performance by minimising congestion. The strategy aims to achieve these objectives by improving accessibility for walking and cycling, maximizing the effectiveness of public transport, and undertaking targeted road improvements to tackle congestion hotspots. Effective transport infrastructure requires flood risks to be minimized.

New cycle and pedestrian routes along the Riverside are proposed to allow people to commute from the central areas of the town, out to the new areas of development.

The increase in population expected in the town will require amenity and welfare facilities. The Waste Water Treatment Works, located in Chilton Trinity will be expanded to cope with increased demand. The works are located adjacent to the River Parrett within the tidal floodplain, although the works are protected from flooding by existing tidal emebankments.

The Strategic Urban Extension to the town at North East Bridgwater forms the primary development site, shaped by the urban design principles agreed by partners.

National infrastructure proposals may also have an additional impact on the town. Plans are in place to support the nuclear de-commissioning process through an energy skills centre, and additional proposals for new nuclear investment will be submitted to the Infrastructure Planning Commission during 2010.

5.2 Regional Development and Infrastructure

There are several regional schemes currently being considered which are of national importance, which also have implications on the location, timing and form of the tidal defences required on the River Parrett.

Hinkley Point Nuclear Development

A new nuclear power station (Hinkley Point C) is being considered for construction to be located alongside Hinkley Point A, which is now closed and being decommissioned and Hinkley Point B, which is due for closure in 2016. On the 15 April 2009 the Government formally identified Hinkley Point as a preferred site.

Because of the extensive construction involved, there are options for construction and operational traffic accessing the site to do so via a new embanked road running across the flood plain at Cannington, part of the road linking the M5 and the Hinkley Point site. Vehicles leaving the M5 at junction 23 would cross the River Parrett via a new bridge near Dunball Wharf/Drove and cross the tidal floodplain to link up with the A39 in Cannington. If the new nuclear power station is approved, it is likely that the new construction access will be seen as enabling works and would be constructed possibly within 5 years from the decision to go ahead. However, this option is not certain and the developer EDF is yet to confirm transport proposals, and wider community benefit proposals.

There is opportunity to incorporate flood defence options into the new bridge structure. This is discussed in section 8.2.

Severn Estuary Tidal Power

The capture of tidal energy has long been considered an option for the Severn Estuary. The issues of energy security and climate change have provided added impetus to the feasibility of using the high tidal range in the Severn Estuary for power production.

At the time of writing the Department of Energy and Climate Change (DECC formerly BERR) has commissioned a study to investigate the feasibility of deriving power from the Severn Estuary. The first phase of the study aimed to investigate whether there were any fundamental reasons why options could not be taken forward for further investigation. This phase has just reported to the Government and work has commenced on more detailed studies in phase 2. The results of this detailed feasibility stage will be subject to full public consultation in 2010.

A detailed discussion of the options being considered is outside the scope of this study. However the 10 options considered in phase 1 are summarised below, and those that were provisionally short listed are also shown:

Table 5.1: Severn Estuary Tidal Power Options

Option No	Option Name	Provisionally Short listed
1	Outer Barrage from Minehead to Aberthaw	No
2	Middle Barrage from Hinkley to Lavernock Point	No
3	Middle Barrage from Brean Down to Lavernock Point (commonly known as Cardiff to Weston Barrage)	Yes
4	Inner Barrage (Shoots Barrage)	Yes
5	Beachley Barrage	Yes
6	Lagoon Enclosure on the Welsh Grounds (Fleming Lagoon)	Yes
7a	Onshore Tidal Lagoons (Bridgwater Bay)	Yes
7b	Offshore Tidal Lagoons	No
8	Tidal Fence	No*
9	Tidal Reef	No*
10	Severn Lake Scheme	No

* £500,000 committed for further investigations
(Source: http://severntidalpowerconsultation.decc.gov.uk/feasibility_options)

The barrages (short listed options 3,4 and 5) would operate by holding back water as the tide recedes and the stored water would then be discharged through large turbines. Because a barrage essentially acts as a partial dam, it has a secondary effect of reducing the propagation of extreme tides into the upper estuary. None of the short listed barrage options are downstream or the River Parrett confluence with the Severn and the impact on flood risk in Bridgwater is likely to be modest.

Option 7a, the Bridgwater Bay tidal lagoon option would have a significant impact on the River Parrett Estuary and flood risks in Bridgwater if it were constructed. At this stage there is insufficient information available to comment further.

In the event that any of the options are progressed, any impact from the proposals on flood risk in Sedgemoor District will need to be considered by the organisations promoting the option and mitigation identified if necessary. If a viable scheme is identified it is very unlikely that it would be completed before 2020.

The Severn Estuary tidal power options have the potential for major impacts to the whole of the Severn Estuary and the associated environment. Considerations of these options are at an early stage. However as some options may have significant implications on flood risk in Bridgwater and the Sedgemoor District Council area and long term flood management of Bridgwater must take this aspect into account.

5.3 Aspirations for the River Parrett and the Bridgwater and Taunton Canal

Navigation on the River Parrett has played an important part in the development of the town and the surrounding area. 400-500 ton vessels used to navigate the tight course as far as the Bridgwater town bridge and into the quays of the Port of Bridgwater. Today, Sedgemoor District Council acts as the Competent Harbour Authority for the port and provides pilotage for all boats over 30m length entering the Port to oversee the difficulties of the constantly changing channel resulting from the large tidal range and strong currents. Although river traffic has been reducing since the 1930s, bulk cargoes, mainly marine sands gravels and salts, are still received at Dunball, which marks today's furthest upstream boundary for large vessels in the River.

There have been plans by British Waterways and others to reopen the lock between the River Parrett and the Bridgwater and Taunton Canal. However because of the difficult tidal regime and the continually changing river section, navigation will remain challenging in the future, if re-establishing this link was achieved.

The economic impact of obstructing navigation upstream (south) of Dunball presently would be very modest. However if navigation was obstructed downstream of Dunball (the main commercial wharf) the impacts would be more significant. The options identified in this report do not propose potential obstructions downstream of Dunball Wharf.

5.4 Technical Constraints

There are several technical constraints that need to be considered when selecting the most appropriate method of flood defence for the River Parrett through Bridgwater. This section considers technical issues only. Sections 6 and 7 consider wider issues. The risks associated with these key technical challenges can be reduced by good planning and design. However there is normally an increase in cost associated with these issues, which have been considered later in the report.

The key technical constraints are summarised in Table 5.2.

