MOTT MACDONALD

Environment Agency

Medway Estuary and Swale Coastal Flood and Erosion Risk Strategy

Technical Appendix G - Economic Assessment

January 2019

Environment Agency

Mott MacDonald
Mott MacDonald House
8-10 Sydenham Road
Croydon CR0 2EE
United Kingdom

T +44 (0)20 8774 2000
F +44 (0)20 8681 5706
mottmac.com

Environment Agency
Guildbourne House
Chatsworth Road
Worthing

Medway Estuary and Swale Coastal Flood and Erosion Risk Strategy

Technical Appendix G - Economic Assessment

January 2019

Mott MacDonald Limited. Registered in England and Wales no. 1243967.
Registered office: Mott MacDonald House, 8-10 Sydenham Road, Croydon CR0 2EE, United Kingdom

Issue and Revision Record

Revision	Date	Originator	Checker	Approver	Description
A	07/09/17	L Wiggins	B Riley	Z Hutchison	First issue for comment
B	20/10/17	L Wiggins	B Riley	Z Hutchison	Second Issue
C	28/03/18	L Eyres	B Riley	Z Hutchison	Third Issue
D	12/06/18	L Eyres	B Riley	Z Hutchison	Fourth Issue
E	09/07/18	B Riley	V Deakin	Z Hutchison	Fifth Issue
F	05/10/18	A Clark	B Riley	Z Hutchison	Sixth Issue following LPRG review
G	28/11/18	L Eyres	B Riley	Z Hutchison	Issue following additional LPRG comments
H	16/01/19	L Eyres	B Riley	Z Hutchison	Issue following additional LPRG comments

Document reference: MMD-347800-A-RE-008-H

Information class: Standard

This document is issued for the party which commissioned it and for specific purposes connected with the above-captioned project only. It should not be relied upon by any other party or used for any other purpose.

We accept no responsibility for the consequences of this document being relied upon by any other party, or being used for any other purpose, or containing any error or omission which is due to an error or omission in data supplied to us by other parties.

This document contains confidential information and proprietary intellectual property. It should not be shown to other parties without consent from us and from the party which commissioned it.

Contents

1 Introduction

The Environment Agency (EA) has appointed Mott MacDonald (MM) to develop the Medway Estuary and Swale Coastal Flood and Erosion Strategy (hereafter known as MEASS), with the aim of providing a Flood and Coastal Risk Management (FCRM) Strategy for the Tidal Medway Estuary, the Swale Estuary, and the Isle of Sheppey. The aim of MEASS is to assess how to best manage the coastline to protect people, properties, designated habitats, and agricultural land from coastal flood and erosion risk. As with all flood and coastal risk management work, the wider impacts must be considered. This means that the best technical solutions for defences need to be found, while also considering the impacts and benefits for local communities, the environment, and the cost to the tax payer.

1.1 Why the Strategy is being developed

There are currently coastal flooding and erosion risks to the communities and landowners around the Medway Estuary and Swale. Aging flood defences, rising sea levels and climate change mean that coastal flood and erosion risk to people, properties, habitats, and agricultural land will significantly increase in the coming years. Over the next 100 years it is predicted that 17,226 properties will be at an increased risk of tidal flooding (up to a 0.1%AEP event) within MEASS area.

Currently most of the Strategy frontage is defended, especially around the Isle of Sheppey to protect the important port at Sheerness, and along the tidal River Medway to protect the Medway Towns. A significant proportion of the defences in the area are nearing the end of the design lives and the risk of failure during a storm event is high. However, it is not sustainable in the long term to continue to maintain all of the defences in their current position. Therefore, MEASS will assess how this risk can be best managed, in line with government guidance, to deliver the most sustainable FCRM management approach.

The strategy area has large extents of both intertidal and freshwater habitats which are both nationally and internationally designated. Intertidal habitat is at risk as sea levels rise, ‘squeezing’ it against the existing defences. Freshwater habitat is at risk from the failure of the defences, resulting in the inundation of saltwater, as well as the increased overtopping which could be associated from sea level rise. Therefore, MEASS is also legally obliged to assess how the adverse impacts to these designated habitats can be mitigated by realigning defences or creating compensatory areas in other locations.

1.2 Strategy Area

The Strategy area includes the Isle of Sheppey, the tidal extents of the Medway Estuary and the Swale estuary. The boundaries of the strategy area are:

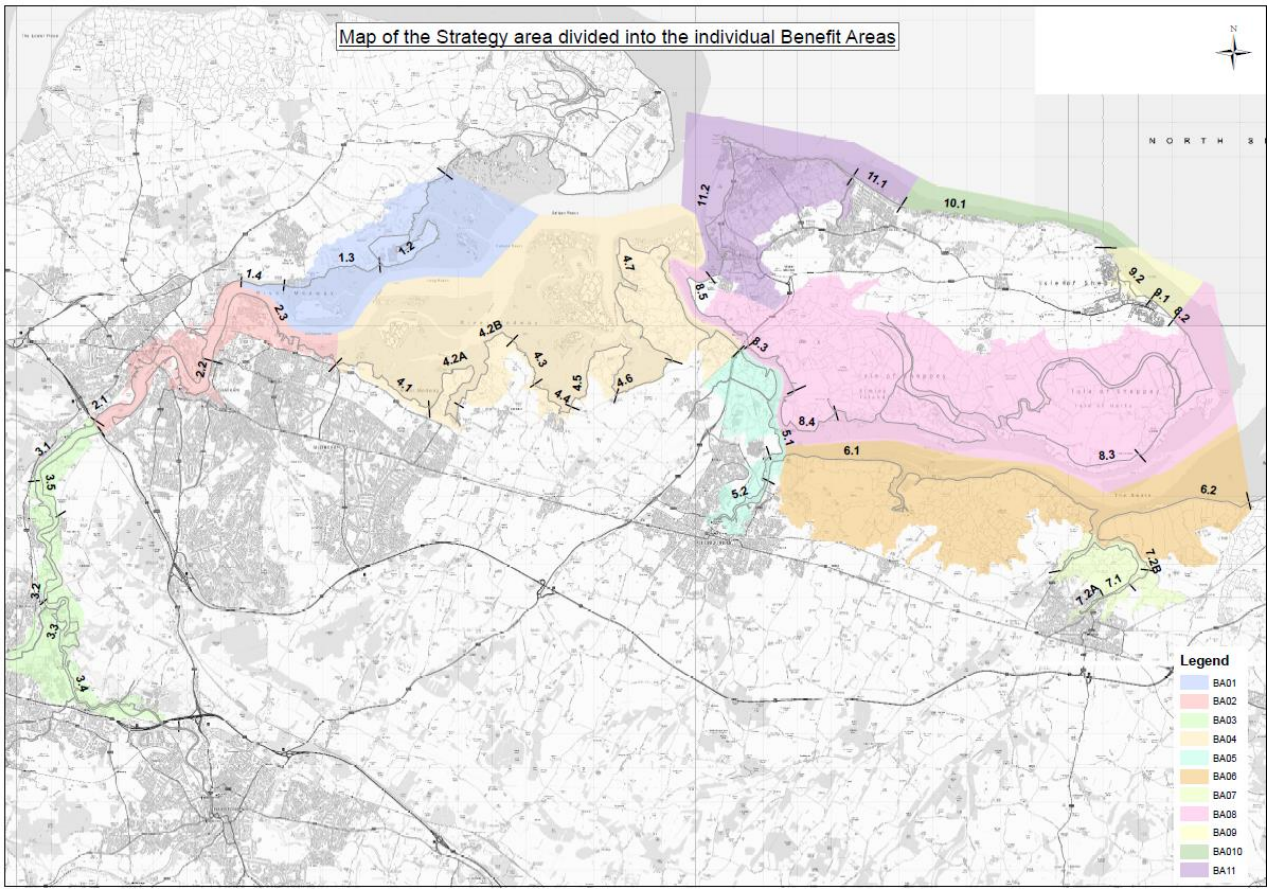
- Allington Sluice as the upstream tidal limit of the Medway;
- the village of Stoke on the Hoo Peninsula; and
- the Sportsman Public House on Cleve Marshes near Faversham.

MEASS encompasses the large urban areas of the Medway Towns including Rochester, Strood, Chatham and Gillingham; major industrial and commercial areas along the estuaries; and large swathes of rural farmland and extensive salt marsh and mudflats. Many of the rural areas are highly designated and protected for their heritage, landscape and environmental value.

1.2.1 Benefit Areas

As the Strategy frontage is approximately 120km in length, and there are complex interactions between the different land uses, MEASS area has been broken down into a series of Benefit Areas (BAs) based on the extent of discrete flood cells. These BAs have been broken down further into 35 sub-Benefit Areas based on the SMP Policy Units (Figure 1).

Figure 1: The division of the frontage into 11 BAs and 35 sub BAs based on discrete flood cells (determined from modelling) and land use. Please note that BA1.1 is now included in the Thames Estuary 2100 Strategy. BA8.1 and 8.2 were merged to form BA8.2 to reflect the interconnectivity between these areas.



Source: Mott MacDonald, 2017. Contains Ordnance Survey Data © Crown copyright and database right 2015

1.3 Aims of the strategy

MEASS will assess and consider a variety of economic, environmental, and technical approaches to manage the coastal flood and erosion risk, in order to balance the wide range of features and interests within the area.

The vision statement of MEASS is to "*work with the community to plan how we will sustainably reduce flood risk to 17,226 homes in the Medway Estuary, Swale and Sheppey over the next 100 years (under a 0.1%AEP event), whilst also protecting and enhancing the local environment*."

Building on from this vision statement a series of primary and secondary objectives for MEASS have been developed (Table 1) to drive the delivery of an effective FCRM strategy which supports as many local plans and aspirations as possible.

Table 1: MEASS Primary and Secondary Objectives

Primary Objectives		Secondary Objectives	
1)	Reduce flood and erosion risk to properties and infrastructure at significant or very significant risk in light of coastal change over the next 100 years.	3)	Favour options that reduce the whole life costs of current defences.
2)	Maintain the integrity of Natura 2000 sites (protected under the Habitats and Birds Directives) assuming the loss due to coastal squeeze of 113ha of saltmarsh habitat between years 0-20 and a further 140ha of saltmarsh habitat between years 20-50.	4)	Favour options that support delivery of the Thames River Basin Management Plan.
		5)	Help enable local plan objectives to be realised where possible.

1.4 Aims of this Report

This Report is a Technical Appendix to MEASS. The aim of this Report is to outline the method used to undertake the economic assessment and how this fed into the decision-making process for the preferred option. The Report is split into the following Sections:

- **Section 2: Economic assessment of the options** – this Section outlines the method that was used to undertake the economic assessment, and outlines where the results of the assessment are presented in the Strategy.
- **Section 3: Choosing the preferred option** – this Section presents the method and results of the assessment of the economic assessment and the choosing of the preferred options.
- **Section 4: Benefit Areas – Preferred Options** - this Section of the Report aims to summarise the economics, and provide a justification for the preferred options for each BA.
- **Section 5: Strategy wide assessment** – following the description of the preferred options a review of the whole Strategy economics was undertaken to determine the viability of the Strategy as a whole.

2 Economic assessment of the options

2.1 Overview

MEASS economic assessment is based on the latest Flood and Coastal Risk Management Appraisal Guidance [FCERM-AG], (EA, 2010), which provides guidance on the methodology to undertake effective economic appraisals. The guidance assists in considering economic benefits and losses that arise from flood and coastal risk management options.

The economic assessment uses the spreadsheet template provided by the Environment Agency (*accessed* 2017) which is the basis on which the Environment Agency will approve coastal defence schemes and grant funding. The economic assessment includes information and guidance from the HM Treasury Green Book (2011) and Multi-Coloured Manual (Middlesex University, 2016). It should be noted that the economic assessment was undertaken in line with current DEFRA and treasury guidance (FCERM-AG, 2010) and is appropriate as any future government funding for schemes will be assessed against these criteria.

Each BA has a Do Nothing and Do Minimum option against which to assess and compare all the other options. In each case the Do Nothing scenario is Option A, and the Do Minimum scenario is Option B.

2.2 Assessment of Benefit Cost Ratios

Each short listed option is considered both in terms of economic losses and benefits arising from potential flood and erosion risk. The damage assessment used to assess the benefits of the short listed options is presented in Technical Appendix C of MEASS. The costs of the options and the assumptions and methods used to cost the options are presented in Technical Appendix D of MEASS. The results from these two assessments feed into the economic assessment presented in this Report.

The economic appraisal is used as the basis for assessing the suitability of each short listed option and uses a benefit cost ratio (BCR) to summarise the results. The BCR determines the advantages and disadvantages of the option by expressing all of the potential effects and benefits in terms of its monetary cost. An option is considered to be ‘justified’ if the benefits outweigh the costs.

If an option is considered to be economically justified (BCR greater than 1), under FCERM-AG the option may be eligible for Grant in Aid (GiA) funding. The process then goes to look at wider benefits, outcomes and whether certain options can provide broader “win-win” schemes.

2.3 Partnership Funding Calculations/ GiA funding

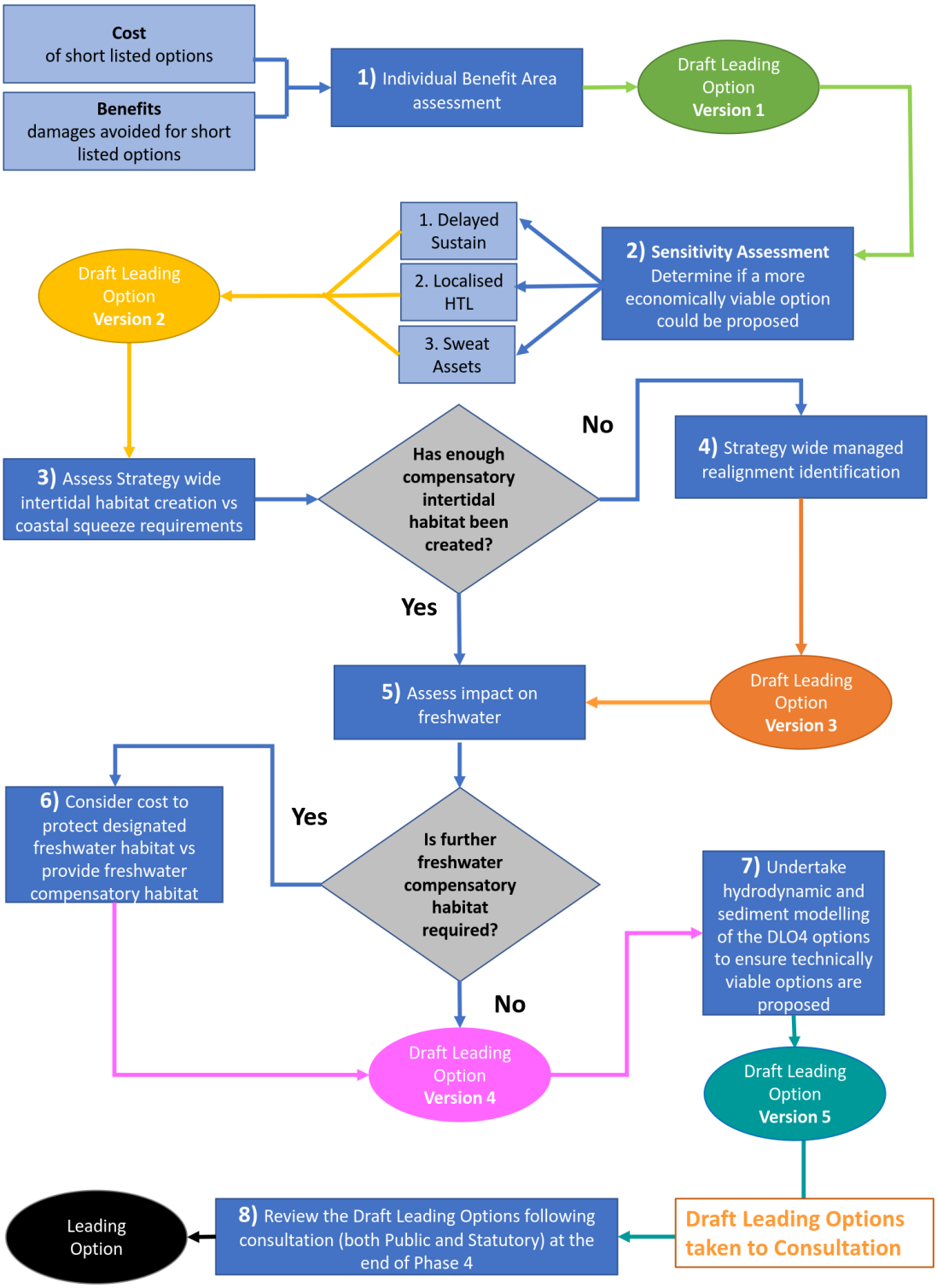
The availability of GiA for a scheme is assessed under the ‘Flood and Coastal Resilience Partnership Funding’ approach, which allows a proportion of government funding to be made available to any scheme. The amount of funding is assessed relative to the benefits delivered by the scheme including the number of households protected against flooding and erosion, and the creation of habitat. The funding allocations are based on the FDGiA Calculator. This tool identifies the maximum amount of funding available based on Partnership Funding Scores.

2.4 Wider economic assessment of the short list of options

Following the economic assessment of the options, in line with the FCERM-AG, further assessment of the options was undertaken to assess sensitivity options, impact on designated areas and coastal squeeze mitigation. From the Preliminary Leading Options presented in Section 2 there were a large number of BAs with BCRs below 1. Through undertaking sensitivities and looking at the BAs in more detail, economically viable schemes could be identified that maximise the benefits for the costs as well as minimising and mitigating impacts on the environment.

This process is outlined in Figure 2. The wider economic assessment (Draft Leading Options 1 and 2 in Figure 2) are explained further in Section 3, and the wider environmental assessment has been explained in more detail in Section 4. The method undertaken was to go through several stages of assessments, updating the leading option at each stage if applicable, to ensure the final preferred option presents a consideration of the different stages. The results of each of the stages is presented in Table 8.

Figure 2: Flowchart outlining the decision-making process to decide the Draft Leading Options and preferred option.



3 Economic Assessment

3.1.1 Task 1: Individual BA Assessments

An individual economic assessment of the options for each of the BAs has been undertaken for each short listed option. The results of this are presented in the Appraisal Summary Tables (ASTs) which provide a clear way of displaying the large number of results. Additionally, the ASTs present the results of a high-level socio-environmental assessment, a review of the technical feasibility of options following modelling and preliminary comments received from stakeholders. These additional factors were scored and used alongside the economic assessment results to help determine the Preliminary Leading Option. More information on the development of the ASTs and the final tables are included in Technical Appendix E of MEASS.

Where the BCR was below 1 for all options, a No Active Intervention (NAI) policy is initially adopted. A NAI will typically only involve non-structural management which is usually thorough the monitoring of risk, land-use planning, flood-warning systems, development control and emergency response plans.

3.1.2 Task 2: Review option sensitivities

Following the first task, a sensitivity assessment was undertaken to determine if there was a more economically viable option which could be proposed for the BAs, particularly those displaying low BCRs.

Initially, to provide an understanding of the sensitivities of the BCRs, a review of the costs and benefits was undertaken. The costs were decreased by 10% and 20%, the benefits were increased by 10% and 20%, and the combination of the different scenarios were compared. Following this high-level assessment, it was noted that there may be the opportunity to optimise benefits and costs of options. Three sensitivity tests were identified and assessed. If the results from the sensitivity tests provided an improved BCR and SoP which could be offered compared to the DLO1, this option was taken on as the DLO2. The sensitivity tests undertaken included:

1. **Delay sustain -** Delay the first phase of the Sustain option until the defences reach their residual lives. The aim of this sensitivity is to delay the first phase of the capital works until the median residual life of the current assets. This will delay the capital works, and as such reduce the cost of the option, which might make it more feasible to be taken through as the preferred option.
2. **HTL in localised areas -** Along the frontages where it is not economically viable to defend the whole frontage, this sensitivity assessed whether there are key lengths of frontage that can be maintained to protect the areas which are more densely populated/ key assets are at risk. The aim of this is to reduce the costs of the options by only focussing the defences where there are assets at risk and allowing NAI in the areas where there are fewer assets.
3. **Short term maintenance -** Undertake short term ongoing maintenance to extend the residual life of the current assets. The aim of this assessment is to assess the cost associated with undertaking patch repairs of the current assets to extend the residual life, and reduce the time until the NAI policy will be implemented

3.2 Results of the economic assessment

Initial results of the economic assessment (Draft Leading Option 1 and 2) are presented in Table 2 (presentation of Benefit Cost Ratios) and Table 3 (Incremental Benefits and Preferred Economic Option Selection).

