

## Strategy Appraisal Report

Authority scheme  
reference

IMSW001215

Defra/WAG LDW  
number

Promoting  
authority

Environment Agency, South West Region

Strategy  
name

Severn Estuary Flood Risk Management Strategy



Wentlooge Levels, South East Wales



Awre Peninsula, Gloucestershire



Severn Beach, South Gloucestershire



South of Clevedon, North Somerset

Date

April 2014

Version

2<sup>nd</sup> Submission to LPRG



## StAR for Severn Estuary Flood Risk Management Strategy

Version	Status	Signed off by:	Date signed	Date issued
StAR development stage – draft status				
1	Working draft Exec. Summary submission to project team	PJC	09/08/13	09/08/13
2	Full draft submission to project team	PJC	29/08/13	29/08/13
StAR development stage – final status				
3	Final submission to project team	PJC	05/09/13	05/09/13
4	Final submission for assurance review	PJC	10/09/13	10/09/13
5	Submission for sign-off	PJC	09/10/13	09/10/13
6	<b>Submission to LPRG</b>	<b>PJC</b>	<b>18/10/13</b>	<b>18/10/13</b>
7	<b>2<sup>nd</sup> submission to LPRG</b>	<b>GQ</b>	<b>30/4/14</b>	<b>30/4/14</b>

Template version – April 2011

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## Glossary and Acronyms

**Asset maintenance protocol:** EA document describing our approach to maintaining flood and coastal risk management assets in England. It describes how we decide which assets we maintain and how we work with those affected by our decisions.

**Benefit Cost Ratio (BCR):** BCRs are used to identify the relative worth of one approach over another. It is the ratio of the PV benefits to the PV costs for each option.

**Breach:** Failure of existing linear flood defences allowing flood water inundation of the land behind.

**Do Minimum:** An option where the Operating Authority takes the minimum amount of action necessary to provide a flood management service. For many places, this means patch and repair works of existing defences with no replacement should the defences fail.

**Do Nothing:** An option used in appraisal to act as a baseline against which all other options are tested. It assumes that no action whatsoever is taken. In the case of existing works, it assumes for the purposes of appraisal that Risk Management Authorities cease all maintenance, repairs and other activities immediately. In the case of new works, it assumes that there is no intervention, and natural and other external processes are allowed to take their course.

**Flood and Coastal Erosion Risk Management Appraisal Guidance (FCERM-AG):** Defra guidance to Risk Management Authorities on the process for appraising flood and coastal defence projects to ensure best use of public money.

**Flood Risk Management Asset:** Any structure that contributes to flood management, e.g. groynes, sea walls, drainage outfalls, flood banks.

**Flood Risk:** Flood risk is a combination of two components: the chance (or probability) that a location will flood, and the impact (or consequence) that the flooding would cause if it occurred.

**Flood & Coastal Risk Management Grant in Aid (FCRM GiA):** Government money allocated to Risk Management Authorities (Environment Agency, Local Authorities, Internal Drainage Boards) for capital works which manage and reduce flood and coastal erosion risk.

**Fluvial:** Relating to the flow in the river that originates from the upstream catchment and not the sea.

**Habitats Regulations Assessment (HRA):** Formal assessment process that all European Union Member States are required to adhere to, where a project or plan may affect a site that has been protected under the Habitats Directive or the Birds Directive. Sites protected ('designated') under the Habitats Directive are called Special Areas of Conservation (SACs) and those designated under the Birds Directive are called Special Protection Areas (SPAs). HRA also applies to sites protected under the Ramsar Convention, although this is not always specified in law. These sites are designated because of their high value in terms of nature conservation, meaning that they contain rare and highly valued habitats or species, and often both.

**Incremental Benefit Cost Ratio (IBCR):** The ratio of the additional benefit to the additional cost, when two options are compared.

**Joint Probability:** The probability of two separate events occurring at the same time. In flood risk management, the two separate events may be heavy rainfall and a tidal surge.

**Lead Local Flood Authority:** After flooding in 2007 the government commissioned a review, which recommended that "Local authorities should lead on the management of local flood risk, with the support of the relevant organisations" (The Pitt Review, 2008). This led to the Flood and Water Management Act (2010) and the set up of Lead Local Flood Authorities (LLFA) who have new powers and duties for managing flooding from local sources, namely Ordinary Watercourses, surface water (overland runoff) and groundwater.

**Managed Realignment:** Moving the line of flood defence inland to either a new flood defence or to higher ground. Managed realignment could be achieved through the partial or complete removal of the existing flood defences or by allowing controlled tidal flows through the existing defences.

**Multi-coloured Manual (MCM):** The MCM provides techniques and data that can be used in assessing potential flood damages and hence the benefits of flood and coastal erosion risk management projects.

**Natura 2000 Network (N2K):** European network of protected sites which represent areas of the highest value for natural habitats and species of plants and animals which are rare, endangered or vulnerable in the European Community. The Natura 2000 network includes Special Areas of Conservation (SAC) or Sites of Community Importance (SCI) where they support rare, endangered or vulnerable natural habitats and species of plants or animals (other than birds). Where areas support significant numbers of

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wild birds and their habitats, they may become Special Protection Areas (SPA). SACs and SCIs are designated under the Habitats Directive and SPAs are classified under the Birds Directive.

**Net Present Value (NPV):** Stream of all benefits net of all costs for each year of the projects life discounted back to the present date.

**Present Value (PV):** Monetary value of ongoing or future costs or benefits, discounted to provide equivalent present day costs.

**PV Benefits (PVb):** The PV of quantifiable changes that a project will produce over its lifetime.

**PV Costs (PVc):** The PV of all costs for implementation of a particular scheme over its lifetime.

**PV Damage Avoided:** The PV of flood damages avoided once an option has been implemented.

**Ramsar:** Ramsar is the town in Iran that hosted a meeting in 1971 that adopted the Convention on Wetlands of International Importance, subsequently known as the Ramsar Convention. Ramsar designated wetland sites have the same level of effective protection in UK law as Natura 2000 sites (see Habitats Regulations Assessment in this glossary). At the centre of the Ramsar philosophy is the "wise use" concept. The wise use of wetlands is defined as "the maintenance of their ecological character, achieved through the implementation of ecosystem approaches, within the context of sustainable development".

**Scheduled Monument (SM):** To protect archaeological sites for future generations, the most valuable sites may be "scheduled". Scheduling means nationally important sites and monuments are protected by law by being placed on a list, or 'schedule'. Further information can be found on the English Heritage ([www.english-heritage.org.uk](http://www.english-heritage.org.uk)) website.

**Site of Special Scientific Interest (SSSI):** Sites notified under the Wildlife and Countryside Act 1981 (as amended by the Countryside and Rights of Way (CROW) Act 2000) for their flora, fauna, geological or physiographical features. Notification of a SSSI includes a list of activities that may be harmful to the special interest of the site. Section 28 of the Wildlife and Countryside Act 1981 (provisions relating to SSSIs) has been replaced by a new Section 28 in Schedule 9 of the CROW Act.

**Special Area of Conservation (SAC):** An internationally important site for habitats and/or species, designated as required under the European Community 'Habitats Directive' (92/43/EEC). SACs are protected for their internationally important habitat and non-bird species. SACs also receive SSSI designation under The Countryside and Rights of Way (CROW) Act (2000) and The Wildlife and Countryside Act (1981) (as amended).

**Special Protection Area (SPA):** A site of international importance for birds, designated as required by the EC Birds Directive. The Government has to consider the conservation of SPAs in all its planning decisions. SPAs receive SSSI designation under The Countryside and Rights of Way (CROW) Act 2000 and The Wildlife and Countryside Act 1981 (as amended).

**Standard of Protection (SoP):** The standard a defence provides against overtopping or breach, measured by Annual Event Probability (AEP) or return period. This may be different to the flood risk of properties or infrastructure that are sited some way back from a defence, due to the potential impact of any available flood storage.

**Strategic Environmental Assessment (SEA):** A process set out in European and domestic legislation that must be followed to ensure that significant environmental effects arising from policies, plans and programmes are identified, assessed, mitigated, communicated to decision-makers, monitored and that opportunities for public involvement are provided.

**Strategy Appraisal Report (StAR):** A business case including a programme of works that supports a recommendation to implement a management plan. The plan is approved by the Environment Agency under the Non-Financial Scheme of Delegation from Defra and does not confer any financial authorisation. The plan is supported by technical appendices.

**Sustain:** Active intervention to raise defence levels to keep pace with sea level rise, thereby retaining the pre-existing level of flood risk.

**Water Framework Directive (WFD):** A European Directive to help to protect and enhance the quality of surface freshwater (including lakes, streams and rivers), groundwaters, groundwater dependant ecosystems, estuaries and coastal waters out to one mile from low-water. European Community Directive (2000/60/EC) on integrated river basin management. The WFD sets out environmental objectives for water status based on: ecological and chemical measures; common monitoring and assessment strategies; arrangements for river basin administration and planning; and a programme of measures to meet the objectives.

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## **For technical approval of the business case**

**Environment Agency Region: South West**

**Project name: Severn Estuary Flood Risk Management Strategy**

**Approval Value: £ 490,938,000 (100 year whole life cost)  
£ 122,140,000 (15 year cost)**

**Sponsoring Director: David Jordan     Director of Operations**

### **Non-financial scheme of delegation**

Part 11 of the Non-financial scheme of delegation states that approval of FCERM Strategies/Complex Change Projects, following recommendation for approval from the Large Projects Review Group, is required from the Regional Director or Director, Wales and Director of Operations.

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# Approval history sheet

APPROVAL HISTORY SHEET (AHS)			
<b>1. Submission for review (to be completed by team)</b>			
<b>Project Title:</b> Severn Estuary Flood Risk Management Strategy		<b>Project Code:</b> IMSW001215	
<b>Project Manager:</b> Graham Quarrier		<b>Date of Submission:</b> 18 <sup>th</sup> October 2013	
<b>Lead Authority:</b> Environment Agency		<b>Version No:</b> 1	
<b>Consultant Project Manager:</b> Paul Canning		<b>Consultants:</b> Atkins Ltd	
<i>The following confirm that the documentation is ready for submission to PAB or LPRG. The Project Executive has ensured that relevant parties have been consulted in the production of this submission.</i>			
<b>Position</b>	<b>Name</b>	<b>Signature</b>	<b>Date</b>
Project Executive	J Taberham		
	<b>Job Title:</b>	SW Regional Operations Manager, ncpms	
<b>2. Review by: Large Projects Review Group (LPRG)</b>			
<b>Date of Meeting(s):</b>		<b>Chairman:</b>	
<b>Recommended for approval:</b> In the sum of £:		<b>Date:</b>	<b>Version No:</b>
<b>3. Environment Agency NFSoD approval</b> <i>Officers in accordance with the NFSoD.</i>			
<b>Version No:</b>		<b>Date:</b>	
Project Approval	<b>By:</b> In the sum of: £	<b>Date:</b>	
<b>4. Defra or WAG approval</b> <i>(Delete as appropriate)</i>			
Submitted to Defra / WG or Not Applicable (as appropriate)		<b>Date:</b>	
Version No. (if different):			
Defra/ WG Approval: or Not applicable (as appropriate)		<b>Date:</b>	
Comments:			

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**NON FINANCIAL SCHEME OF DELEGATION (NFSoD) COVERSHEET FOR A FCRM  
COMPLEX CHANGE PROJECT / STRATEGIC PLAN**

1.	<b>Project name</b>	<b>Severn Estuary Flood Risk Management Strategy</b>		<b>Start date</b>	January 2008
	<b>End date</b>			March 2014	
	<b>Business unit</b>	South West	<b>Programme</b>	FCRM GiA	
	<b>Project ref.</b>	IMSW001215	<b>Regional SoD ref.</b>		<b>Head Office SoD ref.</b> -

2.	<b>Role</b>	<b>Name</b>	<b>Post Title</b>
	<b>Project Sponsor</b>	Richard Cresswell	Director, SW Region
	<b>Project Executive</b>	John Taberham	Regional Operations Manager
	<b>Project Manager</b>	Graham Quarrier	ncpms Project Manager

3.	<b>Risk Potential Assessment (RPA) Category</b>	<b>Low</b>	<input type="checkbox"/>	<b>Medium</b>	<input type="checkbox"/>	<b>High</b>	<input checked="" type="checkbox"/>
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4.	<b>NFSoD value</b>	<b>£k</b>
	<b>Whole Life Costs (WLC) of Complex Change Project / Strategic Plan</b>	490,938 over 100 years 122,140 up to 2030

5.	<b>Required level of Environmental Impact Assessment (EIA)</b>	<b>N/A</b>	<b>Low</b>	<b>Medium</b>	<b>High</b>
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>

6.	<b>NFSoD approver name</b>	<b>Post title</b>	<b>Signature</b>	<b>Date</b>
	NRW (to be confirmed)	<b>NRW (to be confirmed)</b>		
	Richard Cresswell	<b>Regional Director</b>		
	David Jordan	<b>Director of Operations</b>		
	<b>NFSoD consultee name</b>	<b>Post title</b>	<b>Signature</b>	<b>Date</b>
	Richard Nunn	LPRG Chair		
	Nick Lyness	AFCRM, Wessex, SW, EA		16-10-13
	Anthony Perry	AFCRM, West Area, Midlands, EA		15-10-13
	Tim England	AFCRM, SE Area, NRW		16-10-13
	Miles Jordan	Head of AOS		16-10-13



# 1 Executive summary

## 1.1 Introduction and background

- 1.1.1 This Strategy Appraisal Report (StAR) presents the business case and implementation plan for the Severn Estuary Flood Risk Management (FRM) Strategy (referred to as ‘the Strategy’).
- 1.1.2 The Strategy covers the coast from Gloucester to Lavernock Point near Penarth in South East Wales, and from Gloucester to Hinkley Point in Somerset. The study area includes the conurbations of Cardiff, Newport, Weston-super-Mare, Burnham-on-Sea, parts of Gloucester, and many towns and villages, supporting a total population within the floodplain of 180,000. The total frontage is 235km in length.
- 1.1.3 The Severn Estuary is of international importance for nature conservation and is designated as a Special Area of Conservation (SAC), Special Protection Area (SPA) and Ramsar site (refer to Key Plan 2). These designations form part of the European Natura 2000 (N2K) network of sites. There are several freshwater SSSIs adjacent to the Severn Estuary. The Strategy may also affect designated sites not immediately adjacent to the Severn Estuary, notably the Somerset Levels and Moors SPA / Ramsar.
- 1.1.4 Existing FRM assets consist of seawalls, revetments, embankments and gated structures. The FRM asset length in the study area totals 208km, with the remaining 27km being natural coastline.
- 1.1.5 The Strategy has been divided into 34 hydraulically discrete flood cells for appraisal purposes. The Strategy identifies for each flood cell an expenditure profile for the recommended management options over the next 15 years, within the context of a 100-year overall plan. The Strategy has drawn from and reviewed the policy making process within the Severn Estuary, and North Devon and Somerset, Shoreline Management Plan 2 (SESMP2 and NDASSMP2, 2010) that cover the Strategy frontage. As climate change and coastal squeeze predictions have changed since completion of the SMP2s, the Strategy has identified areas where SMP2 policy may need to be updated.
- 1.1.6 The Strategy considers the longer term implications of coastal change, climate change and sea level rise, and therefore enables the Environment Agency, local authorities and communities to understand the various technical, environmental and financial constraints when making local choices to best manage flood risk to local communities.
- 1.1.7 Key strategic issues for the Strategy area are the management of a significant quantity of FRM assets around the estuary, whilst balancing the legislative requirements to maintain Natura 2000 (N2K) sites under the EU Habitats and Birds Directives, all in the context of climate change. The SMP2 established that there are no strategic erosion issues.
- 1.1.8 The objectives of the Strategy are:
- Promote sustainable flood risk management solutions to protect local communities, including priority projects in the short term that are resilient to climate change.
  - Manage tidal flood risks around the estuary and identify opportunities to restore estuarine processes in support of the Water Framework Directive (WFD) and support the objectives of international, national and local conservation designations.
  - Identify potential locations for new inter-tidal habitat to compensate for losses of habitat caused by rising sea levels where attributable to FCRM asset influences (e.g. coastal and tidal defences) and uncertain causes of change.
  - Seek ways to enhance the environmental, amenity and recreational value.

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## 1.2 Problem

- 1.2.1 The Strategy area contains assets at risk of flooding with Present Value damages (PVd) of £11,294,522k over the next 100 years for the Do Nothing option. There are 101,743 properties (75,813 residential and 25,930 commercial) currently at risk with a 0.1% (1 in 1000) chance of flooding in any year, increasing to 111,588 properties by 2110 – see Table 1.1. The majority of these properties are along Cardiff, Newport, Weston-super-Mare and Burnham-on-Sea.

**Table 1-1 Summary of properties at 0.1%AEP risk for Do Nothing option (without Strategy)**

Flood Cell	Properties at risk, now	Properties at risk, 2110	SoP* 2010	Do Nothing PVd, £K
Penarth	4	6	5%	£462
Tremorfa	6,805	9,599	0.1%	621,271
Wentlooge Levels	7,819	8,539	2-0.1%	846,347
River Ebbw - River Usk	2,606	3,542	20-0.1%	176,018
Caldicot Levels	12,244	12,984	20-0.1%	1,569,225
Mathern	56	61	0.5%	9,709
Tidenham	0	0	100%	0
Stroat	0	0	100%	0
Lydney	166	273	0.1%	17,929
Purton	0	0	20%	0
Awre	0	0	20%	0
Bullo	0	0	0.1%	0
Ruddle	0	0	0.1%	0
Newnham-on-Severn	50	54	2%	9,080
Westbury-on-Severn and Rodley	183	218	10-0.1%	32,379
Wallmore Common	112	115	0.5%	9,928
Minsterworth	72	75	0.1%	21,403
Minsterworth Ham	104	132	10%	17,545
The Rea	76	109	0.1%	7,461
Stonebench	8	11	0.5%	1,303
Elmore Back	112	115	2%	6,283
Longney	120	133	0.1%	10,362
Upper Framilode	967	1,101	1-0.1%	59,856
Arlingham	264	323	0.1%	21,197
Slimbridge	473	608	0.1%	11,502
Berkeley to Littleton-upon-Severn	1,534	1,803	10-0.1%	144,844
Avonmouth to Aust	6,286	6,617	5-0.1%	712,486
Portbury	4,277	5,018	0.1%	67,294
Woodhill	0	0	0.1%	0
Clevedon to Weston-Super-Mare	41,365	43,629	5-0.1%	4,615,014
Brean to Burnham-on-Sea	14,156	14,584	0.1%	2,163,473
Huntspill	1,269	1,270	0.1%	66,279
Pawlett	398	419	1-0.1%	51,104
Stear Peninsula	217	250	10%	24,769
<b>Total</b>	<b>101,743</b>	<b>111,588</b>		<b>11,294,522</b>

Note: \*gives the chance of FCRM assets overtopping or breaching in any year.

- 1.2.2 Wave attack increases flood risk south of the Severn Crossings. Upstream of the Severn Crossings the estuary is more sheltered and waves are not significant. The SMP2 established that there are no strategic erosion issues.

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- 1.2.3 Critical infrastructure at risk includes parts of the Cardiff to London and Bristol to Weston-super-Mare main rail lines; branch railways at Chepstow, Caldicot and Severn Beach; the M4, M5, M48 and M49 motorways; A455, A48, A403, A5, A369, A370, A371 and B4239 roads; 3 nuclear power stations, major power transmission lines (275kV/400kV) and 363 sub-stations; docks at Avonmouth, Portbury, Portishead, Lydney, Newport and Sharpness; 116 care homes, 5 hospitals and 89 schools; and 8 sewage treatment works.
- 1.2.4 The FRM assets located along the estuary coastline are identified as causing coastal squeeze of inter-tidal habitat within the N2K sites. By continuing to Hold the Line there would be a legal duty to secure compensatory habitat to replace between 300 to 500 Ha (dependent on climate change scenario) of intertidal habitat by 2030. Projects under construction secure 277ha of intertidal habitat by 2015. The total requirement for compensatory habitat identified within the strategy is considerably less than that calculated within the SMP2. The strategy has dealt with only those habitat losses that can be reasonably attributed to the presence of flood risk assets. This has reduced the number of sites for Managed Realignment required to be found.

## 1.3 Options considered

- 1.3.1 An initial three staged process was adopted to appraise options; a) Review of SMP2 policies and identification of preferred High Level Options (HLO); b) develop a long-list of technically viable options defining their type and alignment then refine to a short-list and; c) select the preferred option on the outcome of the FCERM-AG decision rule. The Strategic Environmental Assessment (SEA) and Habitat Regulations Assessment (HRA) informed the option selection at each stage.
- 1.3.2 The FRM options considered are covered by Do Nothing, Do Minimum, Maintain current defence height, Sustain existing flood risk, Improve existing flood risk, and Managed Realignment (MR). Tidal barrage options across the estuary were rejected as high cost and environmentally unacceptable.
- 1.3.3 These options evolved after the first consultation in 2011. In particular the MR option evolved into an Adaptation option in accordance with the EA's Asset Maintenance Protocol. Under this option there would be joint working with landowners to either keep the defence or realign with landowner consent.
- 1.3.4 Compensatory habitat opportunities were primarily considered within and adjacent to the N2K site. Fifty seven potential sites were investigated at a high level, and were progressively refined through stakeholder workshops and technical criteria. Two habitat creation projects are underway on site (2013-14). In other areas landowners have been made aware that managed realignment is an option that could be considered earlier if or when increased flood risk impacts on land management practices. In the longer term we have identified further opportunities for voluntary realignment projects.
- 1.3.5 Non structural measures include influencing the planning system to focus on long term re-development out of the floodplain and Flood Incident Management (FIM) initiatives to improve flood resilience of properties and the community response to flooding.

## 1.4 Recommended Strategy

- 1.4.1 The Strategy combines the options for each flood cell to provide a strategic solution with optimal Standard of Protection (SoP). Options recommended in the Strategy are described below, based on the UKCP09 medium 95%ile emissions scenario. The short, medium and long term schemes will be dependent on the actual level of sea level rise that occurs.
- 1.4.2 **Priority FRM schemes** (within five years): The preferred option is to Improve flood risk by upgrading localised FRM asset weak spots to 0.1%AEP SoP along the Wentlooge Levels, River Ebbw to River Usk, Caldicot Levels, specific weak points between Avonmouth and Aust, and Congresbury Yeo (north of Weston-super-Mare) which

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includes localised intertidal habitat creation. These schemes will improve protection to 54,741 residential and 16,546 non-residential properties in total (Table 1.1 gives the total numbers at risk) and reduce risk to life. All these Strategy recommendations are being progressed at a project level due to their strong economic and partnership funding cases.