Table 5.2: Key Technical Constraints

Item	Constraint	Commentary
1	Geomorphology	The tidal flows in the Parrett Estuary are fast and carry a high sediment load. Studies have shown that permanently interfering with the tidal and fluvial flow in the river is likely to cause major geomorphological change. For both technical and environmental reasons, large changes in river regime are highly undesirable and options should generally aim to minimise any impact on the existing flow regime in the river.
2	Ground Conditions	From a construction perspective the existing ground conditions throughout the Parrett estuary are very poor. The construction of heavy civil engineering structures would almost certainly require the use of load bearing piles. Unfortunately the depth of poor material is significant (typically in excess of 5m below river bed levels).
3	Tidal Conditions	The extreme tidal range and the potential for extreme tides throughout the tidal River Parrett provide significant technical challenges during construction.
4	Surface water Drainage	This report focuses on the risks from high tides to Bridgwater. However during periods of high tides, surface water which would normally drain into the River Parrett cannot do so. This problem would become more serious with climate change.
5	Access and Maintenance	Currently maintenance of the existing defences is undertaken by the Environment Agency. Where defences are proposed it is essential that appropriate access is available for inspection, maintenance and repair. In upgrading existing defences new access is required (and current standards are higher than in the past). This access is not always available because of existing buildings or other constraints
6	Navigation	Options could interfere with navigation between the Bristol Channel and Bridgwater. This issue is further discussed in section 5.3 above.

Environmental constraints are discussed in the following section.

6. ENVIRONMENTAL CONSIDERATIONS

This section summarises the current state of the environment in Bridgwater and the immediate area. This baseline will be used in order to assess the effect of each proposed option on the existing environment. The locations of the environmental constraints within the study are presented on Figure 3 and discussed in Table 6.1.

This section is a summary of the key environmental issues. Further details of these are available in the Strategic Environmental Assessment of Annex A (Parrett Estuary Flood Risk Management Strategy: Preferred Strategy Report 2009). The potential options to address flood risk are discussed in section 7, together with the impacts on the receptors below.

Table 6.1: Baseline Environmental Information

Receptor	Sub-Feature/ Detail	Baseline Information
Humans	-	• Bridgwater has a population approximately 34,000. • Economic activity within Bridgwater is relatively high, but the majority of the activity is of low value and therefore tends to be in low-wage/low-skills sectors
Flora & Fauna	Statutory Designations	The Severn Estuary Natura 2000 site boundary lies approximately 500m downstream of the area. Relevant designations are: • Severn Estuary Special Protection Area (SPA; Birds Directive 79/409/EEC); • Severn Estuary candidate Special Area of Conservation (cSAC; Habitats Directive 92/43/EEC) • Severn Estuary Ramsar site, Wetland of International Importance (Ramsar Convention 1971). • Bridgwater Bay Site of Special Scientific Interest (SSSI; Wildlife and Countryside Act 1981 amended 1991) • Bridgwater Bay National Nature Reserve (NNR; National Parks and Access to the Countryside Act 1949 as amended)
	Non-Statutory Designations	There is one County Wildlife Site (CWS) within the study area, the Chilton Trinity Ponds CWS which is important for wildlife in a county context as it supports nationally notable freshwater invertebrate and plant species, otter (*Lutra lutra*) and a number of legally protected bird species including, kingfisher (*Alcedo atthis*), bittern (*Botaurus stellaris*) and Cetti's warbler (*Cettia cetti*). The CWS is protected from development through policy CNE9 of the Sedgemoor District Council Local Plan.
	Habitats	The Parrett Estuary supports a diverse assemblage of plants due to its tidal nature ranging from freshwater assemblages, through brackish water species to marine algae at the mouth. Priority BAP habitats in the vicinity of the study area are mudflats, saltmarsh and floodplain grazing marsh (Sedgemoor Local Biodiversity Action Plan, 1998).
	Mammals	Protected species recorded within the study area include otter (Lutra lutra) protected under schedule 5 of the Wildlife and Countryside Act (1981), and badger (Meles meles) protected under the Badger Protection Act 1992 (see Figure 3 for post 1990 distribution of records).
	Birds	An extensive list of waders and waterfowl species are known to

Receptor	Sub-Feature/ Detail	Baseline Information
		utilise the Parrett Estuary within the SPA boundary which lies 500m downstream of the study area. However, bird communities are highly mobile, and their range will extend beyond the designated boundaries, potentially into the study area.
	Fish	The Severn Estuary cSAC (commences approximately 500m downstream of the study area) was recommended partially due to the occurrence of important migratory fish species such as allis and twait shad (*Alosa alosa* and *A. fallax*), river lamprey (*Lampetra fluviatillis*), sea lamprey (*Petromyzon marinus*) and European eel (*Anguilla anguilla*). The River Parrett supports a mixed freshwater and estuarine coarse fishery. The coarse fisheries typically includes a wide distribution of roach, bream, pike, tench, ruffe and eel. There is a small, but important, run of salmon into the Parrett as they migrate to their spawning ground in the River Tone upstream of Bridgwater.
Water	-	The main inputs of fluvial flow within the estuary region are the Rivers Parrett, Brue and Huntspill. Within the fluvial region a complex system of rhynes, ditches, minor tributaries, streams and brooks drain land adjacent to the River Parrett, with its main tributaries the Rivers Tone, Isle, Yeo and Cary, which discharges through the King's Sedgemoor Drain (KSD) into the Parrett Estuary at Dunball.. The River Parrett has been found to meet the chemical and biological water quality standards (grades A-C) under the General Quality Assessment scheme (EA, 2008a). In total 20 industrial consented discharges lie within the study area. These include a Sewage Treatment Works at Chilton Trinity (ST 303 386) as well as two outfalls from industrial units (Wessex Water Services Ltd own the outfalls) (see Figure 3 for discharge point locations).
Landscape & Visual Amenity	-	The townscape of Bridgwater displays much evidence of its historic riverside purpose. The Sedgemoor Local Plan 1991-2011 sets out a 'Green Wedge' landscape designation to the north of Bridgwater. The 'Green Wedge' seeks to retain the rural character of the area and promote land management which benefits the landscape, countryside access, amenity, nature conservation or urban area containment. Bridgwater is predominantly surrounded by a rural landscape which is characterised by low lying, flat topography. Much of this lies below highest tide levels in the Parrett Estuary and Bristol Channel, and is therefore reliant on man made flood defences for flood protection. The area is intersected by a network of man-made drainage channels called 'rhynes'. The Parrett Estuary area to the north of Bridgwater, is characterized by low lying, gently undulating topography, which, closer to the estuary, becomes predominantly flat, with an average elevation of around 5m AOD (EA, 2008b). The M5 itself and the clay Moors of Somerset form the eastern boundary to the study area.
Archaeology & Cultural Heritage	-	One Scheduled Monument consisting of a motte with two baileys exists within the study area (ST 308 413). Two grade II listed buildings exist within the study area in Bridgwater. There are 29 historic environment records within the study area. The

Receptor	Sub-Feature/ Detail	Baseline Information
		majority of the records are historically important buildings/structures along the banks of the River Parrett/Parrett Estuary; the majority of which are existing examples of pill boxes or other Second World War structures. Some of the flood banks along the Parrett Estuary are known to be medieval in origin and therefore have archaeological significance in their own right.
Traffic & Transport	-	Rail (main line to London), road (M5 and A38) links, and power supplies (power lines cross the study area) all lie within the study area. Dunball Wharf is a small port north of Bridgwater (ST 308 407), the port operates as a small scale centre of commerce with navigation routes via the Parrett Estuary. The port is currently used to land marine aggregate dredged from the Severn Estuary (Somerset County Council, 2004). Sedgemoor District Council is the harbour conservancy and pilotage authority for the Port of Bridgwater. Approximately 80 ships used the estuary in 2003 delivering 105,000 tonnes of cargo. The majority of this tonnage (60%) was sand, the rest being building construction materials and agricultural products i.e. animal feed and fertilisers.
Land Use	-	Land use within the study area is a mixture of residential, commercial, industrial and agricultural. The majority of the commercial and residential properties exist within Bridgwater. To the north of the study area the land is predominantly used for agriculture, with much being improved grassland for cattle grazing or arable areas. The provisional Agricultural Land Classification (ALC) provides a method for assessing the quality of farmland to enable informed decisions to be made about its future use within the planning system (Defra, 2006). An assessment of the provisional ALC maps found that outside of the urban centre of Bridgwater, the land within the study area is entirely provisional Grade 3 (moderate-good) indicating that loss of this land to development will result in an impact upon the national resource of 'best and most versatile' agricultural land.