Table 2: Results of the economic assessment (to Draft Leading Option 2) displaying the Benefit Cost Ratios. The options have been ordered by increasing costs and then those options which have a BCR below 1 have been highlighted in grey as these are not taken forward for consideration of incremental benefit costs (Table 3).

Benefit Area	Option	SoP in 100 years (% AEP)	Costs (£k)	Benefit(£k)	NPV (£k)	BCR
1.2	a) Do nothing	>50%	-	-	-	0
	b) Do minimum (ongoing maintenance)	>50%	307	13,044	12,738	42.5
	c) Maintain (capital) embankment/ seawall/ rock revetment	50%	19,293	38,248	18,955	1.98
	f) Maintain defences until year 5. Then raise (sustain) the embankment, seawall and rock revetment in year 5.	0.10%	20,836	41,148	20,312	1.97
	d) Raise embankment/seawall (sustain) and new rock revetment	0.10%	23,067	41,151	18,084	1.8
	e) Raise embankment/ seawall/ revetment/ sheet piling (upgrade) and new rock revetment	0.10%	29,642	41,151	11,509	1.4
1.3	a) Do nothing	>50%	-	-	-	0
	b) Do minimum (ongoing maintenance)	>50%	137	331	195	2.4
	c) Maintain (capital) embankment/ seawall/ rock revetment	50%	4,032	2,048	-1,985	0.5
	f) Construct new set back embankment at identified managed realignment sites and maintain existing embankment and revetment.	50% in some areas, 1% for MR site	4,972	2,223	-2,749	0.4
	d) Raise embankment/seawall (sustain) and new rock revetment	1%	6,268	4,298	-1,969	0.7
	g) Construct new set back embankment at identified managed realignment sites and raise embankment revetment (sustain)	1%	8,285	4,349	-3,936	0.5
	h) Construct new set back embankment at identified managed realignment sites and raise embankment revetment (upgrade)	1%	10,345	4,543	-5,803	0.4
	e) Raise embankment/seawall/ revetment/sheet piling (upgrade) and new rock revetment	1%	10,974	4,497	-6,476	0.4
1.4	a) Do nothing	N/A	-	-	-	0
	b) Monitoring only	N/A	-	-	-	0
2.1	a) Do nothing	>50%	-	-	-	0
	b) Do minimum (ongoing maintenance)	>50%	864	276	-588	0.3
	c) Maintain (capital) embankments, walls, flood gates and revetments	50%	13,931	10,472	-3,459	0.8

Benefit Area	Option	SoP in 100 years (% AEP)	Costs (£k)	Benefit(£k)	NPV (£k)	BCR
	d) Raise (sustain) embankments, walls, flood gates and revetments	1%	19,385	38,820	19,435	2
	e) Raise (upgrade) embankments, walls, flood gates and revetments	1%	32,830	40,747	7,918	1.2
2.2	a) Do nothing	>50%	-	-	-	0
	b) Do minimum (ongoing maintenance)	>50%	855	64	-791	0.1
	f) Raise (sustain) embankments, walls, flood gates and revetments in localised areas	0.10%	5,238	6,037	799	1.2
	c) Maintain (capital) embankments, walls, flood gates and revetments	50%	14,963	1,273	-13,690	0.1
	d) Raise (sustain) embankments, walls, flood gates and revetments	0.10%	17,628	11,307	-6,321	0.6
	e) Raise (upgrade) embankments, walls, flood gates and revetments	0.10%	35,608	11,307	-24,301	0.3
2.3	a) Do nothing	>50%	-	-	-	0
	b) Do minimum (ongoing maintenance)	>50%	447	1,317	870	2.9
	c) Maintain (capital) embankments, walls, flood gates and revetments	50%	6,541	21,360	14,820	3.3
	d) Raise (sustain) embankments, walls, flood gates and revetments	0.50%	14,256	63,084	48,828	4.4
	e) Raise (upgrade) embankments, walls, flood gates and revetments	0.50%	20,226	63,193	42,966	3.1
3.1	a) Do nothing	>50%	-	-	-	0
	b) Do minimum (ongoing maintenance)	>50%	220	1	-219	0
	c) Maintain (capital) embankments, walls and revetments	50%	2,905	3	-2,902	0
	d) Raise (sustain) embankments, walls and revetments	0.50%	5,858	673	-5,185	0.1
3.2	a) Do nothing	>50%	-	-	-	0
	b) Do minimum (ongoing maintenance)	>50%	372	102	-270	0.3
	h) Raise (sustain) embankments, walls and flood gates in localised areas	5%	1,642	2,789	1,147	1.7
	c) Maintain (capital) embankments, walls and flood gates	50%	4,082	102	-3,980	0
	d) Raise (sustain) embankments, walls and flood gates	5%	11,408	3,031	-8,377	0.3

Benefit Area	Option	SoP in 100 years (% AEP)	Costs (£k)	Benefit(£k)	NPV (£k)	BCR
	f) Construct new setback embankment at identified managed realignment sites. Raise (sustain) embankments, walls and revetments around other areas	5%	13,771	3,074	-10,697	0.2
	e) Raise (upgrade) embankments, walls and flood gates	5%	14,671	3,090	-11,581	0.2
	g) Construct new setback embankment at identified managed realignment sites. Raise (upgrade) embankments, walls and revetments around other areas	5%	16,182	3,133	-13,050	0.2
3.3	a) Do nothing	>50%	-	-	-	0
	b) Do minimum (ongoing maintenance)	>50%	592	17,398	16,806	29.4
	c) Maintain (capital) embankments, walls and flood gates	50%	8,898	205,958	197,061	23.1
	f) Raise (sustain) embankments, walls and flood gates in year 20	0.10%	11,303	213,624	202,321	18.9
	d) Raise (sustain) embankments, walls and flood gates	0.10%	17,957	215,079	197,123	12
	e) Raise (upgrade) embankments, walls and flood gates	0.10%	25,472	215,079	189,608	8.4
3.4	a) Do nothing	>50%	-	-	-	0
	b) Do minimum (ongoing maintenance)	>50%	701	317	-384	0.5
	c) Maintain (capital) embankments, walls and flood gates	50%	7,375	3,645	-3,730	0.5
	h) Raise (sustain) embankments, walls and flood gates in localised areas	0.10%	10,079	21,243	11,164	2.1
	d) Raise (sustain) embankments, walls and flood gates	0.10%	29,548	22,281	-7,267	0.8
	f) Construct new setback embankment at identified managed realignment sites. Raise (sustain) embankments, walls and revetments around other areas.	2%	29,949	22,431	-7,518	0.7
	e) Raise (upgrade) embankments, walls and flood gates	0.10%	45,393	22,320	-23,073	0.5
	g) Construct new setback embankment at identified managed realignment sites. Raise (upgrade) embankments, walls and revetments around other areas.	2%	44,777	22,431	-22,346	0.5
3.5	a) Do nothing	>50%	-	-	-	0
	b) Do minimum (ongoing maintenance)	>50%	34	71	37	2.1
	c) Maintain (capital) embankments and walls	50%	3,389	160	-3,230	0

Benefit Area	Option	SoP in 100 years (% AEP)	Costs (£k)	Benefit(£k)	NPV (£k)	BCR
	d) Construct new setback embankments at identified managed realignment sites and maintain (capital) embankments, walls and flood gates around other areas. MR site at Wouldham Marshes (site 12)	5%	11,385	398	-10,987	0.3
4.1	a) Do nothing	>50%	-	-	-	0
	b) Do minimum (ongoing maintenance)	>50%	86	596	510	6.9
	d) Raise (sustain) embankments, walls and revetment	2%	4,572	9,252	4,680	2
	c) Maintain (capital) embankments, walls and revetment	50%	4,494	1,467	-3,027	0.3
	e) Construct new setback embankments at identified managed realignment sites and maintain (capital) embankments, walls and flood gates around other areas. Adaptation of Riverside Country Park	2%	4,649	1,896	-2,753	0.4
	f) Construct new setback embankments at identified managed realignment sites and sustain embankments, walls and flood gates around other areas. Adaptation of Riverside Country Park	2%	6,365	9,252	2,886	1.5
4.2a	a) Do nothing	>50%	-	-	-	0
	b) Do minimum	>50%	236	24	-211	0.1
	c) Maintain (capital) embankments, walls and revetment	50%	7,512	162	-7,350	0
	d) Raise (sustain) embankments, walls and revetment	2%	8,363	536	-7,826	0.1
	e) Raise (upgrade) embankments, walls and revetment	2%	12,422	575	-11,847	0
4.2b	a) Do nothing	>50%	-	-	-	0
	b) Do minimum (ongoing maintenance)	>50%	33	312	279	9.4
	c) Maintain (capital) embankments, walls and revetment	50%	4,781	261	-4,521	0.1
	e) Construct new setback embankments at identified managed realignment and maintain embankments, along the rest of the section.	5%	5,691	1,044	-4,647	0.2
	f) Construct new setback embankments at identified managed realignment and sustain embankments, walls and revetment along the rest of the section.	5%	6,369	1,785	-4,584	0.3
	d) Raise (sustain) embankments, walls and revetment	5%	7,016	1,673	-5,343	0.2
4.3	a) Do nothing	0%	-	-	-	0
	b) Monitoring only	0%	-	-	-	0

Benefit Area	Option	SoP in 100 years (% AEP)	Costs (£k)	Benefit(£k)	NPV (£k)	BCR
4.4	a) Do nothing	>50%	-	-	-	0
	b) Do minimum (ongoing maintenance)	>50%	33	33	-	0.99
	e) Raise (sustain) embankments and walls in localised areas	1%	788	865	76	1.1
	c) Maintain (capital) embankments, and walls	5%	1,499	384	-1,114	0.3
	d) Raise (sustain) embankments and walls	1%	3,191	1,089	-2,101	0.3
4.5	a) Do nothing	>50%	-	-	-	0
	b) Do minimum (ongoing maintenance)	>50%	214	6	-208	0
	c) Adaptation- relocation of landfill	N/A	-	151	151	0
	f) Construct new setback embankments at identified managed realignment sites in first epoch. Tie the managed realignment site into high ground. MR site at Barksore Marshes	2%	1,741	355	-1,386	0.2
	d) Maintain (capital) embankments	50%	2,282	151	-2,131	0.1
	e) Raise (upgrade) embankments	2%	6,842	192	-6,650	0
4.6	a) Do nothing	N/A	-	-	-	0
	c) Monitoring only	N/A	95	-	-95	0
	b) Adaptation- rollback of road	N/A	8,768	808	-7,960	0.1
4.7	a) Do nothing	>50%	-	-	-	0
	b) Do minimum (ongoing maintenance)	>50%	246	655	409	2.7
	c) Maintain (capital) embankments, and walls	50%	20,893	761	-20,132	0
	d) Raise (sustain) embankments and walls	5%	25,651	1,349	-24,303	0.1
	f) Construct new setback embankments at identified managed realignment sites and maintain SOP(capital) of existing embankments and walls around other areas.	50% (5% at MR site)	29,434	1,029	-28,406	0
	e) Raise (upgrade) embankments and walls	5%	32,284	1,370	-30,913	0
	g) Construct new setback embankments at identified managed realignment sites and sustain SOP of existing embankments and walls around other areas.	5%	34,684	1,497	-33,187	0
	h) Construct new setback embankments at identified managed realignment sites and upgrade SOP of existing embankments and walls around other areas.	5%	40,964	1,517	-39,448	0
5.1	a) Do nothing	>50%	-	-	-	0

Benefit Area	Option	SoP in 100 years (% AEP)	Costs (£k)	Benefit(£k)	NPV (£k)	BCR
	b) Do minimum (ongoing maintenance)	>50%	298	11,023	10,725	37
	c) Maintain (capital) embankments and walls.	50%	4,828	63,476	58,648	13.1
	f) Maintain defences until year 20. Then raise (sustain) embankments and walls.	0.10%	6,924	67,408	60,484	9.7
	d) Raise (sustain) embankments and walls.	0.10%	11,284	67,585	56,301	6
	e) Raise (upgrade) embankments and walls.	0.10%	14,705	67,585	52,880	4.6
5.2	a) Do nothing	>50%	-	-	-	0
	b) Do minimum (ongoing maintenance)	>50%	358	4,390	4,032	12.2
	c) Maintain (capital) embankments and walls.	50%	3,372	55,254	51,882	16.4
	d) Raise (sustain) embankments and walls.	0.50%	6,754	67,428	60,674	10.0
	f) Construct new setback embankments at identified managed realignment sites. Sustain embankments and walls along the rest of the section. MR site at the Northern end of Milton Creek (site 22)	0.50%	8,783	67,428	58,645	7.7
	g) Construct new setback embankments identified managed realignment sites. Upgrade embankments and walls along the rest of the section. MR site at the Northern end of Milton Creek (site 22)	0.50%	12,285	67,491	55,206	5.4
	e) Raise (upgrade) embankments and walls.	0.50%	12,535	67,491	54,955	5.4
6.1	a) Do nothing	>50%	-	-	-	0
	b) Do minimum (ongoing maintenance)	>50%	261	532	271	2
	e) Maintain embankments until year 20. Then construct new setback embankments at identified managed realignment sites. Maintain SOP of existing embankments around rest of frontage.	50%	12,518	2,776	-9,743	0.2
	c) Maintain (capital) embankments	50%	12,935	2,113	-10,822	0.2
	f) Maintain embankments until year 20. Then construct new setback embankments at identified managed realignment sites. Raise (sustain SOP) existing embankments around rest of frontage.	1%	16,272	4,828	-11,444	0.3
	d) Raise (sustain) embankments	1%	27,821	6,025	-21,796	0.2
6.2	a) Do nothing	>50%	-	-	-	0
	b) Do minimum (ongoing maintenance)	1%	681	3,115	2,434	4.6

Benefit Area	Option	SoP in 100 years (% AEP)	Costs (£k)	Benefit(£k)	NPV (£k)	BCR
	f) Maintain embankments until year 20. Then construct new setback embankments at identified managed realignment sites. Maintain embankments and walls at the Sportsman Pub. MR site covers Cleve Hill.	2%	12,250	3,390	-8,860	0.3
	g) Maintain embankments until year 20. Then construct new setback embankments at identified managed realignment sites. Raise (sustain) embankments at the Sportsman Pub. MR site covers Cleve Hill.	2%	12,217	3,400	-8,817	0.3
	c) Raise (sustain) embankments and walls	0.50%	12,786	3,131	-9,654	0.2
	d) Construct new setback embankments at identified managed realignment sites. Maintain embankments and walls at the Sportsman Pub. MR site covers Cleve Hill.	0.50%	14,295	3,439	-10,856	0.2
	e) Construct new setback embankments at identified managed realignment sites. Raise (sustain) embankments at the Sportsman Pub. MR site covers Cleve Hill.	2%	22,418	3,450	-18,968	0.2
7.1	a) Do nothing	>50%	-	-	-	0
	b) Do minimum (ongoing maintenance)	>50%	121	1,502	1,382	12.5
	c) Maintain (capital) embankments	50%	4,159	401	3,758	0.1
	d) Raise (sustain) embankments	5%	10,667	5,218	5,449	0.5
	e) Raise (upgrade) embankments	5%	13,973	5,478	8,495	0.4
7.2a	a) Do nothing	>50%	-	-	-	0
	b) Do minimum (ongoing maintenance)	>50%	153	152	-1	0.9
	c) Maintain (capital) embankments and walls.	50%	1,381	-490	-1,871	0
	d) Raise (sustain) embankments and walls.	0.50%	5,515	12,235	6,721	2.2
	e) Raise (upgrade) embankments and walls.	0.50%	9,257	12,559	3,302	1.4
7.2b	a) Do nothing	>50%	-	-	-	0
	b) Do minimum (ongoing maintenance)	>50%	61	181	120	3
	c) Maintain (capital) embankments and walls.	50%	866	1,421	555	1.6
	e) Maintain embankments and walls until year 20. Then raise (sustain) embankments and walls.	0.10%	1,194	1,421	227	1.2
	d) Raise (sustain) embankments and walls.	0.10%	1,947	1,421	-526	0.7
8.2	a) Do nothing	>50%	-	-	-	0

Benefit Area	Option	SoP in 100 years (% AEP)	Costs (£k)	Benefit(£k)	NPV (£k)	BCR
	b) Do minimum (ongoing maintenance)	4%	455	1,681	1,225	3.7
	c) Raise (sustain) embankments	1%	10,310	1,966	-8,344	0.2
	e) Maintain embankments and walls until year 50. The construct new setback embankments at identified managed realignment sites. Raise (sustain SOP) existing embankments and walls along rest of frontage. MR site at Swale Nature Reserve (Site 30)	1%	12,275	1,863	-10,411	0.2
	d) Raise (upgrade SOP) embankments	1%	13,852	1,967	-11,885	0.1
8.3	a) Do nothing	>50%	-	-	-	0
	b) Do minimum (ongoing maintenance)	>50%	304	4,359	4,055	14.3
	c) Maintain (capital) embankments, and walls	6%	20,893	6,248	-14,645	0.3
	d) Raise (sustain) embankments and walls	2%	25,651	6,654	-18,997	0.3
	e) Raise (upgrade) embankments and walls	2%	29,434	6,342	-23,093	0.2
	f) Construct new setback embankments at identified managed realignment sites and maintain SOP(capital) of existing embankments and walls around other areas.	6%	34,684	6,710	-27,974	0.2
8.4	a) Do nothing	>50%	-	-	-	0
	b) Do minimum (ongoing maintenance)	>50%	55	0	-55	0
	d) Construct new setback embankments at Elmley (Site 36)	5%	2,233	134	-2,099	0.1
	c) Maintain (capital) embankments	9%	3,770	76	-3,694	0
8.5	a) Do nothing	>50%	-	-	-	0
	b) Do minimum (ongoing maintenance)	>50%	217	331	114	1.5
	c) Maintain (capital) embankments	5%	3,202	2,410	-791	0.8
	d) Raise (sustain) embankments	0.10%	6,236	2,495	-3,740	0.4
9.1	a) Do nothing	N/A -erosion	-	-	-	0
	b) Do minimum (ongoing maintenance)	N/A -erosion	161	2,134	1,973	13.3
	c) Maintain (capital) walls, groynes and beach	N/A -erosion	5,207	13,660	8,453	2.1
	d) Maintain defences and then adaptation of property from year 50	N/A -erosion	6,463	11,712	5,249	1.7
9.2	a) Do nothing	>50%	-	-	-	0

Benefit Area	Option	SoP in 100 years (% AEP)	Costs (£k)	Benefit(£k)	NPV (£k)	BCR
	b) Do minimum (ongoing maintenance)	>50%	150	2,162	2,012	14.4
	c) Maintain (capital) embankments walls, groynes and beach and adaptation along Warden Cliffs	4%	2,503	9,063	6,560	3.6
	d) Raise (sustain) embankments walls, groynes and beach and adaptation along Warden Cliffs	0.50%	5,400	9,545	4,145	1.8
10.1	a) Do nothing	N/A -erosion	-	-	-	0
	b) NAI -monitoring only	N/A -erosion	95	-	-95	0
	c) NAI - roll back of property over time	N/A -erosion	5,996	7,729	1,733	1.3
11.1	a) Do nothing	>50%	-	-	-	0
	b) Do minimum (ongoing maintenance)	5%	1,019	13,931	12,912	13.7
	c) Maintain SOP embankments, walls, flood gates, groynes and beach.	5%	997	13,931	12,934	14
11.2	a) Do nothing	>50%	-	-	-	0
	b) Do minimum (ongoing maintenance)	>50%	609	90,966	90,357	149.4
	c) Maintain (capital) embankments, walls, flood gates, groynes and beach.	6%	11,613	599,084	587,471	51.6
	d) Raise (sustain) embankments, walls, flood gates, groynes and beach.	0.10%	18,081	607,198	589,117	33.6
	e) Raise (upgrade) embankments, walls, flood gates, groynes and beach.	0.10%	25,506	607,177	581,671	23.8

Table 3: Incremental Benefit Cost Ratios and selection of the Preferred Economic Option. It should be noted that this table does not present the final Strategy option, which is also affected by assessment of impacts to internationally designated sites. The final Strategy options are presented in Section 6 of this Report.