- 1.4.3 **Priority compensatory habitat schemes** (construction underway): The preferred option is Managed Realignment near Stroath (including Plusterwine and Alvington) and for the Steart Peninsula. These are the most feasible sites within the Severn Estuary SPA / Ramsar site to offset inter-tidal habitat losses, providing up to 277 ha of replacement habitat by 2015. All these Strategy recommendations are already well progressed at a project level to work with the willingness of landowners and communities to proceed. The locations of Tidenham, Frampton and Portbury may provide further compensatory habitat as terrestrial habitats convert to intertidal habitat, if no improvements to defences occur, as seems likely.
- 1.4.4 **Short term FRM schemes** (by 2030): The preferred option is to Improve or Sustain SoP by upgrading localised FRM asset weak spots along Upper Framilode (0.1%AEP SoP), Berkeley to Littleton-upon-Severn and Westbury-on-Severn to Rodley (1%AEP SoP). These schemes require partnership funding. The Westbury-on-Severn scheme would need to align with the objectives of the National Trust who is a major landowner.
- 1.4.5 **Short term adaptation schemes** (by 2030): We are discussing potential options with landowners at Awre and Minsterworth Ham (all Gloucestershire), in accordance with the Asset Maintenance Protocol for situations where the economic case for the EA to maintain defences is low. No decisions have been made, though the options for realignments that could provide up to 444ha of replacement habitat could still be a possibility. The locations of Tidenham, Frampton and Portbury may provide further reduction in loss of intertidal habitat, if no improvements to defences occur, as seems likely.
- 1.4.6 **Medium to Long term** (after 2030): The preferred option around the majority of the estuary is to incrementally Sustain SoP at 0.1%AEP. Exceptions to this are Penarth, Mathern and Newnham-on-Severn (2%AEP SoP); Minsterworth Ham, Stonebench and Berkeley to Littleton-upon-Severn (1%AEP SoP); and The Rea (0.5%AEP SoP). There may be opportunities for Adaptation at Elmore Back (Gloucestershire), Brean and Pawlett Hams (Somerset), depending on the magnitude and timing of actual sea level rise experienced, funding and the approach from landowners. Further sites may also provide opportunities if climate change accelerates and landowners seek alternative ways to manage land.
- 1.4.7 **Non structural measures:** Flood warning improvements, planning and development control changes are recommended to continue.
- 1.4.8 The preferred Strategy options are in accordance with SMP2 policy, except for the following specific flood cells: Lydney, Longney, Arlingham, Slimbridge, Congresbury Yeo and Huntspill. The need for managed realignment at these sites has been deferred or is not required under updated sea level rise scenarios.

## 1.5 Economic case

- 1.5.1 Table 1.2 summarises the 100 year economic case for each flood cell and the cash costs for the next 15 years. The optimised SoP is quoted as the lowest standard over the 100 year appraisal period taking account of climate change (refer to Table 1.1 for current SoP).

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## 1.6 Environmental considerations

- 1.6.1 The Strategy will provide replacement habitat to compensate for the impact of losses within the Strategy area. The SEA, which includes WFD assessment and Habitat Regulations Assessment (HRA), informed the selection of the options.
- 1.6.2 The HRA concludes that the preferred policy options are likely to adversely affect the integrity of the Severn Estuary SPA and Ramsar site at some locations. No alternative solutions are identified that entirely avoid adverse effects while protecting people and public safety. Consequently, the preferred policy options will be progressed through an Appendix 20 (statement of case), which considers the Imperative Reasons of Overriding Public Interest (IROPI) and compensatory habitat requirements. This has been drafted and will be submitted to Defra in spring 2014.
- 1.6.3 Assessment of compatibility with the WFD has concluded that the options will not cause deterioration in any water body nor prevent any from reaching future good status or potential. The Strategy's Do Nothing, Managed Realignment, and potentially Adaptation, options will make significant contributions to WFD objectives.
- 1.6.4 Natural England and Welsh Government support the Strategy as an environmentally acceptable solution. A strategic environmental monitoring plan has been drafted addressing uncertainties surrounding the future effects of coastal squeeze and the need for and success of compensatory habitat creation. This will be finalised in discussion with Natural England and the Welsh Government as part of the SEA Statement of Environmental Particulars once the Strategy has been recommended for approval.
- 1.6.5 We have consulted twice on the Strategy. In 2011 there was widespread concern over the perceived emphasis on creation of compensatory intertidal habitat. We took stock of feedback received, worked closely with those communities and stakeholders that would have been most affected. We incorporated into our proposals revised Sea Level Rise guidance and options (from the EA's Asset Maintenance Protocol) for landowners with uneconomic or low funding-priority defences. We used local engagement prior to the 2013 consultation, and on-line material, drop-ins and local meetings for the 2013 consultation, such that the proposals were better received by stakeholders.

**Table 1-2 Benefit-cost assessment**

Flood Cell	Option	PV costs, £K	PV benefits, £K	Average BCR	Total cash costs, £K	Cash costs, 15 year, £K	Scheme timing
Penarth	Sustain, 2%AEP SoP	82	299	3.7	675	10	Medium-long term
Tremorfa	Sustain, 0.1%AEP SoP	2,043	621,271	304.1	14,985	1,004	
Wentlooge Levels	Improve, 0.1%AEP SoP	5,008	846,347	169.0	29,025	3,538	Priority FRM
River Ebbw - River Usk	Improve, 0.1%AEP SoP	5,708	176,018	30.8	23,307	3,670	
Caldicot Levels	Improve, 0.1%AEP SoP	23,749	1,569,225	66.1	80,866	18,153	
Mathern	Sustain, 2%AEP SoP	3,655	8,110	2.2	22,544	1,382	Medium-long term
Tidenham	Do nothing	0	0	NA	0	0	Priority MR
Stroat	Adaptation by 2030	1,322	3,345	2.5	1,322	1,322	
Lydney	Sustain, 0.1%AEP SoP	1,332	17,929	13.5	8,225	125	Medium-long term
Purton	Do nothing	0	0	NA	0	0	Short term adaptation
Awre	Adaptation by 2030	3,238	12,262	3.8	3,238	3,238	
Bullo	Do nothing	0	0	NA	0	0	Medium-long term
Ruddle	Do nothing	0	0	NA	0	0	
Newnham-on-Severn	Sustain, 2%AEP SoP	1,090	8,683	8.0	4,591	1,302	Short term FRM
Westbury-on-Severn and Rodley	Sustain, 1%AEP SoP	1,872	30,488	16.3	5,506	1,733	Medium-long term
Wallmore Common	Sustain, 0.1%AEP SoP	320	9,928	31.0	2,040	260	
Minsterworth	Sustain, 0.1%AEP SoP	436	17,545	40.3	1,856	425	Short term adaptation
Minsterworth Ham	Adaptation by 2030	1,295	48,770	37.7	4,351	1,227	
The Rea	Sustain, 0.5%AEP SoP	392	6,911	17.6	1,276	386	Medium-long term
Stonebench	Sustain, 1%AEP SoP	334	1,303	3.9	2,158	269	
Elmore Back	Maintain (2%AEP SoP), Adaptation after 2030	10,397	17,660	1.7	19,927	19,927	
Longney	Sustain, 0.1%AEP SoP	629	10,362	16.5	4,683	477	
Upper Framilode	Improve, 0.1%AEP SoP	1,718	59,856	34.8	6,320	1,764	Short term FRM
Arlingham	Sustain, 0.1%AEP SoP	1,864	21,197	11.4	13,283	670	Medium-long term
Slimbridge	Sustain, 0.1%AEP SoP	1,047	11,502	11.0	7,747	785	
Berkeley to Littleton-upon-Severn	Improve, 1%AEP SoP	9,603	129,705	13.5	37,405	9,630	Short term FRM
Avonmouth to Aust	Improve, 0.1%AEP SoP	13,649	712,486	52.2	39,725	14,553	Priority FRM
Portbury	Maintain, 0.1%AEP SoP	56	67,294	1,211.5	186	37	Medium-long term
Woodhill	Do nothing	0	0	NA	0	0	
Clevedon to Weston-Super-Mare	Improve, 0.1%AEP SoP, local Adaptation	14,849	4,615,014	310.8	65,768	12,007	Priority FRM
Brean to Burnham-on-Sea	Sustain, 0.1%AEP SoP, local Adaptation after 2030	4,307	2,176,890	505.5	39,103	475	Medium-long term
Huntspill	Sustain, 0.1%AEP SoP	180	68,932	383.2	1,742	74	
Pawlett	Maintain, 0.1%AEP SoP, Adaptation after 2030	3,276	75,811	23.1	16,938	289	
Stear Peninsula	Adaptation by 2030	20,489	61,138	3.0	32,144	23,407	Priority MR
<b>Total</b>		<b>133,937</b>	<b>11,406,279</b>		<b>490,938</b>	<b>122,140</b>	

Notes: Green shaded rows are Priority FRM schemes. Orange shaded rows are Priority MR schemes. Costs include 60% Optimism Bias; excludes inflation. Standard of Protection may be determined by overtopping or breach risk (refer to Appendix D for details). Flood risk to properties may be better than the SoP if storage is available behind the defence.

## 1.7 Implementation and Outcome Measures

- 1.7.1 The recommended Strategy, subject to funding, will reduce flood risk and meet the legal obligation of the Severn Estuary SAC / SPA / Ramsar for replacement habitat. Table 1.3 shows the spend profile and Outcome Measures for the next five years, costs for the next 15 and 100 years, and FCRM GiA Partnership Funding (PF) score.
- 1.7.2 Procurement for capital works will be through the Environment Agency frameworks.

**Table 1-3 Annualised Cash Spend Profile, Outcome Measure and Cash Costs**

	2013-14	2014-15	2015-16	2017-18	2018-19	Future 10 years	Total 15 years	Total 100 years
<b>Priority compensatory habitat schemes (within 5 years)</b>								
<b>Two projects:</b> Stroata, Steart Peninsula, all PF scores>200%. Total OM4 of 277Ha.								
<b>Operating authorities:</b> Environment Agency								
Cost, £K	12,309	12,309	9	9	9	85	24,729	33,467
<b>Priority FRM schemes (within 5 years)</b>								
<b>Five projects:</b> Wentlooge Levels, River Ebbw-River Usk, Caldicot Levels, Congresbury Yeo, all PF scores>200%, Avonmouth to Aust, PF score 120%. Total OM2 of 35,137 properties. Total OM4 of 11Ha.								
<b>Operating authorities:</b> Environment Agency, South Gloucestershire Council, Bristol City Council								
Cost, £K	4,213	9,764	14,127	14,127	5,800	5,654	53,686	245,011
<b>Short term adaptation schemes (by 2030)</b>								
<b>Two projects:</b> Awre, Minsterworth Ham, all PF scores >200%. Potential OM2 of 116 properties. Potential OM4 of 444Ha.								
<b>Operating authorities:</b> Environment Agency								
Cost, £K	5	5	5	5	5	4,439	4,464	7,588
<b>Short term FRM schemes (by 2030)</b>								
<b>Three projects:</b> Westbury-on-Severn and Rodley, PF score 20%, Upper Framilode, PF score 120%, Berkeley to Shepperdine, PF score 90%. Potential OM2 of 994 properties.								
<b>Operating authorities:</b> Environment Agency								
Cost, £K	38	38	38	38	38	11,172	11,363	42,911
<b>Remaining area:</b> incremental adaptation and improvement to keep pace with climate change								
<b>Operating authorities:</b> Environment Agency								
Cost, £K	1,860	1,860	1,860	1,860	1,860	18,598	27,898	161,961
<b>Total Strategy area (sum of the above)</b>								
Cost, £K	18,426	23,976	16,038	16,038	7,712	39,949	122,140	490,938

Notes: costs include capital and maintenance costs; 60% Optimism Bias; excludes inflation; PF score for 15 yr benefit duration.

## 1.8 Contributions and funding

- 1.8.1 The priority FRM schemes along the Wentlooge Levels, River Ebbw to River Usk, Caldicot Levels, Avonmouth to Aust and Congresbury Yeo should attract FCRM Grant in Aid funding of £41,527k.
- 1.8.2 Partnership Funding is not currently an FRM policy in Wales, but NRW will seek contributions from the major beneficiaries of the sea defences along the Welsh Coast. These contributions could be funding or resources to support the development and implementation of improvements to the defences in accordance with the strategy. NRW is already working closely with Newport Council (relevant to the River Ebbw to River Usk, and Caldicot Levels flood cells) to develop and implement some of the early actions in the strategy. NRW also works with the other two authorities (Cardiff and Monmouthshire) along the estuary to ensure the existing sea defences are kept fully operational and improved when and where necessary.
- 1.8.3 The priority FRM scheme to improve weak spots between Avonmouth and Aust should attract some FCRM funding. The need for substantial future investment in defences for sustainable development has been identified in both South Gloucestershire and Bristol City Councils' Infrastructure Delivery Plans. We are working closely with these Councils

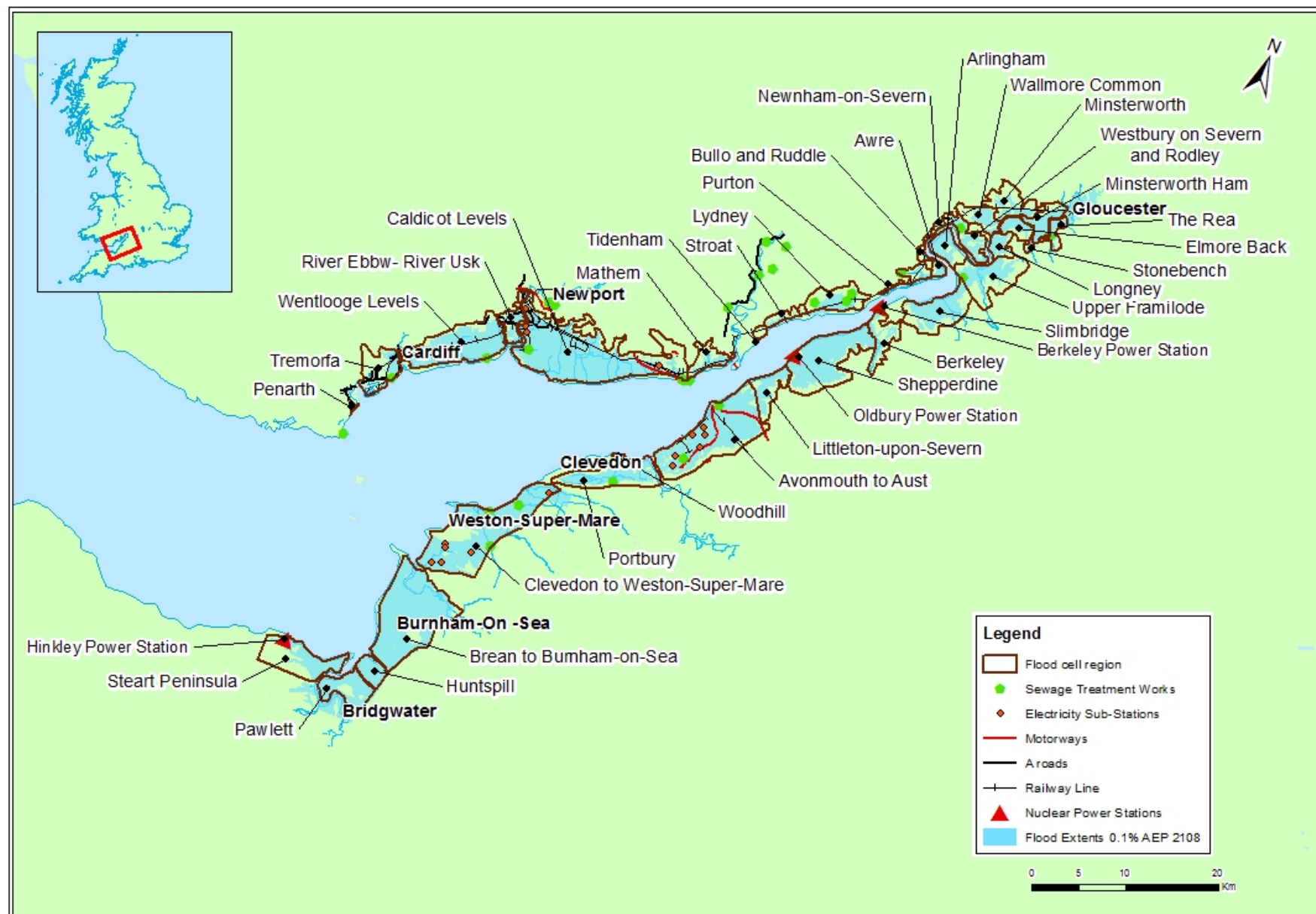
- on finding the best flood risk management measures and funding arrangement for around £65 Million of FCRM investment, largely implemented through development.
- 1.8.4 The priority compensatory habitat schemes in progress at Stroat (Plusterwine and Alvington) and Steart Peninsula also qualify for central funding of £21,017k given the need to provide this strategic approach.
  - 1.8.5 The short term FRM schemes (by 2030) at Upper Framilode (0.1%AEP SoP), Berkeley to Littleton-upon-Severn and Westbury-on-Severn (1%AEP SoP) require a total of £7,370k FCRM GIA funding and Partnership Funding of £1,579k, based on a Partnership Funding score of 100%.
  - 1.8.6 The short term adaptation schemes at Awre and Minsterworth Ham could qualify for a total of £4,190k FCRM GIA funding, if landowners decide to explore options that include realignment and habitat creation.
  - 1.8.7 Contributions will be sought from partners for all FCRM schemes.

## 1.9 Recommendations: Severn Estuary FRM Strategy

- 1.9.1 We recommend that the Severn Estuary FRM Strategy is approved at a Whole Life Cost of £490,939k (excluding inflation) for managing the risk of flooding to 111,588 properties over 100 years. Contribution plans should be developed to secure funding ahead of implementing the schemes recommended in this Strategy.

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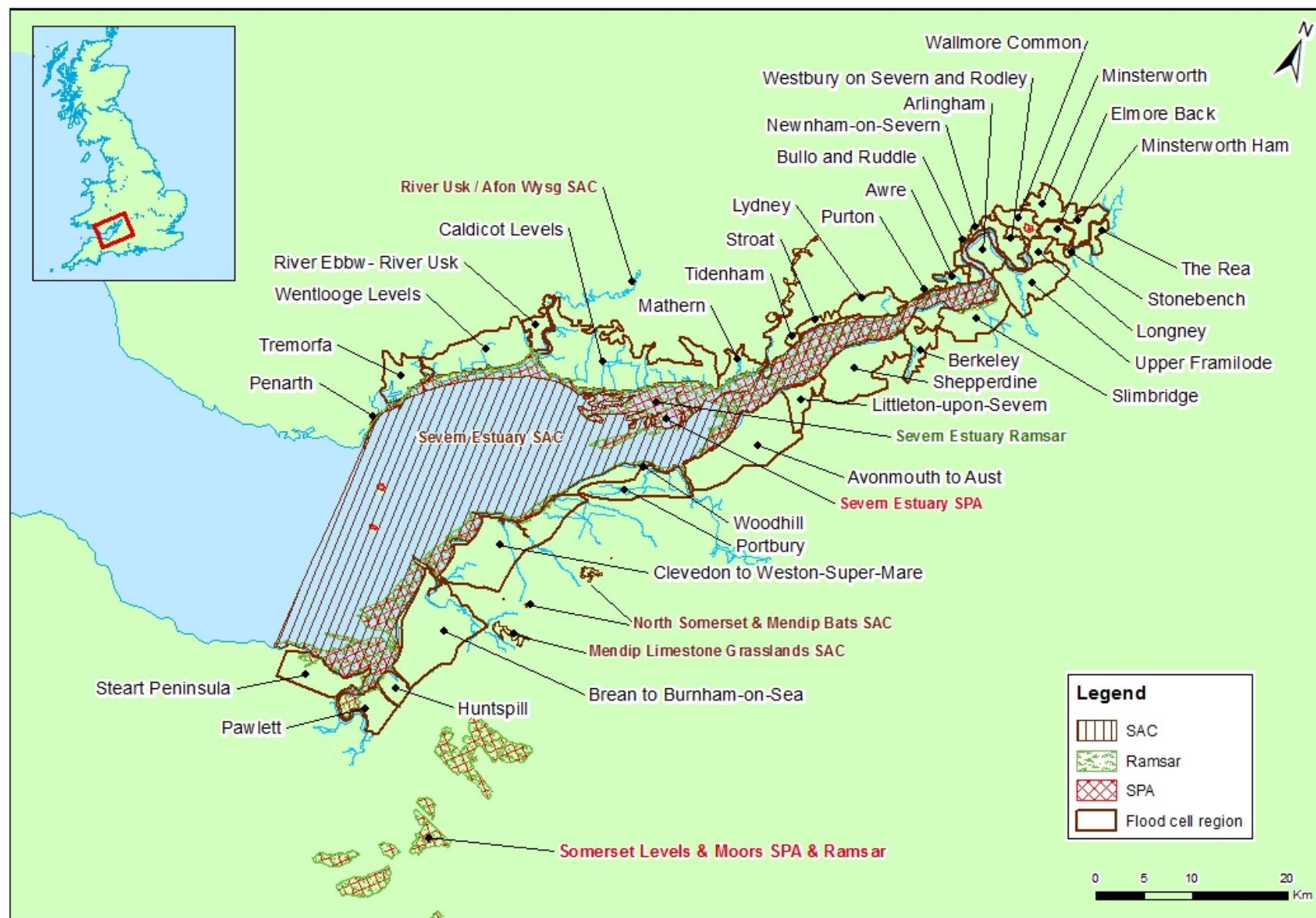
## Key Plan 1 Strategy area, flood cells and key assets



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## Key Plan 2 Environmental designations



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## 2 Introduction and background

### 2.1 Purpose of this report

- 2.1.1 The Severn Estuary Flood Risk Management (FRM) Strategy has been developed to identify the preferred strategic tidal flood risk management approach for an area covering the coast from Gloucester to Lavernock Point near Penarth in South East Wales, and from Gloucester to Hinkley Point in Somerset. The study area includes the conurbations of Cardiff, Newport, Weston-super-Mare, Burnham-on-Sea, parts of Gloucester, and many towns and villages, supporting a total population within the floodplain of 180,000.
- 2.1.2 The Strategy identifies the recommended management options for the short term 15 year programme within the context of a 100 year overall plan. A strategic approach is required as the problems are long-term and large-scale, include linked coastal processes and multiple benefit areas and require a consistent approach to the management of internationally designated habitats within the Severn Estuary.
- 2.1.3 The Strategy has been developed in accordance with Flood and Coastal Erosion Risk Management Appraisal Guidance (FCERM-AG) and associated Environment Agency procedures. The appraisal considers the longer-term implications of coastal change, climate change and sea level rise, and therefore enables the Environment Agency and interested parties to understand the various technical, environmental and financial constraints when making local choices. Following Strategy approval, scheme Project Appraisal Reports (PARs) will be developed in line with the recommended short term programme.

### 2.2 Background

#### Strategic and legislative framework

- 2.2.1 The Strategy identifies the most appropriate FCERM activities needed over the next 100 years, adding greater local detail to, being informed by and/or supporting the following most significant plans:
- The **Severn Estuary Shoreline Management Plan 2** (SE SMP2, 2010) recommends selectively holding the existing defence line by maintaining or improving existing defences, and notably NAI or MR at Tidenham, Stroat, Lydney, Awre, Minsterworth Ham, Elmore Back, Longney, Arlingham, Slimbridge and Congresbury Yeo.
  - The **North Devon and Somerset Shoreline Management Plan 2** (NDAS SMP2, 2011) recommends selectively holding the existing defence line by maintaining or improving existing defences, and notably NAI or MR at Brean, Huntspill, Pawlett Ham and Steart peninsula.
  - The **Ogmore and Tawe, Taff and Ely, Eastern Valleys, Wye and Usk, Severn Tidal Tributaries, Bristol Avon, North and Mid Somerset, and River Parrett Catchment Flood Management Plans** (2008) cover the strategy area. They generally recommend further action to maintain, sustain or improve FRM, with localised policies to reduce FRM at The Rea and Stonebench in Gloucestershire.
  - The **Severn, and South West, River Basin Management Plans** (2009), together with further investigations to support their update in 2015, have been used to guide the implications of the Strategy on the WFD water bodies that might be affected by it.
  - The **Severn Estuary Coastal Habitat Management Plan** (CHaMP, 2006). The Strategy re-ran the CHaMP model with the Defra (2006) and more recent UKCP09 climate change guidance. The CHaMP model was used to provide the initial prediction of habitat change that would occur in the future. These were then considered further as regards cause of change. The findings are summarised in Table 5.1, with more detail given in Appendix C.