7. OPTION SELECTION

7.1 Option Shortlist

Section 3 confirms that flood risk management is a key issue to the future regeneration of Bridgwater. The expected effects of climate change will, in the absence of other measures, significantly increase the flood risk to both existing and new development. A comprehensive range of technical options have been identified to address this risk, and are summarised in Appendix A. The options have been considered primarily in relation to risks to Bridgwater specifically rather the whole of the Parrett Estuary. The wider risks to the whole estuary are considered in the Parrett Estuary Flood Risk Management Strategy Report (Environment Agency, Draft 2009), refer to Annex A. Further details of the options (particularly those that have been rejected) are included in Appendix A.

PPS25 aims to ensure that planned development is safe, without increasing flood risk elsewhere, and where possible, to reduce flood risk overall. PPS25 stresses the need to use opportunities offered by new development to reduce the causes and impacts of flooding. Many of the sites identified for development benefit from existing flood defences built over the last 30 years, but require major works to ensure that the developments are safe for their lifetime. The issue of how the options should be delivered and the relationship between new and existing development is discussed in section 6. The options assessed further (from the comprehensive list) are summarised below:

Table 7.1: Short List of Flood Defence Options

Ref [Note 1]	Name	Description
A	Do Nothing	Undertake no further maintenance or construction work within the catchment.
B	Do Minimum	Undertake general maintenance. Existing defences will deteriorate gradually and be subject to higher flood levels due to sea level rise.
C	Re-engineer Walls and Banks	Improve and raise existing walls and embankments
D	New Tidal Barrier	Construct a structure across the estuary to exclude extreme high tides. In conjunction with embankment/wall raising where necessary
E	Raising Ground Levels in Association with New Development	Raising ground levels to ensure low risk of tidal flooding. Generally relevant to new development only
F	Flood Warning and Flood Awareness	Enhance the public understanding of flood risk and issue warnings to allow better preparation in advance of flooding

Note 1: Reference has been rationalised from the comprehensive list in Appendix A.

The description of the options and the qualitative performance of the options are described below. Further details are included in Appendix A.

Option A: Do nothing

It is important to understand what would happen if no further work was undertaken to address flood risks in Bridgwater (i.e. the 'walk away' option). This is the baseline against which all other options should be compared.

If this option were adopted existing flood defences would deteriorate, and any damage would not be repaired. The assessment suggests that the defence system would be in poor condition by about 2030. As sea levels rise and the defence deteriorates, flood risks would increase significantly eventually (probably by the middle of the century) leading to abandonment of much of the centre of the town and the loss of existing residential and commercial areas.

This approach would result in the escalation of uncertainty and this, with the loss of investor confidence, and lack of policy or infrastructure solution will result in the whole town being prejudiced and investment will be blocked and will withdraw. The community will face deteriorating property values and businesses will relocate. This will result in decline in its economic prospects and community viability which will not be politically acceptable.

Bridgwater as an urban centre would not be viable by the middle of the century with this approach.

Option B: Do Minimum

This option involves carrying out general maintenance of existing defences, but otherwise allows the performance of the defence to deteriorate in line with sea level rise and the age of the system. Under this option work would not include major repairs due to subsidence, channel erosion or material degradation.

Regardless of the level of general maintenance to the embankments and walls, the condition of the defences will deteriorate over time. In response to higher water levels and weaker defences, the frequency of overtopping will increase, significantly increasing flood risk with time.

Whilst maintenance activities would be focussed on reducing risks to existing development, this approach is only a small improvement over the do nothing option and again would not ensure a sustainable future for Bridgwater.

Option C: Re-Engineer Existing Defences

Existing walls and banks would be re-engineered as required to meet the increasing risks from sea level rise and degradation of the defences with time. Re-engineering would include raising and strengthening defences through the town

Works would be carried out to keep pace with the sea level changes and erosion rates whilst maintaining an acceptable standard of protection.

The re-engineer option is feasible. However, it would become increasingly costly and difficult to address higher flood levels. In many cases the assessment indicates that existing walls and embankments in the town would have to be raised by over a metre in the next 100 years.

In most cases it would be necessary to completely rebuild walls, as simply raising them would not be possible because the foundations will not support the additional loads. In many places access is already difficult and raising walls or embankments will not be straightforward, and therefore the works will be expensive. With this type of increase in defence level, many existing bridges in the town centre will have to be rebuilt or raised as these will become the weak spots in the defence, with the loss of historic structures such as Town Bridge. For banks to be higher they also need to be wider to remain stable and provide safe access.

Today water levels through the town are only above the natural ground level in the town for short periods in very high tides, and this is contained by the low defences. In the future with this option, flood levels will frequently be above the road levels through the town albeit prevented from flowing onto the roads by the new defences. Some existing surface water drainage would become problematical as the sewers would not be able to discharge for longer periods. Whilst there are technical solutions to this problem, there is a further cost penalty.

Through the centre of the town the defence height will often be so high that it will have a significant impact on the urban landscape. In some places it would be difficult for many people to see over the top of the defences. This will lead to fragmentation of the town centre urban landscape.

Option D – New Tidal barrier

This option considers constructing a barrier structure across the river that would be operated to stop the upstream passage of extreme tidal floods from the Bristol Channel. The structure would be situated downstream (north) of Bridgwater to protect most of the town. New embankments would be required downstream of the town and barrier to ensure complete protection of the Bridgwater area. Both the barrier and embankments are required to provide the protection to the town.

The gated structure would only close during periods of unusually high tides which threaten flooding of the town. When not in use the barrier gates would be, depending on design, raised out of the water or flat on the riverbed. The barrier would be similar in operation to the Thames Barrier in London, although the mechanics of the system would differ reflecting the different conditions in the Parrett Estuary compared with the Thames.

The system would use embankment works downstream of the barrier location to maintain the standard of defence at the appropriate level and to remove the risk of flooding around the structure.

With the barrier in place the defences in Bridgwater generally become redundant. However during the time when the barrier is closed, flow down the River Parrett will have to be stored in the river. Analysis has shown that a small flood defence would still be needed, but significantly lower than it is today. Further details of this option are included in section 5.