Benefit Area	Option	SoP in 100 years (% AEP)	Costs (£k)	Benefit (£k)	NPV (£k)	BCR	IBCR	IBCR must be greater than:	Preferred Option	Justification
1.2	a) Do nothing	>50%	-	-	-	0			Option c is the economically preferred option, however Option f is the Strategy preferred option.	Maintain (capital) option has highest NPV and highest BCR following the Do Minimum and an incremental BCR greater than 1. However, the Maintain option is not desirable due to the potential impacts on nationally important infrastructure due to sea level rise and therefore it does not meet the Strategy objectives. Under local choices, the Sustain Option will be preferred and would require and additional £1.5m funding over 100 years.
	b) Do minimum (ongoing maintenance)	>50%	307	13,044	12,738	42.5				
	c) Maintain (capital) embankment/ seawall/ rock revetment	50%	19,293	38,248	18,955	1.98	1.33	1		
	f) Maintain defences until year 5. Then raise (sustain) the embankment, seawall and rock revetment in year 5.	0.10%	20,836	41,148	20,312	1.97	1.88	5		
	d) Raise embankment/seawall (sustain) and new rock revetment	0.10%	23,067	41,151	18,084	1.8	N/A	5		
	e) Raise embankment/ seawall/ revetment/ sheet piling (upgrade) and new rock revetment	0.10%	29,642	41,151	11,509	1.4	N/A	5		
1.3	a) Do nothing	>50%	-	-	-	0			Option b	Due to the limited assets at risk in the area, options to hold the line long term do not provide a BCR above one. The current defences have a 25-year median residual life. If patch and repair maintenance continue, the overall BCR is above one and the NPV is positive, enabling HTL policy in the short term.
	b) Do minimum (ongoing maintenance)	>50%	137	331	195	2.4	Highest BCR			
1.4	a) Do nothing	N/A	-	-	-	0	No BCR>1		Do Nothing	No short listed options were identified to provide erosion protection long this frontage. NAI aligns with SMP policy and requirements of the SSSI.
2.1	a) Do nothing	>50%	-	-	-	0			Option d	This option has the highest BCR, NPV and a high incremental BCR, However it is to be noted that there is still a significant amount of contributions that will be required. It has one of the highest environmental ranking from the short list of options. There is a higher economic justification for raising the defences in the short term rather than waiting for defences to reach their residual life to provide increased flood risk in the short term.
	d) Raise (sustain) embankments, walls, flood gates and revetments	1%	19,385	38,820	19,435	2	Highest BCR			
	e) Raise (upgrade) embankments, walls, flood gates and revetments	1%	32,830	40,747	7,918	1.2	0.14	3		

Benefit Area	Option	SoP in 100 years (% AEP)	Costs (£k)	Benefit (£k)	NPV (£k)	BCR	IBCR	IBCR must be greater than:	Preferred Option	Justification
2.2	a) Do nothing	>50%	-	-	-	0			Option f	Localised HTL option is the only option which provides a BCR above 1. This option will still provide protection to all residential properties at risk of flooding to at least a 1% AEP. In the NAI areas there is limited assets at risk due to the rising ground. There is a higher economic justification for raising the defences in the short term rather than waiting for defences to reach their residual life to provide increased flood risk in the short term.
	f) Raise (sustain) embankments, walls, flood gates and revetments in localised areas	0.10%	5,238	6,037	799	1.2	Highest BCR			
2.3	a) Do nothing	>50%	-	-	-	0			Option d	This option has the highest NPV and incremental BCR of over 5. It should be noted that the Upgrade option also presents a BCR of greater than one (but not an incremental BCR greater than 1) and therefore the SoP could be increased at OBC stage depending on third party contributions available. There is a higher economic justification for raising the defences in the short term rather than waiting for defences to reach their residual life to provide increased flood risk in the short term.
	b) Do minimum (ongoing maintenance)	>50%	447	1,317	870	2.9				
	c) Maintain (capital) embankments, walls, flood gates and revetments	50%	6,541	21,360	14,820	3.3	3.29	1		
	d) Raise (sustain) embankments, walls, flood gates and revetments	0.50%	14,256	63,084	48,828	4.4	5.41	3		
	e) Raise (upgrade) embankments, walls, flood gates and revetments	0.50%	20,226	63,193	42,966	3.1	0.02	3		
3.1	a) Do nothing	>50%	-	-	-	0	No BCR>1		Do Nothing	No short listed options were identified with BCRs above one which provided increased protection. There are limited assets at risk from flood damages in the area.
3.2	a) Do nothing	>50%	-	-	-	0			Option h	Localised HTL sensitivity provides the only option with a BCR above 1 and a positive NPV, and will provide protection to all residential properties at risk of flooding to at least a 5% AEP. In the NAI areas there is limited assets at risk due to the rising ground.
	h) Raise (sustain) embankments, walls and flood gates in localised areas	5%	1,642	2,789	1,147	1.7	Highest BCR			
3.3	a) Do nothing	>50%	-	-	-	0			Option c is the economically preferred option, however Option f is the Strategy preferred option	Maintain (capital) option has the highest benefits following the Do Minimum and an incremental BCR greater than 1. However, the Sustain option protects over 440 additional properties and therefore much better meets the Strategy objectives. Under local choices, the Sustain Option will be preferred and would require and additional £2.4m funding over 100 years.
	b) Do minimum (ongoing maintenance)	>50%	592	17,398	16,806	29.4				
	c) Maintain (capital) embankments, walls and flood gates	50%	8,898	205,958	197,061	23.1	22.70	1		
	f) Raise (sustain) embankments, walls and flood gates in year 20	0.10%	11,303	213,624	202,321	18.9	3.19	5		
	d) Raise (sustain) embankments, walls and flood gates	0.10%	17,957	215,079	197,123	12	N/A	5		

Benefit Area	Option	SoP in 100 years (% AEP)	Costs (£k)	Benefit (£k)	NPV (£k)	BCR	IBCR	IBCR must be greater than:	Preferred Option	Justification
	e) Raise (upgrade) embankments, walls and flood gates	0.10%	25,472	215,079	189,608	8.4	N/A	5		
3.4	a) Do nothing	>50%	-	-	-	0			Option h	Localised HTL sensitivity provides the only short listed option with a positive NPV and a BCR above 1. This option will provide protection to all residential properties at risk of flooding to at least a 1% AEP. In the NAI areas there is limited assets at risk due to the rising ground. There is a higher economic justification for raising the defences in the short term rather than waiting for defences to reach their residual life to provide increased flood risk in the short term.
	h) Raise (sustain) embankments, walls and flood gates in localised areas	0.10%	10,079	21,243	11,164	2.1	Highest BCR			
3.5	a) Do nothing	>50%	-	-	-	0			Option b then Do Nothing	Do minimum only provides maintenance of defences for 5 years due to the low residual life of the existing embankments. Therefore, overall policy in epoch 1 would be No Active Intervention.
	b) Do minimum (ongoing maintenance)	>50%	34	71	37	2.1	Highest BCR			
4.1	a) Do nothing	>50%	-	-	-	0			Option d	HTL sustain has the highest NPV and an iBCR greater than 1. There is a higher economic justification for raising the defences in the short term rather than waiting for defences to reach their residual life to provide increased flood risk in the short term.
	b) Do minimum (ongoing maintenance)	>50%	86	596	510	6.9				
	d) Raise (sustain) embankments, walls and revetment	2%	4,572	9,252	4,680	2	1.93	1		
	f) Construct new setback embankments at identified managed realignment sites and sustain embankments, walls and flood gates around other areas. Adaptation of Riverside Country Park	2%	6,365	9,252	2,886	1.5	0.00	1		
4.2a	a) Do nothing	>50%	-	-	-	0	No BCR>1		Do Nothing	No short listed options were identified which would provide increased protection and with BCRs above one/positive NPVs.
4.2b	a) Do nothing	>50%	-	-	-	0			Option b	Due to the limited assets at risk in the area, options to Hold the Line in the long term do not provide a BCR above one. The current defences have a 15-year median residual life. If patch and repair maintenance continues, the overall BCR is above one and the NPV is positive, enabling HTL policy in the short term.
	b) Do minimum (ongoing maintenance)	>50%	33	312	279	9.4	Highest BCR			

Benefit Area	Option	SoP in 100 years (% AEP)	Costs (£k)	Benefit (£k)	NPV (£k)	BCR	IBCR	IBCR must be greater than:	Preferred Option	Justification
4.3	a) Do nothing	0%	-	-	-	0	No BCR>1		Do Nothing	No short listed options were identified which would provide increased protection and with BCRs above one/positive NPVs.
4.4	a) Do nothing	>50%	-	-	-	0			Option e	Localised HTL sensitivity provides the only solution with a BCR above 1 and a positive NPV. This option will provide protection to all residential properties at risk of flooding to at least a 1% AEP. In the NAI areas there is limited assets at risk due to the rising ground.
	e) Raise (sustain) embankments and walls in localised areas	1%	788	865	76	1.1	Highest BCR			
4.5	a) Do nothing	>50%	-	-	-	0	No BCR>1		Do Nothing	No short listed options were identified which would provide increased protection and with BCRs above one/positive NPVs.
4.6	a) Do nothing	N/A	-	-	-	0	No BCR>1		Do Nothing	No short listed options were identified with BCRs above one which provided increased protection.
4.7	a) Do nothing	>50%	-	-	-	0			Option b	Due to the limited assets at risk in the area, options to Hold the Line in the long term do not provide a BCR above one. The current defences have a 15-year median residual life. If patch and repair maintenance continues, the overall BCR is above one and the NPV is positive, enabling HTL policy in the short term.
	b) Do minimum (ongoing maintenance)	>50%	246	655	409	2.7	Highest BCR			
5.1	a) Do nothing	>50%	-	-	-	0			Option c is the economically preferred option, however Option f is the Strategy preferred option	Maintain (capital) option has the highest benefits following the Do Minimum and an incremental BCR greater than 1. However, the Sustain option protects over 160 additional properties and therefore much better meets the Strategy objectives. Under local choices, the Sustain Option will be preferred and would require and additional £2.1m funding over 100 years.
	b) Do minimum (ongoing maintenance)	>50%	298	11,023	10,725	37				
	c) Maintain (capital) embankments and walls.	50%	4,828	63,476	58,648	13.1	11.58	1		
	f) Maintain defences until year 20. Then raise (sustain) embankments and walls.	0.10%	6,924	67,408	60,484	9.7	1.88	5		
	d) Raise (sustain) embankments and walls.	0.10%	11,284	67,585	56,301	6	N/A	5		
	e) Raise (upgrade) embankments and walls.	0.10%	14,705	67,585	52,880	4.6	N/A	5		
5.2	a) Do nothing	>50%	-	-	-	0			Option d	The sustain option has an incremental BCR of greater than 3 and it has one of the highest environmental ranking from the short list of
	b) Do minimum (ongoing maintenance)	>50%	358	4,390	4,032	12.2				

Benefit Area	Option	SoP in 100 years (% AEP)	Costs (£k)	Benefit (£k)	NPV (£k)	BCR	IBCR	IBCR must be greater than:	Preferred Option	Justification
	c) Maintain (capital) embankments and walls.	50%	3,372	55,254	51,882	16.4	16.88	1		options. There is a higher economic justification for raising the defences in the short term rather than waiting for defences to reach their residual life to provide increased flood risk in the short term.
	d) Raise (sustain) embankments and walls.	0.50%	6,754	67,428	60,674	10.0	3.60	3		
	f) Construct new setback embankments at identified managed realignment sites. Sustain embankments and walls along the rest of the section. MR site at the Northern end of Milton Creek (site 22)	0.50%	8,783	67,428	58,645	7.7	0.00	3		
	g) Construct new setback embankments identified managed realignment sites. Upgrade embankments and walls along the rest of the section. MR site at the Northern end of Milton Creek (site 22)	0.50%	12,285	67,491	55,206	5.4	N/A	3		
	e) Raise (upgrade) embankments and walls.	0.50%	12,535	67,491	54,955	5.4	N/A	3		
6.1	a) Do nothing	>50%	-	-	-	0			Option b	Do minimum option is the only one with a BCR above 1.
	b) Do minimum (ongoing maintenance)	>50%	261	532	271	2	Highest BCR			
6.2	a) Do nothing	>50%	-	-	-	0			Option b	Ongoing maintenance is the only short listed option with a BCR above 1 and a positive NPV.
	b) Do minimum (ongoing maintenance)	1%	681	3,115	2,434	4.6	Highest BCR			
7.1	a) Do nothing	>50%	-	-	-	0			Option b	Due to the limited assets at risk in the area, options to Hold the Line in the long term do not provide a BCR above one. The current defences have a 30-year median residual life. If patch and repair maintenance continues, the overall BCR is above one and the NPV is positive, enabling HTL policy in the short term.
	b) Do minimum (ongoing maintenance)	>50%	121	1,502	1,382	12.5	Highest BCR			
7.2a	a) Do nothing	>50%	-	-	-	0			Option d	The sustain option has the highest BCR and NPV value and second highest environmental ranking.
	d) Raise (sustain) embankments and walls.	0.50%	5,515	12,235	6,721	2.2	Highest BCR			
	e) Raise (upgrade) embankments and walls.	0.50%	9,257	12,559	3,302	1.4	0.09	3		

Benefit Area	Option	SoP in 100 years (% AEP)	Costs (£k)	Benefit (£k)	NPV (£k)	BCR	IBCR	IBCR must be greater than:	Preferred Option	Justification
7.2b	a) Do nothing	>50%	-	-	-	0			Option c is the economically preferred option, however Option e is the Strategy preferred option	Maintain (capital) option has the highest benefits following the Do Minimum and an incremental BCR greater than 1. However, the land will still be flooded under a 50% AEP. An additional £330k would enable protection to a 0.1% AEP. Under local choices, the Sustain Option will be preferred and would require and additional £330k funding over 100 years.
	b) Do minimum (ongoing maintenance)	>50%	61	181	120	3				
	c) Maintain (capital) embankments and walls.	50%	866	1,421	555	1.6	1.54	1		
	e) Maintain embankments and walls until year 20. Then raise (sustain) embankments and walls.	0.10%	1,194	1,421	227	1.2	0.00	5		
8.2	a) Do nothing	>50%	-	-	-	0			Option b	This option is the only option with BCR greater than one and a positive NPV score. However the option is the lowest ranked environmentally and further environmental mitigation would be required.
	b) Do minimum (ongoing maintenance)	4%	455	1,681	1,225	3.7	Highest BCR			
8.3	a) Do nothing	>50%	-	-	-	0			Option b	Due to the limited assets at risk in the area, options to Hold the Line in the long term do not provide a BCR above one. The current defences have a 25-year median residual life. If patch and repair maintenance continues, the overall BCR is above one and the NPV is positive, enabling HTL policy in the short term.
	b) Do minimum (ongoing maintenance)	>50%	304	4,359	4,055	14.3	Highest BCR			
8.4	a) Do nothing	>50%	-	-	-	0	No BCR>1		Do Nothing	No short listed options were identified which would provide increased protection and with BCRs above one/positive NPVs.
8.5	a) Do nothing	>50%	-	-	-	0			Option b	Do minimum has a BCR above 1 which Is the highest BCR out of the shortlisted options.
	b) Do minimum (ongoing maintenance)	>50%	217	331	114	1.5	Highest BCR			
9.1	a) Do nothing	N/A -erosion	-	-	-	0			Option c	This option has an incremental BCR greater than 1 and the highest NPV value.
	b) Do minimum (ongoing maintenance)	N/A -erosion	161	2,134	1,973	13.3				
	c) Maintain (capital) walls, groynes and beach	N/A -erosion	5,207	13,660	8,453	2.1	2.28	Erosion		
	d) Maintain defences and then adaptation of property from year 50	N/A -erosion	6,463	11,712	5,249	1.7	-1.55			
9.2	a) Do nothing	>50%	-	-	-	0			Option c	This option has the highest BCR and an IBCR greater than 1. Other options do not have a high enough incremental benefit cost ratio to
	b) Do minimum (ongoing maintenance)	>50%	150	2,162	2,012	14.4				

Benefit Area	Option	SoP in 100 years (% AEP)	Costs (£k)	Benefit (£k)	NPV (£k)	BCR	IBCR	IBCR must be greater than:	Preferred Option	Justification
	c) Maintain (capital) embankments walls, groynes and beach and adaptation along Warden Cliffs	4%	2,503	9,063	6,560	3.6	2.93	1		justify protecting to a higher standard of protection. Property relocation allows for management of the risk to residents whilst maintaining the integrity of the SSSI cliffs.
	d) Raise (sustain) embankments walls, groynes and beach and adaptation along Warden Cliffs	0.50%	5,400	9,545	4,145	1.8	0.17	3		
10.1	a) Do nothing	N/A -erosion	-	-	-	0			Option c	This option the only option with a BCR greater than 1, however there are a significant amount of contributions required. It also supports the implementation of Swale Borough Council's coastal change management plan.
	c) NAI - roll back of property over time	N/A -erosion	5,996	7,729	1,733	1.3	Highest BCR			
11.1	a) Do nothing	>50%	-	-	-	0			Option c	This option has the highest NPV and BCR. However, the option is ranked the lowest environmentally and mitigation will be required. As the risk is from erosion, the assessment of the increase in SoP provided by other options are not applicable because the main risk is from the erosion of the toe of the cliff and not from overtopping.
	b) Do minimum (ongoing maintenance)	5%	1,019	13,931	12,912	13.7				
	c) Maintain SOP embankments, walls, flood gates, groynes and beach.	5%	997	13,931	12,934	14	Highest BCR	N/A - options have same SOP		
11.2	a) Do nothing	>50%	-	-	-	0			Option c is the economically preferred option, however Option d is the Strategy preferred option	Maintain (capital) option has the highest benefits following the Do Minimum and an incremental BCR greater than 1. However, the Sustain option protects over 5,000 additional properties and therefore much better meets the Strategy objectives. Furthermore, Sustain has the highest NPV value and better environmental scoring. Under local choices, the Sustain Option will be preferred and would require and additional £6.5m funding over 100 years.
	b) Do minimum (ongoing maintenance)	>50%	609	90,966	90,357	149.4				
	c) Maintain (capital) embankments, walls, flood gates, groynes and beach.	6%	11,613	599,084	587,471	51.6	46.18	1		
	d) Raise (sustain) embankments, walls, flood gates, groynes and beach.	0.10%	18,081	607,198	589,117	33.6	1.25	5		
	e) Raise (upgrade) embankments, walls, flood gates, groynes and beach.	0.10%	25,506	607,177	581,671	23.8	N/A	5		

4 Wider assessment of options – wider benefits and environmental considerations

4.1 Task 3: Review Strategy wide coastal squeeze requirements

A review has been undertaken of the coastal process, sea level rise, and the implications of these on intertidal habitat (details are presented in Technical Appendix J). The results have been compared with previous studies such as the Greater Thames CHAMP (ABPmer, 2008) and the two SMPs (Medway and Swale Shoreline Management Plan, Halcrow, 2010a, and Isle of Grain and South Foreland Shoreline Management Plan, Halcrow, 2010b) to help determine the potential loss of intertidal habitat due to coastal squeeze and the resultant compensatory habitat requirements. This assessment of habitat at risk provided the requirement for the hectares of saltmarsh habitat that needs to be created to mitigate against the coastal squeeze losses (Table 4). The assessment concluded that the intertidal mudflat area is likely to increase in area with sea level rise and therefore no compensatory habitat is required for mudflat.

Due to the future uncertainties with these figures, compensatory habitat has currently only been identified in detail for epochs 1 and 2 with proposed areas for epoch 3. The implementation plan (Technical Appendix H) identifies the need to review habitat trends in the estuary, success of managed realignment sites and update regarding whether further compensatory habitat is required.

Table 4: Results of the coastal processes study indicating the potential loss of saltmarsh habitat, and therefore amount of compensation required for each epoch

	Hectares of saltmarsh habitat replacement required for each epoch		
	0 - 20 years	20 – 50 years	50 – 100 years
Saltmarsh	113	140	308
Hectares of the above which is within SPA/Ramsar designations	110	135	290

Source: Technical Appendix J of MEASS: Coastal Process Report (Mott MacDonald, 2016)

4.2 Task 4: Identify Managed Realignment Sites

Following an assessment of the compensatory saltmarsh habitat requirements, a strategy wide assessment of the proposed managed realignment (MR) sites was undertaken to determine the most appropriate MR sites to be taken forwards. No MR sites were identified as the leading options in Tasks 1 or 2, however there is a requirement to develop MR sites to compensate for the coastal squeeze losses, and allow HTL options to be implemented in the rest of the Strategy area.

To assess the MR sites each of the sites was put into one of three groups:

- Group 1 – Not environmentally designated MR sites;
- Group 2 – Environmentally designated MR sites, but potentially no adverse impacts on the SPA and Ramsar features (following discussions with Natural England and subject to future surveys); and
- Group 3 – Environmentally designated MR sites with a risk of adversely impacting on the SPA and Ramsar features.