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- 2.2.2 Works identified by this Strategy will be implemented using powers under Section 165 of the Water Resources Act 1991 and the Coast Protection Act 1949. Schemes will be subject to the Town and Country Planning Regulations, Marine and Coastal Access Act 2009 and Land Drainage regulations where required.
- 2.2.3 Continuing to maintain FRM assets in the Strategy area will have adverse effects on the Severn Estuary SPA, SAC and Ramsar sites and potentially, the Somerset Levels and Moors SPA and Ramsar sites. We have a legal duty under the Habitats/Birds Directives to take measures to maintain the integrity of the N2K sites. Where there are no alternative solutions that avoid adversely impacting the integrity of N2K sites in some locations, Imperative Reasons of Overriding Public Interest would be required and compensatory habitat would need to be secured.
- 2.2.4 The requirements of the Water Framework Directive (Council Directive 2000/60/EC establishing a framework for Community action in the field of water policy) were considered. The Water Framework Directive sets a target of aiming to achieve at least 'good status' in all waters, with 'Protected Area' objectives for water-dependant N2K sites also being particularly relevant to the Strategy. An assessment of the compliance of the Strategy responses with the Water Framework Directive environmental objectives has been undertaken and can be found in Appendix E.
- 2.2.5 SEA of the various FRM options was undertaken in line Defra policy and in accordance with the requirements of the Environmental Assessment of Plans and Programmes Regulations (SI 1633 2004) and the Environmental Assessment of Plans and Programmes (Wales) Regulations (SI 1656 2004). Environmental issues were thus fully incorporated into the decision making process in a transparent and auditable way, described in Appendix E.

### Previous studies

- 2.2.6 The Strategy takes into account the FRM and environmental studies listed below. These provide a comprehensive source of information in terms of the range of options considered for the Strategy and adjacent areas.
- Gwent Levels Foreshore Management Plan (2004).
  - Tidal Usk FRM Strategy (2008).
  - Newport to Chepstow FRM Strategy (2006).
  - Tidal Severn FRM Strategy (2008).
  - Clevedon to St. Thomas's Head Strategic Overview (2005).
  - Parrett Estuary FRM Strategy (2009).

### Social and political background

- 2.2.7 Conurbations within the study area with populations of more than 10,000 include Penarth, Cardiff, St Mellons, Newport, Caldicot, Lydney, Chepstow, Gloucester, Quedgeley, Portishead, Clevedon, Congresbury, Weston-super-Mare and Burnham-on-Sea. Particularly vulnerable communities are predominantly found in Bridgwater, Weston-super-Mare, Bream, Shirehampton and Avonmouth.
- 2.2.8 There are significant areas of commercial and industrial development at Cardiff, Newport, Chepstow, Lydney, Gloucester, Avonmouth, Clevedon and Weston-super-Mare.
- 2.2.9 Important infrastructure around the estuary includes: the M48, M4 and M5, two Severn road crossings, the Severn rail tunnel, several strategic rail routes including South Wales to London main line and the Chepstow to Gloucester rail link, numerous sewage treatment works and pumping stations and several power stations (including Avonmouth, Berkeley, Oldbury and Uskmouth).
- 2.2.10 If no work were undertaken to manage flood risk around the estuary these areas would be at increased risk of flooding over time, with major consequences for people, property, transport links and key services.

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- 2.2.11 The Cardiff Flats and Gwent Levels (Lavernock Point to River Wye) predominantly comprise an area of historically reclaimed land, with an extensive network of ditches (reens / rhynes) to drain water out to sea. Land use in the area is primarily agricultural, with a large number of towns and villages located within the floodplain and the cities of Cardiff and Newport on the fringes. Strategic infrastructure includes main transport routes (M4, M48 and London-Wales railway line), the main power transmission line between England and south east Wales, Newport Docks and Uskmouth power station.
- 2.2.12 Land use in the Upper Estuary (River Wye/Sharpness Docks to Gloucester Weirs) is predominantly agricultural, but includes the city of Gloucester and a large number of towns and villages. Strategic infrastructure includes the Gloucester-Chepstow railway line, the A40 and A48, the Gloucester-Sharpness canal, Lydney Harbour and Sharpness Docks.
- 2.2.13 The South Gloucestershire to Somerset coast (Sharpness to Hinkley Point) consists of five large low-lying areas. Agricultural land dominates in the north, whilst larger residential and commercial developments are present in the south (Aust, Severn Beach, Avonmouth, Portishead, Clevedon, Weston-super-Mare and Burnham-on-Sea). Strategic infrastructure consists of the M4, M5 and M48, the London-Wales and Bristol-Weston railway lines, the main power transmission line between England and south east Wales, Oldbury power station, chemical processing plants, Avonmouth, Royal Portbury and Portishead Docks, and a significant tourism area around Berrow and Brean.

### Location and designations

- 2.2.14 The Strategy area is afforded a very high level of protection under European law, with large areas designated as a Special Protection Area (SPA) under the Birds Directive and as Special Area of Conservation (SAC) under the Habitats Directive. The area surrounding the estuary is also designated as a wetland of international importance under the Ramsar Convention and as a Site of Special Scientific Interest (SSSI). The site supports internationally important numbers of migratory and overwintering birds as well as a nationally important population of wildfowl. In addition, several freshwater SSSIs (e.g. the Gwent Levels SSSI complex) lie behind the existing coastal defences.
- 2.2.15 In total there are 7 sites of European Importance (SAC/SPA/Ramsar), over 50 SSSIs and 4 National Nature Reserves (NNRs) within the study area. Climate change and sea level rise will have implications for the habitats, number and distribution of bird species for which the Severn Estuary SAC/SPA/Ramsar site and Somerset Levels and Moors SPA/Ramsar site is designated. Increased flooding would affect the habitats and species which make these sites special and could contravene the Habitats Regulations. An overview of designations is given in Figure 2.

### History of flooding

- 2.2.16 The Severn Estuary is highly dynamic, with one of the highest tidal ranges in the world of over 12m, and significant wave climate and fluvial inputs. Tidal processes tend to dominate the whole estuary, although upstream of Arlingham peninsula fluvial-tidal processes are finely balanced. Wave climate is a significant driving force from the downstream extent to the Severn Crossings, at which point its influence decreases and is negligible upstream of the Arlingham peninsula. The estuary geomorphology is complex and varied, broadly split into exposed rock and sandbanks (generally in the central region of the estuary), mudflats, saltmarsh and headlands (along the estuary margins), and floodplains ranging in size from the massive coastal floodplains (between 1,000Ha and 10,000Ha) to constrained floodplains upstream of the Arlingham peninsula. Whilst there is a consensus of opinion on the general sediment transport processes, detailed understanding is prone to large uncertainties. The floodplains are now inactive due to a diverse range of FRM assets covering 208km of the 235km total, including groyne/breakwater systems, foreshore management, wave return walls, concrete/masonry walls, revetments, rock armour and embankments. These floodplains

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have experienced significant agricultural, residential, industrial and infrastructure development.

- 2.2.17 The existing floodplains around the Severn Estuary are susceptible from both tidal and fluvial flooding. The worst, and earliest, flooding event on record was in 1607, generally accepted to have been caused by an extreme tidal event. A number of studies note that the areas worst affected were the Gwent Levels and areas around Burnham-on-Sea, with significant loss of life and property. Further particularly severe historic events are thought to have occurred in 1672, 1770 and 1809. There has been further flooding within the study area throughout the 20th century, with local tidal flooding in 1990 and 1999, and significant fluvially-dominated flooding around Gloucester in 2000 and 2007. The last widespread flooding from tidal sources occurred in 1981, significantly affecting the South Gloucestershire to Somerset coast. This triggered a major investment programme lasting until the mid 1990s.

## 2.3 Current approach to flood risk management

### Measures to manage the probability of flood risk

#### Gwent Levels

- 2.3.1 The Gwent Levels consists predominantly of large coastal floodplains of 3,400Ha (Wentlooge Levels) and 6,400Ha (Caldicot Levels and Mathern), with flood risk managed by seawalls, revetments, rock armouring, wave recurve walls and embankments. Along the Penarth frontage, the existing seawall and promenade protect against present day flooding with a 5% AEP. Along Tremorfa, the Cardiff Bay barrage, relatively high ground and road levels result in a present day flood risk of 0.1% AEP. Along the Wentlooge Levels, the coastal embankments and revetments generally provide a SoP of 0.1% AEP, however short lengths along the River Rhymney and near Sluice Farm have a SoP of 5% AEP which defines flood risk to the wider floodplain. Between the rivers Ebbw and Usk the minimum present day SoP is 20% AEP, due to low-level non-engineered structures along the River Usk right bank, although the flow route through to the general floodplain is limited due to high ground. Similar to the Wentlooge Levels, the coastal embankments and revetments along the Caldicot Levels have a general SoP of 0.5-0.1% AEP, with short weaker lengths along the River Usk defining the flood risk as 5% AEP to the wider floodplain. Along Mathern, the embankments provide a SoP of 0.5% AEP.

#### Upper Estuary

- 2.3.2 The Upper Estuary has a larger number of constrained floodplains (each less than 1,000Ha), with flood risk managed by embankments, pumping stations and flood storage in the most upstream extent. Along the west bank at Tidenham and Stroat, the railway embankment forms the de facto defence, although culverts running under the railway embankment allow constrained landward inundation. Towards Lydney the present day SoP is greater than 0.1% AEP, due to recent construction of a rock armoured embankment. Around the Awre peninsula (Purton and Awre itself) flooding can occur under 20% AEP. Further upstream towards Newnham-on-Severn, Westbury-on-Severn and Rodley, flooding is managed by embankments with a SoP of 2-10% AEP. Walmore Common and Minsterworth are protected by embankments with a SoP of 0.5% AEP or above, whilst further upstream Minsterworth Ham has a 10% AEP. Along the east bank, the Rea, Stonebench, Longney, Upper Framilode, Arlingham and Slimbridge all have a SoP of 1% AEP or above, and Elmore Back has a greater chance of flooding with a SoP of 5% AEP.

#### South Gloucestershire to Somerset coast

- 2.3.3 The South Gloucestershire to Somerset coast consists predominantly of massive coastal floodplains (between 5,000Ha to 10,000Ha). The embankments along Berkeley,

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Shepperdine and Littleton-upon-Severn generally have a SoP of 2-0.5% AEP, although there is a short reach near Shepperdine with a SoP of 10% AEP. Between Avonmouth and Aust, the railway embankment, seawalls and revetments allow flooding with a SoP of 0.5% AEP, although around Avonmouth Docks the chance of flooding is greater. Between Portbury Warth, Clevedon, Weston-Super-Mare, Brean and Burnham-on-Sea there are fluvial embankments, and coastal revetments, seawalls and dune systems with a SoP of 0.5-0.1% AEP, although south of Clevedon weaker fluvial earth embankments result in a SoP of 5% AEP locally. The coastal earth embankments along Steart peninsula result in a SoP of 5% AEP.

### Measures to manage the consequences of flood risk

- 2.3.4 The Environment Agency's and Natural Resources Wales' Flood Warning system covers the Strategy area. The adoption of this service was promoted through the exhibitions held during the public consultations along with information on flood resilience. The exhibitions were also used to promote the Environment Agency's Flood Line service and offer guidance on measures homeowners can take to increase the flood resilience of their properties.
- 2.3.5 Management of flood risk through Development Control will continue to regulate development in the floodplain to avoid putting new assets at risk in accordance with the National Planning Policy Framework (NPPF).
- 2.3.6 Emergency planning is a vital part of managing the risks to coastal communities and the relevant authorities continually review and update their procedures to account for changing circumstances. It will be necessary to ensure the Strategy outcomes and identified risks are fed into the local emergency planning system.
- 2.3.7 A Community Engagement Officer works with the local authorities and communities to develop emergency plans and increase preparedness for flooding. This has been effective in improving the Environment Agency relationship with Emergency Planning Officers and getting the local community involved in flood exercises, such as the Exercise Watermark in March 2011.
- 2.3.8 The Environment Agency and Natural Resources Wales continue to further encourage flood resilience measures with property owners at risk in the Strategy area.

## 3 Problem definition and objectives

### 3.1 Outline of the problem

- 3.1.1 The Severn Estuary has nationally important infrastructure, numbers of properties and development in its floodplains, and is an internationally designated environment. The present and future management of flood risk must be developed in conjunction with a plan for habitat creation in and around the estuary to ensure the integrity of the European sites is maintained.
- 3.1.2 The Do Nothing PVD is £11,294,522k over the next 100 years. Under current conditions there are 101,743 properties (75,812 residential and 25,931 commercial) at risk with a 0.1% (1 in 1000) chance of flooding in any year. For the Do Nothing option this will increase to 111,028 properties by 2110 (see Table 3.1), taking account of the predicted sea level rise over the next 100 years. The majority of these properties are along Cardiff, Newport, Weston-super-Mare and Burnham-on-Sea.
- 3.1.3 The existing FRM assets protect cities, towns and villages to a varying standard, detailed in Table 3.1. Other assets and features at flood risk include:
- Parts of the Cardiff to London and Bristol to Weston-super-Mare main railways.
  - Branch railways at Chepstow, Caldicot and Severn Beach.
  - The M4, M5, M48 and M49 motorways, and the A455, A48, A403, A5, A369, A370, A371 and B4239 roads.
  - The docks at Avonmouth, Portbury, Portishead, Lydney, Newport and Sharpness.
  - Three nuclear power stations, major power transmission lines (275kV/400kV) and 363 sub-stations.
  - 116 care homes, 5 hospitals, 89 schools and 8 sewage treatment works.
  - Terrestrial and freshwater nature conservation sites.
  - Important local recreation and tourist features including amenity and designated bathing beaches, public footpaths and cycleways.
  - Approximately 38,000Ha of agricultural land (80% of which is good to moderate quality, 5% of which is very good to excellent quality).
  - Archaeological and architectural assets in historic centres and throughout the Strategy area.

### 3.2 Consequences of doing nothing

- 3.2.1 Without ongoing maintenance, approximately 40% of FRM assets (and natural features having an FRM function) would cease to function in the short term epoch (2010 to 2030), with the remainder losing their function in the medium term epoch (2030 to 2060). Significant changes to the estuary system would occur, with re-activation of the natural floodplains (with 100,000Ha below MHWS), regular flooding of around 180,000 properties and £11,294,522k Present Value damages to the built environment.
- 3.2.2 Property will continue to be at flood risk as identified in section 3.1. Following any event that caused a breach, the FRM asset would not be repaired under the Do Nothing option and regular tidal flooding would be rapidly established. Approximately 101,743 properties by 2030 would be flooded too frequently to be habitable, so would be written off. This will increase to 111,588 properties by year 100 (see Table 1.1). The assets, features and infrastructure identified in section 3.1.3 would also be regularly flooded by 2030.
- 3.2.3 Consequences to the natural environment could include environmentally designated areas (particularly those in freshwater) being permanently exposed to regular tidal flooding. Estuary-scale geomorphological impacts could result in the re-creation of tidal islands throughout the estuary, and the loss of large meanders in the upper estuary. In the upper estuary, tidal dominance could propagate further upstream, with an increase in Extreme Water Levels (EWLs) of up to 0.2m between Sharpness and Newnham. In

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contrast, the activation of all the floodplains could allow fluvially dominated areas upstream of Newnham to evacuate high flows more efficiently, resulting in a reduction in EWLs of up to 0.5m.

### 3.3 Strategic issues

3.3.1 A strategic approach has been adopted for the Severn Estuary for the following reasons:

- To investigate sustainable FRM options for the Strategy area.
- To investigate potential solutions for effects on internationally designated habitat and to support morphological mitigation proposals under the WFD by considering at an appropriate scale the legal obligations likely to fall to the Environment Agency.

3.3.2 This strategy has been informed by the Severn Estuary and North Devon & Somerset SMP2s (approved in 2012), signed off by the Secretary of State as they identified adverse effects on the N2K sites. The Strategy recommends changes to SMP2 policy, predominantly due to revised climate change guidance, at the following sites:

- Lydney: SMP2 policy for MR in the long term. The Strategy recommends maintaining the existing embankments, with raising in the medium to long term.
- Longney: SMP2 policy for MR in the medium term. The Strategy recommends maintaining the existing embankments, with raising in the medium to long term.
- Arlingham: SMP2 policy for MR in the long term. The Strategy recommends maintaining the existing embankments, with raising in the long term.
- Slimbridge: SMP2 policy for MR in the short term. The Strategy recommends maintaining the existing embankments, with raising in the long term.
- Congresbury Yeo: SMP2 policy for MR in the short term. The Strategy recommends maintaining the existing embankments, with raising in the medium to long term.
- Huntspill: SMP2 policy for MR in the long term. The Strategy recommends maintaining the existing embankments, with raising in the long term.

### 3.4 Key constraints

3.4.1 The key constraints (and opportunities) include:

- Urban areas with a growing population, and infrastructure, at flood and/or erosion risk. There is flood risk-related anxiety for local residents, while owners of property at risk may either be unable to obtain insurance or pay particularly high premiums.
- Presence of internationally, nationally and locally designated conservation sites within and around the Strategy area, which will be affected by climate change, sea level rise and development pressure.
- Presence of water bodies (WFD) including the Severn Estuary (upper, middle, lower), Parrett and Usk waterbodies, noted as highly modified water bodies (HMWB) due to flood protection; and the Bristol Avon waterbody, noted as a HMWB due to flood protection, navigation and quay line.
- High archaeological potential of the Strategy area, historic settlements, and diverse historic landscapes.
- Landscapes and views that are internationally, nationally, regionally or locally designated for their scenic value within the mapped flood extents. These include the nationally designated Mendip Hills AONB.

3.4.2 The above is detailed in the SEA Environmental Report (including WFD assessment) and addendum (refer to Appendix E) and Habitat Regulations Assessment. These assessments have been undertaken due to the high environmental sensitivity of the natural and built environment within the Strategy area, in accordance with current Defra policy and Environment Agency procedures.

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## 3.5 Objectives








3.5.1 Objectives were developed by the SMP2 and SEA (at both management plan and strategy levels) in consultation with stakeholders. The detailed objectives are given in Appendix D (Annex B). In overview, objectives addressed the following issues:

- Manage the risk of flooding to people and property;
- Manage the risk of flooding to key community, recreational and amenity facilities;
- Manage the risk of flooding to industrial, commercial and economic assets and activities, including tourism and agriculture;
- Seek to minimise the impact of policies on marine operations and activities;
- Manage the risks of flooding to critical infrastructure;
- Allow natural processes and to maintain the visibility of geological exposures throughout geological SSSIs;
- Maintain the integrity of internationally designated sites and the favourable condition of their features;
- Manage adverse impacts on nationally designated conservation sites;
- Enhance nationally designated conservation sites, where practical;
- Manage the risk to scheduled sites and other internationally, nationally, regionally and locally important cultural historic environment sites and their setting.









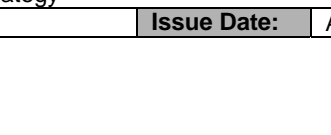
**Table 3-1 Summary of existing defences, standard of protection and assets at risk.**






Flood cell	SMP2 policy	Standard of Service, source of flood risk and existing FRM assets	Photographs	Properties at risk in 0.1%AEP event		Key assets at risk	Extreme wave, tide and fluvial climate in 2010 (from Appendix C)
				Residential	Commercial		
Penarth	HTL (all epochs)	5%AEP (wave-tidal). Seawall and groynes.		1 in 2010-2110.	3 in 2010. 5 in 2110.	Severn N2K sites. Listed pier.	EWLs (100-0.1%AEP) 7.9-9.0m AOD. Wave heights (100-0.1%AEP) 1.1-1.7m. Modest correlation of wave-tide climate.
Tremorfa	HTL (all epochs)	0.1%AEP (wave-tidal). Revetments, rock armouring and embankments.		5685 in 2010. 7982 in 2110.	1120 in 2010. 1617 in 2110.	Branchline railway. Power/gas sub-stations. Queen Alexandra and Roath Docks. Severn N2K sites. Over 10 Listed Buildings. Several historic landfill sites.	
Wentlooge Levels	HTL (all epochs)	Generally 0.1%AEP, with 5%AEP low spot (wave-tidal). Revetments, rock armouring, embankments and polders.		6046 in 2010. 6668 in 2110.	1773 in 2010. 1871 in 2110.	Mainline railway. Power/gas sub-stations. Severn N2K sites. Levels are a Historic Landscape. Two SMs. Over 10 Listed Buildings. Several historic landfill sites and 1 existing landfill site.	EWLs (100-0.1%AEP) 8.0-9.0m AOD. Wave heights (100-0.1%AEP) 1.1-1.7m. Modest correlation of wave-tide climate.
River Ebbw to River Usk	HTL (all epochs)	Generally 0.1%AEP, with 20%AEP (tidal) low spot. Revetments, rock armouring and embankments.		1800 in 2010. 2406 in 2110.	806 in 2010. 1136 in 2110.	Newport Docks. Power/gas sub-stations. Severn N2K sites. River Usk SAC. 30-50 Listed Buildings. Historic and existing landfills.	EWLs (100-0.1%AEP) 8.1-8.9m AOD. Wave heights (100-0.1%AEP) 1.2-1.9m. Modest correlation of wave-tide climate.
Caldicot Levels	HTL (all epochs)	Generally 0.1%AEP, with 5%AEP low spot (wave-tidal). Revetments, rock armouring and embankments.		8333 in 2010. 8946 in 2110.	3911 in 2010. 4038 in 2110.	Mainline railway. M4 motorway. Power/gas sub-stations. Severn N2K sites with terrestrial SSSI behind. Newport Wetlands NNR. Levels are a Historic Landscape. A few SMs. Historic and current landfill sites. Source protection zone.	EWLs (100-0.1%AEP) 7.9-9.5m AOD. Wave heights (100-0.1%AEP) 0.8-2.3m. Modest correlation of wave-tide climate.
Mathern	HTL (all epochs)	0.5%AEP (wave-tidal). Revetments, rock armouring and embankments.		1 in 2010-2110.	55 in 2010. 60 in 2110.	Branchline railway. M4 motorway. Power/gas sub-stations. Severn N2K sites. Levels are a Historic Landscape. Cluster of Listed Buildings. Several current and historic landfill sites. Grade 3 land.	EWLs (100-0.1%AEP) 8.5-9.3m AOD. Wave heights (100-0.1%AEP) 0.9-1.4m. Modest correlation of wave-tide climate.