Option E –Raising Ground Levels in Association with New Development

Where new development is proposed (and any existing development can be demolished) it may be possible to raise ground levels above the present and future tidal flood levels. Where the opportunity exists, raising ground levels is often attractive. It reduces flood risk to the new properties built on the higher land and may also help in relation to surface water sewer flooding problems.

However the approach can only be adopted in areas where new development is proposed. Whilst options C and D provide benefit to both existing and new development, this option will generally only provide benefit to the new development. If this approach was adopted in isolation then, in the long term, there is a danger that new development ‘safe islands’ are created within the wider community which is liable to flood. Such an approach does not provide a viable sustainable solution to flood risk in Bridgwater. PPS25 requires that safe access and escape routes are provided to development, and this would also not be delivered by this approach.

PPS25 states that parties should work in constructive partnership to address flood risk and that early consideration of flood risk should identify opportunities for development of infrastructure that offers wider sustainability benefits.

Raised new development may have detrimental impacts in terms of accessibility and the urban design of the town, introducing different heights, steps etc. The option would generate social

inclusion barriers through gradient differences in new developments which would hinder accessibility by all.

Ground raising in association with new development is seen as worthwhile. However generally it is more appropriate if new development contributes to the overall flood risk management approach in the town rather than piecemeal protection of isolated sites.

Option F: Flood Warning and Flood Awareness

Flood warning and flood awareness should be an integral part of any flood management plan. It is particularly appropriate where flooding is relatively infrequent and good warning can be given. However, in this case, flood warning will not address the increasing risks associated with sea level rise. Flood warning should complement other options but should not be considered a stand alone option. For the purposes of this report the option is not discussed further.

7.2 Economic Appraisal

Economic performance is an essential analysis when considering options to protect Bridgwater from future flooding. When selecting options the aim is to identify those approaches which maximise the benefit relative to the resources used. As is normal practice, we have considered the public flood risk benefits to all existing development. In reality there will be considerable benefit to areas for future development as discussed in section 5. However these benefits are considered to generally accrue to private developers rather than the public as a whole and are excluded from this assessment. Finance of the preferred option is discussed in section 9, which considers both public and private sources of funding.

The approach adopted in considering existing development only is consistent with Treasury rules. However if the 'do nothing' approach were adopted there would also be the cost of stifling all new investment, resulting in no development, the possible withdrawal of business and home owners as a result of increased threat. Financial risk would be increased, contributing to the further deterioration in land values, and failure to tackle local deprivation. Economic costs would be much greater and the town would enter a cycle of steep decline.

Four Options have been considered for appraisal:

- Option A: Do Nothing
- Option B: Do minimum
- Option C: Re-engineer existing defences
- Option D: New Tidal Barrier

Further details of the analysis are included in the Appendix B, which discusses the underlying assumptions, and the assessment methodology. However, in summary:

- When considering options C and D, the most cost effective arrangements have been chosen within each option (i.e. minimising costs of walls or the barrier)
- In options C and D works have been phased so that work is only undertaken when required. The existing defences through Bridgwater are in good condition and work should not be undertaken unnecessarily. Available evidence from both sea level rise estimates and the expected deterioration of defences suggest that major works in Bridgwater should be built in the window 2030 to 2050, with planning commenced well in advance.
- The assessment takes into account sea level rise
- In order to test the economic efficiency of different options, it is necessary to discount, in accordance with Treasury Guidelines, all of the costs and benefits of the option from the time when they arise in the future, to their present value. This can be seen as summing the

benefits (or costs) over a period of 100 years but allowing for the different time when the benefit occurs

- In accordance with good practice and Treasury guidance, an allowance of 60% has been added to all costs (not benefits) to allow for 'optimism bias' (the observed tendency to underestimate costs when considering complex construction projects)
- Benefits are derived from the reduction in flood damages avoided. Where this damage exceeds the value of the property the flood damage is limited to the market value of the property (described as being 'capped').
- At the time of writing, property asset values and material costs are changing rapidly. The assessment is representative of asset values and material costs in December 2008.

Based on the above assumptions the following results have been derived:

Table 7.2: Economic Summary (Base Date: Dec 2008)

Option	Present Value Flood Damage £million	Present Value Flood Benefits £million	Present Value Costs £million	Whole Life Costs[Note 1] £million
A. Do Nothing	1699	-	-	-
B. Do Minimum	915	784	0.63	2.1
C. Re-Engineer Existing Defences	Negligible	1699	24	94
D. New Tidal Barrier	Negligible	1699	18	54

Note 1: The whole life costs are also shown in this column. This is cash cost without discounting. Capital and maintenance costs are included.

From the above table it can be concluded:

- If the defences are not maintained, £1.7 billion damage would be caused, representing the ultimate loss of approximately 8400 homes and 800 non-residential properties. The scale of this loss would bring into question the viability of the town.
- Even if the current defences are maintained, increasing sea levels and the deterioration of the defences will cause almost £1 billion of damage. Maintenance delays flood risk (so reducing the present value of damages) but does not deal with the underlying damages.
- Both options C & D could provide a solution to flood risk.
- If options C or D were progressed, as part of a wider town regeneration strategy, confidence would increase, land values would rise and business interest and investment would be in a positive cycle.
- Providing the tidal barrier is constructed when required (in the construction window between 2030 and 2050) this option is less expensive (present value cost of £18m, 25% less than the re-engineer banks). Because of the 'up front' costs of building the barrier in the near future and the associated maintenance cost, building the barrier early is not cost effective.
- The benefit/cost ratio of the barrier is over 90 clearly showing the value of protecting the town. The investment is also attractive when compared with the 'Do Minimum' option.

In conclusion a tidal barrier is the preferred option based on the economic appraisal. However not all criteria can be valued within an economic appraisal. Therefore it is important that all implications are considered.

7.3 Selection of preferred Option

Table 7.3 summarises the assessment of the four main options. The assessment is detailed in appendix B. Based on the assessment in Table 7.3, option D a tidal barrier constructed at the

appropriate time (2030-2050) in connection with appropriately maintained and raised flood defences downstream is the preferred option. Further details of the preferred option are discussed in section 8.