The aim of the assessment was to identify the preferred MR sites, and therefore a ranking was given to the sites to allow the sites with the wider benefits to be taken through. Group 1 was ranked first, followed by Group 2 and Group 3 on the following elements:

- Impact on designated sites - if the MR option was considered unlikely to have an adverse impact on a designated site it was ranked preferentially;
- BCR – if the BCR was greater than one this indicated the site has wider economic benefits as well as providing compensatory habitat and was ranked preferentially; and
- Partnership Funding (PF) score - if the PF score was greater than 100% (in some cases due to the Outcome Measure 4 contributions the PF score was greater than 100% even through the BCR was below 1) it indicated that the site may be easier to fund and was ranked preferentially.

If the site did not meet any of these criteria it was excluded from the assessment.

The total area of intertidal habitat provided by the remaining sites was then assessed, assessing all of Group 1 sites, then Group 2 sites. Group 3 sites were not required to be used as Group 1 and 2 sites provided sufficient hectares. When ranking the Group 2 sites, there was additional consideration on whether the site is proposed to be a NAI site if not taken through as MR. This assessment was made because the site is likely to require compensatory freshwater habitat if it is left as NAI, therefore it might be more beneficial to develop the MR site and manage the creation of intertidal habitat in addition to providing freshwater habitat compensation.

The majority of MR sites are required within the first epoch for compensation. MR site 27 (Cleve Hill) has the potential to provide a large amount of the required compensation however the project team are aware that there are a number of risks on the site associated with pylons and associated infrastructure. Therefore, delaying this site until the 2nd epoch will allow further studies to be undertaken to further understand how the risks can be managed.

The proposed MR sites are outlined in Table 5.

Table 5: The MR sites proposed to be taken forwards based on a Strategy wide assessment

Epochs	Type of compensation being provided	MR Site	Area of saltmarsh habitat (ha)	Total Ha provided	Total for Epoch
1	Coastal squeeze and SPA/Ramsar habitat compensation	22 – Kemsley	4.8	115.4	**125.6ha**
		13 – Danes Hill	1.9		
		41 – Spitend	7.3		
		36 – Elmley	66.2		
		20a - Tailness Marsh	5.6		
		2 – Abbotts Court	29.6		
	Coastal squeeze	4 – Halling Marshes	10.2	10.2	
2	Coastal squeeze and SPA/Ramsar habitat compensation	27 - Cleve Hill	202.7	202.7	**202.7ha**
	Coastal squeeze	N/A – ha is covered in epoch 1		-	

Epochs	Type of compensation being provided	MR Site	Area of saltmarsh habitat (ha)	Total Ha provided	Total for Epoch
3	Coastal squeeze and SPA/Ramsar habitat compensation	20 - Chetney Marsh	175	175	175ha + 72.96ha (extra from epoch 2) = **247.96ha**
	Coastal squeeze	To be confirmed in the future		-	

4.3 Tasks 5 and 6: Review the impacts on freshwater habitat and consider if a moderation case could be appropriate in some areas

A strategy wide assessment was undertaken to determine the extent of freshwater compensation that might be required due to impacts on designated freshwater habitat. Freshwater compensation is required when there is likely to be inundation of designated SPA/ Ramsar freshwater habitat. Potential impacts on freshwater SSSI and Priority habitat have also been considered throughout the optioneering process. Where capital schemes will be undertaken adjacent to SSSI or Priority Habitat, potential impacts will be mitigated through the design. Where No Active Intervention causes increased flooding on Priority Habitat and SSSI areas, no allowance for compensation has been included within the preferred options. However, opportunities to increase habitat elsewhere has been considered through the different options and these wider opportunities are highlighted in the Implementation Plan and Funding Plan in Technical Appendices H and R respectively.

The extent of freshwater habitat that would be affected in each BA was calculated using the flood extents from the modelling and shapefiles of the designated areas in GIS. When looking at potential impacts on freshwater habitat a general framework was followed, as displayed in Figure 3.

Figure 3: Framework for assessing impacts on designated freshwater habitat

1. What is the option?	2. Potential impacts on Site to be assessed	3. Potential Impacts on Option decisions	4. Key Assumptions
NAI	Flooding of site – part of site becomes intertidal and part of site has overtopping in extreme events.	Comparison of compensation cost v HTL with SLR and assessment of sustainability and feasibility regarding ha required.	Assume landowner is not going to HTL and that compensation is required by the time the defences reach residual life.
HTL Maintain	Increased overtopping under extreme events in the future due to SLR.	Comparison of compensation cost v HTL with SLR and assessment of sustainability and feasibility regarding ha required.	In most cases, where this is the case the option has been amended to allow for gradual increase in crest height over time.
HTL Sustain	Standard of protection improved and therefore reduced risk of flooding from tidal water.	No action.	No impacts.
Managed Realignment	Flooding of site – part of site becomes intertidal and part of site has overtopping in extreme events	Include compensation costs in Strategy.	Compensation required.

Source: Mott MacDonald, 2017

Following this assessment, the cost of replacing this freshwater habitat were calculated using the EA's Project Cost Tool spreadsheet (Environment Agency, 2015). These costs were compared with the costs of maintaining the defences over the 100 years, and raising them in line with sea level rise so there is no increased risk from overtopping over time. Where it is considered more cost effective to maintain the defences and raise in line with sea level rise, this influences DLO4. The results are presented in Table 6.

During the review of this assessment, as well as a review of the SEA and HRA which were being drafted in parallel, it was highlighted that there was a requirement that habitat is replaced close to the site of loss to maintain SPA and Ramsar functionality. Therefore, BA4 was assessed and BA4.7 was selected as a Managed Realignment – Habitat Adaptation policy. This policy assumes maintenance (patch and repair) of the current defences (earth embankments) for the first 15 years. After year 15 the natural adaptation of the frontage will be allowed to occur. This option involves the natural adaptation of the frontage, by slowly reducing maintenance efforts and allowing inundation in particular areas, to help ensure a slower and more gradual adaptation of the functionality of the freshwater designated habitat and the SPA and Ramsar intertidal habitat. As such this is a more sustainable option and in line with the Natural England's Coastal Management theme plan (IPENSTP019) (Natural England, 2016). Because this delays the time that freshwater compensation is required as defences will be held for longer and only slowly allowed to reduce in SoP over time, the cost for compensating the habitat is lower and although is an option which is driven by the environmental requirements, can also be seen to be a cost effective way of managing the frontage. Details on the economics can be found in Table 29.

Table 6: Comparison between the cost of creating freshwater compensation or continuing to maintain the defences (moderation approach)

BA	Compensation required (ha)	PV cost of compensation (£k)	Cost to maintain current defences	Is it cost effective to maintain the defences?	Decision
1.3	37	£1,257	£4,032	No	Compensate – more cost effective to create new freshwater habitat.
4.2a	32	£2,000	£7,512	No	Compensate – more cost effective to create new freshwater habitat.
4.2b	88	£3,243	£4,781	No	Compensate – significantly more cost effective to create new habitat, but will have to ensure that the current function is maintained.
4.5	77	£2,381	£2,572	No	Compensate – although the habitat will be difficult to replace, it is significantly more cost effective than maintaining the defences.
4.7	385	£14,511	£20,893	No	MR: Habitat Adaptation – although it is cheaper to compensate for the loss of habitat, additional comments were received from environmental stakeholders which recommend that an adaptation approach was implemented in this BA to support the functionality of the intertidal SPA and Ramsar habitat, and have the least worst impacts on the freshwater habitat.
6.1	837	£20,228	£14,283	Yes	Maintain the defences – more cost effective to maintain the defences, and difficult habitat to replace due to the significant Ha required.
6.2	35	£1,444	£913	Yes	Maintain the defences – more cost effective to maintain the defences.
7.1	111	£2,335	£4,159	No	Compensate – significantly more cost effective to create new habitat, but will have to ensure that the current function is maintained.
8.2 and 8.3*	1492	£52,210	£28,048	Yes	Maintain the defences – more cost effective to maintain the defences, and difficult habitat to replace due to the significant Ha required.
8.4	93	£4,022	N/A	N/A	Compensate – MR site planned here so compensation is required.

*Note: 8.2 and 8.3 assessed together as part of same flood cell and therefore need to maintain or compensate both BAs

4.4 Task 7: Modelling of the DLOs

Task 7 of the assessment has been to model the DLOs to ensure that there is not an increase in flood risk in areas, that the defences have the effect assumed within the optioneering and to check that there is not significant increased scour or flows in areas. To allow this to be assessed a hydrodynamic model and sediment model were run. The details of the outcome of the model runs are presented in Technical Appendix I of MEASS.

Based on the results of the modelling none of the DLOs were changed, but the localised alignment of some of the defences was altered/ extended to reduce the flood risk. The largest change is in BA8.5, where there will need to be some localised defences to provide protection

from flooding to BA11.2 and will also ensure no flooding of designated areas. These defences have been assessed as part of the BA11.2 assessment and can be found in Table 45.

4.5 Task 8: Review of the DLOs following consultation

Following the above tasks, the options have gone through consultation with statutory consultees, land/ asset owners, MEASS Stakeholder Engagement Group and the wider public. The aims of these consultations were to gain support for the strategy and identify if there are any key blockers/ opposition. Following the consultation, the comments were reviewed and the DLOs updated accordingly. Because this is the last task within the reviews, these DLOs then became the Preferred Strategy Options.

The majority of the comments received were relating to further details or key risks in the area and have influenced the Implementation Plan and key risks for each BA. However, a number of discussions on the HRA led to option updates. These are summarised below. It is to be noted that the table for intertidal compensation presented in Section 3.1.4 already contains these updates.

Table 7: Option updates undertaken following consultation

Benefit Area	Old Option	New Option	Impacts	Reason for Change
1.3 Abbotts Court	Maintain to year 25 then No Active Intervention.	Managed Realignment site to the west of the site in year 11. The rest of the site stays as maintain until year 25 then No Active Intervention.	• Land behind the Managed Realignment site will have a minor improvement in flood protection. • Managed Realignment site provides required compensatory habitat required for the Strategy. • Wider habitat biodiversity outcomes. • Freshwater compensation is required in year 11 rather than year 25.	The Strategy will contribute to a process called coastal squeeze in the Medway Estuary. This means that under sea level rise scenarios, the saltmarsh in the estuary will be at risk of habitat loss. Under international law, there is a requirement to provide compensatory habitat. Although alternatives to this site were investigated, they cannot provide the required amount of habitat compensation, and therefore this was required as an additional site. Timing in year 11 to allow current mineral activities on the site to be completed.
3.5 Wouldham Marshes	Managed Realignment site from Year 5.	No Active Intervention.	• The defences are at risk from failure from year 5. • As this is not a formalised Managed Realignment site, the landowner is able to opt to maintain defences themselves through private funding. • Risk of flooding under extreme events to Ringshill Farm Cottages and Starkey Castle Lodge. Property level protection may be required here.	The Managed Realignment site was proposed to provide compensation for SPA and RAMSAR internationally designated habitat. However, following further discussions with different experts and reviewing additional bird data, it has been determined that the site will not be suitable for Managed Realignment. The alternative potential here is No Active Intervention. This means that there is no central government funding but the defences could be privately maintained.

Benefit Area	Old Option	New Option	Impacts	Reason for Change
			• Impacts to priority habitat.	
4.7 Chetney	Maintain to year 15 then Habitat Adaptation	MR site at Tailness Marsh in year 5 and Maintain to year 15 then Habitat Adaptation	• The majority of the site will stay as previously proposed. • The north east corner of the frontage at Tailness Marshes will, if modelling results are positive, become a Managed Realignment in the shorter term by year 5. • Compensation for this site will therefore be discussed earlier than the rest of the site.	The Strategy will contribute to a process called coastal squeeze in the Medway Estuary. This means that under sea level rise scenarios, the saltmarsh in the estuary will be at risk of habitat loss. Under international law, there is a requirement to provide compensatory habitat and there are requirements to provide more compensation in the shorter term (first 5 years) of the Strategy.
8.3 South Sheppey	Maintain and raise in line with sea level rise.	Maintain and raise in line with sea level rise with Managed Realignment at Spitend Marshes in year 5.	• The majority of the site will stay as previously proposed. • The area by Spitend marshes will become a Managed Realignment by year 5. • Compensation for this site will therefore be discussed during development of designs for the site. • Great Bells Farm will provide compensatory freshwater habitat.	The Strategy will contribute to a process called coastal squeeze in the Medway Estuary. This means that under sea level rise scenarios, the saltmarsh in the estuary will be at risk of habitat loss. Under international law, there is a requirement to provide compensatory habitat and there are requirements to provide more compensation for the Strategy.

4.6 Preferred option decision making

The results of the decision-making process explained above are outlined in Table 8. The table outlines the leading option that was outlined at each stage of the assessment, and a justification for why this option was chosen. The final preferred option is in bold; further details on the preferred options for each BA are outlined in Section 4.

Table 8: Summary of the Draft Leading Options and the justifications for each decision

BA	DLO1 – Economic Assessment		DLO2 – Economic Sensitivities		DLO3 – Review of compensatory intertidal habitat requirements		DLO4 – Review of compensatory freshwater habitat requirements		DLO5 – Modelling of leading options		DLO6 - Consultation Phase	
	Option	**Justification**	**Option**	**Justification**	**Option**	**Justification**	**Option**	**Justification**	**Option**	**Justification**	**Option**	**Justification**
1.2	Maintain (capital) embankment/seawall/ rock revetment.	This option has the highest BCR, however there is still a significant amount of contributions that will be required to allow the scheme to progress.	**Maintain defences until year 5. Then raise (sustain) the embankment, seawall and rock revetment in year 5.**	Delayed sustain option has highest NPV and BCR and better environmental scoring compared to the Maintain option.								
1.3	Do minimum - ongoing maintenance until year 25, followed by NAI.	The current defences have a 25-year median residual life if maintenance continues and have a positive BCR if maintained until residual life fails, enabling HTL policy in the short term.					Ongoing maintenance until year 25, followed by No Active Intervention (NAI). Freshwater habitat compensation required by year 25 (capital works in year 20).	The current defences have a 25-year median residual life and have a positive BCR if maintained until residual life fails, enabling HTL policy in the short term. After this there is a legal requirement to compensate for the loss of SPA and Ramsar habitat.			**Ongoing maintenance until year 25, followed by No Active Intervention (NAI). Managed Realignment site at the east of the site with freshwater habitat compensation required in year 11.**	The current defences have a 25-year median residual life and have a positive BCR if maintained until residual life fails, enabling HTL policy in the short term. The justification for the MR site is related to the Strategy wide requirement for coastal squeeze compensation.
1.4	**No Active Intervention (NAI).**	No short listed options were identified which provided increased protection and NAI aligns with SMP policy too.										
2.1	**Raise (sustain) embankments, walls, flood gates and revetments.**	This option has the highest BCR, however there is still a significant amount of contributions that will be required to allow the scheme to progress. It is also ranked second environmentally.										
2.2	No Active Intervention (NAI).	The BCR is less than one for all the options, so there is no economically viable option.	**Raise (sustain) embankments, walls, flood gates and revetments in localised areas.**	It can be justified to HTL in small sections where there is a concentration of assets at risk. NAI would be applied in the other sections.								

BA	DLO1 – Economic Assessment		DLO2 – Economic Sensitivities		DLO3 – Review of compensatory intertidal habitat requirements		DLO4 – Review of compensatory freshwater habitat requirements		DLO5 – Modelling of leading options		DLO6 - Consultation Phase	
	Option	Justification	Option	Justification	Option	Justification	Option	Justification	Option	Justification	Option	Justification
2.3	**Raise (sustain) embankments, walls, flood gates and revetments.**	This option has the highest BCR and a significantly lower amount of contributions required. It should be noted that the Upgrade option also shows BCR of greater than one so SoP could be increased at OBC stage depending on third party contributions available.										
3.1	**No Active Intervention (NAI)**	The BCR is less than one for all the options, so there is no economically viable option.										
3.2	No Active Intervention (NAI).	The BCR is less than one for all the options, so there is no economically viable option.	Raise (sustain) embankments, walls and flood gates in localised areas.	It can be justified to HTL in small sections where there is a concentration of assets at risk. NAI would be applied in the other sections.	**Construct new setback embankments at Halling Marshes. Raise (sustain) embankments, walls and flood gates in localised areas.**	It can be justified to HTL in small sections where there is a concentration of assets at risk. MR site at Halling Marshes from Year 5. The hectares are required to help compensate for coastal squeeze across the Strategy in the first epoch.						
3.3	Maintain (capital) embankments, walls and flood gates.	This option has the highest BCR.	**Raise (sustain) embankments, walls and flood gates from year 20.**	Delayed sustain option has highest BCR and better environmental scoring compared to the Maintain option.								
3.4	No Active Intervention (NAI).	The BCR is less than one for all the options, so there is no economically viable option.	**Raise (sustain) embankments, walls and flood gates in localised areas.**	It can be justified to HTL in small sections where there is a concentration of assets at risk. NAI would be applied in the other sections.								

BA	DLO1 – Economic Assessment		DLO2 – Economic Sensitivities		DLO3 – Review of compensatory intertidal habitat requirements		DLO4 – Review of compensatory freshwater habitat requirements		DLO5 – Modelling of leading options		DLO6 - Consultation Phase	
	Option	Justification	Option	Justification	Option	Justification	Option	Justification	Option	Justification	Option	Justification
3.5	No Active Intervention (NAI).	Do minimum only provides maintenance of defences for 5 years due to the low residual life of the existing embankments. Therefore, overall policy in epoch 1 would be NAI.			Construct new setback embankments at identified managed realignment site at North Wouldham Marshes and maintain (with capital works) embankments, walls and flood gates around other areas.	The high PF score prioritises this site to be taken forward. The hectares are required to help compensate for coastal squeeze across the Strategy in the first epoch.					**No Active Intervention (NAI).**	Managed Realignment will not provide the required functionality for SPA/Ramsar compensation and therefore cannot be justified. No short listed options were identified which would provide increased protection and with BCRs above one.
4.1	Raise (sustain) embankments, walls and revetment.	BCR greatest for Sustain approach.			**Construct new setback embankments at Danes Hill and sustain embankments, walls and flood gates around other areas.**	Option has a BCR above one and the hectares are required to help compensate for coastal squeeze across the Strategy in the first epoch.						
4.2a	No Active Intervention (NAI).	The BCR is less than one for all the options, so there is no economically viable option.					**No Active Intervention (NAI) with freshwater compensation required by year 9 (capital works in year 4).**	It is not viable to maintain the defences but there is a legal requirement to compensate for the loss of SPA habitat.				
4.2b	Do minimum - ongoing maintenance until Year 15, followed by NAI	The current defences have a 15 year median residual life if maintenance continues and have a positive BCR if maintained until residual life fails, enabling HTL policy in the short term.					**Ongoing maintenance until year 15, followed by No Active Intervention (NAI) and freshwater compensation required by 15 (capital works in year 10).**	The current defences have a 15-year median residual life and have a positive BCR if maintained until residual life fails, enabling HTL policy in the short term. After this there is a legal requirement to compensate for the loss of SPA habitat.				
4.3	**No Active Intervention (NAI).**	The BCR is less than one for all the options, so there is no economically viable option.										
4.4	Do minimum – ongoing maintenance.	The Do minimum has the highest BCR.	**Raise (sustain) embankment and revetment in localised areas.**	It can be justified to HTL in small sections where there is a concentration of assets at risk. NAI would be applied in the other sections.								

BA	DLO1 – Economic Assessment		DLO2 – Economic Sensitivities		DLO3 – Review of compensatory intertidal habitat requirements		DLO4 – Review of compensatory freshwater habitat requirements		DLO5 – Modelling of leading options		DLO6 - Consultation Phase	
	Option	Justification	Option	Justification	Option	Justification	Option	Justification	Option	Justification	Option	Justification
4.5	No Active Intervention (NAI).	The BCR is less than one for all the options, so there is no economically viable option.					**No Active Intervention (NAI) with freshwater compensation required by year 21 (capital works in year 16).**	It is not viable to maintain the defences but there is a legal requirement to compensate for the loss of SPA habitat.				
4.6	**No Active Intervention (NAI).**	The BCR is less than one for all the options, so there is no economically viable option. However NAI is the current proposed management method so there is no deviation from the SMP.										
4.7	Do minimum - ongoing maintenance until Year 15, followed by NAI.	The current defences have a 15-year median residual life if maintenance continues and have a positive BCR if maintained until residual life fails, enabling HTL policy in the short term.					Ongoing maintenance until year 15, followed by managed realignment: habitat adaptation, with freshwater compensation potentially required by year 30.	The current defences have a 15-year median residual life and have a positive BCR if maintained until residual life fails, enabling HTL policy in the short term. After this there is a legal requirement to compensate for the loss of SPA habitat. Habitat adaptation is preferred over managed realignment as it is more cost effective and will reduce adverse impacts on freshwater designated sites.			**Ongoing maintenance until year 15 followed by Habitat Adaptation. Managed Realignment site at Tailness in year 5.**	IThe current defences have a 15-year median residual life and have a positive BCR if maintained until residual life fails, enabling HTL policy in the short term. After this there is a legal requirement to compensate for the loss of SPA habitat. Habitat adaptation is preferred over managed realignment as it is more cost effective and will reduce adverse impacts on freshwater designated sites. The MR site in the first epoch will help contribute to coastal squeeze compensation in the short term, with the rest of the frontage contributing coastal squeeze compensation in the third epoch.