Flood cell	SMP2 policy	Standard of Service, source of flood risk and existing FRM assets	Photographs	Properties at risk in 0.1%AEP event		Key assets at risk	Extreme wave, tide and fluvial climate in 2010 (from Appendix C)
				Residential	Commercial		
Tidenham and Stroat	NAI (all epochs)	FRM assets are not present or redundant.		None.	None.	Branchline railway. Severn N2K sites. Some Grade 2 land. Two SMs. Broadstone and Roman Villa. Two Listed Buildings.	EWLs (100-0.1%AEP) 8.9-9.9mAOD. Wave heights (100-0.1%AEP) 0.5-1.3m. Modest correlation of wave-tide climate.
Lydney	HTL, HTL, MR	0.1%AEP (wave-tidal). Embankments and rock armouring.		52 in 2010. 105 in 2110.	114 in 2010. 168 in 2110.	Lydney harbour. Severn N2K sites. Lydney Cliff SSSI. Clusters of listed buildings. Some Grade 2 Land. Historic landfill sites.	EWLs (100-0.1%AEP) 9.1-10.1mAOD. Wave heights (100-0.1%AEP) 0.4-1.0m. Modest correlation of wave-tide climate.
Purton	NAI (all epochs)	20%AEP (tidal). Embankments.		None.	None.	Severn N2K sites. Grade 3 land. Cluster of listed buildings.	EWLs (100-0.1%AEP) 9.5-10.4mAOD. Wave heights (100-0.1%AEP) 0.4-1.0m. Modest correlation of wave-tide climate.
Awre	MR (all epochs)					Severn N2K sites. Grade 3 land. PRoWs.	
Bullo and Ruddle	NAI (all epochs)	FRM assets are not present.		None.	None.	2 Listed buildings.	EWLs (100-0.1%AEP) 9.4-10.4mAOD. Negligible wave climate. No correlation of fluvial-tidal climate.
Newnham-on-Severn	HTL (all epochs)	2%AEP (tidal). Embankments.		24 in 2010. 25 in 2110.	26 in 2010. 29 in 2110.	2-3 Listed buildings.	EWLs (100-0.1%AEP) 9.5-10.5mAOD. Negligible wave climate. No correlation of fluvial-tidal climate.
Westbury-on-Severn & Rodley	HTL (all epochs)	Generally 0.1%AEP, with 10%AEP low spot (tidal). Embankments.		58 in 2010. 66 in 2110.	125 in 2010. 152 in 2110.	Branchline railway. Approximately 90 listed buildings. PRoWs. Westbury House and Gardens.	EWLs (100-0.1%AEP) 9.6-10.5mAOD. Negligible wave climate. No correlation of fluvial-tidal climate.
Walmore Common	HTL (all epochs)	0.1%AEP (tidal). Embankments.		33 in 2010. 34 in 2110.	79 in 2010. 81 in 2110.	Walmore Common SPA, Ramsar, NNR and SSSI. Approximately 20 listed buildings.	EWLs (100-0.1%AEP) 9.7-10.4mAOD. Negligible wave climate. No correlation of fluvial-tidal climate.
Minsterworth	HTL (all epochs)	0.1%AEP (fluvial-tidal). Embankments.		19 in 2010. 21 in 2110.	53 in 2010. 54 in 2110.	Branchline railway. Few listed buildings. PRoWs including Gloucestershire Way.	EWLs (100-0.1%AEP) 9.5-10.2mAOD. Negligible wave climate. No correlation of fluvial-tidal climate.
Minsterworth Ham	MR (all epochs)	10%AEP (fluvial). Embankments.		24 in 2010. 36 in 2110.	80 in 2010. 96 in 2110.	Branchline railway. About 10 listed buildings. PRoWs including Gloucestershire Way.	EWLs (100-0.1%AEP) 9.5-10.2mAOD. Negligible wave climate. No correlation of fluvial-tidal climate.
The Rea	HTL (all epochs)	0.1%AEP (fluvial). Embankments and high ground.		15 in 2010. 16 in 2110.	61 in 2010. 93 in 2110.	Approximately 10 Listed Buildings. Gloucester Refuse tip.	EWLs (100-0.1%AEP) 9.5-10.1mAOD. Negligible wave climate. No correlation of fluvial-tidal climate.
Stonebench	HTL (all epochs)	0.5%AEP (fluvial). Embankments, walls and high ground.		4 in 2010. 5 in 2110.	4 in 2010. 6 in 2110.	Gloucester-Sharpness canal.	EWLs (100-0.1%AEP) 9.4-10.0mAOD. Negligible wave climate. No correlation of fluvial-tidal climate.

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Flood cell	SMP2 policy	Standard of Service, source of flood risk and existing FRM assets	Photographs	Properties at risk in 0.1%AEP event		Key assets at risk	Extreme wave, tide and fluvial climate in 2010 (from Appendix C)
				Residential	Commercial		
Elmore Back	HTL, MR, HTL	5%AEP (fluvial-tidal). Embankments.		24 in 2010. 25 in 2110.	88 in 2010. 90 in 2110.	Approximately 40 listed buildings. Severn Valley Way. Some Grade 2 land.	EWLs (100-0.1%AEP) 9.6-10.3mAOD. Negligible wave climate. No correlation of fluvial-tidal climate.
Longney	HTL, MR, HTL	0.1%AEP (tidal). Embankments.		40 in 2010. 42 in 2110.	80 in 2010. 91 in 2110.	Approximately 30 listed buildings. Severn Valley Way.	EWLs (100-0.1%AEP) 9.7-10.4mAOD. Negligible wave climate. No correlation of fluvial-tidal climate.
Upper Framilode	HTL (all epochs)	Generally 0.1%AEP, with 1%AEP low spot (tidal). Embankments and walls.		515 in 2010. 589 in 2110.	452 in 2010. 512 in 2110.	Gloucester-Sharpness canal. Severn N2K sites. Severn Valley Way, small clusters of listed buildings. Some Grade 2 land.	EWLs (100-0.1%AEP) 9.7-10.6mAOD. Negligible wave climate. No correlation of fluvial-tidal climate.
Arlingham	HTL, HTL, MR	0.1%AEP (tidal). Embankments.		89 in 2010. 114 in 2110.	175 in 2010. 209 in 2110.	Severn N2K sites. Approximately 30 listed buildings. Small historic landfill site. Some grade 2 land.	EWLs (100-0.1%AEP) 9.6-10.5mAOD. Negligible wave climate. No correlation of fluvial-tidal climate.
Slimbridge	MR, HTL, HTL	0.1%AEP (tidal). Embankments.		192 in 2010. 249 in 2110.	281 in 2010. 359 in 2110.	Gloucester-Sharpness canal. Severn N2K sites. Severn Estuary SSSI, Purton Passage SSSI, Frampton Pools SSSI. Historic Garden and Park at Frampton. Approximately 100 listed buildings. 2 SMs at Wansfield Court. Three landfill sites. Some Grade 3 land.	EWLs (100-0.1%AEP) 9.6-10.4mAOD. Wave heights (100-0.1%AEP) 0.4-1.0m. Modest correlation of wave-tide climate.
Berkeley to Littleton-upon-Severn.	HTL (all epochs)	Generally 2-0.5%AEP, with 10%AEP low spot (wave-tidal). Embankments and revetments.		398 in 2010. 471 in 2110.	1136 in 2010. 1332 in 2110.	Severn N2K sites, SSSIs. Berkeley Castle Historic Park and Garden. Over 300 listed buildings. Approximately 10 SMs. Three historic and one existing landfill sites. Berkeley and Oldbury nuclear power stations. Some Grade 3 land.	EWLs (100-0.1%AEP) 8.7-10.3mAOD. Wave heights (100-0.1%AEP) 0.3-1.4m. Modest correlation of wave-tide climate.
Avonmouth to Aust	HTL (all epochs)	Generally 0.5%AEP, with 5%AEP low spot (wave-tidal). Embankments, revetments and wave recurve walls.		3576 in 2010. 3764 in 2110.	2710 in 2010. 2853 in 2110.	Avonmouth Docks. Branchline railway. M4, M5, M48, M49 motorways. Power stations and sub-stations. Severn N2K sites. Two SSSIs. Clusters of Listed Buildings. Two SMs, approximately 10 historic and 6 existing landfill sites.	EWLs (100-0.1%AEP) 8.3-9.5mAOD. Wave heights (100-0.1%AEP) 0.6-2.6m. Modest correlation of wave-tide climate.

Flood cell	SMP2 policy	Standard of Service, source of flood risk and existing FRM assets	Photographs	Properties at risk in 0.1%AEP event		Key assets at risk	Extreme wave, tide and fluvial climate in 2010 (from Appendix C)
				Residential	Commercial		
Woodhill	NAI (all epochs)	0.1%AEP (wave-tidal). Seawalls.		None.	None.	Severn N2K sites and SSSIs.	EWLs (100-0.1%AEP) 8.3-9.2mAOD. Wave heights (100-0.1%AEP) 0.9-2.6m. Modest correlation of wave-tide climate.
Portbury	HTL (all epochs)	0.1%AEP (wave-tidal). Embankments.		3035 in 2010. 3412 in 2110.	1242 in 2010. 1606 in 2110.	Royal Portbury Docks. M5 motorway. Power sub-stations. Severn N2K sites. Gordano Valley NNR. 11 SSSIs. Approximately 35 listed buildings.	EWLs (100-0.1%AEP) 7.3-8.8mAOD. Wave heights (100-0.1%AEP) 1.6-4.4m. Modest correlation of wave-tide climate.
Clevedon to Weston-super-Mare	MR, MR, MR	Generally 0.1%AEP, with 5%AEP low spots (wave-tidal). Revetments, rock armouring and embankments.		34471 in 2010. 36281 in 2110.	6894 in 2010. 7348 in 2110.	M5 motorway. Mainline railway. Power sub-stations. Severn N2K sites. Two cSACs. Many SSSIs. Mendips AONB. Approximately 150 listed buildings. Two small landfill sites. Three Source Protection Zones. Some Grade 3 land.	
Brean to Burnham-on-Sea	HTL, MR, MR	0.5-0.1%AEP (wave-tidal). Revetments, rock armouring and embankments.		10532 in 2010. 10835 in 2110.	3624 in 2010. 3749 in 2110.	M5 motorway. Mainline railway. Power sub-stations. Severn N2K sites. Three SSSIs. Bridgwater Bay NNR. Over 20 listed buildings. Three SMs. Some Grade 3 land.	EWLs (100-0.1%AEP) 7.3-8.3mAOD. Wave heights (100-0.1%AEP) 2.5-5.0m. Modest correlation of wave-tide climate.
Huntspill	HTL, HTL, MR	0.1%AEP (wave-tidal). Revetments and embankments.		559 in 2010. 560 in 2110.	710 in 2010-2110.	M5 motorway. Mainline railway. Power sub-stations. Severn N2K sites. Huntspill River NNR, Bridgwater Bay SSSI. Over 10 Listed Buildings. One SM.	EWLs (100-0.1%AEP) 8.2-9.1mAOD. Wave heights (100-0.1%AEP) 2.3-4.5m. Modest correlation of wave-tide climate.
Pawlett	HTL, MR, HTL	0.1%AEP (tidal). Embankments.		76 in 2010. 86 in 2110.	322 in 2010. 333 in 2110.	M5 motorway. Mainline railway. Power sub-stations. Severn N2K sites. Bridgwater Bay NNR. Two Listed Buildings. One SM. Some Grade 2 land.	EWLs (100-0.1%AEP) 8.2-9.1mAOD. Negligible wave climate. No correlation of fluvial-tidal climate.
Steart Peninsula	MR, MR, MR	5%AEP (wave-tidal). Embankments and seawalls.		60 in 2010. 73 in 2110.	157 in 2010. 177 in 2110.	Severn N2K sites. Bridgwater Bay NNR. Approximately 10 Listed Buildings. Six SMs.	EWLs (100-0.1%AEP) 8.2-9.1mAOD. Wave heights (100-0.1%AEP) 2.3-4.5m. Modest correlation of wave-tide climate.

## 4 Options for managing flood risk

### 4.1 High Level Options

- 4.1.1 A High Level Option assessment has been completed, reviewing and expanding the policies identified previously at SMP2 level. These policies were transferred to a flood cell scale and a range of High Level Options considered for each flood cell.
- 4.1.2 The range of High Level Options are defined as:
- No Active Intervention. No further works would be carried out to manage flood risk, except relating to legal compliance such as public health and safety.
  - Maintain. Maintenance of flood / erosion defence assets, ensuring structural integrity and standard of service, but not accounting for climate change impacts.
  - Sustain. Improvements to assets that would be carried out to ensure the Standard of Protection remains consistent, and keeps pace with climate change.
  - Improve. Improvements to existing or construction of new assets, increasing the Standard of Protection over and above climate change impacts.
  - Managed Realignment. Realigning the location of the existing assets, either through a partial or full set-back to high ground.
  - Adaptation. This comprises a suite of sub-options for where the EA is unable to continue maintaining the entire length of defence and/or a tipping point is reached where increased flood frequency is impacting on land management practices. These include:
    - Working in partnership between public authorities, landowners and community to maintain and/or improve the existing defence.
    - Landowners taking on responsibility for the maintenance and/or improvements of the defences (subject to the appropriate consents or permissions being obtained).
    - Landowners, community and the EA exploring a voluntary managed realignment scheme to construct new defences, provide an improved standard of protection for properties and allow some land to be used for habitat creation.
    - Adapting properties, property access and land use to become more resilient to flooding.
    - Doing nothing and allowing the standard of protection to reduce as the condition of existing defences deteriorate
- 4.1.3 For each flood cell the High Level Options were further considered based on policy context, present day flood risk, environmental issues and socio-economic viability.
- 4.1.4 Potential Managed Realignment and Adaptation option locations were considered in a phased manner to understand whether they might be suitable sites for developing compensatory habitat. Several factors were considered; local expert input, ground elevation, proximity to built environment, minimum area, pollution sources, agricultural land quality, biotype and likely cost per hectare. This first-stage process identified a selection of potential locations and most likely timescales:
- Short term: Stroat, Awre, Minsterworth Ham, Slimbridge, various sites at Berkeley to Littleton-upon-Severn, various sites at Clevedon to Weston-super-Mare, Steart.
  - Medium to long term: various sites at Wentlooge Levels, various sites at Caldicot Levels, Mathern, Lydney, Westbury-on-Severn to Rodley, Elmore Back, Longney, Arlingham, various sites at Berkeley to Littleton-upon-Severn, Avonmouth to Aust, Brean to Burnham-on-Sea, Huntspill, Pawlett.
- 4.1.5 The outcome of this was the identification of one to three high level options suitable for further appraisal – see Table 4.1. From these high level options, Alignment and Type (long list) options for each unit was identified.

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**Table 4-1 Summary of Preferred High Level Options**

<b>Flood cell</b>	<b>Location</b>	<b>Preferred High Level Options*</b>
FC3-1, FC4-1, FC4-4, FC4-5, FC8-1	Tidenham, Purton, Bullo, Ruddle, Woodhill	No Active Intervention
FC1-P, FC1-0, FC2-1, FC4-6, FC4-7, FC4-8, FC4-9, FC5-3, FC5-4, FC8-0.	Penarth, Tremorfa, Mathern, Newnham-on-Severn, Westbury-on-Severn and Rodley, Walmore Common, Minsterworth, The Rea, Stonebench, Portbury.	Maintain, Sustain
FC1-1, FC1-2, FC2-0, FC5-7, FC6-1 to 6-3, FC7-0	Wentlooge Levels, River Ebbw to River Usk, Caldicot Levels, Upper Framilode, Berkeley to Littleton-upon-Severn, Avonmouth to Aust	Improve, Sustain
FC3-2, FC11-0	Stroat, Steart Peninsula	Managed Realignment
FC4-2, FC4-3, FC4-10, FC5-5, FC10-2	Awre, Minsterworth Ham, Elmore Back, Pawlett	Maintain, Adaptation
FC9-0	Clevedon to Weston-super-Mare	Improve, Sustain, Adaptation
FC3-3, FC5-6, FC5-8, FC5-9, FC10-0, FC10-1	Lydney, Longney, Arlingham, Slimbridge, Brean to Burnham-on-Sea, Huntspill	Maintain, Sustain, Adaptation

- 4.1.6 Estuary-wide options such as a tidal barrier across the estuary (circa £5 to £35 Billion dependent on location, sourced from the DECC Severn Tidal Power Feasibility Study) were not considered economically justifiable in FCERM-AG terms, and would significantly impact the internationally designated sites.

## 4.2 Asset Type (long list) options

- 4.2.1 The 'Asset Type' stage was undertaken for each flood cell, informed by the High Level Options but not excluding options where potential constraints (legal or funding) may limit implementation of the preferred High Level Option. This stage considered the type of technical solution to achieve the High Level Options, and where relevant for Managed Realignment, the range of alignments.
- 4.2.2 A wide range of the Maintain, Sustain and Improve options, technical solutions were considered, including:
- Maintenance, covering both reactive and proactive activities.
  - Soft or hard foreshore management: beach recharge/recycling, groynes and breakwaters.
  - Improvements to existing defences, and/or new flood defences: embankments, revetments and walls.
  - Secondary defences, set back with less risk exposure than front-line defences.
  - Point structures, relating to refurbishing and improvement of pumping stations, outfalls, regulated tidal exchange (RTE) or breaches.
  - Flood conveyance and storage.
  - Individual property protection (IPP) or resilience.
  - Demountable or temporary defences.
- 4.2.3 Non-structural measures to manage the consequences of risk include monitoring, flood risk awareness (education, flood forecasting, flood warning) and land management (development control, agricultural practice and aggregate dredging).
- 4.2.4 Options short-listed were determined based on assessment of the suitability of each option to the specific problem(s) for each unit. The Options Assessment Report in Appendix C (see Sections 5 to 6) details fully the tabulated process applied in the short-list selection.

## 4.3 FRM Response (short-list) options for appraisal

- 4.3.1 The technical short-listed options were developed into standard flood and erosion risk management options for detailed appraisal. A description of each option for each flood cell is detailed in Tables 4.2 to 4.5 below.
- 4.3.2 The options of Do Nothing, Do Minimum, Maintain and Sustain are common to either all or most of the flood cells. For succinctness they are not described in detail in Tables 4.2 to 4.5. The range of %AEP SoP considered for these options ranged from the existing %AEP SoP, reducing to 100%AEP SoP (effectively loss of FRM function).
- 4.3.3 For the options of Improve, Managed Realignment and Adaptation, the range of %AEP SoP considered was 2, 1, 0.5 and 0.1%AEP SoP.

**Table 4-2 Welsh coastline**

Flood cell and location	Option description
FC1-P: Penarth	Do Nothing, Do Minimum, Maintain, Sustain.
FC1-0, Tremorfa	Do Nothing, Do Minimum, Maintain, Sustain.
FC1-1, Wentlooge Levels	Do Nothing, Do Minimum, Maintain, Sustain.
	Improve: existing embankment near Sluice Farm improved with raising and/or hardening (rock armour, revetment or wave recurve).
FC1-2, River Ebbw to River Usk	Do Nothing, Do Minimum, Maintain, Sustain.
	Improve: existing FRM assets near Transporter Bridge improved with raising or hardening (rock armour, revetment or wave recurve).
FC2-0, Caldicot Levels	Do Nothing, Do Minimum, Maintain, Sustain.
	Improve: existing FRM assets near Transporter Bridge and Chapel Farm improved with raising or hardening (rock armour, revetment or wave recurve).
FC2-1, Mathern	Do Nothing, Do Minimum, Maintain, Sustain.

**Table 4-3 Gloucestershire west bank**

Flood cell and location	Option description
FC3-1, Tidenham	Do Nothing, Do Minimum.
FC3-2, Stroat	Do Nothing, Do Minimum.
	Managed realignment: localised breaching of existing embankments, constrained by embankment and railway.
FC3-3, Lydney	Do Nothing, Do Minimum, Maintain, Sustain.
	Adaptation: refer to list of options in section 4.1.2.
FC4-1, Purton	Do Nothing, Do Minimum.
FC4-3, Awre	Do Nothing, Do Minimum, Maintain.
	Adaptation: refer to list of options in section 4.1.2.
FC4-4, Bullo	Do Nothing, Do Minimum.
FC4-5, Ruddle	Do Nothing, Do Minimum.
FC4-6, Newnham-on-Severn	Do Nothing, Do Minimum, Maintain, Sustain.
FC4-7, Westbury-on-Severn & Rodley	Do Nothing, Do Minimum, Maintain, Sustain.
FC4-8, Walmore Common	Do Nothing, Do Minimum, Maintain, Sustain.
FC4-9, Minsterworth	Do Nothing, Do Minimum, Maintain, Sustain.
FC4-10, Minsterworth Ham	Do Nothing, Do Minimum, Maintain, Sustain.
	Adaptation: refer to list of options in section 4.1.2.



**Table 4-4 Gloucestershire east bank**

<b>Flood cell and location</b>	<b>Option description</b>
FC5-3, The Rea	Do Nothing, Do Minimum, Maintain, Sustain.
FC5-4, Stonebench	Do Nothing, Do Minimum, Maintain, Sustain.
FC5-5, Elmore Back	Do Nothing, Do Minimum, Maintain. Adaptation: refer to list of options in section 4.1.2.
FC5-6, Longney	Do Nothing, Do Minimum, Maintain, Sustain. Adaptation: refer to list of options in section 4.1.2.
FC5-7, Upper Framilode	Do Nothing, Do Minimum, Maintain, Sustain. Improve: existing embankment improved with raising or hardening (rock armour, revetment or wave recurve).
FC5-8, Arlingham	Do Nothing, Do Minimum, Maintain, Sustain. Adaptation: refer to list of options in section 4.1.2.
FC5-9, Slimbridge	Do Nothing, Do Minimum, Maintain, Sustain. Adaptation: refer to list of options in section 4.1.2.

**Table 4-5 South Gloucestershire, Avonmouth and Somerset coastline**

<b>Flood cell and location</b>	<b>Option description</b>
FC6-1 to 6-3, Berkeley, Shepperdine and Littleton-upon-Severn	Do Nothing, Do Minimum, Maintain, Sustain. Improve: existing embankment improved with raising or hardening (rock armour, revetment or wave recurve).
FC7-0, Avonmouth to Aust	Do Nothing, Do Minimum, Maintain, Sustain. Improve: existing embankment improved with raising or hardening (rock armour, revetment or wave recurve).
FC8-0, Portbury	Do Nothing, Do Minimum, Maintain, Sustain.
FC8-1, Woodhill	Do Nothing, Do Minimum, Maintain, Sustain.
FC9-0, Clevedon to Weston-super-Mare	Do Nothing, Do Minimum, Maintain, Sustain. Adaptation: refer to list of options in section 4.1.2. Improve: existing embankment improved with raising or hardening (rock armour, revetment or wave recurve).
FC10-0, Brean to Burnham-on-Sea	Do Nothing, Do Minimum, Maintain, Sustain. Adaptation: refer to list of options in section 4.1.2.
FC10-1, Huntspill	Do Nothing, Do Minimum, Maintain, Sustain. Adaptation: refer to list of options in section 4.1.2.
FC10-2, Pawlett	Do Nothing, Do Minimum, Maintain, Sustain. Adaptation: refer to list of options in section 4.1.2.
FC11-0, Steart Peninsula	Do Nothing, Do Minimum. Managed Realignment: localised breaching of existing embankments, with landward embankment construction.