Table 7.3: Selection Matrix

The selection of the preferred option is based on a combination of technical, environmental and economic criteria. Each criteria has been assessed in summary below. The assessment (✓or ×) is generally assessed in comparison with the present situation. The analysis is detailed below:

Criteria	Option A. Do Nothing	Option B. Do Minimum	Option C. Re-Engineer Existing Defences	Option D. Barrier and Embankment System
Flood Risk Management & impact on built environment	Flood protection will deteriorate with the failing defences and higher sea levels	Existing defences are maintained but eventually fall into disrepair and are overtopped by increasing sea levels	The standard of the flood protection will be maintained in line with sea level rise, by raising defences. Increased long term security provided	The standard of flood protection will be maintained by a tidal barrier and raised embankment system. Increased long term security provided
	×××	××	✓✓	✓✓
Human Impacts & Public Safety	Increasing threat to public safety Increasing vulnerability and uncertainty	Increasing threat to public safety Increasing vulnerability and uncertainty	Safety of system maintained and enhanced. However increasing visual impact of high walls	Safety of system maintained and enhanced. Opportunity to reduce visual impact of flood defences through the town
	×××	×××	✓	✓✓
Biodiversity	Progressive loss of freshwater and terrestrial habitats	Progressive loss of freshwater and terrestrial habitats	Freshwater and terrestrial habitats maintained by new defences. However the increasing size of defences and potential impact of ground water flooding will be detrimental	Freshwater and terrestrial habitats maintained by new defences. Some minor negative impact due to construction works, but new opportunities to enhance biodiversity upstream of barrier
	××	××	×	✓
Sustainable Defence	Not sustainable	Owing to changing climates and subsequent rise in sea levels, this option is not sustainable.	Defences become increasingly difficult to raise in response to increasing sea levels. Access is frequently limited and surface water drainage will become an issue	New barrier eliminates need to raise defences upstream. However long term liability for operation and maintenance
	×××	××	×	✓
Maintenance & Operation	Although not maintained themselves, the banks may be used as access to other areas. As their condition deteriorates steadily, they will become more dangerous to use.	Increasing probability of overtopping and breach will impact on maintenance frequency.	The progressive bank elevation raising will ensure that a minimum standard of defence is always provided, allowing maintenance operatives to work safely when they are required.	Maintenance and operation on the barrier would be planned appropriately.
	×××	××	✓✓	✓✓
Other Considerations (landscape/townscape, historic environment)	Major detrimental impacts on landscape and historic environment	Major long term detrimental impacts on landscape and historic environment	Townscape generally maintained, but higher walls will be detrimental	Townscape maintained, with potential for further enhancement
	×××	×××	××	✓✓
Economic	Minimum cost option but with unacceptable flood damage	Due to increasing sea level rise and deteriorating defences, damages will become unacceptable	Flood defence maintained but costs become prohibitive in the future due to difficulty in raising defences through the town	Flood defence maintained, at minimum cost
	×××	×××	✓✓	✓✓✓

×××	Major adverse
××	Moderate adverse
×	Minor adverse
✓	Minor beneficial
✓✓	Moderate beneficial
✓✓✓	Major beneficial

8. DETAILS OF THE PREFERRED TIDAL BARRIER OPTION

A tidal barrier would be constructed downstream (i.e. north) of Bridgwater to stop high tides from the Bristol Channel propagating upstream into Bridgwater. This would be constructed with new defences downstream of the barrier to protect areas of Bridgwater downstream of the barrier location. The key elements are shown in Figures 4.

The exact location and detailed design of the barrier does not have to be determined now. However safeguarding the possible future position(s) of the barrier should be included in the LDF to ensure that appropriate access can be maintained. These issues are important and are discussed in 8.1 and 8.2 below.

The barrier would only be operated when required to resist high tides. Analysis has shown that the barrier will be required from between 2030-2050 when the present defences are predicted to be vulnerable to increasing sea level rise and are likely to reach the end of their lives. The barrier should be planned from 2020 onwards using best sea level rise information. Further details on the recommended phasing is summarised in 8.4.

8.1 Barrier Location

A number of potential locations for the barrier have been identified as shown in Figure 4. These sites are all downstream of the main urban area, where a barrier can be constructed and the area benefiting from the barrier is maximised. For the purposes of this analysis the assumption has been made that the barrier would be constructed in the river (requiring considerable temporary construction works to allow construction). It may be possible to build the barrier on land and then redirect the main river channel. There are costs and benefits with each approach, but it is expected that building the barrier in the river is likely to be the most expensive option, and there may be savings associated with building it on land.

An assessment of the relative environmental merits of each location has been undertaken and the results are reported in Appendix C. However there does not appear to be any overriding environmental driver in considering the location of the barrier.

Therefore the dominant criterion becomes the relative cost of constructing the barrier at the different sites. The cost of the barrier is lower closer to the town where the River Parrett is narrow. However there is a saving in building the barrier further downstream as this reduces the length and therefore cost of raising embankments in the lower estuary (i.e. more land is protected by the barrier).

The table below is based on the present value (i.e. discounted costs). The undiscounted (real cash cost) of the barrier varies from £24.5 million at location 5 to £68 million at location 1.

Table 8.1: Economic Selection of Barrier Location

Location	Cost of Barrier Present value £m	Present value of embankment saving (relative to option 5) £m	Net Present Cost £m
5	7	0	7
4	8	1	7
3	14	3	11
2	19	4	15
1	19	5	14

Based on this analysis, there is little to choose between locations 4 and 5, but the costs increase significantly downstream as the River Parrett becomes wider. It is recommended that the barrier is

located in the reach between possible sites 4 and 5, the exact location would have to consider the issues of ease of access, costs etc. This potential area should be safeguarded within the Local Development Framework as shown in Figure 4. If the barrier were to be built remote from the river, the river would have to be diverted through it. There are significant issues associated with the diversion of the river including the Saltlands Waste Disposal Site (a historic landfill through which the channel would probably have to be routed), the Chilton Trinity Sewage Treatment Works and the Waste Disposal Centre. This report does not aim to prejudge whether a diversion would be economic, but the option should be retained.

8.2 Other Barrier Options

There is an option to combine the barrier with a potential new crossing of the River Parrett in connection with the new road access to a new Nuclear Power Station at Hinkley Point if this is approved. However it is likely that the new access would be built in the near future (perhaps approximately 2015) and the analysis indicates that the new barrier would not be required until about 2030, approximately 15 years later.

However the early delivery of the barrier would be perceived by the public as positive for the town and a community benefit. Early delivery of the barrier would also increase confidence in the town and would put the town on a stable footing for future economic growth.

Nevertheless the construction savings associated with combining the structures are likely to be modest, because the type of construction required for a bridge is very different to that required for a barrier, with the extensive foundation and structural works required to build a barrier. As table 8.1 shows, the costs of building the barrier at the potential crossing point of the new road is much higher than closer to the town. There are also risks in building the barrier early because the construction work would be undertaken in advance of better knowledge of sea level rise in the future. The approach by the developer is not yet known and is therefore relatively uncertain. On balance this option is not recommended.

8.3 Structure Design

The detailed design of the structure does not need to be determined at this stage, and should be subject to a detailed study. In the future there may be other design requirements, new construction materials or new environmental drivers which may influence the choice of the design. The approach in this study is to adopt an established design and to consider the key construction requirements, methods and materials required in detail. In some ways the architectural appearance and ultimate design of the tidal gates is a secondary issue when considering the cost of the structure and how it will be built. Ultimately, of course, an attractive design providing a flexible, safe and reliable structure is essential to support the regeneration of Bridgwater.

Most of the difficulty and cost of construction relates to heavy foundation and structural work required, given the poor ground conditions within the River Parrett area and the very high tidal range.

The critical elements of the design are summarised in Figures 5 and 6. The design and operation of the gates is indicative but is well established.