BA	DLO1 – Economic Assessment		DLO2 – Economic Sensitivities		DLO3 – Review of compensatory intertidal habitat requirements		DLO4 – Review of compensatory freshwater habitat requirements		DLO5 – Modelling of leading options		DLO6 - Consultation Phase	
	Option	Justification	Option	Justification	Option	Justification	Option	Justification	Option	Justification	Option	Justification
5.1	Maintain (capital) embankments and walls.	This option has the highest BCR.	**Maintain defences until year 20. Raise (sustain) embankments and walls from year 20.**	Delayed sustain option has highest BCR and better environmental scoring compared to the Maintain option.								
5.2	Maintain (capital) embankments and walls.	This option has the highest BCR.	Maintain defences until year 20. Raise (sustain) embankments and walls from year 20.	Delayed sustain option has highest BCR and better environmental scoring compared to the Maintain option.	**Construct new setback embankments at identified managed realignment site at Kemsley. Raise (sustain) embankments and walls along the rest of the section.**	This area has a MR site which has a PF score over 100% and BCR over 1 and is not impacting on any designated sites. The hectares are required to help compensate for coastal squeeze across the Strategy in the first epoch.						
6.1	Do minimum option - ongoing maintenance until Year 25, followed by NAI.	The current defences have a 25 year median residual life if maintenance continues and have a positive BCR if maintained until residual life fails, enabling HTL policy in the short term					**Maintain embankments and upgrade SoP with sea level rise in year 50.**	The current defences have a 25 year residual life. Following this, the cost to compensate the large area of freshwater habitat is much greater than the cost to maintain the defences with sea level rise. Therefore it is more cost-effective to maintain the defences and raise with sea level rise.				
6.2	Ongoing maintenance of embankments and walls.	Ongoing maintenance has a BCR above one.			Ongoing maintenance until Year 20. Then construct new setback embankments at identified managed realignment sites. Maintain embankments and walls at the Sportsman Pub.	This managed realignment site has a PF score above 100%. A small area of the frontage will be maintained to ensure no loss of properties. The hectares are required to help compensate for coastal squeeze across the Strategy in the second epoch.	**Ongoing maintenance until year 20. Then construct new setback embankments at Cleve Hill managed realignment site. Maintain embankments and walls either side and at the Sportsman Pub raise in year 50 with sea level rise.**	The cost to compensate the freshwater habitat near the Sportsman Pub is much greater than the cost to maintain the defences with sea level rise (Note – freshwater behind the MR site will be protected by the setback embankments).				

BA	DLO1 – Economic Assessment		DLO2 – Economic Sensitivities		DLO3 – Review of compensatory intertidal habitat requirements		DLO4 – Review of compensatory freshwater habitat requirements		DLO5 – Modelling of leading options		DLO6 - Consultation Phase	
	Option	Justification	Option	Justification	Option	Justification	Option	Justification	Option	Justification	Option	Justification
7.1	Do minimum - ongoing maintenance until Year 30, followed by NAI.	The current defences have a 30 year median residual life if maintenance continues and have a positive BCR if maintained until residual life fails, enabling HTL policy in the short term.					**Ongoing maintenance until year 30, followed by NAI. Freshwater compensation required by year 30 (capital works in year 25).**	The current defences have a 30-year median residual life and have a positive BCR if maintained until residual life fails, enabling HTL policy in the short term. After this there is a legal requirement to compensate for the loss of SPA habitat.				
7.2a	**Raise (sustain) embankments and walls.**	Sustain option has the highest BCR and second environmental ranking.										
7.2b	Maintain (capital) embankments and walls.	This option has the highest BCR.	**Maintain defences until year 20. Raise (sustain) embankments and walls from year 20.**	Delayed sustain option has highest BCR and better environmental scoring compared to the Maintain option.								
8.2	Ongoing maintenance of embankments.	This option has the highest BCR (only option with BCR greater than one). However the option is the lowest ranked environmentally and further environmental mitigation would be required.					**Maintain embankments and upgrade SoP with sea level rise in year 50.**	The cost to compensate the freshwater habitat at risk of overtopping is greater than the cost to maintain the defences in line with sea level rise.				
8.3	Do minimum - ongoing maintenance until Year 25, followed by NAI.	The current defences have a 20 year median residual life if maintenance continues and have a positive BCR if maintained until residual life fails, enabling HTL policy in the short term.					Maintain embankments and upgrade SoP with sea level rise in year 50. NAI at Isle of Harty.	The current defences have a 25 year residual life. Following this, the cost to compensate the large area of freshwater habitat is much greater than the cost to maintain the defences with sea level rise.			**Maintain embankments and upgrade SOP with sea level rise in year 50. No Active Intervention (NAI) at Isle of Harty and a Managed Realignment site in year 5 at the end of Spitend Marshes.**	The current defences have a 25 year residual life. Following this, the cost to compensate the large area of freshwater habitat is much greater than the cost to maintain the defences with sea level rise. The justification for the MR site is related to the Strategy wide requirement for coastal squeeze compensation.

BA	DLO1 – Economic Assessment		DLO2 – Economic Sensitivities		DLO3 – Review of compensatory intertidal habitat requirements		DLO4 – Review of compensatory freshwater habitat requirements		DLO5 – Modelling of leading options		DLO6 - Consultation Phase	
	Option	Justification	Option	Justification	Option	Justification	Option	Justification	Option	Justification	Option	Justification
8.4	No Active Intervention (NAI).	The BCR is less than one for all the options, so there is no economically viable option. However NAI is the current proposed management method so there is no deviation from the SMP.			**Construct setback defences to form Managed Realignment site in year 5 at Elmley Round Field.**	Managed realignment as although designated freshwater habitat is present, alternative is NAI which would be increased impacts over MR option. Required as part of coastal squeeze compensation across the Strategy in the first epoch.						
8.5	Do minimum – ongoing maintenance of embankments until year 30 followed by NAI.	This is the only option with a BCR greater than 1.							**Raise (sustain) embankments in localised sections.**	Following the modelling of the preferred options it was found that the defences in BA8.5 would need to be raised to the same SoP as the defences in BA11.2 to prevent flooding of Queenborough and Sheerness. The costs and benefits for this option will be included within the assessment of BA11.2.		
9.1	**Maintain (with capital works) walls, groynes and beach.**	This option has the highest BCR and no other options have a BCR of greater than one.										
9.2	**Maintain (with capital works) embankments walls, groynes and beach. NAI and localised property adaptation along Warden Cliffs.**	This option has the highest BCR and no other options have a BCR of greater than one.										
10.1	**No Active Intervention (NAI) with localised property adaptation (potentially not GiA funded).**	This is the only option with a BCR greater than 1, however there are a significant amount of contributions required. This will help satisfy the stakeholders requests to protect the property. Conversations and studies would be required to secure funding for property adaptation solutions.										

BA	DLO1 – Economic Assessment		DLO2 – Economic Sensitivities		DLO3 – Review of compensatory intertidal habitat requirements		DLO4 – Review of compensatory freshwater habitat requirements		DLO5 – Modelling of leading options		DLO6 - Consultation Phase	
	Option	Justification	Option	Justification	Option	Justification	Option	Justification	Option	Justification	Option	Justification
11.1	**Maintain embankments, walls, flood gates, groynes and beach**.	This option has a BCR greater than one and a high PF score. Option C was taken over Option B due to the wider environmental benefits.										
11.2	**Raise (sustain) embankments, walls, flood gates, groynes and beach**.	This option has been chosen as the preferred option because it provides the highest SoP and the PF score is greater than 100%.										

5 Funding Managed Realignment Sites

In order for the Strategy to comply with the Habitats Regulations, intertidal habitat must be delivered through Managed Realignment (MR) to balance the losses resulting from Hold the Line policy in other areas of the strategy. Without MR sites these Hold the Line options cannot progress; therefore the justification for the MR sites lies in the benefits realised through Hold the Line policies across the wider Strategy area.

In order to select the preferred MR sites, an iterative process of ranking and screening out options on environmental impact, Partnership Funding and Benefit Cost Ratio scores, and best value for money was undertaken (more information can be found in Section 3.1.4).

In order to present the economics for FDGiA funding and tie in with partnership funding calculations etc, the cost associated with the MR sites has been proportionately distributed across HTL schemes, based on the proportionate OM1 benefit values. Therefore for each HTL scheme proposed, there will be a cost (worked out proportionately) associated with the MR sites which will be built over the lifetime of the scheme to provide the intertidal habitat required as a result of the defences.

Therefore, within the economic assessment, the cost of the MR schemes will not be presented within the specific BA they lie in, as the justification for them comes from a wider consideration and the legal requirements of MEASS to protect SPA designated habitat. The costs of the MR sites are presented in Table 9 and the proposed split of MR site costs is presented in Table 10. These costs have been incorporated into the whole life costs presented in Section 5.

Table 9: MR costs (present value costs with 60% optimism bias). This works out as an average of £70k (PV cost) per ha over the Strategy.

Benefit Area	MR cost (£k)	Hectares
1.3 Abbotts Court	4,060	29.6
3.2 Halling	3,961	10.2
4.1 Danes Hill	1,273	1.9
4.7 Chetney	7,078	180.6
5.2 Kemsley	2,132	4.8
6.2 Cleve Hill	11,778	202.7
8.3 Spitend Marshes	2,815	7.3
8.4 Elmley	2,277	66.2
TOTAL	**35,375**	**503**

Table 10: Proposed proportional split down of coastal squeeze costs

BA	Option	OM1s (£k)	% share of OM1s from HTL sites	Coastal squeeze proportion (ha) based on % share of OM1s and total coastal squeeze requirements	Cost of compensation (£k) based on £72k per hectare	Option cost (£k)	Total BA cost (£k) (option cost plus intertidal habitat cost)
1.2	HTL	41,148	3.4%	17.3	1,218	20,836	22,054
1.3	HTL to year 25	331	0.0%	0.1	10	137	147
2.1	HTL	38,820	3.2%	16.4	1,149	19,385	20,534
2.2	HTL localised	6,037	0.5%	2.5	179	5,238	5,417
2.3	HTL	63,084	5.3%	26.6	1,868	14,256	16,124
3.2	HTL localised (with MR)	2,789	0.2%	1.2	83	1,642	1,725
3.3	HTL	213,624	17.9%	90.0	6,325	11,303	17,628
3.4	HTL localised	21,243	1.8%	8.9	629	10,079	10,708
4.1	HTL (with MR)	9,252	0.8%	3.9	274	4,572	4,846
4.2b	HTL to year 15	312	0.0%	0.1	9	33	43
4.4	HTL localised	865	0.1%	0.4	26	788	814
5.1	HTL	67,408	5.6%	28.4	1,996	6,924	8,920
5.2	HTL (with MR)	67,428	5.6%	28.4	1,996	6,754	8,751
6.2	HTL (with MR)	3,390	0.3%	1.4	100	681	781
7.1	HTL to year 30	1,502	0.1%	0.6	44	121	165
7.2a	HTL	12,235	1.0%	5.2	362	5,515	5,877
7.2b	HTL	1,421	0.1%	0.6	42	1,194	1,236
9.1	HTL	13,660	1.1%	5.8	404	5,207	5,612
9.2	HTL localised	9,063	0.8%	3.8	268	2,503	2,771
11.1	HTL	13,931	1.2%	5.9	412	997	1,409
11.2	HTL	607,198	50.8%	255.8	17,979	18,081	36,060

6 Benefit Areas – Strategy Preferred Options

This Section of the Report aims to summarise the economics, and provide a justification for the preferred option for each Benefit Area. Tables 11-45 have been developed to summarise this information and include:

- **Details of the preferred option** – a description of the SoP provided by the preferred option and an indication of when the options will be constructed.
- **Justification** – an explanation for why the option has been chosen as the preferred option over the other short listed options.
- **Outcome Measure 1: Economics** – A summary of the costs, benefits and resultant Benefit Cost Ratio (BCR) associated with the preferred option.
- **Outcome Measure 2: Probability of Houses at Risk of Flooding** – provides a summary of the residential properties at risk of flooding for a very significant (>5%AEP event), significant (<5% to >1.3% AEP event), and moderate flood (1.3% to >0.5% AEP event). These figures are taken from the Partnership Funding calculator and show the number of properties at risk before (under a Do Nothing scenario) and after (based on the protection provided by the preferred option).
- **Outcome Measure 3: Houses better protected from erosion** – similar to Outcome Measure 2, this is lifted from the Partnership Funding calculator and describes the number of residential properties at risk from erosion under a Do Nothing option that are being protected under the preferred option. Medium term loss refers to residential properties at risk of erosion between years 0-20; long-term loss refers to residential properties at risk from erosion in years 21-50.
- **Outcome Measure 4: Statutory environmental obligations met** – refers to the hectares of intertidal habitat created with the option. This is from the Partnership Funding calculator, and additional GiA is available per hectare of habitat created.
- **Environmental Impact** – provides an indication of the potential environmental impacts of the preferred option, and if any further compensatory habitat will be required.
- **Funding of Preferred Options** – outlines the Partnership Funding score and the further contributions that will be required to make the preferred option eligible for GiA, if applicable. If the option is not fully funded also includes information on the potential third-parties who could provide contributions, subject to further discussions.
- **Moderation Case (cost-effectiveness analysis) for the designated freshwater habitat** – for leading options where freshwater habitat compensation is required by law, this section of the tables presents a summary of a cost-effectiveness assessment that was undertaken to determine the most appropriate way to fund either the compensation of the freshwater habitat, the maintenance of the defences to protect the freshwater habitat to the same SoP over time, or a Managed Realignment - Habitat Adaptation option to more sustainably manage the frontage over time.

Table 11: Summary of Economics and Outcome Measures for BA1.2

BA 1.2 – Maintain defences until year 8. Then raise (sustain) the embankment, seawall and rock revetment in year 8.

Overall Policy	2018-2038	2039-2068	2069-2118
	HTL Sustain	HTL Sustain	HTL Sustain

Details of Preferred Option

Maintenance of the current defences (embankment, seawall and rock revetment) for the first 8 years. Following this the defences will be raised to 5.3m AOD and then raised again in year 50 to 6.6m AOD to ensure a 0.1% SoP in 100 years taking account of sea level rise.

Justification

Maintain (capital) option has highest NPV and highest BCR following the Do Minimum and an incremental BCR greater than 1. However, the Maintain option is not desirable due to the potential impacts on nationally important infrastructure due to sea level rise and therefore it does not meet the Strategy objectives. Under local choices, the Sustain Option will be preferred and would require and additional £1.5m funding over 100 years.

Outcome Measure 1 – Economics

PVb (£)	£ 41,148k	**PVc (£)**	£22,054k	**BCR**	1.87

Outcome Measure 2 – Probability of Houses at Risk of Flooding

Risk Probability Zone	Households Before	Households After
Very Significant (>=5%)	0	0
Significant (<5% to >1.3%)	1	0
Moderate (1.3% to >0.5%)	1	0

Outcome Measure 3 – Houses better protected from erosion

	Long term loss (21-50 years)	Medium term loss (0-20 years)
Number of households	0	0

Outcome Measure 4 – Statutory environmental obligations met

Ha of intertidal habitat created	0

Environmental Impact

Potential significant effects on the Medway Estuary and Marshes SPA and Ramsar and constituent qualifying features due to coastal squeeze. The saltmarsh habitats of Stoke Saltings and Slede are predicted to reduce in area due to sea level rise, with potential impacts on breeding waders like Redshank and Oystercatcher, and a number of duck species. Potential loss of reed bed habitat around Damhead Creek could impact on Marsh Harrier breeding, as a breeding pair has been known to breed here in the recent past. No new habitat would be created behind the existing defences.

There could be potential adverse effects on connectivity across northern part of Medway estuary as coastal squeeze takes effect. Loss of saltmarsh habitat here, and across the estuary, would act to reduce available habitats and therefore as mitigation the Strategy is looking at creating habitat in Managed Realignment sites.

Funding of Preferred Option

Adjusted PF score	10%	**External contributions required**	£19,759k

This option is eligible for Government funding, however significant third-party contributions will be required. Potential contributors might include:

- Kingsnorth Power Station
- Damhead Creek Power Station
- Local businesses in Kingsnorth Industrial Estate
- National Rail

Table 12: Summary of Economics and Outcome Measures for BA1.3

BA 1.3 - Ongoing maintenance until year 25, followed by No Active Intervention (NAI). Managed Realignment site at the east of the site with freshwater habitat compensation required in year 5.

Overall Policy	2018-2038	2039-2068	2069-2118
	HTL Maintain with MR	MR and NAI	MR and NAI

Details of Preferred Option

Maintenance (patch and repair) of the current defences (earth embankments and rock revetment) for the first 25 years. After this all maintenance will be ceased which will increase the risk of failure of the defences.

Additionally, construction of a MR site from year 5 to the east of the BA to help compensate for the strategy wide coastal squeeze impacts. Setback embankments would be constructed to manage tidal water and a breach in the current defences created. This will also require compensatory freshwater habitat.

Justification

Due to the limited assets at risk in the area, options to hold the line long term do not provide a BCR above one. The current defences have a 25-year median residual life. If patch and repair maintenance continues, the overall BCR is above one and the NPV is positive, enabling HTL policy in the short term.

The justification for the MR site is related to the Strategy wide requirement for coastal squeeze compensation.

Outcome Measure 1 – Economics

PVb (£)	£331k	**PVc (£)**	£147k	**BCR**	2.26

Outcome Measure 2 – Probability of Houses at Risk of Flooding

Risk Probability Zone	Households Before	Households After
Very Significant >5%	0	0
Significant	1	1
Moderate	0	0

Outcome Measure 3 – Houses better protected from erosion

	Long term loss	Medium term loss
Number of households	0	0

Outcome Measure 4 – Statutory environmental obligations met

Ha of intertidal habitat created	0

Environmental Impact

Potential significant effects on the Medway Estuary and Marshes SPA and Ramsar and constituent qualifying features due to coastal squeeze in the first 25 years. Once the policy of NAI is implemented after year 25, there may be failure of the defence, which will allow saltmarsh and mudflat to form in place of the arable and grazing marsh behind. However this will result in the loss of designated freshwater grazing marsh, and have potential adverse effects on the connectivity of the freshwater habitats. Freshwater habitat compensation will be required from year 5 due to the managed realignment site in this area.

Funding of Preferred Option

Adjusted PF score	13%	**External contributions required**	£128k

The option is eligible for a small amount of GiA, which will be used for the maintenance of the defences over the first 25 years. The compensatory habitat needs to be implemented to meet the legal requirements of the SPA and Ramsar and will be required when the Managed Realignment site is created.

Moderation Case (cost-effectiveness analysis) for the designated freshwater habitat

This excludes the area of freshwater covered by the Abbotts Court MR site which will need compensating to make clear is not to do with the MR site.

Option	Freshwater Habitat Compensation	Maintaining and raising the defences in line with sea level rise
Cost	£1,257k	£4,032k
Other factors	37ha of freshwater habitat compensation required.	Coastal squeeze of the intertidal SPA and Ramsar if the defences are held.
Rank	1	2

Table 13: Summary of Economics and Outcome Measures for BA1.4

BA 1.4 – No Active Intervention (NAI).