## 5 Options appraisal and comparison

### 5.1 Technical issues

- 5.1.1 The assessment of High Level Options, and long and short-lists of options has provided confidence in identifying options which fulfil the technical objectives for each part of the Strategy area.
- 5.1.2 A wide range of modelling and engineering design guidance was used, described in the Options Assessment report (Appendix D – refer to Section 2).
- 5.1.3 **Climate change:** The impact of climate change has been assessed based on Environment Agency guidance (Adapting to Climate Change, 2010). This sets out a range of scenarios indicating sea level rise of 0.06-0.11m by 2030 and between 0.39-1.7m by 2110. **We are mindful that the current sea level rise trend being monitored in the Severn Estuary is approximately 2mm per year which is at the lower end of the scenarios presented in the guidance (refer to Permanent Service for Mean Sea Level website and studies by Cardiff University).**
- 5.1.4 **Option appraisal:** The appraisal over 100 years (to 2110) reflects the latest guidance on climate change. In the short term the option designs can include for the effects of climate change with relative certainty. In the longer term, the options designs will need to be flexible as the magnitude of climate change is relatively uncertain. This is reflected in the sea level rise indicated above.

### 5.2 Environmental assessment

- 5.2.1 The Environmental Assessment of Plans and Programmes Regulations 2004 (SEA Regulations) do not formally require a SEA of flood risk management strategies. However, in view of the environmental sensitivity of the Strategy area and in line with Environment Agency and Defra policy, a SEA Environmental Report was prepared and consulted on (Appendix E).
- 5.2.2 The key environmental constraints including environmental baseline features are discussed in Section 3.2 and presented in figures in the SEA Environmental Report (Appendix E).

#### Habitat Regulations

- 5.2.3 A HRA (including Appropriate Assessment) has been prepared to fulfil the requirements of The Conservation of Habitats and Species Regulations 2010 (as amended), which identified the potential for the Strategy to have significant impacts on the Severn Estuary SAC / SPA / Ramsar and Somerset Levels and Moors SPA / Ramsar sites.
- 5.2.4 The areas of designated habitat gains and losses calculated for the European sites are shown in Table 5.1. Where change is determined as man-made (i.e. due to the presence of flood defences), or uncertain in the short term (too complex to clearly identify as otherwise), the Environment Agency and Natural Resources Wales has a responsibility to address this. There would also be up to 6.2 Ha of direct designated intertidal habitat losses in the footprint of new, extended or raised defences in the long term.
- 5.2.5 40 Ha have been allocated from the Steart MR project as compensation for estimated historic losses. This 40Ha is not included in the Steart contribution to the habitat required to meet the future compensatory habitat requirements.

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**Table 5-1 Predicted habitat (mudflat, saltmarsh and transitional grassland) changes from FRM and uncertain causes in the European sites**

Climate change scenario	Change cause	Habitat change relative to 2010 <sup>1</sup> (Ha) without compensation		
		Short-term (2010 - 2030)	Medium-term (2030 - 2060)	Long-term (2060 - 2110)
Low 50%ile emissions	FRM	-300	-600	-900
	Uncertain		NA	
Medium 95%ile emissions	FRM	-427	-815	-1580
	Uncertain	-71	NA	
Upper end	FRM	-500	-900	-1700
	Uncertain		NA	

Note: <sup>1</sup> habitat change agreed to be the Environment Agency's responsibility in medium 95%ile emission scenario

## Water Framework Directive

- 5.2.6 A description of the surface water bodies potentially affected by the Strategy is provided in the WFD Assessment Report (Appendix E), which also assesses compliance with WFD requirements as discussed below.
- 5.2.7 The assessment concludes that implementation of the Strategy is not expected to cause deterioration in the status of any of the water bodies or prevent them from achieving their environmental objectives.
- 5.2.8 At Steart 478ha of previous intensively improved agricultural land have or are in the process of being replaced by 277ha of saltmarsh, 47ha of mudflat and 113ha coastal grazing marsh. The vast majority of saltmarsh and mudflat will be claimed under OM4b (excluding the 40ha for historic losses) . The coastal grazing marsh habitat created has been claimed under OM4a as it directly addresses a pressure identified in the South West River Basin District: Challenges and choices document, which identifies that pollution from rainwater running off of agricultural land affects nine internationally and 41 nationally protected wildlife sites in the South West River Basin District. Although the intertidal area has been created as coastal squeeze compensatory habitat its creation also has significant WFD benefits.

## Stakeholder Involvement and Consultation

- 5.2.9 Consultation was undertaken with statutory and other stakeholders during the Strategy and comprised email updates, newsletters, project website, targeted stakeholder meetings, public exhibitions and other reports/consultation brochures. In addition formal consultation has been undertaken as part of the SEA process. A full programme of the consultation undertaken is included in the SEA (Appendix E).
- 5.2.10 The local stakeholder engagement was deliberately targeted at those communities that might be affected by Adaptation or Managed Realignment options. There has been discussion of the sub-options with Adaptation (see section 4.1.2), as promoted by the EA's Asset Maintenance Protocol. This work has built the foundations of ongoing relationships between Parish Councils, landowners and the Area Partnership & Strategic Overview teams that will continue beyond the development of the strategy.

## Environmental Impacts of Alternative Options

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5.2.11 Table 5.2 summarises the key environmental impacts of alternative options for groups of flood cells with common features. Potential mitigation or enhancement opportunities common to all flood cells include:

- Do Nothing, Adaptation and Managed Realignment options: Provide information on Asset Maintenance Protocol, Flood Warning Service, Emergency Response Plans and Evacuation Plans. Engage with IDBs, NFU/FUW representatives regarding agricultural impacts. Project level studies relating to heritage, landscape and environmental designations. Consultation with stakeholders regarding ProW impacts.
- Maintain, Sustain or Improve options: Compensatory habitat required. Project level studies relating to heritage, landscape and environmental designations.

5.2.12 The significant environmental benefits of the Strategy are outlined in Section 6.

## 5.3 Option costs

5.3.1 Cost estimates for all options, prepared to a 2013 Q1 price date, include the capital costs and future operation, maintenance and repair costs for a 100 year appraisal period. A detailed summary of the costs for each option (for each flood cell) is included in the Options Assessment report (Appendix D, see Annex M).

5.3.2 A unit cost database developed for the Strategy included actual out-turn construction costs from Environment Agency projects. The quantities for each option were derived using a Bill of Quantities (BoQ) type method. Capital costs were determined based on the unit rates described and including construction allowances for general items and preliminaries. Remaining costs such as design and supervision costs were determined based on a percentage of the capital construction costs, dependent on scale of construction.

5.3.3 Maintenance requirements and costs for the various strategic options were identified and included in the whole life present value costs. Costs were included for options where future works would be required to enable the option to adapt for climate change.

## 5.4 Options benefits (damages avoided)

5.4.1 Benefit estimates for all options were based on depth damage data taken from the Multi Coloured Manual (MCM) Handbook, updated to a 2013 Q1 price date.

5.4.2 The benefits of each option include flood damage avoidance to properties, emergency services and railway infrastructure in line with FCERM-AG. Temporary accommodation costs of £6,695 for residential properties and £5,461 for non-residential properties are included, following guidance from the Flood Hazard Research Centre (FHRC).

5.4.3 Residential and non-residential property market values were obtained from the National Receptor Database and Land Registry rateable values. Threshold levels were obtained from LiDAR data with adjustment for floor level. These values were used to cap recurrent flood damages, such that the sum of PV damage over time did not exceed the market value of the asset.

5.4.4 Depth damage values were increased to account for additional salt water damage in line with guidance from the MCM.

5.4.5 Property flood damages have been capped at market value.

5.4.6 Agricultural damages were calculated following Defra guidance and applying average market values by agricultural grade. Environmental benefits were calculated using the standard (EFTEC) approach in line with Environment Agency guidance.

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- 5.4.7 For each flood cell the options benefits were calculated for Years 0, 20, 50 and 100, in order to take account of both rising sea levels and degrading defence condition.
- 5.4.8 The benefits are summarised in Section 6 and further details included in the Baseline Report (Appendix C, in Section 5 and Annex E) and Options Assessment Report (Appendix D in Annex N).
- 5.4.9 The effect on the business case of risk to life has been considered in sensitivity testing and shown not to affect the option selection.
- 5.4.10 The loss of Public Right of Way footpaths including parts of the South West Coastal Path (which would be lost for Do Nothing and Do Minimum options) were not determined since there are alternative routes for recreational value, and the loss to the UK would be negligible.

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**Table 5-2 Key environmental impacts, mitigation and opportunities**

Option	Key positive impacts	Key negative impacts
<b>Tidenham (FC3-1), Stroath (FC3-2), Purton (FC4-1), Awre (FC4-3), Bullo (FC4-4), Ruddle (FC4-5), Woodhill (FC8-1)</b>		
Do nothing	Allows naturally functioning system.	No protection to agricultural land (grade 2 to 4) and limited listed buildings.
Maintain	Limited.	Increasing flood risk to agricultural land (grade 2 to 4). Coastal squeeze for flood cells within the N2K sites.
Adaptation or MR	Potentially allows naturally functioning system, with creation of intertidal habitat.	No protection to agricultural land (grade 2 to 4).
<b>Penarth ((FC1-P), Tremorfa (FC1-0), Mathern (FC2-1), Newnham-on-Severn (FC4-6)</b>		
Do Nothing	Allows naturally functioning system.	No protection to limited population numbers and commercial assets.
Maintain	Limited.	Increased flood risk in the medium-long term to limited population numbers, commercial development and historic landscape and buildings. Coastal squeeze for flood cells within the N2K sites.
Sustain or Improve	Sustained or reduced flood risk in the short-long term to limited population numbers, commercial development and historic landscape and buildings.	Coastal squeeze and footprint impacts for flood cells within the N2K sites. Potential for localised landscape impacts in the medium-long term.
<b>Wentlooge Levels (FC1-1), River Ebbw to River Usk (FC1-2), Caldicot Levels (FC2-0), Westbury-on-Severn and Rodley (FC4-7), Walmore Common (FC4-8), Upper Framilode (FC5-7), Berkeley to Littleton-upon-Severn (FC6-1 to 6-3), Avonmouth to Aust (FC7-0), Portbury (FC8-0)</b>		
Do nothing	Allows naturally functioning system.	No protection to significant population numbers, industrial-commercial development, critical infrastructure, terrestrial SSSIs, heritage (listed buildings, SMs, park and garden) and landfill zones.
Maintain	Limited.	Increased flood risk in the medium-long term to significant population numbers, industrial-commercial development, critical infrastructure, terrestrial SSSIs, heritage (listed buildings, SMs, park and garden), landscape and landfill zones. Coastal squeeze for flood cells within the N2K sites.
Sustain or Improve	Sustained or reduced flood risk in the short-long term to significant population numbers, industrial-commercial development, critical infrastructure, terrestrial SSSIs, heritage (listed buildings, SMs, park and garden), landscape and landfill zones.	Coastal squeeze and footprint impacts for flood cells within the N2K sites. Potential for localised landscape impacts in the medium-long term.
<b>Lydney (FC3-3), Minsterworth Ham (FC4-10), Elmore Back (FC5-5), Longney (FC5-6), Arlingham (FC5-8), Slimbridge (FC5-9), Clevedon to Weston-super-Mare (FC9-0), Brean to Burnham-on-Sea (FC10-1), Huntspill (FC10-1), Pawlett (FC10-2), Steart Peninsula (C11-0)</b>		
Do Nothing	Allows naturally functioning system.	No protection to population numbers, commercial development, critical infrastructure, heritage (listed buildings, SMs) and landfill zones.
Maintain	Limited.	Increased flood risk in the long term to population numbers, commercial development, critical infrastructure and heritage (listed buildings, SMs). Coastal squeeze for flood cells within the N2K sites.
Sustain or Improve	Sustained or reduced flood risk in the long term to population numbers, commercial development, critical infrastructure and heritage (listed buildings, SMs).	Coastal squeeze and footprint impacts for flood cells within the N2K sites. Potential for localised landscape impacts in the long term.
Adaptation	Potentially allows naturally functioning system, with creation of intertidal habitat. Managed flood risk to population numbers, commercial development and critical infrastructure.	No protection to agricultural land (grade 2 to 4).
<b>Minsterworth (FC4-9), The Rea (FC5-3), , Stonebench (FC5-4)</b>		
Do nothing	Allows naturally functioning system.	No protection to population numbers.
Maintain	Limited.	Increased flood risk in the long term to population numbers. Coastal squeeze for flood cells within the N2K sites.
Sustain or Improve	Sustained or reduced flood risk in the long term to population numbers.	Coastal squeeze and footprint impacts for flood cells within the N2K sites. Potential for localised landscape impacts in the long term.

## 6 Selection and details of the Strategy

### 6.1 Option selection

- 6.1.1 This section details the selection of the options for the Strategy appraisal flood cells, based on the decision rule. In each case a benefit-cost assessment table is presented to determine the preferred economic option following the decision process of FCERM-AG. The environmentally preferred option and issues are also summarised for each flood cell to determine the overall preferred option. Further selection details are given in the Options Assessment Report (Appendix D).
- 6.1.2 The locations of Tidenham, Purton, Bullo, Ruddle and Woodhill have no assets at flood risk, have a preferred option of Do Nothing and are therefore not covered in the discussion.
- 6.1.3 The selection process is presented as follows:
- A. Locations with potential Improve options in the short term, prioritised in order of greatest risk to property and assets.
  - B. Locations with potential Maintain or Sustain options, to identify the progressive response to climate change over the next 100 years.
  - C. Locations with potential for Adaptation (including Managed Realignment), to help us understand the potential for a contribution towards meeting the strategic need for compensatory intertidal habitat to offset coastal squeeze and footprint impacts.

#### A. Improve and Sustain locations

- 6.1.4 Table 6.1 summarises the benefit-cost assessment for the potential Improve and Sustain option locations, that currently have a lower SoP in the FRM asset system. This includes consideration of managing assets in their current form (i.e. no further hardening of assets than there is presently), or managing assets with hardening (i.e. upgrading to rock armouring, revetments, vertical walls or wave recurve walls) by the most effective method.
- 6.1.5 At the Wentlooge Levels, River Ebbw to River Usk, and Caldicot Levels (all Wales), all Sustain or Improve options return high BCRs, with the highest BCR for Sustain or Improve defences in current form with 2%AEP SoP. As iBCRs are well above unity for all %AEP, the economically preferred option is Improve defences in current form with 0.1%AEP SoP. The environmentally preferred option is Improve, as a reduction in flood risk will benefit people, property, infrastructure and historic assets. All Sustain or Improve options would continue to cause intertidal habitat loss by coastal squeeze and direct footprint increase impacts within the Severn Estuary SPA, SAC and Ramsar. The selected option for Wentlooge Levels, River Ebbw to River Usk, and Caldicot Levels is Improve defences in current form with 0.1%AEP SoP, recommended as priority schemes within 5 years due to their strong economic case. Scheme level business cases are currently underway for the Wentlooge Levels and Caldicot Levels locations.
- 6.1.6 At Clevedon to Weston-super-Mare, all Sustain or Improve options return high BCRs, with the highest BCR for Sustain or Improve defences in best value hardened form with 2%AEP SoP. As iBCRs are well above 5 for all %AEP, the economically preferred option is Improve defences in best value hardened form with 0.1%AEP SoP. The environmentally preferred option is Improve, as a reduction in flood risk will benefit people, property, infrastructure and historic assets. All Improve options would continue to cause intertidal habitat loss by coastal squeeze and direct footprint increase impacts within the Severn Estuary SPA, SAC and Ramsar. The selected option is Improve defences in current form with 0.1%AEP SoP, recommended as a

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priority scheme within 5 years due to the strong economic case. A scheme level business case is currently underway.

- 6.1.7 At Upper Framilode, all Sustain or Improve options return high BCRs, with the highest BCR for Sustain or Improve defences in current form with 2%AEP SoP. As iBCRs are well above unity for all %AEP, the economically preferred option is Improve defences in current form with 0.1%AEP SoP. The environmentally preferred option is Improve, as a reduction in flood risk will benefit people, property, infrastructure and historic assets. The selected option is Improve defences in current form with 0.1%AEP SoP. Delivery is scheduled within 15 years as any scheme requires further engagement with the local communities, and may require Partnership Funding.
- 6.1.8 At Avonmouth to Aust, all Sustain or Improve options return high BCRs, with the highest BCR for Sustain or Improve defences in best value hardened form with 2%AEP SoP. As iBCRs are well above 5 for all %AEP, the economically preferred option is Improve defences in best value hardened form with 0.1%AEP SoP. The environmentally preferred option is Improve, as a reduction in flood risk will benefit people, property, infrastructure and historic assets. All Sustain or Improve options would continue to cause intertidal habitat loss by coastal squeeze and direct footprint increase impacts within the Severn Estuary SPA, SAC and Ramsar. The selected option is Improve defences in best value hardened form with 0.1%AEP SoP, recommended as a priority scheme within 5 years due to the strong economic case. However the majority of assets to be protected are business-related rather than homes, so outcomes measures are lower than might be expected and schemes will require partnership funding. The need for substantial future investment in defences for sustainable development has been identified in both South Gloucestershire and Bristol City Councils' Infrastructure Delivery Plans. We are working closely with these Councils on finding the best flood risk management measures and funding arrangement for around £65 Million of investment.
- 6.1.9 At Westbury-on-Severn to Rodley, the most favourable Sustain or Improve option under the decision rule is the 2%AEP SoP option. The iBCR of above unity justifies moving up to 1%AEP SoP. The environmentally preferred option is Improve, as a reduction in flood risk will benefit people, property, infrastructure and historic assets. The selected option is Improve defences in current form with 1%AEP SoP. Delivery is scheduled within 15 years as any scheme will be sensitive to the requirements of the National Trust in their management of Westbury Court water gardens, and would require Partnership Funding and further engagement with the local communities.
- 6.1.10 At Berkeley to Littleton-upon-Severn all Sustain or Improve options return high BCRs, with the highest BCR for Sustain or Improve defences in current form with 2%AEP SoP. The iBCRs vary between unity and 5, with the economically preferred option being Improve defences in current form with 1%AEP SoP. The environmentally preferred option is Improve, as a reduction in flood risk will benefit people, property, infrastructure and historic assets. All Sustain or Improve options would continue to cause intertidal habitat loss by coastal squeeze and direct footprint increase impacts within the Severn Estuary SPA, SAC and Ramsar. The selected option is Improve defences in current form with 1%AEP SoP. Delivery is scheduled within 15 years as any scheme requires Partnership Funding and further engagement with the local communities.

## B. Maintain and Sustain locations

- 6.1.11 Table 6.2 summarises the benefit-cost assessment for the potential Maintain and Sustain option locations, that currently have higher SoP in the FRM asset system and may require incremental improvement during or after the short term, to keep pace with climate change.
- 6.1.12 At Penarth and Mathern (both Wales), all options return BCRs around or above unity, with the highest BCR for Sustain defences in current form with 2%AEP SoP. As

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iBCRs are all below unity, this is the economically preferred option. The environmentally preferred option is Improve, as a reduction in flood risk will benefit people, property, infrastructure and historic assets. All Maintain or Sustain options would continue to cause intertidal habitat loss by coastal squeeze and/or direct footprint increase impacts within the Severn Estuary SPA, SAC and Ramsar. The selected option is Sustain defences in current form with 2%AEP SoP.

- 6.1.13 At Tremorfa (Wales), all options return high BCRs, with the highest BCR for Sustain defences in current form with 2%AEP SoP. As iBCRs are well above unity for all %AEP, the economically preferred option is Sustain defences in current form with 0.1%AEP SoP. The environmentally preferred option is Improve, as a reduction in flood risk will benefit people, property, infrastructure and historic assets. All Maintain or Sustain options would continue to cause intertidal habitat loss by coastal squeeze and/or direct footprint increase impacts within the Severn Estuary SPA, SAC and Ramsar. The selected option is Sustain defences in current form with 0.1%AEP SoP.
- 6.1.14 At Lydney, Walmore Common, Minsterworth, Longney, Arlingham, Slimbridge and Portbury all options return BCRs above unity, with the highest BCR for Sustain defences in current form with 2%AEP SoP. As iBCRs are above 5 for all %AEP, the economically preferred option for all locations is Sustain defences in current form with 0.1%AEP SoP. The environmentally preferred option is Maintain or Improve, as a maintained or reduced flood risk will benefit people, property, infrastructure and historic assets. All Maintain or Sustain options at Lydney, Slimbridge and Portbury would continue to cause intertidal habitat loss by coastal squeeze and/or direct footprint increase impacts within the Severn Estuary SPA, SAC and Ramsar. The selected option for all locations is Sustain defences in current form with 0.1%AEP SoP.
- 6.1.15 At Huntspill all options return BCRs above unity, with the highest BCR for Sustain defences in best value hardened form with 2%AEP SoP. As iBCRs are well above 5 for all %AEP, the economically preferred option for all locations is Sustain defences in best value hardened form with 0.1%AEP SoP. The environmentally preferred option is Maintain/Sustain, as no increase in flood risk will benefit people, property, infrastructure and historic assets. The Maintain or Sustain options would continue to cause intertidal habitat loss by coastal squeeze and/or direct footprint increase impacts within the Severn Estuary SPA, SAC and Ramsar. The selected option for all locations is Sustain defences in best value hardened form with 0.1%AEP SoP.
- 6.1.16 At Newnham-on-Severn, The Rea and Stonebench all options return BCRs above unity, with the highest BCR for Sustain defences in current form with 2%AEP SoP. As iBCRs are variable between unity and 5, the economically preferred option is Sustain defences in current form with 0.5%AEP SoP (The Rea), 1%AEP SoP (Stonebench) and 2%AEP SoP (Newnham-on-Severn). The environmentally preferred option is Maintain or Improve, as reduced or maintained flood risk will benefit people, property, infrastructure and historic assets. The selected option for all locations is Sustain defences in current form with SoP as defined above.

## C. Managed Realignment or Adaptation locations

- 6.1.17 Table 6.3 summarises the benefit-cost assessment for the potential Adaptation option locations. This identifies that the locations with clearly higher BCRs for Managed Realignment or Adaptation options, rather than Maintain, Sustain or Improve options are Stroat, Awre, Minsterworth Ham and Steart. These locations could meet the strategic need for compensatory intertidal habitat to offset coastal squeeze in the Strategy area in the short term, dependent on partnership working with local communities.
- 6.1.18 Stroat offers high potential for MR for up to 39 Ha of habitat creation (short to long term), with landward flooding constrained by natural ground levels and embankments. The MR option is the only option that returns a BCR that is greater than unity. The environmentally preferred option is NAI as it supports a naturally

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functioning system. It has a habitat creation cost of £34K/Ha. The preferred option is MR within 5 years; the scheme is currently being constructed.