8.4 Indicative Programme

The programme for the construction of the barrier is driven by the need for the structure in the future to resist increasing sea levels and the gradual deterioration of defences through the town. Both the rate of sea level rise and the deterioration of defences are difficult to predict with accuracy. However the current defences are in generally good condition and it is unlikely that the barrier will be required before 2030.

However, work is required to maintain the current flood walls and banks through the town until the barrier is built. Therefore the programme and later the financing discussed in section 9 consider the complete flood management system and not just the barrier (although this is the single largest element of work).

Based on this assumption the following timeline is envisaged. Further details are provided in Appendix D

Table 8.2: Programme

Period	Work
2009-2011	Maintain and monitor current flood defences through Bridgwater. Undertake maintenance and small scale bank or wall work as required. Council to approve and implement interim Supplementary Planning Document on Bridgwater strategic flood defence tariff. Evaluate the impact of national infrastructure projects and seek contributions from planning mitigation or community benefit, as appropriate. Develop approach to comprehensive infrastructure planning and agree priorities.
2011-2020	Continue maintenance of current defences through Bridgwater. Monitor defence condition. Local Development Framework Core Strategy in place integrating flood infrastructure requirement within wider SDC infrastructure plan.
2020-2030	Continue maintenance of current defences through Bridgwater. Monitor defence condition. Seek to use Supplementary Planning Guidance contributions to fund feasibility and development programme, subject to Government confirmation of funding rules. Assess detailed current sea level rise estimates and review expected design life of existing assets. Commence detailed design if considered appropriate.
2030-2050 (timing dependent on future sea level rise and deterioration of defences)	Complete detailed design of barrier. Construct new barrier. Construct new embankments downstream of the barrier to protect Bridgwater.
Beyond 2030-2050	Operate and maintain barrier.

Period	Work
	Maintain and raise defences downstream of Bridgwater as necessary

The timeline above considers works necessary to protect the centre of Bridgwater. Works to protect areas further downstream of Bridgwater (e.g. Cannington) are outside of the scope of this study but are considered within the Parrett Estuary Flood Risk Management Strategy Report (Draft 2009) included in Annex A (CD Only).

9. FINANCE

The report has shown that a new tidal barrier is the preferred option taking into account the national economic benefits that accrue to existing development. However the construction of the barrier provides benefits to both existing development and new regeneration areas as identified in the emerging Local Development Framework. This section is concerned with how the barrier should be financed, and the following principles should be considered:

- Generally flood management works are not undertaken by the Government to allow intensification of land. The primary reason for this exclusion is to preclude Government funding of works which would enable land to be developed for private gain.

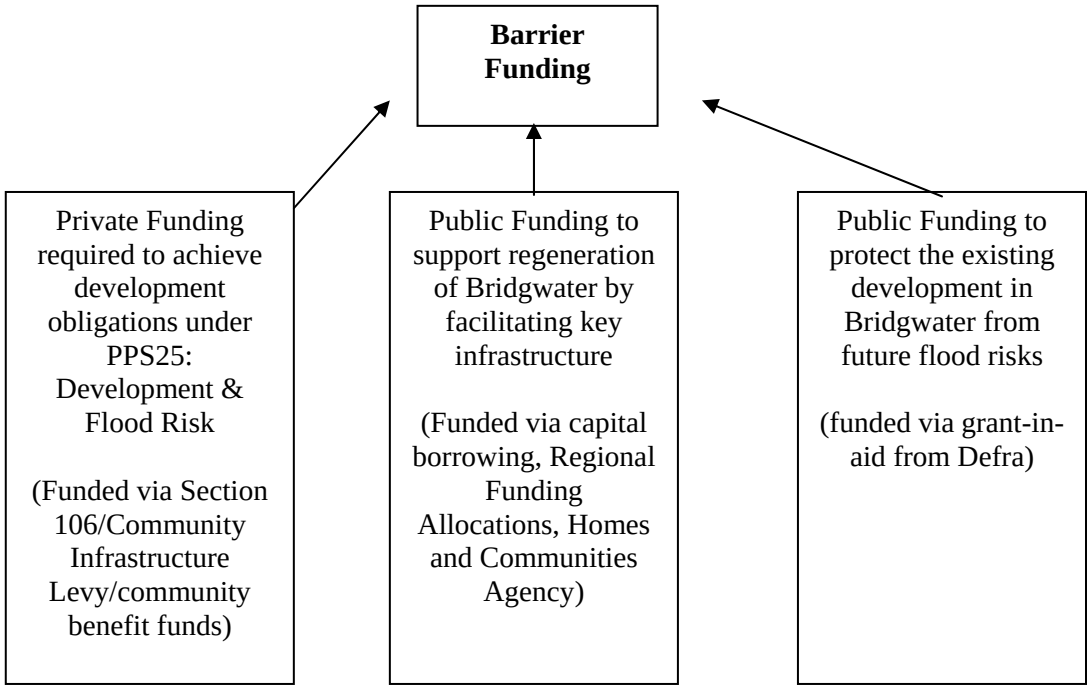
- Where works are proposed for economic regeneration or similar purposes there are a variety of sources available. Flood management works should be seen in the same way as other infrastructure requirements (e.g. highways, public transport etc)

- The flood management system including the barrier is essential for the development of key areas identified in the emerging LDF. PPS25: Development and Flood Risk states that '*The future users of the development must not be placed in danger from flood hazards and should remain safe throughout the lifetime of the plan or proposed development and land use.*' In many areas within Bridgwater only a strategic solution to flood risk provides this requirement, and the barrier is the most cost effective way of providing the strategic solution.

Flood management in Bridgwater will be achieved with the barrier working in combination with the system of embankments downstream to provide the level of protection required. However the banks downstream predominately provide protection to existing development rather than to new development areas. Where justified, flood protection downstream of Bridgwater to the mouth of the River Parrett will generally have to be met by public investment.

Essentially the cost of the barrier can be met either through private or public investment. Within this context the funding options are summarised below, and discussed in 9.1:

Table 9.1: Funding Sources



9.1 New Development Obligations and Outline contribution Model

PPS25 is risk based and aims to promote development in low flood risk sites or, where this is not possible, to ensure that development takes into account the level of risk and ensure that new development is safe. For the main areas of Bridgwater only a strategic solution to flood risk from high tide levels provides the level of safety required. Whilst local options (such as individual site raising) is generally worthwhile, this approach will not ensure that appropriate safe access is provided and would make emergency access very difficult or impossible. Taken to the logical extreme a piecemeal approach would result in 'islands' of new safe development between areas at high risk of flooding (including key infrastructure).

Development in Bridgwater can only take place if a strategic solution to flood risk is delivered. In accordance with the requirements of PPS25, development would not be approved without a strategic solution as a piecemeal approach is not appropriate. For this reason contributions from the new development areas to the strategic barrier solution appears the appropriate way forward.

The value of contribution should be based on the benefit derived from the barrier solution. The Sedgemoor District Council Strategic Flood Risk Assessment defines the flood risk zones in Bridgwater. The flood zones from the SFRA and the proposed development areas are shown in Figure 7. The majority of Bridgwater is shown in Flood Zone 3a High Probability. In accordance with PPS25 these zones are established ignoring the presence of defences. Flood Zone 3a comprises land assessed as having a 1 in 200 or greater annual probability of flooding from the sea in any year, based on current sea levels. The current flood defences in Bridgwater reduce the actual risk significantly today as previously described.