Overall Policy	2018-2038	2039-2068	2069-2118
	NAI	NAI	NAI
Details of Preferred Option			
In line with current approach, no maintenance will be undertaken. Rate of cliff retreat will increase with sea level rise, but this will support the SSSI designation at the site.			
Justification			
No short listed options were identified to provide erosion protection long this frontage. NAI aligns with SMP policy and requirements of the SSSI.			
Outcome Measure 1 – Economics			
PVb (£k)	£0	**PVc (£k)**	£0	**BCR**	0
Outcome Measure 2 – Probability of Houses at Risk of Flooding			
Risk Probability Zone	**Households Before**	**Households After**	
Very Significant >5%	0	0	
Significant	0	0	
Moderate	0	0	
Outcome Measure 3 – Houses better protected from erosion			
	Long term loss	**Medium term loss**	
Number of households	0	0	
Outcome Measure 4 – Statutory environmental obligations met			
Ha of intertidal habitat created	0		
Environmental Impact			
This option is not likely to have significant effects on any designated sites and their constituent qualifying features as the cliffs are left naturally to erode. This supports the SSSI designation for the geology.			
Funding of Preferred Option			
Adjusted PF score	n/a	**External contributions required**	n/a

Table 14: Summary of Economics and Outcome Measures for BA2.1

BA 2.1 – Raise (sustain) embankments, walls, flood gates and revetments.

Overall Policy	2018-2038	2039-2068	2069-2118
	HTL Sustain	HTL Sustain	HTL Sustain

Details of Preferred Option

This option involves improving the current SoP provided by the defences to 1% AEP SoP with sea level rise; in year 9 to 5.1m AOD and then in year 50 to 6.2m AOD to continue to provide protection in line with sea level rise.

Justification

This option has the highest BCR, NPV and a high incremental BCR, However it is to be noted that there is still a significant amount of contributions that will be required to allow the scheme to progress. It has one of the highest environmental ranking from the short list of options. There is a higher economic justification for raising the defences in the short term rather than waiting for defences to reach their residual life to provide increased flood risk in the short term.

Outcome Measure 1 – Economics

PVb (£)	£38,820k	**PVc (£)**	£20,534k	**BCR**	1.89

Outcome Measure 2 – Probability of Houses at Risk of Flooding

Risk Probability Zone	Households Before	Households After
Very Significant >5%	28	0
Significant	38	0
Moderate	26	0

Outcome Measure 3 – Houses better protected from erosion

	Long term loss	Medium term loss
Number of households	0	0

Outcome Measure 4 – Statutory environmental obligations met

Ha of intertidal habitat created	0

Environmental Impact

This option is not predicted to have any direct or indirect impacts on any designated sites and their constituent qualifying features.

Funding of Preferred Option

Adjusted PF score	14%	**External contributions required**	£17,618k

The option is eligible for Government funding, however significant third-party contributions will be required. Potential contributors might include:

- Medway Council
- Industry along the water front
- National Rail

Table 15: Summary of Economics and Outcome Measures for BA2.2

BA 2.2 - Raise (sustain) embankments, walls, flood gates and revetments in localised areas.

Overall Policy	2018-2038	2039-2068	2069-2118
	HTL Sustain Localised	HTL Sustain Localised	HTL Sustain Localised

Details of Preferred Option

Localised raising of the defences to protect properties and assets at risk of flooding around Rochester and Chatham against a 0.1% AEP with sea level rise. The localised defences will be raised in year 8 to 5.4m AOD and then in year 50 to 6.8m AOD to continue to provide protection in line with sea level rise. The rest of the BA will have a NAI approach and management will cease on the defences.

Justification

Localised HTL option is the only option which provides a BCR above 1. This option will still provide protection to all residential properties at risk of flooding to at least a 1% AEP. In the NAI areas there is limited assets at risk due to the rising ground.

There is a higher economic justification for raising the defences in the short term rather than waiting for defences to reach their residual life to provide increased flood risk in the short term.

Outcome Measure 1 – Economics

PVb (£)	£6,037k	**PVc (£)**	£5,417k	**BCR**	1.11

Outcome Measure 2 – Probability of Houses at Risk of Flooding

Risk Probability Zone	Households Before	Households After
Very Significant >5%	13	0
Significant	55	0
Moderate	26	0

Outcome Measure 3 – Houses better protected from erosion

	Long term loss	Medium term loss
Number of households	0	0

Outcome Measure 4 – Statutory environmental obligations met

Ha of intertidal habitat created	0

Environmental Impact

This option is not predicted to have any direct or indirect impacts on any designated sites and their constituent qualifying features.

Funding of Preferred Option

Adjusted PF score	18%	**External contributions required**	£4,440k

The option is eligible for Government funding, however significant third-party contributions will be required. Potential contributors might include:

- Medway Council
- Industry along the water front

Table 16: Summary of Economics and Outcome Measures for BA2.3

BA 2.3 - Raise (sustain) embankments, walls, flood gates and revetments.

Overall Policy	2018-2038	2039-2068	2069-2118
	HTL Sustain	HTL Sustain	HTL Sustain

Details of Preferred Option

This option involves improving the SoP provided by the defences to 0.5% AEP SoP with sea level rise; in year 5 to 5.1m AOD and then in year 50 to 6.3m AOD to continue to provide protection in line with sea level rise.

Justification

This option has the highest NPV and incremental BCR of over 5. It should be noted that the Upgrade option also presents a BCR of greater than one (but not an incremental BCR greater than 1) and therefore the SoP could be increased at OBC stage depending on third party contributions available. There is a higher economic justification for raising the defences in the short term rather than waiting for defences to reach their residual life to provide increased flood risk in the short term.

Outcome Measure 1 – Economics

PVb (£)	£63,084k	**PVc (£)**	£16,124k	**BCR**	3.91

Outcome Measure 2 – Probability of Houses at Risk of Flooding

Risk Probability Zone	Households Before	Households After
Very Significant >5%	24	0
Significant	157	0
Moderate	195	0

Outcome Measure 3 – Houses better protected from erosion

	Long term loss	Medium term loss
Number of households	0	0

Outcome Measure 4 – Statutory environmental obligations met

Ha of intertidal habitat created	0

Environmental Impact

This option is not predicted to have any direct or indirect impacts on any designated sites and their constituent qualifying features.

Funding of Preferred Option

Adjusted PF score	33%	**External contributions required**	£10,783k

The option is eligible for Government funding, however significant third-party contributions will be required. Potential contributors might include:

- Medway Council
- Industry along the water front
- Historic Dockyard

Table 17: Summary of Economics and Outcome Measures for BA3.1

BA 3.1 – No Active Intervention (NAI).

Overall Policy	2018-2038	2039-2068	2069-2118
	NAI	NAI	NAI
Details of Preferred Option			
All maintenance will be ceased, and the current defences will not be maintained. There will be an increased risk of overtopping and the defences will be at risk from failure from year 20 causing increased risk of overflow flooding.			
Justification			
No short listed options were identified with BCRs above one which provided increased protection. There are limited assets at risk from flood damages in the area.			
Outcome Measure 1 – Economics			
PVb (£) £0	**PVc (£)** £0	**BCR** 0.0	
Outcome Measure 2 – Probability of Houses at Risk of Flooding			
Risk Probability Zone	**Households Before**	**Households After**	
Very Significant >5%	0	0	
Significant	0	0	
Moderate	0	0	
Outcome Measure 3 – Houses better protected from erosion			
	Long term loss	**Medium term loss**	
Number of households	0	0	
Outcome Measure 4 – Statutory environmental obligations met			
Ha of intertidal habitat created	0		
Environmental Impact			
This option is not predicted to have any direct or indirect impacts on any designated sites and their constituent qualifying features.			
Funding of Preferred Option			
Adjusted PF score n/a	**External contributions required** n/a		

Table 18: Summary of Economics and Outcome Measures for BA3.2

BA 3.2 - Construct new setback embankments at Halling Marshes. Raise (sustain) embankments, walls and flood gates in localised areas.

Overall Policy	2018-2038	2039-2068	2069-2118
	HTL Sustain Localised and MR	HTL Sustain Localised and MR	HTL Sustain Localised and MR

Details of Preferred Option

Localised raising of the defences to protect properties and assets at risk of flooding around Halling against a 5%AEP with sea level rise. The localised defences will be raised in year 10 to 5.1m AOD and then in year 50 to 6.1m AOD to continue to provide protection in line with sea level rise. The rest of the BA will have a NAI approach and management will cease on the defences.

Additionally, construction of a MR site from year 5 at Halling marsh to help compensate for the strategy wide coastal squeeze impacts. Setback embankments would be constructed to manage tidal water and a breach in the current defences created.

Justification

Localised HTL sensitivity provides the only option with a BCR above 1 and a positive NPV, and will provide protection to all residential properties at risk of flooding to at least a 5% AEP. In the NAI areas there is limited assets at risk due to the rising ground.

MR site at Halling Marshes is required to help compensate for coastal squeeze across the Strategy in the first epoch. The justification for the MR site is related to the Strategy wide requirement for coastal squeeze.

Outcome Measure 1 – Economics

PVb (£)	£2,789k	**PVc (£)**	£1,725k	**BCR**	1.62

Outcome Measure 2 – Probability of Houses at Risk of Flooding

Risk Probability Zone	Households Before	Households After
Very Significant >5%	21	0
Significant	0	0
Moderate	0	0

Outcome Measure 3 – Houses better protected from erosion

	Long term loss	Medium term loss
Number of households	0	0

Outcome Measure 4 – Statutory environmental obligations met

Ha of intertidal habitat created	0

Environmental Impact

There may be a change to the habitat type in the SSSI at Holborough Marshes due to uncontrolled saline intrusion once the defences fail in year 25. A variety of habitats are present including extensive reed beds, open water, fen, grassland, scrub and woodland. The many different habitats support a wide variety of breeding birds and the site is also important for wintering wildfowl and waders. A number of scarce wetland plants occur and it is also a locality of a rare moth, a rare beetle, and 3 are bee species. The area has nationally important GCN populations.

Funding of Preferred Option

Adjusted PF score	28%	**External contributions required**	£1,236k

The option is eligible for Government funding, however significant third-party contributions will be required. Potential contributors might include:

- Local Councils
- Land and property owners

Table 19: Summary of Economics and Outcome Measures for BA3.3

BA 3.3 - Raise (sustain) embankments, walls and flood gates from year 20.

Overall Policy	2018-2038	2039-2068	2069-2118
	HTL Maintain	HTL Sustain	HTL Sustain

Details of Preferred Option

Maintenance of the current defences (embankment, seawall and rock revetment) for the first 20 years. Following this the defences will be raised to 6m AOD and then raised again in year 50 to 7.4m AOD to ensure a 0.1% SoP in 100 years taking account of sea level rise.

Justification

Maintain (capital) option has the highest benefits following the Do Minimum and an incremental BCR greater than 1. However, the Sustain option protects over 440 additional properties and therefore much better meets the Strategy objectives. Under local choices, the Sustain Option will be preferred and would require and additional £2.4m funding over 100 years.

Outcome Measure 1 – Economics

PVb (£)	£213,624k	**PVc (£)**	£17,628k	**BCR**	12.12

Outcome Measure 2 – Probability of Houses at Risk of Flooding

Risk Probability Zone	Households Before	Households After
Very Significant >5%	50	0
Significant	50	0
Moderate	185	0

Outcome Measure 3 – Houses better protected from erosion

	Long term loss	Medium term loss
Number of households	0	0

Outcome Measure 4 – Statutory environmental obligations met

Ha of intertidal habitat created	0

Environmental Impact

This option is not predicted to have any direct or indirect impacts on any designated sites and their constituent qualifying features. The increased SoP provided by improving the defence will protect the SSSI at Holborough to Burham Marshes.

Funding of Preferred Option

Adjusted PF score	76%	**External contributions required**	£ 4,285k

This option is eligible for GiA funding however third party funding is also required.

Table 20: Summary of Economics and Outcome Measures for BA3.4

BA 3.4 - Raise (sustain) embankments, walls and flood gates in localised areas.

Overall Policy	2018-2038	2039-2068	2069-2118
	HTL Sustain Localised	HTL Sustain Localised	HTL Sustain Localised

Details of Preferred Option

Localised raising of the defences around Aylesford and Wouldham to protect properties and assets at risk of flooding against a 0.1%AEP with sea level rise. The localised defences will be raised in year 8 to 5.0m AOD and then in year 50 to 6.0m AOD to continue to provide protection in line with sea level rise. The rest of the BA will have a NAI approach and management will cease on the defences.

Justification

Localised HTL sensitivity provides the only short listed option with a positive NPV and a BCR above 1. This option will provide protection to all residential properties at risk of flooding to at least a 1% AEP. In the NAI areas there is limited assets at risk due to the rising ground.

There is a higher economic justification for raising the defences in the short term rather than waiting for defences to reach their residual life to provide increased flood risk in the short term.

Outcome Measure 1 – Economics

PVb (£)	£21,243k	**PVc (£)**	£10,708k	**BCR**	1.98

Outcome Measure 2 – Probability of Houses at Risk of Flooding

Risk Probability Zone	Households Before	Households After
Very Significant >5%	25	0
Significant	15	0
Moderate	59	0

Outcome Measure 3 – Houses better protected from erosion

	Long term loss	Medium term loss
Number of households	0	0

Outcome Measure 4 – Statutory environmental obligations met

Ha of intertidal habitat created	0

Environmental Impact

Risk from overtopping to the freshwater habitats and Holborough to Burham Marshes SSSI which include extensive reed beds, open water, fen, grassland, scrub and woodland. This could have significant impacts on breeding birds and wintering wildfowl and waders. Additionally a number of scarce wetland plants will be lost and a rare moth, a rare beetle, and 3 rare bee species will be impacted.

Funding of Preferred Option

Adjusted PF score	16%	**External contributions required**	£8,952k

The option is eligible for Government funding, however significant third-party contributions will be required. Potential contributors might include:

- Local Councils
- Land and property owners

Table 21: Summary of Economics and Outcome Measures for BA3.5

BA 3.5 - No Active Intervention (NAI).

Overall Policy	2018-2038	2039-2068	2069-2118
	NAI	NAI	NAI
Details of Preferred Option			
All maintenance will be ceased and the current defences will not be maintained. There will be an increased risk of overtopping and the defences will be at risk from failure from year 5 causing increased risk of overflow flooding.			
Justification			
Do minimum only provides maintenance of defences for 5 years due to the low residual life of the existing embankments. Therefore, overall policy in epoch 1 would be No Active Intervention.			
Outcome Measure 1 – Economics			
PVb (£)	£0	**PVc (£)** £0	**BCR** 0.0
Outcome Measure 2 – Probability of Houses at Risk of Flooding			
Risk Probability Zone	**Households Before**	**Households After**	
Very Significant >5%	0	0	
Significant	0	0	
Moderate	0	0	
Outcome Measure 3 – Houses better protected from erosion			
	Long term loss	**Medium term loss**	
Number of households	0	0	
Outcome Measure 4 – Statutory environmental obligations met			
Ha of intertidal habitat created	75.6		
Environmental Impact			
This option is predicted to have impacts on Priority Habitat (Freshwater Grazing Marsh) over time as increasing overtopping occurs on the defences.			
Funding of Preferred Option			
Adjusted PF score	0%	**External contributions required**	£0

Table 22: Summary of Economics and Outcome Measures for BA4.1

BA 4.1 - Construct new setback embankments at Danes Hill and sustain embankments, walls and flood gates around other areas.

Overall Policy	2018-2038	2039-2068	2069-2118
	HTL Sustain with MR	HTL Sustain with MR	HTL Sustain with MR

Details of Preferred Option

Most of the defences along the frontage will raised to increase the SoP in line with sea level rise. In year 8 the defences will be raised to 4.9m AOD, and in year 50 the defences will be raised to 5.9m AOD to provide a 2%AEP SoP in line with sea level rise.

Additionally, construction of a MR site from year 5 at Danes Hill to help compensate for the strategy wide coastal squeeze impacts. Setback embankments will be constructed to manage tidal water and a breach in the current defences created.

Justification

HTL sustain has the highest NPV and an iBCR greater than 1. There is a higher economic justification for raising the defences in the short term rather than waiting for defences to reach their residual life to provide increased flood risk in the short term.

MR site at Danes Hill is required to help compensate for coastal squeeze across the Strategy in the first epoch. The justification for the MR site is related to the Strategy wide requirement for coastal squeeze.

Outcome Measure 1 – Economics

PVb (£k)	£9,252k	**PVc (£k)**	£4,846k	**BCR**	1.91

Outcome Measure 2 – Probability of Houses at Risk of Flooding

Risk Probability Zone	Households Before	Households After
Very Significant >5%	6	0
Significant	2	0
Moderate	0	0

Outcome Measure 3 – Houses better protected from erosion

	Long term loss	Medium term loss
Number of households	0	0

Outcome Measure 4 – Statutory environmental obligations met

Ha of intertidal habitat created	5.5

Environmental Impact

There may be potential significant effects on the intertidal Medway Estuary and Marshes SPA and Ramsar and its constituent qualifying features due to coastal squeeze where Hold the Line is maintained, although the Managed Realignment (c. 5.6 ha) will serve to mitigate for this loss by the creation of saltmarsh and mudflat habitats.

Funding of Preferred Option

Adjusted PF score	13%	**External contributions required**	£4,222k

This option is eligible for Government funding, however significant third-party contributions will be required. Potential contributors might include:

- Local landowners
- Local Council

Table 23: Summary of Economics and Outcome Measures for BA4.2a

BA 4.2a – No Active Intervention (NAI) with freshwater compensation required by year 9 (capital works in year 4).

Overall Policy	2018-2038	2039-2068	2069-2118
	NAI	NAI	NAI

Details of Preferred Option

It is not economically viable to maintain the defences, as such all maintenance will be ceased and there will be risk of failure of the defences from year 9 which would result in the inundation of the designated freshwater habitat. Therefore, compensatory freshwater habitat will need to be developed by year 4 to allow it to be in place prior to failure of the defences in year 9.

Justification

No short listed options were identified which would provide increased protection and with BCRs above one/positive NPVs.

It is not viable to maintain the defences however compensation for the impacts on the freshwater habitat is required by law.

Outcome Measure 1 – Economics

PVb (£)	£0	PVc (£)	£0	BCR	0.0

Outcome Measure 2 – Probability of Houses at Risk of Flooding

Risk Probability Zone	Households Before	Households After
Very Significant >5%	0	0
Significant	0	0
Moderate	0	0

Outcome Measure 3 – Houses better protected from erosion

	Long term loss	Medium term loss
Number of households	0	0

Outcome Measure 4 – Statutory environmental obligations met

Ha of intertidal habitat created	0

Environmental Impact

Overtopping and failure of the defences will result in the degradation of reed bed habitat and areas of scrubby woodland within the SPA/Ramsar site. This may impact on the known populations of wildfowl known to use the area, including various Qualifying Feature species within the freshwater SPA and Ramsar habitat.

Compensatory freshwater habitat will be required following failure of the defences.

Funding of Preferred Option

Adjusted PF score	n/a	External contributions required	£0

The option is not eligible for GiA. However, the compensatory habitat needs to be implemented to meet the legal requirements of the SPA and Ramsar. A moderation assessment was undertaken to determine the most cost-effective way to meet the legal obligations.

Moderation Case (cost-effectiveness analysis) for the designated freshwater habitat

Option	Freshwater Habitat Compensation	Maintaining and Raising the defences in line with sea level rise
Cost	£2,000k	£7,512k
Other factors	32ha of freshwater habitat compensation required	Coastal squeeze of the intertidal SPA and Ramsar if the defences are held
Rank	1	2

Table 24: Summary of Economics and Outcome Measures for BA4.2b

BA 4.2b – Ongoing maintenance until year 15, followed by No Active Intervention (NAI) and freshwater compensation required by 15 (capital works in year 10).

Overall Policy	2018-2038	2039-2068	2069-2118
	HTL Maintain	NAI	NAI

Details of Preferred Option

Maintenance (patch and repair) of the current defences (earth embankments) for the first 15 years. After this all maintenance will be ceased which will increase the risk of failure of the defences which would result in the inundation of the designated freshwater habitat. Therefore, compensatory freshwater habitat will need to be developed by year 10 to allow it to be in place prior to failure of the defences from year 15.

Justification

Due to the limited assets at risk in the area, options to Hold the Line in the long term do not provide a BCR above one. The current defences have a 15-year median residual life. If patch and repair maintenance continues, the overall BCR is above one and the NPV is positive, enabling HTL policy in the short term.

Compensation for the impacts on the freshwater habitat is required by law.

Outcome Measure 1 – Economics

PVb (£)	£312k	PVc (£)	£43k	BCR	7.34

Outcome Measure 2 – Probability of Houses at Risk of Flooding

Risk Probability Zone	Households Before	Households After
Very Significant >5%	2	1
Significant	0	1
Moderate	2	2

Outcome Measure 3 – Houses better protected from erosion

	Long term loss	Medium term loss
Number of households	0	0

Outcome Measure 4 – Statutory environmental obligations met

Ha of intertidal habitat created	0

Environmental Impact

There are potential significant effects on the intertidal Medway Estuary and Marshes SPA and Ramsar and constituent qualifying features due to coastal squeeze until failure of the defences in year 15. Once the defences fail there will be degradation and loss of existing designated freshwater grazing marsh, which is known to be of good quality. The southern portion of this site is the best quality, and is currently managed under Stewardship Agreements for breeding waders - there is a large breeding population of avocets in this southern portion. Other waders, including redshank and lapwing, use the whole of this area.