- 6.1.19 Steart offers high potential for MR for up to 237 Ha of habitat creation in the short term (potentially increasing to 302 Ha after the short term), combined with Steart village road access protection via embankments. The MR option (2%AEP SoP) is initially selected as the economically preferred option, with iBCRs not warranting any high SoP. The environmentally preferred option is MR as it supports a naturally functioning system and significant compensatory habitat creation. It has a habitat creation cost of £83K/Ha. The preferred option is MR within 5 years; the scheme is currently being constructed.
- 6.1.20 Awre offers high potential for Adaptation. The most favourable Adaptation option under the decision rule is for localised breaching with landward flooding constrained by natural ground levels and embankments, potentially including 183 Ha of habitat creation. The Adaptation option is the only option that returns a BCR greater than unity. The environmentally preferred option is Adaptation as it supports a naturally functioning system and significant compensatory habitat creation. The habitat creation cost is £18K/Ha. The selected option is Adaptation, with the timescale to be determined by actual sea level rise. **This position may change with partnership working with landowners that is currently underway.**
- 6.1.21 Minsterworth Ham offers high potential for Adaptation. The most favourable Adaptation option under the decision rule is the 2%AEP SoP option with landward embankments and individual property protection (IPP), potentially including up to 261 Ha of habitat creation. The iBCR of 5 justifies moving up to the 1%AEP SoP option. The environmentally preferred option is Adaptation as it could support a naturally functioning system and significant compensatory habitat creation as salinity increases with climate change. The habitat creation cost is £4K/Ha. The selected option is Adaptation, with the timescale to be determined by actual sea level rise. **This position may change with partnership working with landowners that is currently underway.**
- 6.1.22 The locations of Elmore Back, Brean to Burnham-on-Sea, and Pawlett all have similar or higher BCRs for Adaptation options compared to Maintain, Sustain or Improve options. These locations could provide good potential for Adaptation options in the medium to long term, possibly including up to 1,093 Ha of habitat creation. This could meet the strategic need for compensatory intertidal habitat to offset coastal squeeze in the Strategy area in the medium to long term, with the timescale to be determined by actual sea level rise, partnership working with landowners and funding.
- 6.1.23 The locations of Lydney, Clevedon to Weston-super-Mare (Congresbury Yeo), Longney, Arlingham, Slimbridge and Huntspill all have similar or higher BCRs for Maintain, Sustain or Improve options, compared to Adaptation options. As the strategic need for compensatory habitat could be achieved from other sites, these locations are therefore considered further in the 'Improve and Sustain locations' and 'Maintain and Sustain locations' sections above. Nevertheless, these sites could still have potential for Adaptation options if actual sea level rise exceeds current estimates or funding is unavailable, dependent on partnership working with landowners.



Table 6-1 Benefit-cost assessment for potential Improve and Sustain locations.

LOCATION		Present Value benefits (£K)				
Relevant placename	Strategic flood sub-cell	Do Min SoP reduces over time	2% AEP SoP	1% AEP SoP	0.5% AEP SoP	0.1% AEP SoP
Wentlooge Levels	FC1-1	490,578	653,763	723,992	783,335	846,347
River Ebbw - River Usk	FC1-2	-157,346	133,089	147,446	159,723	176,018
Caldicot Levels	FC2-0	39,018	1,220,358	1,303,059	1,427,245	1,569,225
Westbury-on-Severn and	FC4-7	25,697	29,947	30,488	30,923	32,379
Wallmore Common	FC4-8	3,458	8,857	8,959	9,280	9,928
Upper Framilode	FC5-7	15,138	45,313	48,018	51,865	59,856
Arlingham	FC5-8	3,696	10,147	17,242	18,310	21,197
Berkeley to Littleton-upon-Severn	FC6-1,2,3	74,004	119,504	125,466	129,705	144,844
Avonmouth to Aust	FC7-0	91,841	575,704	614,405	642,510	712,486
Clevedon to Weston-Super-Mare	FC9-0	1,594,937	1,453,162	3,875,342	4,261,883	4,615,014

Present Value costs (£K)								
Do Min	Improving defences in their current form when and where necessary				Best value defence hardening when and where necessary			
SoP reduces over time	2% AEP SoP	1% AEP SoP	0.5% AEP SoP	0.1% AEP SoP	2% AEP SoP	1% AEP SoP	0.5% AEP SoP	0.1% AEP SoP
899	2,780	3,631	3,923	5,008	8,169	10,364	11,307	12,088
966	3,044	3,898	4,062	5,708	8,276	9,157	9,618	11,636
4,013	13,186	14,552	16,100	23,749	14,217	15,583	20,681	33,089
221	1,768	1,872	2,110	2,519	0	0	0	0
83	86	86	266	320	0	0	0	0
168	533	1,029	1,443	1,718	0	0	0	0
311	321	1,200	1,532	1,864	0	0	0	0
493	5,261	9,603	12,561	19,225	12,483	19,979	31,342	34,553
1,209	7,591	7,258	9,564	17,489	7,260	7,465	9,486	13,649
1,732	8,441	8,997	10,588	15,374	8,455	8,983	10,560	14,849

Benefit-Cost Ratios								
Do Min	Improving defences in their current form when and where necessary				Best value defence hardening when and where necessary			
SoP reduces over time	2% AEP SoP	1% AEP SoP	0.5% AEP SoP	0.1% AEP SoP	2% AEP SoP	1% AEP SoP	0.5% AEP SoP	0.1% AEP SoP
545.7	235.2	199.4	199.7	169.0	80.0	69.9	69.3	70.0
-162.9	43.7	37.8	39.3	30.8	16.1	16.1	16.6	15.1
9.7	92.5	89.5	88.7	66.1	85.8	83.6	69.0	47.4
116.3	16.9	16.3	14.7	12.9	NA	NA	NA	NA
41.6	NA	NA	34.9	31.0	NA	NA	NA	NA
89.9	85.0	46.6	35.9	34.8	NA	NA	NA	NA
11.9	NA	14.4	NA	11.4	NA	NA	NA	NA
150.0	22.7	13.1	10.3	7.5	9.6	6.3	4.1	4.2
76.0	75.8	84.6	67.2	40.7	79.3	82.3	67.7	52.2
920.7	172.2	430.7	402.5	300.2	171.9	431.4	403.6	310.8

Incremental Benefit-Cost Ratios								
Do Min	Improving defences in their current form when and where necessary				Best value defence hardening when and where necessary			
SoP reduces over time	2% AEP SoP	1% AEP SoP	0.5% AEP SoP	0.1% AEP SoP	2% AEP SoP	1% AEP SoP	0.5% AEP SoP	0.1% AEP SoP
NA	87	83	203	58	22	32	63	81
NA	140	17	75	10	40	16	27	8
NA	129	61	80	19	NA	61	24	11
NA	3	5	2	4	NA	NA	NA	NA
NA	NA	NA	32	12	NA	NA	NA	NA
NA	NA	5	9	29	NA	NA	NA	NA
NA	NA	15	NA	6	NA	NA	NA	NA
NA	10	1	1	2	NA	1	0	5
NA	NA	NA	12	9	80	188	14	17
NA	-21	4354	243	74	NA	4582	245	82

Note: NA identifies that calculation is not relevant or appropriate. Any negative PVb, BCR or iBCR is due to the continuation of property damage under low SoP options, compared to Do Minimum where properties are written off earlier.

Standard of Protection may be determined by overtopping or breach risk (refer to Appendix C for details). Flood risk to properties may be better than the SoP if storage is available behind the defence.

Table 6-2 Benefit-cost assessment for potential Maintain and Sustain locations.

LOCATION		Present Value benefits (£K)				
Relevant placename	Strategic flood sub-cell	Do Min SoP reduces over time	2% AEP SoP	1% AEP SoP	0.5% AEP SoP	0.1% AEP SoP
Penarth	FC1-P	0	299	256	320	369
Tremorfa	FC1-0	25,395	534,211	560,546	578,766	621,271
Mathern	FC2-1	4,297	8,110	8,469	9,059	9,709
Lydney	FC3-3	6,610	13,238	13,655	14,883	17,929
Newnham-on-Severn	FC4-6	6,184	8,683	8,600	8,729	9,080
Wallmore Common	FC4-8	3,458	8,857	8,959	9,280	9,928
Minsterworth	FC4-9	19,031	21,129	21,129	21,129	21,403
The Rea	FC5-3	4,638	5,996	6,544	6,911	7,461
Stonebench	FC5-4	888	1,303	1,303	1,303	1,303
Longney	FC5-6	5,127	8,913	9,178	9,404	10,362
Arlingham	FC5-8	3,696	10,147	17,242	18,310	21,197
Slimbridge	FC5-9	2,320	0	0	0	11,502
Portbury	FC8-0	10,108	0	0	0	67,294
Huntspill	FC10-1	3,511	53,132	53,819	56,449	66,279

Present Value costs (£K)									
Do Min	Improving defences in their current form when and where necessary				Best value defence hardening when and where necessary				
SoP reduces over time	2% AEP SoP	1% AEP SoP	0.5% AEP SoP	0.1% AEP SoP	2% AEP SoP	1% AEP SoP	0.5% AEP SoP	0.1% AEP SoP	
14	82	1	300	479	0	0	0	0	
1,139	1,218	1,872	1,872	2,043	0	0	0	0	
706	3,655	4,363	5,911	7,605	3,100	4,011	6,380	8,012	
173	574	574	805	1,332	0	0	0	0	
66	1,090	1,426	1,481	2,161	0	0	0	0	
83	86	86	266	320	0	0	0	0	
74	76	76	76	436	0	0	0	0	
164	392	392	392	2,714	0	0	0	0	
92	334	334	568	1,481	0	0	0	0	
124	488	548	548	629	0	0	0	0	
311	321	1,200	1,532	1,864	0	0	0	0	
254	801	908	908	1,047	0	0	0	0	
54	56	56	56	56	56	56	56	56	
389	110	110	110	180	0	0	0	0	

Benefit-Cost Ratios									
Do Min	Improving defences in their current form when and where necessary				Best value defence hardening when and where necessary				
SoP reduces over time	2% AEP SoP	1% AEP SoP	0.5% AEP SoP	0.1% AEP SoP	2% AEP SoP	1% AEP SoP	0.5% AEP SoP	0.1% AEP SoP	
0.0	3.7	1.3	1.1	0.8	NA	NA	NA	NA	
22.3	438.8	299.5	309.2	304.1	NA	NA	NA	NA	
6.1	2.2	1.9	1.5	1.3	2.6	2.1	1.4	1.2	
38.3	23.1	23.8	18.5	13.5	NA	NA	NA	NA	
94.0	8.0	6.0	5.9	4.2	NA	NA	NA	NA	
41.6	NA	NA	34.9	31.0	NA	NA	NA	NA	
258.4	NA	NA	NA	49.1	NA	NA	NA	NA	
28.2	15.3	16.7	17.6	2.7	NA	NA	NA	NA	
9.7	3.9	3.9	2.3	0.9	NA	NA	NA	NA	
41.2	18.3	16.7	17.2	16.5	NA	NA	NA	NA	
11.9	NA	14.4	NA	11.4	NA	NA	NA	NA	
9.1	0.0	0.0	0.0	11.0	NA	NA	NA	NA	
187.4	NA	NA	NA	NA	NA	NA	NA	NA	
9.0	482.7	488.9	512.8	368.5	NA	NA	NA	NA	

Incremental Benefit-Cost Ratios									
Do Min	Improving defences in their current form when and where necessary				Best value defence hardening when and where necessary				
SoP reduces over time	2% AEP SoP	1% AEP SoP	0.5% AEP SoP	0.1% AEP SoP	2% AEP SoP	1% AEP SoP	0.5% AEP SoP	0.1% AEP SoP	
NA	4	0	1	0	NA	NA	NA	NA	
NA	6513	40	NA	248	NA	NA	NA	NA	
NA	1	1	0	0	2	0	0	0	
NA	17	NA	5	6	NA	NA	NA	NA	
NA	2	0	2	1	NA	NA	NA	NA	
NA	NA	NA	32	12	NA	NA	NA	NA	
NA	NA	NA	NA	7	NA	NA	NA	NA	
NA	NA	NA	NA	0	NA	NA	NA	NA	
NA	NA	NA	0	0	NA	NA	NA	NA	
NA	10	NA	NA	10	NA	NA	NA	NA	
NA	NA	15	NA	6	NA	NA	NA	NA	
NA	NA	NA	NA	83	NA	NA	NA	NA	
NA	NA	NA	NA	NA	NA	NA	NA	NA	
NA	NA	NA	NA	141	NA	NA	NA	NA	

Note: NA identifies that calculation is not relevant or appropriate. Any negative PVb, BCR or iBCR is due to the continuation of property damage under low SoP options, compared to Do Minimum where properties are written off earlier.

Standard of Protection may be determined by overtopping or breach risk (refer to Appendix C for details). Flood risk to properties may be better than the SoP if storage is available behind the defence.

Table 6-3 Benefit-cost assessment for potential Managed Realignment and Adaptation locations.

LOCATION		Present Value benefits (£K)					
Relevant placename	Strategic flood sub-cell	Do Min SoP reduces over time	2% AEP SoP	1% AEP SoP	0.5% AEP SoP	0.1% AEP SoP	MR environmental benefits
Stroat	FC3-2	0	0	0	0	0	3,345
Lydney	FC3-3	6,610	13,238	13,655	14,883	17,929	2,777
Awre	FC4-3	0	0	0	0	0	12,262
Minsterworth Ham	FC4-10	10,336	15,823	16,557	16,854	17,545	32,213
Elmore Back	FC5-5	2,429	5,413	5,413	5,213	6,283	12,246
Longney	FC5-6	5,127	8,913	9,178	9,404	10,362	7,130
Upper Framilode	FC5-7	15,138	45,313	48,018	51,865	59,856	0
Arlingham	FC5-8	3,696	10,147	17,242	18,310	21,197	4,731
Slimbridge	FC5-9	2,320	0	0	0	11,502	15,488
Clevedon to Weston-Super-Mare	FC9-0	1,594,937	1,453,162	3,875,342	4,261,883	4,615,014	31,721
Brean to Burnham-on-Sea	FC10-0	115,408	1,962,489	2,024,761	2,062,676	2,163,473	13,417
Huntspill	FC10-1	3,511	53,132	53,819	56,449	66,279	2,653
Pawlett	FC10-2	31,631	42,201	43,717	46,019	51,104	24,707
Steart Peninsula	FC11-0	5,840	21,650	22,637	23,073	24,769	39,488

Present Value costs (£K)								
Do Min	Improving defences in their current form when and where necessary				Best value improvements and construction of realignments when and where relevant			
SoP reduces over time	2% AEP SoP	1% AEP SoP	0.5% AEP SoP	0.1% AEP SoP	2% AEP SoP	1% AEP SoP	0.5% AEP SoP	0.1% AEP SoP
67	0	0	0	0	1,322	1,322	1,322	1,322
173	574	574	805	1,332	1,736	1,857	1,857	1,857
118	3,921	6,476	6,476	8,956	3,238	3,238	3,238	3,238
324	1,106	1,106	1,267	5,815	1,295	1,295	1,726	1,726
201	2,547	2,647	3,467	5,722	10,397	11,424	11,424	12,377
124	488	548	548	629	2,433	2,433	2,433	2,950
168	533	1,029	1,443	1,718	0	0	0	0
311	321	1,200	1,532	1,864	0	0	0	2,577
254	801	908	908	1,047	4,998	4,998	4,998	5,056
1,732	8,441	8,997	10,588	15,374	13,597	13,685	13,878	15,566
836	1,220	1,501	2,310	3,891	4,146	4,146	4,169	4,307
389	110	110	110	180	1,121	1,121	1,277	1,277
413	687	687	879	1,915	3,276	3,276	3,276	3,276
865	9,369	11,745	13,904	19,763	20,489	21,968	23,084	24,159

Benefit-Cost Ratios								
Do Min	Improving defences in their current form when and where necessary				Best value improvements and construction of realignments when and where relevant			
SoP reduces over time	2% AEP SoP	1% AEP SoP	0.5% AEP SoP	0.1% AEP SoP	2% AEP SoP	1% AEP SoP	0.5% AEP SoP	0.1% AEP SoP
NA	NA	NA	NA	NA	2.5	2.5	2.5	2.5
38.3	23.1	23.8	18.5	13.5	9.2	8.8	9.5	11.1
NA	0.0	0.0	0.0	0.0	3.8	3.8	3.8	3.8
31.9	14.3	15.0	13.3	3.0	37.1	37.7	28.4	28.8
12.1	2.1	2.0	1.5	1.1	1.7	1.5	1.5	1.5
41.2	18.3	16.7	17.2	16.5	6.6	6.7	6.8	5.9
89.9	85.0	46.6	35.9	34.8	NA	NA	NA	NA
11.9	NA	14.4	NA	11.4	NA	NA	NA	10.1
9.1	0.0	0.0	0.0	11.0	3.1	3.1	3.1	5.3
920.7	172.2	430.7	402.5	300.2	109.2	285.5	309.4	298.5
138.1	1609.0	1349.1	892.8	556.0	476.6	491.6	498.0	505.5
9.0	482.7	488.9	512.8	368.5	49.8	50.4	46.3	54.0
76.6	61.4	63.6	52.4	26.7	20.4	20.9	21.6	23.1
6.8	2.3	1.9	1.7	1.3	3.0	2.8	2.7	2.7

Incremental Benefit-Cost Ratios								
Do Min	Improving defences in their current form when and where necessary				Best value improvements and construction of realignments when and where relevant			
SoP reduces over time	2% AEP SoP	1% AEP SoP	0.5% AEP SoP	0.1% AEP SoP	2% AEP SoP	1% AEP SoP	0.5% AEP SoP	0.1% AEP SoP
NA	NA	NA	NA	NA	NA	NA	NA	NA
NA	17	NA	5	6	4	NA	NA	NA
NA	NA	NA	NA	NA	NA	NA	NA	NA
NA	7	NA	2	NA	6	NA	1	NA
NA	1	0	0	0	NA	0	NA	1
NA	10	NA	NA	10	NA	NA	NA	2
NA	NA	5	9	29	NA	NA	NA	NA
NA	NA	15	NA	6	NA	NA	NA	8
NA	NA	NA	NA	83	NA	NA	NA	197
NA	-21	4354	243	74	NA	27526	1994	209
NA	4809	221	47	64	NA	NA	1608	734
NA	NA	NA	NA	141	NA	69	NA	80
NA	NA	NA	12	5	NA	NA	NA	7
NA	2	0	0	0	1	1	0	2

Note: NA identifies that calculation is not relevant or appropriate. Any negative PVb, BCR or iBCR is due to the continuation of property damage under low SoP options, compared to Do Minimum where properties are written off earlier.

Standard of Protection may be determined by overtopping or breach risk (refer to Appendix C for details). Flood risk to properties may be better than the SoP if storage is available behind the defence.

## 6.2 Sensitivity testing

- 6.2.1 The latest climate change guidance 'Adapting to Climate Change: Advice for FCERM Authorities' (EA, 2010), Annex B, sets out how to apply variable climate change scenarios to options development to enable flexible, adaptive approaches. This methodology was applied in the Strategy, and agreed with the climate change guidance authors and LPRG representatives in October 2011.
- 6.2.2 The climate change testing determined the potential for options to switch significantly to different forms of intervention. Assessments were made on switching of options due to the range of low 50%ile, medium 95%ile, upper end and upper end plus surge climate change scenarios. Further testing assessed alternative forms of options such as primary-secondary alignment systems, particularly where continued defence raising could become impractical.
- 6.2.3 A summary of the sensitivity testing for specific reaches is given below, with further details given in the Options Assessment Report (Appendix D).

### Alternative FRM system approaches

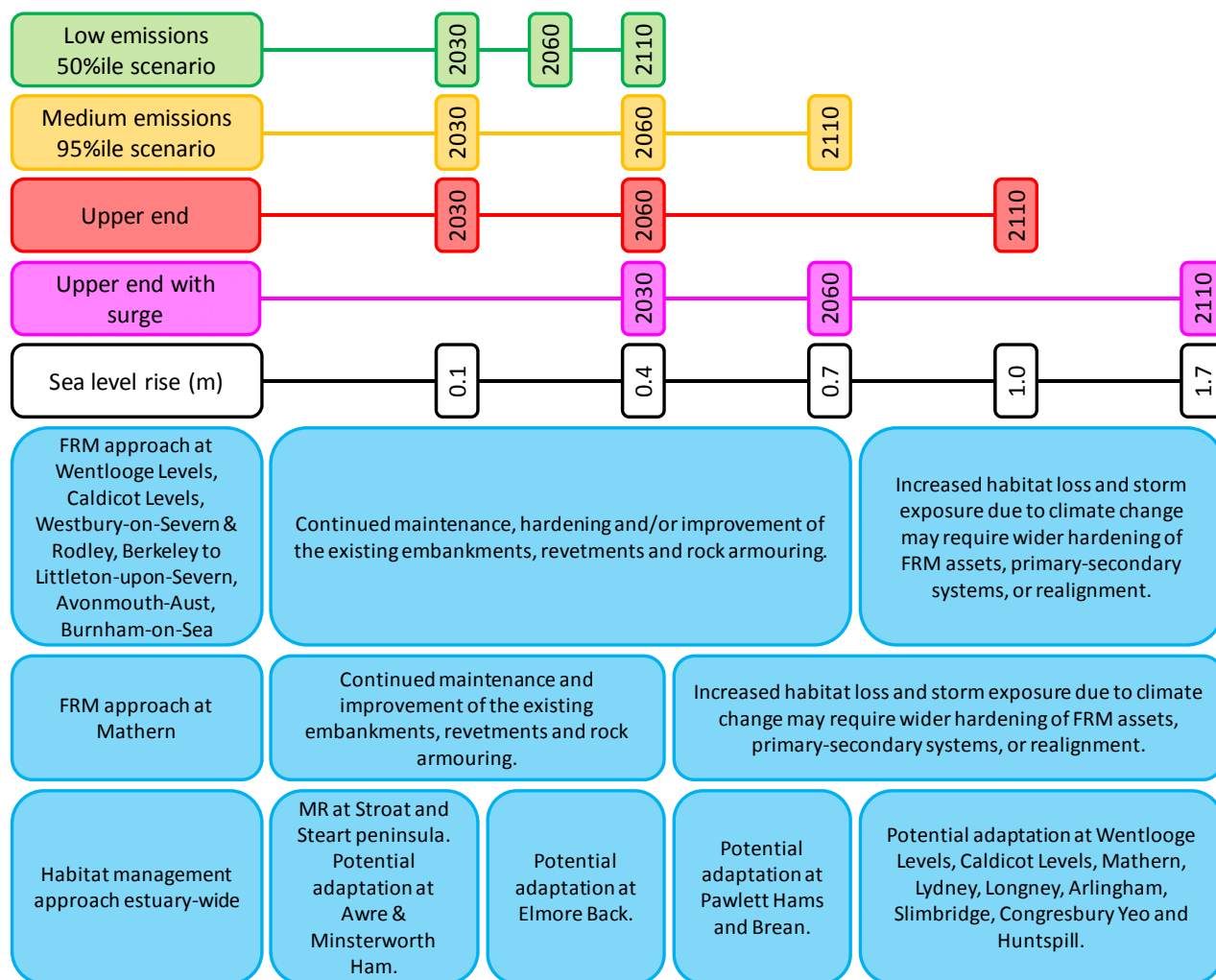
- 6.2.4 Climate change variations could affect the likely form of FRM systems. Under the low 50%ile scenario, the proposed Strategy would remain the same in form, with the magnitude of incremental improvements reduced in the medium to long term.
- 6.2.5 Under the upper end and upper end plus surge scenarios, primary-secondary alignment systems were considered along the Wentlooge Levels, Caldicot Levels, Mathern, Westbury-on-Severn and Rodley, and Berkeley to Littleton-upon-Severn. The proposed Strategy options were found to remain robust in their general form (continued primary alignment improvements), with more extensive hardening becoming prevalent to reduce raising requirements. However, the economic case for alternatives at Mathern was found to be very similar to the proposed Strategy. **These findings are summarised in Table 6-4.**

### Compensatory habitat

- 6.2.6 Climate change variations could reduce or increase the requirement for compensatory habitat, predominantly in the medium to long term. **These findings are summarised in Table 6-4.** The Stroata and Steart MR options (both underway) remain robust under all climate change scenarios.
- 6.2.7 Under the low 50%ile scenario (which is similar to that currently being recorded), Adaptation locations could generally be delayed or no longer required. Awre could be delayed until the medium term and Elmore Back until the long term, with other locations not required. This would be dependent on partnership working with local communities.
- 6.2.8 Further locations may require Adaptation options to be considered under the upper end and upper end plus surge scenarios, but only in the medium to long term. This could affect the locations of Lydney, Clevedon to Weston-super-Mare (Congresbury Yeo), Longney, Arlingham, Slimbridge and Huntspill, giving potential opportunities for additional compensatory habitat. This would be dependent on partnership working with local communities.