It is recommended that contributions are primarily based on the areas which are currently in flood zone 3a and which benefit from the current defences in Bridgwater, although other areas that benefit indirectly from flood defences might also contribute. Whilst more complex methods of apportioning contributions could be derived, there is little merit in this approach as it would not change the areas which will need to contribute based on the proposed development areas.

Appendix D summarises a range of different contribution models that could be adopted. The appendix summarises the costs associated with different elements of the flood management system and considers which party could fund the elements identified.

No single option has been identified as the analysis depends on the cost of other infrastructure requirements, which may influence how costs are met.

9.2 National and Regional Regeneration Funding Opportunities

Whilst new development has to finance the new barrier if the objectives of PPS25 are to be met, the overall investment required may be prohibitive if only new development funds the whole cost of the works. Government funding through various regeneration mechanisms may be appropriate to help support the regeneration of the town, particularly given the relatively deprived status of much of the urban area.

Funding sources may include capital borrowing, Regional Funding Allocations, Homes and Communities Agency.

The total infrastructure requirements to accommodate the level of planned growth and to meet local needs will be scoped, costed and prioritised. This will be set out in the infrastructure plan which will show methods of funding, and identify any gaps and recommend a way forward.

9.3 Environment Agency

The Environment Agency distributes Flood Defence Grant in Aid (FDGiA) funding on behalf of Defra. Funding is targeted at those projects that provide the greatest reduction in flood risk for the least public expenditure. There is greatest emphasis on reducing the numbers of households currently at Significant or Very Significant flood risk. Significant flood risk means an annual probability of between 1.3% and 5%. Very Significant means an annual probability of greater that 5%.

Properties in Bridgwater are currently at a 0.5% probability of flooding which is between Moderate and Low flood risk. Therefore, reducing the risk further for Bridgwater is not currently a national priority. The risk to Bridgwater will increase in time due to sea level rise and the deterioration of the condition in the existing defences. It is apparent that it is likely to be approximately 20 years or more before Bridgwater would become a top priority for FDGiA funding under current arrangements for prioritisation of funding allocations.

The provision of significant funding from third party sources can alter the priority of FDGiA funding allocation. The Agency will consider whether best value for the public purse can be achieved by allocating a smaller FDGiA sum at earlier date than is actually required to manage the flood risk. In any event the funding allocation would be considered alongside other national priorities at the time.

There is no guarantee that defences will be improved in the future, therefore individual flood risk assessments for developments within the tidal floodplain, including an allowance for sea level rise, could not show flood risk was acceptable for the lifetime of the development.

9.4 Capital and Operational Costs

The costs are summarised below (December 2008 prices). At the time of writing costs are fluctuating significantly due to the rapidly changing material and labour market.

Capital Cost:

The capital cost of the barrier has been established by preparing a design of the structure based upon a good understanding of the ground conditions and the environment in which the barrier is to be built. Established construction rates are based on previous similar projects but updated to reflect changing material and labour costs. A summary of the costs are shown below:

Table 9.2 Capital Cost

Item	Comments	Cost £
Cofferdam/Temporary Works	Sheet pile cofferdam	£3,960,000
Excavation		£499,000
Fill		£156,000
Piling		£336,000
Concrete	Rate £150/m3	£2,828,000
Tide Gates		£525,000
Machinery	Rams, powerpack, pipe work etc	£466,000
Landscaping		£171,000
Other Construction		£339,000
Contractors On Costs		£2,810,000
Engineering Design		£1,485,000
Legal/Planning	incls. potential legal issues in connection with navigation	£1,713,000
Sub Total		**£15,288,000**
Optimism Bias	60%	£9,173,000
TOTAL		**£24,461,000**

The main capital costs for the barrier are derived from the costs of constructing the barrier within a cofferdam (a temporary wall to exclude soil and water from the excavation). There are also considerable costs associated with the provision and placing of concrete. In comparison the MEICA costs (Mechanical, Electrical, Instrumentation, Controls and Automation) are relatively low, reflecting the relative ease of constructing mechanical and electrical equipment off site and bringing them to site when required.

Contractors on-costs reflect the cost of setting up, managing and dismantling the site compound. Other costs such as overall construction management and health, safety and security costs are included in this item.

In advance of construction the design, planning and legal aspects of the barrier construction must be addressed. Considerable costs are associated with the legal aspects associated with the navigation.

There is a widely recognised tendency for appraisers on all kinds of projects to be overly optimistic in their early estimate of project costs, time scales and benefits, when compared with the final outturn costs. This is termed ‘optimism bias’. This bias is not confined to construction activities but relates to all large projects. Risks tend to be higher for ‘non-standard’ civil engineering projects when compared with (for example) standard building projects. At this stage in the process Defra Flood and Coastal Defence Project Appraisal Guidance recommends that a 60% allowance is added to the sub-total to allow for this bias.

The key risk items which contribute to the 60% allowance are summarised below. This is the ‘standard’ set of risks found from the review of previous projects.

Table 9.3 Optimism Bias Risk Contribution

Risk Area	Key Risks	Contribution to 60%
Client Specific	Changing project scope Funding delays Limited project intelligence	20
Project Specific	Complex design Innovation Environmental Impact/Planning	18
External Influences	Construction cost inflation (All costs in this report are to current prices, this risk area relates to underestimates of inflation during the design and construction period) Changing legislation Technological change Climate Change [Note 1]	9
Procurement	Late contractor involvement Disputes	8
Environment	Public Relations Contamination Working in rivers/flood risk Environmental sensitivity	5
Total		**60%**

Note 1: Climate change will have a significant impact on when the barrier is built and to what standard. Historically this issue has not been assessed within the analysis of previous projects.

Operation and Maintenance Costs

Operational and maintenance costs are difficult to quantify at this stage and will increase in the future as the gate is used more frequently.

Table 9.4 Operation and Maintenance Costs

Cost Element	Cost
Head Office & Operational Staff Costs	£120,000
Regular general site repairs/maintenance	£30,000
Maintenance of MEICA	£20,000
Replacement of Gates/MEICA (annual contribution)	£30,000
Total	£200,000

9.5 Outline Cash Flow Forecast

Based on the programme discussed in section 8.4, the following cash flow is assumed in relation to the construction of the barrier. All costs are based on current prices (not allowing for inflation). The costs and phasing are approximate and should only be used in consideration of the potential phasing of contributions. Changing sea level rise estimates, regulatory requirements, environmental constraints, other strategic infrastructure (e.g. the Severn Barrage) may have implications on the phasing and value.