Funding of Preferred Option

Adjusted PF score	62%	External contributions required	£16k

The option is eligible for some GiA, which will likely be used for the maintenance of the defences over the first 15 years. The compensatory habitat needs to be implemented to meet the legal requirements of the SPA and Ramsar. A moderation assessment was undertaken to determine the most cost-effective way to meet the legal obligations.

Moderation Case (cost-effectiveness analysis) for the designated freshwater habitat

Option	Freshwater Habitat Compensation	Maintaining and Raising the defences in line with sea level rise
Cost	£3,243k	£4,781k
Other factors	Significant area (88 ha) of freshwater habitat compensation required.	Coastal squeeze of the intertidal SPA and Ramsar if the defences are held.
Rank	1	2

Table 25: Summary of Economics and Outcome Measures for BA4.3

BA 4.3 – No Active Intervention (NAI).

Overall Policy	2018-2038	2039-2068	2069-2118
	NAI	NAI	NAI
Details of Preferred Option			
All maintenance will be ceased and the current defences will not be maintained. There will be an increased risk of overtopping and the defences will be at risk from failure from year 20.			
Justification			
No short listed options were identified which would provide increased protection and with BCRs above one/positive NPVs.			
Outcome Measure 1 – Economics			
PVb (£) £0	**PVc (£)** £0	**BCR** 0.0	
Outcome Measure 2 – Probability of Houses at Risk of Flooding			
Risk Probability Zone	**Households Before**	**Households After**	
Very Significant >5%	0	0	
Significant	0	0	
Moderate	0	0	
Outcome Measure 3 – Houses better protected from erosion			
	Long term loss	**Medium term loss**	
Number of households	0	0	
Outcome Measure 4 – Statutory environmental obligations met			
Ha of intertidal habitat created	0		
Environmental Impact			
A NAI policy should allow natural processes and limit the impacts on the environment.			
Funding of Preferred Option			
Adjusted PF score n/a	**External contributions required** n/a		

Table 26: Summary of Economics and Outcome Measures for BA4.4

BA 4.4 – Raise (sustain) embankment and revetment in localised areas.

Overall Policy	2018-2038	2039-2068	2069-2118
	HTL Sustain Localised	HTL Sustain Localised	HTL Sustain Localised

Details of Preferred Option

Localised raising of the defences to protect the village of Lower Halstow against a 1%AEP with sea level rise. The defences will be raised in year 10 to 5.2m AOD and then in year 50 to 6.0m AOD to continue to provide protection in line with sea level rise. The rest of the BA will have a NAI approach and management will cease on the defences.

Justification

Localised HTL sensitivity provides the only solution with a BCR above 1 and a positive NPV. This option will provide protection to all residential properties at risk of flooding to at least a 1% AEP. In the NAI areas there is limited assets at risk due to the rising ground.

Outcome Measure 1 – Economics

PVb (£)	£865k	**PVc (£)**	£814k	**BCR**	1.06

Outcome Measure 2 – Probability of Houses at Risk of Flooding

Risk Probability Zone	Households Before	Households After
Very Significant >5%	1	0
Significant	0	0
Moderate	1	0

Outcome Measure 3 – Houses better protected from erosion

	Long term loss	Medium term loss
Number of households	0	0

Outcome Measure 4 – Statutory environmental obligations met

Ha of intertidal habitat created	0

Environmental Impact

Where the defences are raised there may be a risk of coastal squeeze, which could have limited adverse effects on the SPA and Ramsar habitat. In the NAI areas there will be the opportunity for the natural roll-back of the intertidal habitat, reducing the impacts of coastal squeeze. There will be no impacts on designated freshwater habitat.

Funding of Preferred Option

Adjusted PF score	8%	**External contributions required**	£748k

This option is eligible for Government funding, however third-party contributions will be required for the majority of the costs. Potential contributors might include:

- Local landowners
- Local Council

Table 27: Summary of Economics and Outcome Measures for BA4.5

BA 4.5 – No Active Intervention (NAI) with freshwater compensation required by year 21 (capital works in year 16).

Overall Policy	2018-2038	2039-2068	2069-2118
	NAI	NAI	NAI

Details of Preferred Option

It is not economically viable to maintain the defences, as such all maintenance will be ceased. This will increase the risk of failure of the defences which could result in the inundation of the designated freshwater habitat. Therefore, compensatory freshwater habitat will need to be developed by year 16 to allow it to be in place prior to failure of the defences from year 21.

Justification

No short listed options were identified which would provide increased protection and with BCRs above one/positive NPVs.

It is not viable to maintain the defences however compensation for the impacts on the freshwater habitat is required by law.

Outcome Measure 1 – Economics

PVb (£)	£0	**PVc (£)**	£0	**BCR**	0.0

Outcome Measure 2 – Probability of Houses at Risk of Flooding

Risk Probability Zone	Households Before	Households After
Very Significant >5%	0	0
Significant	0	0
Moderate	0	0

Outcome Measure 3 – Houses better protected from erosion

	Long term loss	Medium term loss
Number of households	0	0

Outcome Measure 4 – Statutory environmental obligations met

Ha of intertidal habitat created	0

Environmental Impact

.

Funding of Preferred Option

Adjusted PF score	n/a	**External contributions required**	£0

Once the defences fail there will be risk of degradation and loss of existing designated freshwater grazing marsh, which is known to be of moderately good quality, representing good habitat for breeding and overwintering waders.

The compensatory habitat needs to be implemented to meet the legal requirements of the SPA and Ramsar. A moderation assessment was undertaken to determine the most cost-effective way to meet the legal obligations

Moderation Case (cost-effectiveness analysis) for the designated freshwater habitat

Option	Freshwater Habitat Compensation	Maintaining and raising the defences in line with sea level rise
Cost	£2,381k	£2,572k
Other factors	Significant area (77 ha) of freshwater habitat compensation required	Coastal squeeze of the intertidal SPA and Ramsar if the defences are held
Rank	1	2

Table 28: Summary of Economics and Outcome Measures for BA4.6

BA 4.6 – No Active Intervention (NAI).

Overall Policy	2018-2038	2039-2068	2069-2118
	NAI	NAI	NAI
Details of Preferred Option			
All maintenance will be ceased and the current defences will not be maintained. There will be an increased risk of overtopping and the defences will be at risk of failing from year 25.			
Justification			
No short listed options were identified with BCRs above one which provided increased protection.			
Outcome Measure 1 – Economics			
PVb (£) £0	**PVc (£)** £0	**BCR** 0.0	
Outcome Measure 2 – Probability of Houses at Risk of Flooding			
Risk Probability Zone	**Households Before**	**Households After**	
Very Significant >5%	0	0	
Significant	0	0	
Moderate	0	0	
Outcome Measure 3 – Houses better protected from erosion			
	Long term loss	**Medium term loss**	
Number of households	0	0	
Outcome Measure 4 – Statutory environmental obligations met			
Ha of intertidal habitat created	0		
Environmental Impact			
A NAI policy should allow natural processes and limit the impacts on the environment.			
Funding of Preferred Option			
Adjusted PF score n/a	**External contributions required** n/a		

Table 29: Summary of Economics and Outcome Measures for BA4.7

BA 4.7 – Ongoing maintenance until year 15 followed by Habitat Adaptation. Managed Realignment site at Tailness in year 5.

Overall Policy	2018-2038	2039-2068	2069-2118
	MR Hab Adap	MR Hab Adap	MR Hab Adap

Details of Preferred Option

Initial MR site by year 5 in the northeast corner at Tailness marshes, to provide compensation for coastal squeeze in the first epoch of the Strategy.

For the rest of the frontage, maintenance (patch and repair) of the current defences (earth embankments) for the first 15 years. After year 15 the natural adaptation of the frontage will be allowed to occur through the 'MR – habitat adaptation' option.

This option involves the natural adaptation of the frontage, by slowly reducing maintenance efforts and allowing inundation in particular areas. This gradual change will ensure a less severe impact to the freshwater habitat allowing a slower change and adaptation as intertidal habitat forms.

There is a risk regarding the access to the electricity pylons during extreme events, but this risk is reduced compared to undertaking a MR site approach here, as it is envisaged only the fringes of the site will be regularly inundated. The whole of the BA will only be affected in extreme events, and this is similar to the impacts under a NAI option. If required localised adaptation of the access roads etc can be undertaken to allow access to the pylons in extreme events.

Justification

Due to the limited assets at risk in the area, options to Hold the Line in the long term do not provide a BCR above one. The current defences have a 15-year median residual life. If patch and repair maintenance continues, the overall BCR is above one and the NPV is positive, enabling HTL policy in the short term.

It is economically viable to maintain the defences for the first 15 years. After this, there is a legal requirement to compensate or protection the freshwater designated habitat. The MR - habitat adaptation option will allow the freshwater habitat to adapt over time. This will result in a low-level impact over a longer period of time, which is more in line with Natural England's aspirations, and will help mitigate against the loss of functionality of the intertidal habitat in the upper Medway Estuary. As such this is a more sustainable option and in line with the IPENs guidance.

The MR site in the first epoch will help contribute to coastal squeeze compensation in the short term, with the rest of the frontage contributing coastal squeeze compensation in the third epoch.

Outcome Measure 1 – Economics

PVb (£)	£750k	PVc (£)	£599k	BCR	1.25

Outcome Measure 2 – Probability of Houses at Risk of Flooding

Risk Probability Zone	Households Before	Households After
Very Significant >5%	0	0
Significant	1	0
Moderate	0	0

Outcome Measure 3 – Houses better protected from erosion

	Long term loss	Medium term loss
Number of households	0	0

Outcome Measure 4 – Statutory environmental obligations met

Ha of intertidal habitat created	175

Environmental Impact

The aim of this option is to help improve the functionality of the SPA and Ramsar intertidal habitat, by allowing a more natural adaptation of the freshwater habitat. There will be adverse effects on the freshwater SPA and Ramsar habitat as there could be overtopping of the defences in extreme events, but this is the least damaging option as there will be the gradual natural adaptation of the habitat, and is a more sustainable approach to manage the environment in this BA. Further surveys will be required to fully understand the functionality of the designated sites.

Funding of Preferred Option

Adjusted PF score	8%	External contributions required	£550k

The preferred option may be eligible for some GiA due to the creation of intertidal habitat. However, the option needs to be implemented to meet the legal requirements for the SPA and Ramsar habitat so a moderation assessment was completed to determine that the option proposed was the most cost-effective way to meet the legal requirements.

BA 4.7 – Ongoing maintenance until year 15 followed by Habitat Adaptation. Managed Realignment site at Tailness in year 5.

Moderation Case (Cost-Effectiveness Analysis) for Freshwater Habitat			
Option	Freshwater habitat compensation	Maintaining and raising the defences in line with sea level rise	MR – biodiversity adaptation
Cost	£14,511k	£20,893k	£12,999k
Other factors	Significant area (385ha) of freshwater habitat compensation required	Protection of the freshwater habitat (to the current SoP). Potential coastal squeeze implications	Will allow the natural adaptation of intertidal habitat. Potentially less adverse impacts on freshwater SPA and Ramsar as a gradual change. Also in line with IPENs guidance
Rank	**2**	**3**	**1**

Table 30: Summary of Economics and Outcome Measures for BA5.1

BA 5.1 - Maintain defences until year 20. Raise (sustain) embankments and walls from year 20.

Overall Policy	2018-2038	2039-2068	2069-2118
	HTL Maintain	HTL Sustain	HTL Sustain

Details of Preferred Option

Maintenance of the current defences (embankment, seawall and rock revetment) for the first 5 years. Following this the defences will be raised to 5.2m AOD and then raised again in year 50 to 6.5m AOD to ensure a 0.1% SoP with sea level rise.

Justification

Maintain (capital) option has the highest benefits following the Do Minimum and an incremental BCR greater than 1. However, the Sustain option protects over 160 additional properties and therefore much better meets the Strategy objectives. Under local choices, the Sustain Option will be preferred and would require and additional £2.1m funding over 100 years.

Outcome Measure 1 – Economics

PVb (£)	£67,408k	**PVc (£)**	£8,920k	**BCR**	7.56

Outcome Measure 2 – Probability of Houses at Risk of Flooding

Risk Probability Zone	Households Before	Households After
Very Significant >5%	0	0
Significant	0	0
Moderate	0	0

Outcome Measure 3 – Houses better protected from erosion

	Long term loss	Medium term loss
Number of households	0	0

Outcome Measure 4 – Statutory environmental obligations met

Ha of intertidal habitat created	0

Environmental Impact

There are potential significant effects on the intertidal Swale SPA and Ramsar and constituent qualifying features due to coastal squeeze. Coastal squeeze will lead to a loss of saltmarsh habitat. There is unlikely to be any adverse impacts on the freshwater habitat as the SoP provided by the defences is improved.

Funding of Preferred Option

Adjusted PF score	42%	**External contributions required**	£5,175k

The option is eligible for some GiA, however third-party contributions will also be required. Potential contributors might include:

- Highways Agency
- Network Rail
- Ridham Docks
- Southern Water
- Industry around Ridham Docks

Table 31: Summary of Economics and Outcome Measures for BA5.2

BA 5.2 - Construct new setback embankments at identified Managed Realignment site at Kemsley. Raise (sustain) embankments and walls along the rest of the section.

Overall Policy	2018-2038	2039-2068	2069-2118
	HTL Sustain with MR	HTL Sustain with MR	HTL Sustain with MR

Details of Preferred Option

This option involves improving the SoP provided by the defences to improve the SoP to 0.5% AEP with sea level rise; in year 5 to 4.9m AOD and then in year 50 to 6.0m AOD to continue to provide protection in line with sea level rise.

Additionally, construction of a MR site from year 5 at Kemsley to help compensate for the strategy wide coastal squeeze impacts. Setback embankments will be constructed to manage tidal water and a breach in the current defences created.

Justification

The sustain option has an incremental BCR of greater than 3 and it has one of the highest environmental ranking from the short list of options. There is a higher economic justification for raising the defences in the short term rather than waiting for defences to reach their residual life to provide increased flood risk in the short term.

The MR site at Kemsley is required to help compensate for coastal squeeze across the Strategy in the first epoch. The justification for the MR site is related to the Strategy wide requirement for coastal squeeze compensation.

Outcome Measure 1 – Economics

PVb (£)	£67,428k	**PVc (£)**	£8,751k	**BCR**	7.71

Outcome Measure 2 – Probability of Houses at Risk of Flooding

Risk Probability Zone	Households Before	Households After
Very Significant >5%	245	0
Significant	204	0
Moderate	91	0

Outcome Measure 3 – Houses better protected from erosion

	Long term loss	Medium term loss
Number of households	0	0

Outcome Measure 4 – Statutory environmental obligations met

Ha of intertidal habitat created	6.4

Environmental Impact

These options are not likely to have adverse effects on the Swale SPA and Ramsar. The MR site provides mitigation for coastal squeeze.

Funding of Preferred Option

Adjusted PF score	106%	**External contributions required**	£0

This option is eligible for full GiA funding.

Table 32: Summary of Economics and Outcome Measures for BA6.1

BA 6.1 - Maintain embankments and upgrade SOP with sea level rise in year 50.

Overall Policy	2018-2038	2039-2068	2069-2118
	HTL Maintain	HTL Maintain	HTL Maintain

Details of Preferred Option

Maintenance (with capital works) of the current defences, and raise in year 50, to maintain a minimum SoP of 0.5%AEP protection with sea level rise (which is the current SoP offered).

Justification

Do minimum option is the only one with a BCR above 1.However, an option to raise the height of the defences with sea level rise is required as part of the legal obligations to cause no net loss of the designated freshwater habitat.

The current defences have a 25-year residual life. Following this, the cost to compensate the large area of freshwater habitat is much greater than the cost to maintain the defences with sea level rise. Therefore, it is more cost-effective to maintain the defences and raise with sea level rise. The defences are required to be raised with sea level rise as otherwise the frequency of inundation to the freshwater habitat would increase with sea level rise and compensation for this would be required in year 50.

Outcome Measure 1 – Economics

PVb (£)	£0	**PVc (£)**	£0	**BCR**	0

Outcome Measure 2 – Probability of Houses at Risk of Flooding

Risk Probability Zone	Households Before	Households After
Very Significant >5%	6	4
Significant	0	0
Moderate	1	1

Outcome Measure 3 – Houses better protected from erosion

	Long term loss	Medium term loss
Number of households	0	0

Outcome Measure 4 – Statutory environmental obligations met

Ha of intertidal habitat created	0

Environmental Impact

Adverse impacts on the intertidal Swale SPA and Ramsar and constituent qualifying features due to coastal squeeze and therefore as mitigation the Strategy is looking at creating habitat in Managed Realignment sites. Coastal squeeze will lead to a loss of intertidal habitat. But the current SoP of the defences will be maintained to ensure continued level of protection to SPA and Ramsar freshwater habitat.

Funding of Preferred Option

Adjusted PF score	0%	**External contributions required**	£0

The preferred option needs to be implemented to meet the legal requirements of the SPA and Ramsar. A moderation assessment was undertaken to determine the most cost-effective way to meet the legal obligations.

Moderation Case (Cost-Effectiveness Analysis) for Freshwater Habitat

Option	Freshwater Habitat Compensation	Maintaining and Raising the defences in line with sea level rise
Cost	£20,228k	£14,283k
Other factors	Very significant area (837 ha) of freshwater habitat compensation required. Potentially not technically viable to find the space within the Strategy.	Coastal squeeze of the intertidal SPA and Ramsar if the defences are held
Rank	2	1

Table 33: Summary of Economics and Outcome Measures for BA6.2

BA 6.2 - Ongoing maintenance until year 20. Then construct new setback embankments at Cleve Hill managed realignment site. Maintain embankments and walls either side and at the Sportsman Pub.

Overall Policy	2018-2038	2039-2068	2069-2118
	HTL Maintain	MR	MR

Details of Preferred Option

The Cleve Hill MR site will be developed in year 20 to mitigate against the strategy wide impacts of coastal squeeze in the second epoch. The defences either side of the MR site will be maintained (capital), apart from the section of defences fronting the freshwater SPA and Ramsar habitat at the Sportsman Pub, where the defences will be raised in year 50 to continue to provide the same SoP with sea level rise (50%AEP) to the freshwater designated habitat.

There are potential risks associate with the interaction with the electricity pylons and overhead lines for the MR site and this will need to be a careful consideration for the design stage.

Justification

Ongoing maintenance is the only short listed option with a BCR above 1 and a positive NPV.

MR site at Cleve Hill is required to help compensate for coastal squeeze across the Strategy in the second epoch. The justification for the MR site is related to the Strategy wide requirement for coastal squeeze compensation.

The defences will be raised in line with sea level rise near the Sportsman Pub as the cost to compensate the freshwater habitat is much greater than the cost to maintain the defences with sea level rise. This is justified through a cost effectiveness analysis.

Outcome Measure 1 – Economics

PVb (£)	£3,390k	**PVc (£)**	£781k	**BCR**	4.34

Outcome Measure 2 – Probability of Houses at Risk of Flooding

Risk Probability Zone	Households Before	Households After
Very Significant >5%	5	0
Significant	0	0
Moderate	0	0

Outcome Measure 3 – Houses better protected from erosion

	Long term loss	Medium term loss
Number of households	0	0

Outcome Measure 4 – Statutory environmental obligations met

Ha of intertidal habitat created	423.6

Environmental Impact

The development of the MR site will allow the creation of new areas of intertidal habitat, helping reduce the strategy wide coastal squeeze impacts. Also, the freshwater SPA and Ramsar will be protected to the same SoP as the defences will be maintained with sea level rise.

Funding of Preferred Option

Adjusted PF score	34%	**External contributions required**	£514k

Due to the creation of the intertidal habitat with the MR site the option is eligible for full funding through GiA. There is a small amount of GiA available for maintenance over the initial 15 years.

The cost to compensate the area of designated freshwater habitat by the Sportsman Pub to the east of the BA is much greater than the cost to maintain the defences with sea level rise. Therefore, it is more cost-effective to maintain the defences and raise with sea level rise. The defences are required to be raised with sea level rise as otherwise the frequency of inundation to the freshwater habitat would increase with sea level rise and compensation for this would be required in year 50.