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**Table 6-4 Adapting FRM system responses to actual sea level rise**



## Potential developments

- 6.2.9 Consideration was further made of possible developments including aggregate dredging, nuclear power stations, tidal power proposals, and dock expansion.
- 6.2.10 Continued aggregate dredging of licensed sandflats could result in reduced wave attenuation within the estuary. An assessment of the possible sandflat lowering and increased wave heights along the estuary coastline indicated that options would be unlikely to be affected in form, although some minor further FRM asset raising may be required.
- 6.2.11 Available information on nuclear power station proposals at Oldbury and Hinkley indicates that option influences would only be localised and not strategic.
- 6.2.12 The tidal power proposals within the DECC (2010) study were assessed. All the proposals were found to not be economically preferable as an alternative to conventional FRM system improvements.
- 6.2.13 Available information on dock expansion proposals at Avonmouth indicates that there could be alternative, economically preferred alignment landward or seaward of the docks, dependent on the detailed form of the dock expansion proposals.

## Estuary-wide impacts

- 6.2.14 Consideration was also made of possible estuary-wide impacts from changes in asset management.

- 6.2.15 The CHaMP model was used to assess the impact of complete realignment around the estuary, finding limited impact on water levels. Further to this a consideration of the potential level of 'far-field' geomorphological change related to all the potential realignment sites was described. Details of this work are given in the Baseline Assessment report (Appendix C).
- 6.2.16 Fluvial-tidal interaction impacts were assessed using ISIS-TUFLOW in the upper estuary (Sharpness and upstream). The wider upper estuary impacts for Improve and Sustain options (continuation of the existing FCRM system), complete realignment, and the preferred strategy (a combination of options) are documented in the Strategic Options Assessment report (Appendix D). However, economic impacts and option sensitivity within the upper estuary where hydraulic impacts are felt (mainly Elmore Back and upstream) are very limited, due to the lack of significant development in these areas.
- 6.2.17 More generally, it should be noted that the vast majority of realignment sites are extremely small compared to the scale of the Severn Estuary (for example the short term realignment sites represent much less than 1% change in the estuary area).

## 6.3 Details of the preferred options

### Technical aspects

- 6.3.1 Priority improvement schemes to be delivered in the next 5 years consist of:
- Wentlooge Levels (at Sluice Farm): 0.1%AEP SoP via up to 0.7km of earth embankment raising of up to 0.6m.
  - River Ebbw to River Usk (near Transporter Bridge): 0.1%AEP SoP via construction of up to 1.1km of new hard defences.
  - Caldicot Levels (near Transporter Bridge and Chapel Farm): 0.1%AEP SoP via up to 1.2km of embankment raising of up to 0.6m near Transporter Bridge, and up to 1.5km of revetment raising at Chapel Farm of up to 0.2m.
  - Avonmouth to Aust: 0.1%AEP SoP via up to 9.5km of embankment, revetment and wall raising of up to 0.4m.
  - Clevedon to Weston-super-Mare (at Congresbury Yeo): 0.1%AEP SoP via embankment raising of up to 0.5m, with localised realignment.
- 6.3.2 Short term improvement schemes to be delivered in the next 15 years consist of:
- Westbury-on-Severn and Rodley: 1%AEP SoP via embankment raising of up to 0.4m.
  - Upper Framilode: 0.1%AEP SoP via embankment raising of up to 0.3m.
  - Berkeley, Shepperdine and Littleton-upon-Severn: 1%AEP SoP via embankment raising of up to 0.6m.
- 6.3.3 The medium to long term programme to keep pace with climate change would consist of improvements to FRM assets in their current form for the majority of flood cells. The exceptions to this, where increasing wave exposure requires more efficient hardening of assets, consist of Avonmouth to Aust, Clevedon to Weston-super-Mare, Brean to Burnham-on-Sea and Huntspill. Asset raising at all locations is generally up to 1m, although localised wave exposure may require raising of up to 2m locally along Clevedon to Weston-super-Mare.
- 6.3.4 The Strategy is likely to adversely affect the Severn Estuary SAC / SPA / Ramsar and Somerset Levels and Moors SPA / Ramsar sites. Compensatory habitat is required to address a range of potential impacts as a result of coastal squeeze and footprint impact losses. Priority compensatory habitat schemes to be delivered in the next 5 years consist of:

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- Stroat (near Alvington and Plusterwine): Managed Realignment of 39Ha via localised breaching of existing embankments, and use of landward embankments to constrain flooding.
- Steart: Managed Realignment of 237Ha via localised breaching of existing FRM assets, and use of landward embankments to constrain flooding and maintain road access to Steart village.

6.3.5 Short term Adaptation locations, to be delivered in the next 15 years, that could provide opportunity for compensatory habitat consisting of Awre (possible localised breaches), and Minsterworth Ham (possible 1%AEP SoP via localised breaches, landward embankment and IPP). The priority and short term Managed Realignment and Adaptation options identified, could result in a maximum cumulative habitat gain of c220Ha above compensation requirements, under the medium 95%ile emissions scenario. A substantial proportion of the potential gain is related to Minsterworth Ham site at the head of the estuary. Habitat there would be freshwater for many years so would initially be more aligned towards WFD targets. In the longer term this site could reduce the requirement for intertidal habitat because the estuary features would have room to expand upstream as sea level rise occurs.

6.3.6 Medium to long term Adaptation locations, that could provide opportunity for compensatory habitat consist of Elmore Back (2%AEP SoP via localised breaching and landward embankments), Brean (0.1%AEP SoP via localised breaching and landward embankments) and Pawlett (0.1%AEP SoP via localised breaching). If all Adaption options become managed realignment schemes it is possible that there may be a total habitat gain of 300ha by the end of the 100 year period, under the medium 95% emissions scenario.

## Environmental aspects

6.3.7 The Strategy will manage flood risks to the majority of properties in cities, towns and villages around the estuary, through an adaptive approach to rising sea levels and increasing rainfall.

6.3.8 Significant beneficial impacts of the Strategy will include:

- Reduced flood risk over the long-term to around 180,000 people and 111,588 residential and commercial properties, community, recreational and amenity facilities in the major centres of population.
- Reduced flood risk to critical infrastructure and key transport routes including roads and the main railway.
- Continued protection of areas designated for future development.
- Where Do Nothing and Managed Realignment policies form part of the Strategy, the coastal system will be allowed to function naturally, ensuring no adverse effects to designated intertidal habitats in most parts of the Strategy area.
- In total, the Strategy has the potential to create up to 1,945 Ha of compensatory habitat. This will contribute to the biodiversity strategy for the UK.
- Do Nothing, Managed Realignment and Adaptation options could help to restore a more natural system, which will make significant contributions to the achievement of the WFD.
- Reduced flood risk to the historic built environment, and protection of and potential to restore historic landscapes and protection of archaeological remains behind defences.

6.3.9 Mitigation measures are proposed for all negative impacts arising from the Strategy, as detailed in the SEA Environmental Report (Appendix E) and HRA. The mitigation

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measures will be reviewed and assessed as projects are taken forward and design details become available. This will need to be reflected in any Form A, PARs and project level EIAs, HRAs and WFD assessments. Negative impacts include:

- Some isolated properties, minor roads, railways and areas of agricultural land may continue to be affected by an increasing flood risk.
- Potential for a deterioration in views for recreational users, road users and property occupants in later epochs, as FRM assets are raised to manage flood risk from rising sea levels.
- Increasing flood risk to parts of the South West Coast Path.
- Likely loss of internationally designated inter-tidal habitat in the footprint of new or improved FRM assets, and change due to coastal squeeze within the Severn Estuary SAC / SPA / Ramsar and potential impacts to the Somerset Levels and Moors SPA / Ramsar as a result of preferred policy options, with associated impacts on birds (these will be offset by habitat gains elsewhere – see beneficial impacts).
- Some impacts on local conservation sites will need to be carefully managed at project level to avoid adverse impacts.
- FRM asset works may result in additional encroachment of engineered structures into the Severn Estuary, and attention will be needed at scheme level to ensure that these are delivered with appropriate mitigation measures.
- Potential loss of areas of post-medieval reclaimed enclosures where Managed Realignment and/or Adaptation options are recommended.

6.3.10 Uncertain impacts include potential changes in landscape character, which will require further consideration at project level.

6.3.11 The environmental effects of implementing the Strategy against the predictions made by the SEA will be monitored to ensure that the mitigation measures are effective and identify any unforeseen environmental effects. The monitoring plan is provided in the Environmental Report (Appendix E).

## 6.4 Summary of preferred strategy

6.4.1 **Table 6-5** below (next page) shows a summary of the costs for each selected option, split by capital and non-capital expenditure for maintenance.

### Contributions and funding

6.4.2 The Flood and Coastal Resilience Partnership Funding model has been applied to the schemes recommended in this Strategy. Table 7.4 provides the key Outcome Measure data and shows the amount of FCRM GiA potentially available for each capital improvement scheme. Contributions will be sought from partners for all FRM schemes.

6.4.3 Maintenance of existing defences will be determined according to revenue funding priorities and potential maintenance partnerships. Development of such partnerships is the responsibility of the Partnerships & Strategic Overview Teams. The first in the estuary is under negotiation for the Awre peninsula in Gloucestershire.

### Health, safety and sustainable construction

6.4.4 Health and safety elements form a key consideration in design development. At this stage the options are not sufficiently developed to allow a comprehensive assessment of all the health and safety issues. However, the following generic risks have been considered as part of the option appraisal process.

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- 6.4.5 **Flood risk:** The majority of the strategy area is low lying with a flat topography and extreme water levels will lead to rapid flood water progression.
- 6.4.6 **Adaptation including Managed Realignment:** Under certain scenarios, local access ways may be at risk of being inundated during extreme tides. This would require appropriate warning systems and signage. Consideration of these changes would be included within emergency arrangements and the emergency plans modified accordingly.
- 6.4.7 **Access:** These are often open to public access and appropriate design and signage will be required to alert members of the public to the local hazards. Steep embankments and sea walls can create difficulties with access. Consideration should be given during the design of the structures for appropriate access and any signage arrangements required.
- 6.4.8 A fundamental aim of option development has been to identify and achieve integrated engineering, environmental and sustainable solutions. This approach will be further developed within the future scheme detailed appraisal development and subsequent detail design stages.

**Table 6-5 Summary of preferred strategy**

Flood cell	SoP (%AEP)		PV costs (£K)			PV benefits (£K)	Average BCR	Cash costs (£K)		
	Short term	Long term	Capital	Maintenance	Total			Capital	Maintenance	Total
Penarth	5	2	67	15	82	299	4	625	50	675
Tremorfa	0.1	0.1	846	1,197	2,043	621,271	304	10,913	4,072	14,985
Wentlooge Levels	0.1	0.1	3,952	1,056	5,008	846,347	169	27,451	1,574	29,025
River Ebbw to River Usk	0.1	0.1	4,677	1,031	5,708	176,018	31	21,874	1,433	23,307
Caldicot Levels	0.1	0.1	19,588	4,160	23,749	1,569,225	66	74,498	6,368	80,866
Mathern	0.5	2	2,914	741	3,655	8,110	2	20,011	2,533	22,544
Tidenham	DN	DN	0	0	0	0	NA	0	0	0
Stroat	MR	MR	1,322	0	1,322	3,345	3	1,322	0	1,322
Lydney	0.1	0.1	1,204	128	1,332	17,929	13	8,095	130	8,225
Purton	DN	DN	0	0	0	0	NA	0	0	0
Awre	Adapt	Adapt	3,238	0	3,238	12,262	4	3,238	0	3,238
Bullo	DN	DN	0	0	0	0	NA	0	0	0
Ruddle	DN	DN	0	0	0	0	NA	0	0	0
Newnham-on-Severn	2	2	1,055	35	1,090	8,683	8	4,556	35	4,591
Wesbury-on-Severn and Rodley	1	1	1,643	228	1,872	30,488	16	5,274	232	5,506
Walmore Common	0.1	0.1	234	86	320	9,928	31	1,953	87	2,040
Minsterworth	0.1	0.1	360	76	436	17,545	40	1,779	77	1,856
Minsterworth Ham	Adapt	Adapt	1,219	76	1,295	48,770	38	4,275	76	4,351
The Rea	0.1	0.5	223	169	392	6,911	18	1,103	173	1,276
Stonebench	0.5	1	240	94	334	1,303	4	2,062	96	2,158
Elmore Back	2	Adapt	10,331	66	10,397	17,660	2	19,861	66	19,927
Longney	0.1	0.1	501	128	629	10,362	16	4,553	131	4,683
Upper Framilode	0.1	0.1	1,542	176	1,718	59,856	35	6,050	270	6,320
Arlingham	0.1	0.1	1,537	327	1,864	21,197	11	12,950	333	13,283
Slimbridge	0.1	0.1	785	261	1,047	11,502	11	7,481	267	7,747
Berkeley to Littleton-upon-Severn	1	1	9,070	533	9,603	129,705	14	35,653	1,753	37,405
Avonmouth to Aust	0.1	0.1	11,551	2,098	13,649	712,486	52	32,678	7,047	39,725
Portbury	0.1	0.1	0	56	56	67,294	1,211	0	186	186
Woodhill	DN	DN	0	0	0	0	NA	0	0	0
Clevedon to Weston-super-Mare	0.1	0.1	13,168	1,681	14,849	4,615,014	311	60,607	5,161	65,768
Brean to Burnham-on-Sea	0.1	Adapt	3,582	725	4,307	2,176,890	505	36,750	2,353	39,103
Huntspill	0.1	0.1	70	110	180	68,932	383	1,366	376	1,742
Pawlett	0.1	Adapt	2,905	371	3,276	75,811	23	16,093	846	16,938
Stear Peninsula	MR	MR	20,299	191	20,489	61,138	3	31,500	645	32,144
<b>Total for strategy area</b>			<b>118,121</b>	<b>15,816</b>	<b>133,937</b>	<b>11,406,279</b>		<b>454,569</b>	<b>36,369</b>	<b>490,938</b>

Note: PV costs include Optimism Bias at 60%

# 7 Implementation

## 7.1 Project planning

### Phasing and approach

- 7.1.1 The Strategy aims to promote and encourage long term sustainable and strategic management of flood risk. It provides a framework for planning the implementation of capital projects, further studies, surveys and investigations, and will help with targeting and prioritisation of day-to-day activities.
- 7.1.2 A 5 year programme of capital investment for the FRM schemes at Wentlooge Levels, River Ebbw to River Usk, Caldicot Levels, Avonmouth to Aust and Congresbury Yeo, schedules increased spend levels when construction starts from 2015.
- 7.1.3 Capital investment for the Managed Realignment schemes at Stroart and Steart to create compensatory inter-tidal habitat is also over five years.
- 7.1.4 Preferred options for the other flood cells do not require capital investment in the first five years.
- 7.1.5 The main sources of non-FDGiA funding will come from development so that progress depends on Council contributions, Community Infrastructure Levy etc. Such partnerships will be heavily influenced by the timing of Local Authority input.
- 7.1.6 Engagement with communities and stakeholders will need to continue in order to manage the risk and consequences of flooding, and this includes:
- Pursue contributions for the schemes recommended in this Strategy.
  - Encourage all parties with responsibility for maintenance of defences, including private landowners, to monitor and maintain their defences.
  - Promote resilience measures.
- 7.1.7 Ongoing monitoring will play an important role in the implementation of the Strategy, ensuring that climate change and sea level rise predictions remain valid and that both FRM actions and habitat replacement are appropriate to predictions and actual change. Monitoring includes existing tide gauges and other sources of sea level rise monitoring, any future updates to climate change predictions, aerial photography, LiDAR, CASI, bathymetry surveys, NE / NRW condition assessments and the Regional Habitat Creation Project (RHCP).
- 7.1.8 Priority and short term schemes will also need scheme level HRAs, and will need Strategy level HRA / IROPI approval to be in place before they can proceed.

### Programme and spend profile

- 7.1.9 The key actions recommended by this Strategy over the next 5 years are presented in Table 7.1, which identifies the outline programme for the priority Improve and Managed Realignment projects. Funding for these schemes is anticipated to be mainly through FCRM GiA.
- 7.1.10 As the other FRM projects return lower FCRM GiA PF scores they are delayed until after five years (unless funding can be made available from sources in addition to FCRM GiA).
- 7.1.11 Implementation of the preferred Strategy is dependent on the availability of funding. The Environment Agency will continue to work with the local authorities, other partners, riparian owners and local communities to identify and secure alternative funding sources to provide contributions.

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**Table 7-1 Outline programme for next 5 years**

Activity	Target
<b>Wentlooge Levels, Caldicot Levels, Congresbury Yeo FRM schemes</b>	
Commence detailed appraisal	
Approval	2012
Construction start	2013
Construction completion	2014
	2016
<b>River Ebbw to River Usk, Avonmouth to Aust* FRM schemes</b>	
Commence detailed appraisal	2014
Approval	2015
Construction start	2016
Construction completion	2018
<b>Stroat and Steart Managed Realignment schemes</b>	
Construction start	2012
Construction completion	2014

\*subject to landowner, developer and Partnership Funding discussions.

- 7.1.12 An outline programme for the preferred Strategy for capital investment and maintenance over 100 years is given in Table 7.2. Based on this programme a summary of the annualised spend profile and Partnership Funding scores is given in Table 7.3. **The Partnership Funding scores are based on the assumption that a) the scheme life until the next intervention is 15 years, b) construction costs occur immediately, c) households are in the 60% least deprived areas, and d) no contributions are provided.**

**Table 7-2 Outline programme**

Flood cell	Element
<b>Priority Improve and Sustain schemes</b>	
Wentlooge Levels, River Ebbw to River Usk, Caldicot Levels, Avonmouth to Aust, Congresbury Yeo	Year 1-5: variable improve 2-0.1%AEP by raising and/or hardening assets
	Year 5-15: ongoing maintenance
	Year 15-100: variable sustain 2-0.1%AEP with wider raising and/or hardening of assets if climate change justifies this
<b>Priority compensatory habitat schemes</b>	
Stroat and Steart	Year 1-5: managed realignment
	Year 5-100: ongoing maintenance
<b>Short term Improve and Sustain schemes</b>	
Westbury-on-Severn and Rodley, Upper Framilode, Berkeley to Littleton-upon-Severn	Year 1-5: ongoing maintenance, further contribution discussions
	Year 5-15: variable improve 1-0.1%AEP by raising assets
	Year 15-100: variable sustain 1-0.1%AEP with wider raising of assets if climate change justifies this
<b>Short term adaptation schemes</b>	
Awre, Minsterworth Ham	Year 1-5: ongoing maintenance, further landowner discussions
	Year 5-100: adaptation considered if climate change justifies this
<b>Medium to long term Maintain and Sustain schemes</b>	
Penarth, Tremorfa, Mathern, Lydney, Newnham-on-Severn, Wallmore Common, Minsterworth, The Rea, Stonebench, Longney, Arlingham, Slimbridge, Portbury, Hunstpill	Year 1-15: ongoing maintenance
	Year 15-100: ongoing maintenance, with variable sustain 2-0.1%AEP if climate change justifies this
<b>Medium to long term adaptation schemes</b>	
Elmore Back, Brean, Pawlett	Year 1-15: ongoing maintenance, further landowner discussions
	Year 15-100: adaptation considered if climate change justifies this

**Table 7-3 Annualised spend profile and Partnership Funding score summary**

	2013-14	2014-15	2015-16	2017-18	2018-19	Future 10 years	Total 15 years	Total 100 years
<b>PRIORITY MANAGED REALIGNMENT SCHEMES</b>								
<b>Stroat: Managed Realignment, PF score&gt;200%</b>								
<b>Operating authorities:</b> Environment Agency								
Capital, £K	661	661	0	0	0	0	1,322	1,322
Maintenance, £K	0	0	0	0	0	0	0	0
<b>Steart Peninsula: Managed Realignment, PF score&gt;200%</b>								
<b>Operating authorities:</b> Environment Agency								
Capital, £K	11,639	11,639	0	0	0	0	23,279	31,500
Maintenance, £K	9	9	9	9	9	85	128	645
<b>PRIORITY FRM SCHEMES</b>								
<b>Wentlooge Levels: Improve FRM assets in current form 0.1%AEP SoP, PF score&gt;200%</b>								
<b>Operating authorities:</b> Environment Agency								
Capital, £K	255	766	766	766	0	0	2,553	27,451
Maintenance, £K	66	66	66	66	66	657	985	1,574
<b>River Ebbw to River Usk: Improve FRM assets in current form 0.1%AEP SoP, PF score&gt;200%</b>								
<b>Operating authorities:</b> Environment Agency								
Capital, £K	136	136	814	814	814	0	2,712	21,874
Maintenance, £K	64	64	64	64	64	639	958	1,433
<b>Caldicot Levels: Improve FRM assets in current form 0.1%AEP SoP, PF score&gt;200%</b>								
<b>Operating authorities:</b> Environment Agency								
Capital, £K	1,432	4,295	4,295	4,295	0	0	14,317	74,498
Maintenance, £K	256	256	256	256	256	2,558	3,837	6,368
<b>Congresbury Yeo: Improve FRM assets in hardened form 0.1%AEP SoP, PF score&gt;200%</b>								
<b>Operating authorities:</b> Environment Agency								
Capital, £K	1,088	3,265	3,265	3,265	0	0	10,884	60,607
Maintenance, £K	75	75	75	75	75	748	1,123	5,161
<b>Avonmouth to Aust: Improve FRM assets in hardened form 0.1%AEP SoP, PF score~120%</b>								
<b>Operating authorities:</b> Environment Agency, South Gloucestershire Council, Bristol City Council								
Capital, £K	657	657	3,941	3,941	3,941	0	13,137	32,678
Maintenance, £K	94	94	94	94	94	944	1,416	7,047
<b>SHORT TERM ADAPTATION SCHEMES</b>								
<b>Awre: Adaptation, PF score&gt;200%</b>								
<b>Operating authorities:</b> Environment Agency								
Capital, £K	0	0	0	0	0	3,238	3,238	3,238
Maintenance, £K	0	0	0	0	0	0	0	0
<b>Minsterworth Ham: Adaptation, PF score &gt;200%</b>								
<b>Operating authorities:</b> Environment Agency								
Capital, £K	0	0	0	0	0	1,151	1,151	4,275
Maintenance, £K	5	5	5	5	5	51	76	76
<b>SHORT TERM FRM SCHEMES</b>								
<b>Upper Framilode: Improve FRM assets in current form 0.1%AEP SoP, PF score~120%</b>								
<b>Operating authorities:</b> Environment Agency								
Capital, £K	80	80	480	480	480	0	1,601	6,050
Maintenance, £K	11	11	11	11	11	109	163	270
<b>Berkeley to Shepperdine: Improve in current form 1%AEP SoP, PF score~90%</b>								
<b>Operating authorities:</b> Environment Agency								
Capital, £K	0	0	0	0	0	9,285	9,285	35,653
Maintenance, £K	23	23	23	23	23	230	345	1,753
<b>Westbury-on-Severn: Improve 1%AEP SoP, PF score 20%</b>								
<b>Operating authorities:</b> Environment Agency								
Capital, £K	0	0	0	0	0	1,505	1,505	5,274
Maintenance, £K	15	15	15	15	15	152	228	232
<b>Remaining area: incremental adaptation and improvements to keep pace with climate change</b>								
<b>Operating authorities:</b> Environment Agency								
Capital, £K	1,624	1,624	1,624	1,624	1,624	16,236	24,353	150,151
Maintenance, £K	236	236	236	236	236	2,363	3,544	11,810
<b>TOTAL STRATEGY AREA</b>								
Capital, £K	17,572	23,123	15,185	15,185	6,859	31,414	109,337	454,569
Maintenance, £K	854	854	854	854	854	8,535	12,803	36,369

Notes: costs include 60% Optimism Bias; excludes inflation; PF score over 15 years



## Outcome Measures contributions

- 7.1.13 A summary of the Outcome Measures and Partnership Funding contributions is given in Table 7.4. The delivery of these contributions will depend on the timing of implementation for each project.
- 7.1.14 Partnership Funding is not currently an FRM policy in Wales, but NRW will seek contributions from the major beneficiaries of the sea defences along the Welsh Coast. These contributions could be funding or resources to support the development and implementation of improvements to the defences in accordance with the strategy. NRW is already working closely with Newport Council (relevant to the River Ebbw to River Usk and Caldicot Levels flood cells) to develop and implement some of the early actions in the strategy. NRW also works with the other two authorities (Cardiff and Monmouthshire) along the estuary to ensure the existing sea defences are kept fully operational and improved when and where necessary.