Table 9.5: Cash Flow Forecast

Period	Work	Cost £
2009-2020	Review the implications of emerging strategic infrastructure including Hinkley Point Nuclear Power Station access and the Severn Estuary Tidal Power options	£100,000
2020-2030	Undertake detailed feasibility study into tidal barrier (including statutory Environmental Impact Assessment and other relevant studies from future regulations). Assess detailed current sea level rise estimates and review expected design life of existing assets. Undertake detailed planning and consultation. Commence detailed design if considered appropriate.	£1,400,000 £1,000,000 £500,000
2030-2050	Complete detailed design of barrier. Construct new barrier.	£500,000 £24,500,000
Beyond 2030-2050	Operate and maintain barrier.	Nominally £200,000 per annum

10. DELIVERY AND RISKS

10.1 Delivering the Project

Responsibility of the delivery of the flood management system for Bridgwater should lie with the organisation most able to deliver the individual tasks which are required. However this does not relate to how the works should be funded. A summary of the tasks involved in delivering the flood management system is shown below, with a recommendation of the organisation that should manage the specific element.

Table 10.1: Delivery

Key Task	Recommended Authority
Continued maintenance of existing defences	Environment Agency (EA)
Safeguarding within the planning system the location for the Barrier location	Sedgemoor District Council (SDC)
Resolution of navigation issues	SDC
Funding model and receipts	SDC
Liaison with emerging regional projects (Hinkley Point nuclear power station/Severn Tidal Power)	SDC (and EA)
Review climate change implications	EA
Identify design and construction team	EA
Environmental Impact Assessment (Screening and Scoping)	SDC (and EA)
Parrett Tidal Barrier feasibility study	EA
Parrett Tidal Barrier detailed design	EA
Construction of Barrier	EA
Operation and maintenance of the Barrier	EA

10.2 Risks

There are a range of risks which should be considered in the future to ensure the effective delivery of the flood management infrastructure as identified in this report. The key risks are summarised below.

Table 10.2: Principal Risks

Risk	Primary Risk to	Scale of Risk	Discussion and Proposed Mitigation
Identification of incorrect solution	Delivery, Programme & Cost	Low	Changing economic or environmental guidance could change the approach but the assessment is robust to foreseeable changes
Risks to funding	Delivery, Programme & Cost	High	Interim SPD proposed to establish funds. Environment Agency and Sedgemoor District Council to establish fund management responsibility
Unknown Environmental issue	Delivery, Programme & Cost	Medium	The area is environmentally sensitive and risks may occur in the future, either due to an unknown environmental issue or changes in environmental regulations
Difficult ground conditions and	Cost	Medium	Construction of a tidal barrier in the River Parrett is technically

Risk	Primary Risk to	Scale of Risk	Discussion and Proposed Mitigation
flood risks during construction			challenging, and a conservative approach has been taken. However there remains the risk that the temporary and permanent works required are more extensive than originally envisaged
Rate of change of sea levels in response to climate change	Delivery, Programme & Cost	High	The rate of sea level rise will have a significant impact on when the barrier is required. Higher estimates of sea level rise would also increase costs. The overall approach to the provision of flood managememt infrastructure in Bridgwater should regularly be reviewed to ensure that the risks are understood
Regeneration in Bridgwater delayed due to wider economic issues	Delivery, Programme & Cost	Medium	Sedgemoor District Council to reduce risks by effective planning.

11. CONCLUSIONS AND RECOMMENDATIONS

11.1 Conclusions

The sustainable regeneration of Bridgwater can only be achieved if flood risk is managed in the town, and appropriate flood management infrastructure provided. This is supported by national, regional and local planning guidance.

The current flood defences in Bridgwater protect 8,400 households and 800 businesses. The flood defences downstream of Bridgwater to the mouth of the River Parrett protect a further 2,500 households and 140 businesses.

Climate change is the predominant driver of flood risk in the future as identified in the Strategic Flood Risk Assessment. With about a 1m increase in sea levels by 2108, severe tidal flooding of the Bridgwater town centre would occur, to a depth of 2m over large areas under extreme events.

Regionally important development (in particular the Severn Estuary Tidal Power opportunities) may have an impact on flood risk in Bridgwater.

There are a wide range of technical and environmental constraints and opportunities that must be considered when determining the long term flood management infrastructure required to protect the town.

Piecemeal protection of individual new regeneration sites is not a preferred approach to managing future flood risk. This approach would not be sustainable and ultimately safe access to many regeneration sites in the town could not be achieved during tidal flood events.

Continuing the previous approach to flood risk in the town by raising flood defences in the town is not the preferred option. Very high walls would be difficult and expensive to build, and would cause land drainage problems. The landscape implications of such an approach would be dramatic, essentially dividing the centre of the town up with 2m high walls. There would also be heritage issues with the loss of existing bridges which would have to rebuilt.

The preferred approach to flood risk in the town is to construct a new tidal barrier which would be raised when required to exclude high and dangerous tides. The approach is analogous to the approach taken in London with the use of the Thames Barrier. The new barrier would cost about £24.5 million, if constructed near the Bridgwater urban area. As the width of the estuary increases downstream of Bridgwater, costs would increase significantly if a barrier were located further downstream.

The current projections of sea level rise have been used by Defra for flood risk management purposes and these have been incorporated into Planning Policy Statement 25 (PPS25) which sets out Government policy on development and flood risk. Its aims are to ensure that flood risk is taken into account at all stages in the planning process. The sea level rise, combined with the expected deterioration of existing defences, mean that a barrier would be required between 2030 and 2050, the date being dependent on the actual rate of both measures over the next few years. Studies and planning would be required in advance, particularly to address issues such as the existing navigation.

Whilst the barrier is seen as the central approach to flood risk management for Bridgwater in the long term, the current defences must be managed and maintained and future embankments will be required downstream of the barrier location. It is important that the barrier is seen as an important element of an overall flood management system.

11.2 Recommendations

1. Sedgemoor District Council and the Environment Agency should support the construction of a tidal barrier to address future flood risk.
2. The proposed flood management infrastructure required should be regularly reviewed as improved understanding of climate change and sea level rise becomes available. However the solution identified is robust against reasonable changes in estimates, but the timing of the works will be sensitive to the rate of sea level rise.
3. The area identified in Figure 4 should be safeguarded within the Local Development Framework for the future construction of the barrier.
4. It is essential that the Environment Agency and Sedgemoor District Council work together in the evaluation of development proposals which affect the estuary and potentially increase flood risk, and to seek off site contributions and on site mitigation where appropriate to reduce flood risk in Bridgwater.
5. Liaison with Wessex Water should be maintained to ensure that future changes to Chilton Trinity Sewage Works do not unnecessarily constrain options for the barrier in the future.
6. The aspirations and funds available for navigation improvements on the River Parrett may change in the future. Any plans to modify or enhance navigation should be considered in light of the requirements for a barrier in the future. It is likely that the barrier will obstruct navigation to all but the smallest boats. The legal implications and associated costs and time involved in respect of changes to the navigation should be considered in more detail at an early stage.
7. The Severn Estuary Tidal Power project is considering a number of options which may potentially impact on flood risks in Bridgwater. The results from the current DECC study is due to report in 2010, and it is essential that Sedgemoor District Council and the Environment Agency review the potential implications of this study and respond to the consultation.

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FIGURES