**Table 7-4 Partnership Funding summary**

Flood cell	PV cost (£K)	PV benefit (£K)	OM2 total households with reduced flood risk	OM4 statutory environmental obligations met (Ha)	FCRM GiA contribution (£K)	PF score (%)	Contribution needed for 100% PF score (£K)
Priority Improve and Sustain schemes							
Wentlooge Levels	2,924	264,517	7,146	0	2,924	>200	0
River Ebbw to River Usk	3,648	36,378	7,960	0	3,648	>200	0
Caldicot Levels	15,773	393,451	12,335	0	15,773	>200	0
Congresbury Yeo	8,571	399,503	4,101	11	8,571	>200	0
Avonmouth to Aust	10,611	142,593	3,595	0	10,611	~120	0
Priority compensatory habitat schemes							
Stroat	1,322	400	0	39	1,322	>120	0
Steart	19,694	20,178	0	237	13,021	60	0
Short term Improve and Sustain schemes							
Upper Framilode	970	19,510	530	0	970	~120	0
Berkeley to Littleton-upon-Severn	6,603	100,306	405	0	6,107	90	497
Westbury-on-Severn and Rodley	1,375	2,118	59	0	293	20	1,083
Short term adaptation schemes							
Awre	3,238	1,570	0	183	3,238	>200	0
Minsterworth Ham	952	14,494	116	261	952	>200	0

Notes:

1. data presented only for flood cells requiring capital investment in the short term
2. duration of benefits for the period of intervention
3. PV cost and benefit for the duration of benefits
4. OM3 households with reduced erosion risk is always zero
5. Contributions will be sought from partners for all FRM schemes.

## 7.2 Procurement strategy

- 7.2.1 Table 7.5 summarises the key staff involved in the preparation of the Strategy. The Project Board comprised the Business Sponsor, three Area Managers from Midlands West, Wessex and South East Wales, NEAS Principal Environmental project Manager (South-West), ncpms (Project Executive) and the NEECA2 consultant project director.

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7.2.2 A Procurement Strategy meeting will take place during the start-up of any funded projects from the Strategy. The Environment Agency will use their Framework Suppliers to carry out capital works and local Operations Delivery teams to undertake maintenance activities, as appropriate. The projects in SE Wales will be implemented by Natural Resources Wales who may use a different Procurement approach.

7.2.3 Potential for more packaging remains open and will be considered across our programme not just within the Strategy, but the scope will be limited due to number of funding streams, variable programmes of EA, NRW and Councils. Different funding streams could increase risks which may prevent packaging.

7.2.4 NRW has not formally declared an intent to work collaboratively, and is exploring potential packaging of work within Welsh public sector bodies. EA Commercial Services have offered support to NRW, if required.

**Table 7-5 Key staff**

Environment Agency		Framework Suppliers	
<b>Client</b>		<b>NEECA2 Team – Atkins Ltd</b>	
Project Sponsor	Richard Cresswell (SW Regional Director)	Project Director	Richard Samphier
Business Users	Jo Martin (Midlands West Area), Vicky Durston (Wessex Area, SW) Tim England (SE Wales, NRW)	Project Manager	Paul Canning
Project Executive	John Taberham, ncpms	Environmental Consultant	Karen Hills/Kath Wellard
Project Manager	Graham Quarrier, ncpms		
NEAS Officer	Kevin House		

## 7.3 Delivery risks

### High level risk register

7.3.1 The key risks with the implementation of this Strategy are shown in Table 7.6.

**Table 7-6 High level risk schedule and mitigation**

Key project risk	Adopted mitigation measure
Financial: Cost estimates based on broad assessment of principal quantities and rates; confirmation required of potential benefits achievable.	<ul style="list-style-type: none"> <li>Optimism bias of 60% applied to all costs</li> </ul>
Landowner: partnership working and agreement of Managed Realignment and Adaptation options.	<ul style="list-style-type: none"> <li>Continued engagement with landowners.</li> <li>Follow EA Asset maintenance protocol</li> </ul>
Environmental: Presence of potential environmental constraints e.g. protected or invasive species, buried archaeology, PRow, particularly at Managed Realignment sites	<ul style="list-style-type: none"> <li>Carry out desk-based assessments and field surveys at project level to identify constraints</li> <li>Continued consultation with relevant stakeholders</li> <li>NEAS to develop protocol with English Heritage on managing archaeological risk on MR projects</li> </ul>
Environmental: Failure to deliver habitat creation at Managed Realignment and Adaptation sites.	<ul style="list-style-type: none"> <li>Have taken opportunities with willing landowners so that habitat compensation already provided is ahead of losses predicted for approx next 20 years</li> <li>Continued liaison with landowners and key stakeholders to agree acceptability of schemes</li> <li>Understand likely changes at sites and implement project level mitigation, where required</li> </ul>
Political: Significant changes by partners (e.g. Network Rail) causes changes to the strategy area frontage necessitating an alternative strategic approach,	<ul style="list-style-type: none"> <li>Local planners to take account of any proposed changes that impact on the Strategy recommendations.</li> <li>Joint EA/Network Rail strategic group established 2013 to co-ordinate work on difficult issues/areas</li> </ul>
Political: Limited influence of Environment Agency over spatial planning in the	<ul style="list-style-type: none"> <li>Ensure Strategy is fully delivered to Area Partnerships Officer, planning liaison and development control.</li> </ul>

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Strategy area, which is key to delivery of non-structural options relating to planning and development control.	<ul style="list-style-type: none"> <li>• Provide indications of key partners and in what areas to influence them.</li> </ul>
Political: Regional/local authority planning may conflict with objectives for habitat creation, flood resilience and reverting at risk areas to floodplain.	<ul style="list-style-type: none"> <li>• Use NPPF and planning liaison to influence planning</li> <li>• Continue to consult with regional/local authority planners and feed into regional/local plans.</li> </ul>
Delivery: Implementation, including funding level available & change in procedures.	<ul style="list-style-type: none"> <li>• Ensure that non-structural measures are taken forward in case of funding shortfall for structural options.</li> </ul>

## Safety plan

7.3.2 The design decisions made at this strategic stage considered the possible solutions for minimising the health and safety risks whilst still achieving the required flood and coastal erosion risk management. The initial high level risks associated with the options considered include:

- construction and buildability
- operation and maintenance
- foreseeable emergency requirements
- alterations to the existing situation
- adjacent land users.

7.3.3 On the basis of the initial risk assessment, the development of any PAR will include:

- continued early input from the CDM co-ordinator
- use of ECI
- health and safety input into detailed design, buildability and planning
- designers to identify specific risks/mitigation as part of the Design Risk Register
- identify specific residual risks to the contractor
- include SHE boxes on design drawings
- provide the contractor with high quality Pre-construction Information
- discussions with owners and operators
- Operational and Public Safety Risk Assessments.

7.3.4 During the construction phase, site health and safety will be the responsibility of the principal contractor supported by the CDM co-ordinator, supervisor, designers and client. The site will be subject to regular checks and audit by the principal contractor, supervisor and the client.

## 7.4 Decision Points

7.4.1 Any future change in maintenance arrangements of the existing assets will be informed by a) the residual structural life of the asset and b) the functional life of the asset (defined as when SoP reduces below 20%AEP) and climate change impacts. A summary of the future maintenance extent and justification per flood cell, if assets are not improved over time via capital schemes, is given in **Error! Reference source not found..**

7.4.2 The few flood cells with assets that exceed their functional and structural life in the short term, are identified as Adaptation and Managed Realignment options. The majority of flood cells around the estuary have flood cells with assets that do not exceed their structural or functional lifetimes in the short term. These flood cells generally have economic justification to continue maintenance through the medium term. In the long term, the wider reduction in SoP due to climate change would result in frequent and extensive storm damage to assets, rendering maintenance physically difficult and requiring wider capital investment, as per the recommended strategy.

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**Table 7-7 Residual structural and functional life of FRM Assets**

Flood Cell	Short term (up to 0.1m SLR)	Medium term (0.1-0.3m SLR)	Long term (0.3-0.7m SLR)
Tremorfa, River Ebbw-River Usk, Mathern, The Rea, Upper Framilode, Berkeley to Littleton-upon-Severn, Avonmouth to Aust	Residual structural life of most assets will be exceeded in this period, although functional life will continue. Infrequent storm repair and extensive refurbishment of assets would be required and economically justified.	Residual structural life of all assets will be exceeded in this period, although functional life will continue. Infrequent storm repair and extensive refurbishment of assets would be required and economically justified.	Residual structural and functional life of all assets will be exceeded in this period. Frequent storm repair and extensive refurbishment of assets would be required, but may not be economically justified.
Penarth, Wentlooge Levels, Caldicot Levels, Newnham-on-Severn, Westbury-on-Severn and Rodley, Elmore Back, Clevedon to Weston-super-Mare, Pawlett	Residual structural life of assets will be exceeded locally in this period, although functional life will continue. Infrequent storm repair and localised refurbishment of assets would be required and economically justified.	Residual structural and functional life of all assets will be exceeded in this period. Frequent storm repair and extensive refurbishment of assets would be required, but may not be economically justified.	
Tidenham, Stroath, Awre, Minsterworth Ham, Steart Peninsula	Residual structural and functional life of assets will be exceeded in all periods. Frequent storm repair and extensive refurbishment of assets would be required but may not be economically justified.		
Lydney, Wallmore Common, Stonebench, Longney, Arlingham, Slimbridge, Brean to Burnham-on-Sea, Huntspill	Residual structural life of assets will be exceeded locally in this period, although functional life will continue. Infrequent storm repair and localised refurbishment of assets would be required and economically justified.	Residual structural life of all assets will be exceeded in this period, although functional life will continue. Infrequent storm repair and extensive refurbishment of assets would be required and economically justified.	Residual structural and functional life of all assets will be exceeded in this period. Frequent storm repair and extensive refurbishment of assets would be required, but may not be economically justified.
Minsterworth, Portbury		Residual structural life of all assets will be exceeded in this period, although functional life will continue. Infrequent storm repair and extensive refurbishment of assets would be required and economically justified.	

## 7.5 Justification and Affordability

7.5.1 Table 7.8 summarises the issues to be considered by Partnership & Strategic Overviews team as future Medium term plans and partnership agreements are being developed.

**Table 7-7 Partnership Funding sensitivity.**

Priority and short term schemes	Partnership Funding % range	Potential funding sources	PF score sensitivities	Risk of non-affordability	Start date of partnership negotiations
Stroat, Managed Realignment	Constructed in 2013-14.				
Stear Peninsula Managed Realignment					
Wentlooge Levels, Improve 0.1%AEP	830 to 1380	None	Deprivation category, progressive breach	Low, PAR stage underway	Not applicable
River Ebbw-River Usk, Improve 0.1%AEP	400 to 900	Development in Newport			Autumn 2011
Caldicot Levels, Improve 0.1%AEP	240 to 420				
Congresbury Yeo, Improve 0.1%AEP	330 to 490	None		Low, design and build stage underway	Not applicable
Avonmouth to Aust, Improve 0.1%AEP	90 to 200	Development in Avonmouth-Sevenside		Medium, supported by LEP	Spring 2013
Awre, Adaptation	0 to 280	None	Habitat creation	Low, as minimal cost	Autumn 2011
Minsterworth Ham, Adaptation	0 to 490				Deprivation category
Westbury-on-Severn and Rodley, Sustain 1%AEP	20 to 40				
Upper Framilode, Improve 0.1%AEP	180 to 310				
Berkeley to Littleton-upon-Severn, Improve 1%AEP	0 to 90	Nuclear power stations	Progressive breach	Medium	Spring 2013

**Notes:**

Assumed complete inundation of floodplain occurs due to progressive breach, properties in 60% least deprived category, no PF contributions, and construction begins immediately. PF % range based on changing assumptions on deprivation category, progressive breach and habitat creation.

## 7.6 Future Governance

7.6.1 The likely future expenditure around the whole estuary (c£5M/year) does not warrant a separate estuary management group as is required on the Humber and Thames estuaries, for example.

7.6.2 Monitoring of the estuary between strategy reviews, and prompting organisations to act, will be undertaken by the Severn Estuary Coastal Group comprising EA, NRW, NE and Local Authorities.

7.6.3 It is inevitable that the variation of partnership funding that is likely to be available in different flood cells will lead to different approaches being adopted. For example, in less populated agricultural areas, the emphasis may be on sharing maintenance tasks with landowners to reduce costs. Where there are clear business beneficiaries, we are likely to be negotiation on contributions in funding or in kind to enable improvements. In areas where development is significant, we are likely to work closely with Local Authorities to seek funding through the Community Infrastructure Levy or other similar sources.

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7.6.4 We must ensure that any additional work to satisfy a partner's requirement within a project must be fully funded by the partner, otherwise there is a risk that our funding could be regarded as State Aid. Partnership and Strategic Overview teams must seek advice from State Aid specialists when funding agreements are being developed.



## Appendix A Project appraisal report data sheet

Entries required in clear boxes, as appropriate.

### GENERAL DETAILS

Authority Project Ref. (as in forward plan):

IMSW001215

Project Name  
(60 characters  
max.):

Severn Estuary Flood Risk Management Strategy

Promoting Authority: Defra ref (if known)  
Name

Emergency Works:

No Yes/No

Strategy Plan Reference:

n/a

River Basin Management Plan

n/a

System Asset Management Plan

n/a

Shoreline Management Plan:

North Devon and Somerset, Severn  
Estuary

Project Type:

Strategy Plan

Shoreline Management Study/ Preliminary Study/ Strategy Plan/Prelim. Works to Strategy/ Project within Strategy/Stand-alone Project/  
Strategy Implementation/Sustain SOP. Coast Protection/Sea Defence/Tidal Flood Defence/Non-Tidal Flood Defence/Flood Warning  
Tidal/Flood Warning - Fluvial/Special

### CONTRACT DETAILS

Estimated start date of works/study:

2013

Estimated duration in months:

On-going

Contract type\*

(\*Direct labour, Framework, Non Framework, Design/Construct )

### COSTS

Appraisal:

£1000

Costs for Agency approval:

£490,938 (Whole Life Cost)

Total Whole Life Costs (cash):

£490,938

For breakdown of costs see Table in Section 2.4

### CONTRIBUTIONS

Windfall Contributions:

None

Deductible Contributions:

None

ERDF Grant:

None

Other Ineligible Items:

None

### LOCATION - to be completed for all projects

EA Region/Area of project site (all projects):

South-East (Wales), South-West and  
Midlands (England)

Name of watercourse (fluvial projects only):

n/a

District Council Area of project (all projects):

Various

EA Asset Management System Reference:

Varies

Grid Reference (all projects):

ST, SS, SO

(OS Grid reference of typical mid point of project in form ST064055)

## DESCRIPTION

Specific town/district to benefit:

Wentlooge Levels, River Ebbw to River Usk, Caldicot Levels, Stroat, Awre, Westbury-on-Severn to Rodley, Minsterworth Ham, Upper Framilode, Avonmouth to Aust, Congresbury Yeo, Steart

Brief project description including essential elements of proposed project/study  
(Maximum 3 lines each of 80 characters)

Strategy recommends a range of schemes for the next 15 years. FRM schemes: Wentlooge Levels, River Ebbw to River Usk, Caldicot Levels, Westbury-on-Severn to Rodley, Upper Framilode, Avonmouth to Aust, Congresbury Yeo, Steart. MR/adaptation schemes: Stroat, Awre, Minsterworth Ham, Steart.

## DETAILS

Design standard (chance per year):

1 in 1000 Wentlooge Levels, River Ebbw to River Usk, Caldicot Levels, Westbury-on-Severn, Upper Framilode, Avonmouth to Aust, Congresbury Yeo. Other schemes variable

yrs

Existing standard of protection (chance per year)

Varies, 1 in 20 lowest

yrs

Design life of project:

Generally 20yrs until significant sea level rise

yrs

Fluvial design flow (fluvial projects only):

n/a

m<sup>3</sup>/s

Tidal design level (coastal/tidal projects only):

7.7 to 10.4mAOD

m

Length of river bank or shoreline improved:

208

m

Number of groynes (coastal projects only):

0

Total length of groynes\* (coastal projects only):

0

m

Beach Management Project?

No

Yes/No

Water Level Management (Env) Project?

No

Yes/No

Defence type (embankment, walls, storage etc)

Walls and embankments

\* i.e. total length of all groynes added together, ignore any river training groynes

## ADDITIONAL AGREEMENTS:

Maintenance Agreement(s):

n/a

Not Applicable/Received/Awaited

EA Region Consent (LA Projects only):

n/a

Not Applicable/Received/Awaited

Non Statutory Objectors:

n/a

Yes/No

Date Objections Cleared:

Other:

n/a

Not Applicable/Received/Awaited

## ENVIRONMENTAL CONSIDERATIONS

Natural England (or equivalent) letter:

Received

Not Applicable/Received/Awaited

Date received

October 2013

## SITES OF INTERNATIONAL IMPORTANCE

(Answer Y if project is within, adjacent to or potentially affects the designated site)

Special Protection Area (SPA):

Yes

Yes/No

Special Area of Conservation (SAC):

Yes

Yes/No

Ramsar Site

Yes

Yes/No

World Heritage Site

No

Yes/No

Other (Biosphere Reserve etc)

Yes (MPA)

Yes/No

**SITES OF NATIONAL IMPORTANCE** (Answer Y if project is within, adjacent to or potentially affects the designated site)

Environmentally Sensitive Area (ESA):	Yes	Yes/No
Site of Special Scientific Interest (SSSI):	Yes	Yes/No
National/Regional Landscape Designation:	Yes	Yes/No
National Park/The Broads	No	Yes/No
National Nature Reserve	Yes	Yes/No
AONB, RSA, RSC, other	Yes	Yes/No
Scheduled Ancient Monument	Yes	Yes/No
Other designated heritage sites	Yes	Yes/No

**OTHER ENVIRONMENTAL CONSIDERATIONS**

Listed structure consent	No	Not Applicable/Received/Awaited
Water Level Management Plan Prepared?	No	Yes/No
MMO consent required?	Yes	Not Applicable/Received/Awaited
Statutory Planning Approval Required	Yes	Yes/No/Not Applicable

**COMPATIBILITY WITH OTHER PLANS**

Shoreline Management Plan	Yes	Yes/No/Not Applicable
River Basin Management Plan	Yes	Yes/No/Not Applicable
Catchment Flood Management Plan	Yes	Yes/No/Not Applicable
Water Level Management Plan	n/a	Yes/No/Not Applicable
Local Environment Agency Plan	Yes	Yes/No/Not Applicable

**SEA/ENVIRONMENTAL IMPACT ASSESSMENT**

SEA	Agency voluntary	Statutory required/Agency voluntary/not applicable
EIA	Yes	Yes (schedule 1); Yes (schedule 2); SI1217; not applicable
SEA/EIA status	SEA prepared	Scoping report prepared/draft/draft advertised/final

Other agreements	Detail	Result	(Not Applicable/Received/Awaited for each)

**Costs, benefits and scoring data**

(Apportion to this phase if part of a strategy)

**Local authorities only:** For projects done under Coast Protection Act 1949, please separately identify: FRM = Benefits from reduction of asset flooding risk; CERM = Benefits from reduction of asset erosion risk**Benefit type** (DEF: reduces risk (contributes to Defra SDA 27); CM: capital maintenance; FW: improves flood warning; ST: study; OTH: other projects)

DEF

**LAND AREA**

Total area of land to benefit:	43,422		Ha
of which present use is:	FRM	CERM	
Agricultural:	37,636		Ha
Developed:	5,397		Ha

Environmental/Amenity:	389		Ha
Scheduled for development	0		Ha

## PROPERTY & INFRASTRUCTURE PROTECTED

	Number		Value (£'000s)	
	FRM	CERM	FRM	CERM
<sup>1</sup> Residential	82,962		11,294,522	
Commercial/industrial	28066			
Critical Infrastructure	London-Penzance or Wales railways, motorways, nuclear power stations			
Key Civic Sites	NA			
Other (description below):	NA			
Description:				

## Costs and Benefits

<sup>1</sup> Present value of total project whole life costs (£'000s):	133,937	
Project to meet statutory requirement? Y/N	Y	
	Value (£'000s)	
	FRM	CERM
Present value of residential benefits:	11,265,960	
Present value of commercial/industrial benefits:		
Present value of public infrastructure benefits:		
Present value of agricultural benefits:	Minimal	
Present value of environmental/amenity benefits:	140,319	
<sup>1</sup> Present value of total benefits (FRM & CERM)	11,406,279	
Net present value:	11,272,342	
Benefit/cost ratio:	85 (estuary)	
Base date for estimate:	2013	
FCERM-AG Decision Rule stage 3 applied	Yes	Yes/No
FCERM-AG Decision Rule stage 4 applied	Yes	Yes/No

## OTHER OUTCOME MEASURE SCORING DETAILS

Super Output Area No*:	varies	Indicate if deprived:	No	Yes/No
(*as ranked by Indices of Multiple Deprivation)				
Risk:	N/A	VH, H or N/A		
		Wetland	Saltmarsh/Mudflat	
Net gain of BAP habitat:	261	0		Ha
SSSI protected:	Thousands	Ha		
Other Habitat:		Ha		
Heritage Sites:	Thousands	"I or II", "II or other" or "N/A"		

## Exemption Details (if exempt from OM scoring system)

Exempt from Scoring:		Yes/No
Reason (max 100 chars):		

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