Moderation Case (Cost-Effectiveness Analysis) for Freshwater Habitat

Option	Freshwater Habitat Compensation	Maintaining and raising the defences in line with sea level rise
Cost	£1,444k	£913k
Other factors	35ha of freshwater habitat compensation required	Coastal squeeze of the intertidal SPA and Ramsar if the defences are held
Rank	2	1

Table 34: Summary of Economics and Outcome Measures for BA7.1

BA 7.1 - Ongoing maintenance until year 30, followed by No Active Intervention (NAI). Freshwater compensation required by year 30 (capital works in year 25).

Overall Policy	2018-2038	2039-2068	2069-2118
	HTL Maintain	NAI	NAI

Details of Preferred Option

Maintenance (patch and repair) of the current defences (earth embankments) for the first 30 years. After this all maintenance will be ceased which will increase the risk of failure of the defences which would result in the inundation of the designated freshwater habitat. Therefore, compensatory freshwater habitat will need to be developed by year 25 to allow it to be in place prior to failure of the defences from year 30.

Justification

Due to the limited assets at risk in the area, options to Hold the Line in the long term do not provide a BCR above one. The current defences have a 30-year median residual life. If patch and repair maintenance continues, the overall BCR is above one and the NPV is positive, enabling HTL policy in the short term.

Outcome Measure 1 – Economics

PVb (£)	£1,502k	**PVc (£)**	£165k	**BCR**	9.10

Outcome Measure 2 – Probability of Houses at Risk of Flooding

Risk Probability Zone	Households Before	Households After
Very Significant >5%	3	2
Significant	0	1
Moderate	1	1

Outcome Measure 3 – Houses better protected from erosion

	Long term loss	Medium term loss
Number of households	0	0

Outcome Measure 4 – Statutory environmental obligations met

Ha of intertidal habitat created	0

Environmental Impact

There are potential significant effects on the intertidal Swale SPA and Ramsar and constituent qualifying features due to coastal squeeze until failure of the defences in year 30. Once the defences fail there will be degradation and loss of existing SPA and Ramsar freshwater grazing marsh. The freshwater habitat across the Ham Marshes is good breeding and overwintering habitat for a variety of waders and wildfowl.

Funding of Preferred Option

Adjusted PF score	56%	**External contributions required**	£73k

The option is eligible for a small amount of GiA, which will likely be used for the maintenance of the defences over the first 30 years. The compensatory habitat needs to be implemented to meet the legal requirements of the SPA and Ramsar. A moderation assessment was undertaken to determine the most cost-effective way to meet the legal obligations.

Moderation Case (Cost-Effectiveness Analysis) for Freshwater Habitat

Option	Freshwater Habitat Compensation	Maintaining and Raising the defences in line with sea level rise
Cost	£2,335k	£4,159k
Other factors	Significant area (111ha) of freshwater habitat compensation required	Coastal squeeze of the intertidal SPA and Ramsar if the defences are held
Rank	1	2

Table 35: Summary of Economics and Outcome Measures for BA7.2a

BA 7.2a - Raise (sustain) embankments and walls.

Overall Policy	2018-2038	2039-2068	2069-2118
	HTL Sustain	HTL Sustain	HTL Sustain
Details of Preferred Option			
This option involves improving the current SoP provided by the defences to 0.5% AEP with sea level rise; in year 8 to 4.8m AOD and then in year 50 to 6.0m AOD to continue to provide protection in line with sea level rise.			
Justification			
The sustain option has the highest BCR and NPV value and second highest environmental ranking.			
Outcome Measure 1 – Economics			
PVb (£) £12,235k	**PVc (£)** £5,867k	**BCR** 2.08	
Outcome Measure 2 – Probability of Houses at Risk of Flooding			
Risk Probability Zone	**Households Before**	**Households After**	
Very Significant >5%	18	0	
Significant	10	0	
Moderate	24	0	
Outcome Measure 3 – Houses better protected from erosion			
	Long term loss	**Medium term loss**	
Number of households	0	0	
Outcome Measure 4 – Statutory environmental obligations met			
Ha of intertidal habitat created	0		
Environmental Impact			
These options are not likely to have significant effects on any designated sites and their constituent qualifying features.			
Funding of Preferred Option			
Adjusted PF score 18%	**External contributions required** £4,798k		
The option is eligible for some GiA, however significant third-party contributions will also be required. Potential contributors might include: • Local Council • Local businesses including the Shephard Neame brewery			

Table 36: Summary of Economics and Outcome Measures for BA7.2b

BA 7.2b - Maintain defences until year 20. Raise (sustain) embankments and walls from year 20.

Overall Policy	2018-2038	2039-2068	2069-2118
	HTL Maintain	HTL Sustain	HTL Sustain

Details of Preferred Option

Maintenance of the current defences for the first 20 years. Following this the defences will be raised to 5.7m AOD and then raised again in year 50 to 6.4m AOD to ensure a 0.1% SoP with sea level rise.

Justification

Maintain (capital) option has the highest benefits following the Do Minimum and an incremental BCR greater than 1. However, the land will still be flooded under a 50% AEP. An additional £330k would enable protection to a 0.1% AEP. Under local choices, the Sustain Option will be preferred and would require and additional £330k funding over 100 years.

Outcome Measure 1 – Economics

PVb (£)	£1,421k	**PVc (£)**	£1,236k	**BCR**	1.15

Outcome Measure 2 – Probability of Houses at Risk of Flooding

Risk Probability Zone	Households Before	Households After
Very Significant >5%	4	0
Significant	1	0
Moderate	2	0

Outcome Measure 3 – Houses better protected from erosion

	Long term loss	Medium term loss
Number of households	0	0

Outcome Measure 4 – Statutory environmental obligations met

Ha of intertidal habitat created	0

Environmental Impact

There are potential significant effects on the intertidal Swale SPA and Ramsar and constituent qualifying features due to coastal squeeze. Coastal squeeze will lead to a loss of saltmarsh habitat. Therefore as mitigation the Strategy is looking at creating habitat in Managed Realignment sites.

There are no adverse impacts on designated freshwater habitat.

Funding of Preferred Options

Adjusted PF score	12%	**External contributions required**	£ 1,083k

The option is eligible for some GiA, however significant third-party contributions will also be required. Potential contributors might include:

- Local Council
- Local landowners
- Southern Water

Table 37: Summary of Economics and Outcome Measures for BA8.2

BA 8.2 - Maintain embankments and upgrade SOP with sea level rise in year 50.

Overall Policy	2018-2038	2039-2068	2069-2118
	HTL Maintain	HTL Maintain	HTL Maintain

Details of Preferred Option

Maintenance (with capital works) of the current defences, and raise in year 50, to maintain a minimum SoP of 4%AEP with sea level rise.

Justification

This option is the only option with BCR greater than one and a positive NPV score. However the option is the lowest ranked environmentally and further environmental mitigation would be required.

The option is required as part of the legal obligations to cause no net loss of the designated freshwater habitat.

The current defences have a 25-year residual life. Following this, the cost to compensate the large area of freshwater habitat is much greater than the cost to maintain the defences with sea level rise. Therefore, it is more cost-effective to maintain the defences and raise with sea level rise. The defences are required to be raised with sea level rise as otherwise the frequency of inundation to the freshwater habitat would increase with sea level rise and compensation for this would be required in year 50.

Outcome Measure 1 – Economics

PVb (£)	£0	PVc (£)	£0	BCR	0

Outcome Measure 2 – Probability of Houses at Risk of Flooding

Risk Probability Zone	Households Before	Households After
Very Significant >5%	53	51
Significant	14	10
Moderate	9	4

Outcome Measure 3 – Houses better protected from erosion

	Long term loss	Medium term loss
Number of households	0	0

Outcome Measure 4 – Statutory environmental obligations met

Ha of intertidal habitat created	0

Environmental Impact

Adverse impacts on the intertidal Swale SPA and Ramsar and constituent qualifying features due to coastal squeeze. Coastal squeeze will lead to a loss of intertidal habitat. But the current SoP of the defences will be maintained to ensure continued level of protection to SPA and Ramsar freshwater habitat.

Funding of Preferred Option

Adjusted PF score	0%	External contributions required	£ 0

The preferred option needs to be implemented to meet the legal requirements for the SPA and Ramsar habitat. A moderation assessment was undertaken to determine the most cost-effective way to meet the legal obligations.

Moderation Case (Cost-Effectiveness Analysis) for Freshwater Habitat

N.B. The assessment has been undertaken based on a combination of both BA8.2 and BA8.3, as the flood cells are interdependent.

Option	Freshwater Habitat Compensation	Maintaining and raising the defences in line with sea level rise
Cost	£52,210k	£28,048k
Other factors	Very significant area (1,492ha) of freshwater habitat compensation required. This is not technically feasible.	Coastal squeeze of the intertidal SPA and Ramsar if the defences are held.
Rank	2	1

Table 38: Summary of Economics and Outcome Measures for BA8.3

BA 8.3 - Maintain embankments and upgrade SOP with sea level rise in year 50. No Active Intervention (NAI) at Isle of Harty and a Managed Realignment site in year 5 at the end of Spitend Marshes.

Overall Policy	2018-2038	2039-2068	2069-2118
	HTL Maintain with MR	HTL Maintain with MR	HTL Maintain with MR

Details of Preferred Option

Maintenance (with capital works) of the current defences, and raise in year 50, to maintain a minimum SoP of 4%AEP with sea level rise. Managed realignment at Spitend Marshes, which involves set back embankments and a breach in the current defences.

Justification

Due to the limited assets at risk in the area, options to HTL in the long term do not provide a BCR above one. The current defences have a 25-year residual life. If patch and repair maintenance continues, the overall BCR is above one and the NPV is positive, enabling HTL policy in the short term. The current defences have a 20 year residual life. Following this, the cost to compensate the large area of freshwater habitat is much greater than the cost to maintain the defences with sea level rise. Therefore, it is more cost-effective to maintain the defences and raise with sea level rise. The defences are required to be raised with sea level rise as otherwise the frequency of inundation to the freshwater habitat would increase with sea level rise and compensation for this would be required in year 50. The justification for the MR site is related to the Strategy wide requirement for coastal squeeze compensation.

Outcome Measure 1 – Economics

PVb (£)	£0	PVc (£)	£0	BCR	0

Outcome Measure 2 – Probability of Houses at Risk of Flooding

Risk Probability Zone	Households Before	Households After
Very Significant >5%	3	0
Significant	0	0
Moderate	0	0

Outcome Measure 3 – Houses better protected from erosion

	Long term loss	Medium term loss
Number of households	0	0

Outcome Measure 4 – Statutory environmental obligations met

Ha of intertidal habitat created	0

Environmental Impact

Adverse impacts on the intertidal Swale SPA and Ramsar and constituent qualifying features due to coastal squeeze. Coastal squeeze will lead to a loss of intertidal habitat. But the current SoP of the defences will be maintained to ensure continued level of protection to SPA and Ramsar freshwater habitat. At Spitend managed realignment site compensatory habitat will be required due to impacts of the Managed Realignment on freshwater designated SPA and Ramsar habitat.

Funding of Preferred Option

Adjusted PF score	0%	External contributions required	£ 0

The preferred option needs to be implemented to meet the legal requirements for the SPA and Ramsar habitat. A moderation assessment was undertaken to determine the most cost-effective way to meet the legal obligations.

Moderation Case (Cost-Effectiveness Analysis) for Freshwater Habitat

N.B. The assessment has been undertaken based on a combination of both BA8.2 and BA8.3, as the flood cells are interdependent.

This excludes the area of freshwater covered by the Spitend Marshes MR site which will need compensating.

Option	Freshwater Habitat Compensation	Maintaining and raising the defences in line with sea level rise
Cost	£52,210k	£28,048k
Other factors	Very significant area (1,492ha) of freshwater habitat compensation required. This is not technically feasible.	Coastal squeeze of the intertidal SPA if the defences are held
Rank	2	1

Table 39: Summary of Economics and Outcome Measures for BA8.4

BA 8.4 - Construct setback defences to form Managed Realignment site in year 5 at Elmley Round Hills.

Overall Policy	2018-2038	2039-2068	2069-2118
	MR	MR	MR

Details of Preferred Option

Development of a MR site from year 5 to compensate against the strategy wide impacts of coastal squeeze. Most of the MR site will tie into high ground, but some new set-back embankments will need to be constructed near the shoreline to fully tie the site into high ground. These defences will provide a 5%AEP SoP.

Justification

No short listed options were identified which would provide increased protection and with BCRs above one/positive NPVs.

Managed realignment is justified because although designated freshwater habitat is present, the alternative is NAI, which would have greater adverse impacts compared to the MR option which will contribute towards the strategy wide coastal squeeze compensation for the first epoch.

Outcome Measure 1 – Economics

PVb (£)	£0	**PVc (£)**	£0	**BCR**	0.0

Outcome Measure 2 – Probability of Houses at Risk of Flooding

Risk Probability Zone	Households Before	Households After
Very Significant >5%	0	0
Significant	0	0
Moderate	0	0

Outcome Measure 3 – Houses better protected from erosion

	Long term loss	Medium term loss
Number of households	0	0

Outcome Measure 4 – Statutory environmental obligations met

Ha of intertidal habitat created	89

Environmental Impact

Creation of the Managed Realignment site will contribute towards the strategy wide compensatory requirements for coastal squeeze. However, there will be an impact on up to 89 ha of designated freshwater habitats, and those qualifying feature species that use them. This is likely to impact on species like avocet, ringed plover, lapwing that feed and breed in these habitats. Compensatory freshwater habitat will be required.

Funding of Preferred Option

Adjusted PF score	0%	**External contributions required**	£0

Contributions will be required from other HTL schemes in the Strategy area to allow the intertidal compensatory habitat to be developed.

Table 40: Summary of Economics and Outcome Measures for BA8.5

BA 8.5 – No Active Intervention (NAI).

Overall Policy	2018-2038	2039-2068	2069-2118
	N/A	N/A	N/A
Details of Preferred Option			
Note: there will need to be some localised defences within this section to provide protection from flooding to BA11.2 which will also ensure no flooding of designated areas. These defences have been assessed as part of the 11.2 assessment and can be found in Table 41.			
Justification			
See above.			
Outcome Measure 1 – Economics			
PVb (£) £0	**PVc (£)** £0	**BCR** 0.0	
Outcome Measure 2 – Probability of Houses at Risk of Flooding			
Risk Probability Zone	**Households Before**	**Households After**	
Very Significant >5%	0	0	
Significant	0	0	
Moderate	0	0	
Outcome Measure 3 – Houses bett0er protected from erosion			
	Long term loss	**Medium term loss**	
Number of households	0	0	
Outcome Measure 4 – Statutory environmental obligations met			
Ha of intertidal habitat created	0		
Environmental Impact			
There are potential significant effects on the Swale SPA and Ramsar and constituent qualifying features due to coastal squeeze until the defences are at risk of failing in year 25. The defences associated with the BA11.2 works will also ensure no impact to the freshwater designations following failure of the defences.			
Funding of Preferred Option			
Adjusted PF score n/a	**External contributions required** n/a		

Table 41: Summary of Economics and Outcome Measures for BA9.1

BA 9.1 - Maintain (with capital works) walls, groynes and beach.

Overall Policy	2018-2038	2039-2068	2069-2118
	HTL Maintain	HTL Maintain	HTL Maintain

Details of Preferred Option

Capital works will be undertaken on the current defences to ensure that they remain in place to protect the toe of the cliff from erosion.

Justification

This option has an incremental BCR greater than 1 and the highest NPV value.

Outcome Measure 1 – Economics

PVb (£)	£13,660k	**PVc (£)**	£5,612k	**BCR**	2.43

Outcome Measure 2 – Probability of Houses at Risk of Flooding

Risk Probability Zone	Households Before	Households After
Very Significant >5%	0	0
Significant	0	0
Moderate	0	0

Outcome Measure 3 – Houses better protected from erosion

	Long term loss	Medium term loss
Number of households	129	54

Outcome Measure 4 – Statutory environmental obligations met

Ha of intertidal habitat created	0

Environmental Impact

This option is not likely to have significant effects on any designated sites and their constituent qualifying features.

Funding of Preferred Option

Adjusted PF score	55%	**External contributions required**	£2,549k

The option is eligible for some GiA, however third-party contributions will also be required. Potential contributors might include:

- Local Council
- Local businesses

Table 42: Summary of Economics and Outcome Measures for BA9.2

BA 9.2 - Maintain (with capital works) embankments walls, groynes and beach. No Active Intervention (NAI) and localised property adaptation along Warden Cliffs.

Overall Policy	2018-2038	2039-2068	2069-2118
	HTL Maintain with localised NAI	HTL Maintain with localised NAI	HTL Maintain with localised NAI

Details of Preferred Option

Capital works will be undertaken on the defences to ensure that they remain in place, however the SoP will not be improved with sea level rise, so the current minimum SoP of 4% AEP will decline over time. There will be a NAI policy on the SSSI designated cliffs at Warden, but costs have been included for relocating property away from the cliff top.

Justification

This option has the highest BCR and an incremental benefit cost ratio above 1. Other options do not have a high enough incremental benefit cost ratio to justify protecting to a higher standard of protection. Property relocation allows for management of the risk to residents whilst maintaining the integrity of the SSSI cliffs.

Outcome Measure 1 – Economics

PVb (£)	£9,063k	**PVc (£)**	£2,771k	**BCR**	3.27

Outcome Measure 2 – Probability of Houses at Risk of Flooding

Risk Probability Zone	Households Before	Households After
Very Significant >5%	3	0
Significant	0	0
Moderate	6	0

Outcome Measure 3 – Houses bett0er protected from erosion

	Long term loss	Medium term loss
Number of households	8	0

Outcome Measure 4 – Statutory environmental obligations met

Ha of intertidal habitat created

Environmental Impact

This option is not likely to have significant effects on any designated sites and their constituent qualifying features as the cliffs are left naturally to erode which support the SSSI designation for the geology.

Funding of Preferred Option

Adjusted PF score	23%	**External contributions required**	£2,147k

The option is eligible for GiA, however third-party contributions will also be required. Potential contributors might include:

- Local Council
- Local landowners

It should also be noted that the adaptation part of the option will require further investigations and discussions to determine if the option is eligible for GiA, where no active management option is being proposed.

Table 43: Summary of Economics and Outcome Measures for BA10.1

BA 10.1 - No Active Intervention (NAI) with localised property adaptation (potentially not GiA funded).

Overall Policy	2018-2038	2039-2068	2069-2118
	NAI	NAI	NAI

Details of Preferred Option

This option will continue to ensure that there is no active management of the cliffs, in line with the SSSI designation. However, to help reduce the risk to people and property, costs have been included for the relocation of property away from the cliff top.

Justification

This option the only option with a BCR greater than 1, however there are a significant amount of contributions required. It also supports the implementation of Swale Borough Council's coastal change management plan.

Outcome Measure 1 – Economics

PVb (£)	£7,729k	**PVc (£)**	£5,956k	**BCR**	1.30

Outcome Measure 2 – Probability of Houses at Risk of Flooding

Risk Probability Zone	Households Before	Households After
Very Significant >5%	0	0
Significant	0	0
Moderate	0	0

Outcome Measure 3 – Houses better protected from erosion

	Long term loss	Medium term loss
Number of households	54	14

Outcome Measure 4 – Statutory environmental obligations met

Ha of intertidal habitat created	0

Environmental Impact

This option is not likely to have significant effects on any designated sites and their constituent qualifying features as the cliffs are left naturally to erode which support the SSSI designation for the geology.

Funding of Preferred Option

Adjusted PF score	20%	**External contributions required**	£4,752k

The option is eligible for GiA, however third-party contributions will also be required. Potential contributors might include:

- Local Council
- Local landowners

It should also be noted that this option will require further investigations and discussions to determine if the option is eligible for GiA, as no active management options are being proposed.

Table 44: Summary of Economics and Outcome Measures for BA11.1

BA 11.1 - Maintain embankments, walls, flood gates, groynes and beach.

Overall Policy	2018-2038	2039-2068	2069-2118
	HTL Maintain	HTL Maintain	HTL Maintain

Details of Preferred Option

Capital works will be undertaken on the current defences to ensure that they remain in place to protect the toe of the cliff and assets behind the shoreline from erosion.

Justification

This option has the highest NPV and BCR. However, the option is ranked the lowest environmentally and mitigation will be required. As the risk is from erosion, the assessment of the increase in SoP provided by other options are not applicable because the main risk is from the erosion of the toe of the cliff and not from overtopping.

Outcome Measure 1 – Economics

PVb (£)	£13,931k	**PVc (£)**	£1,409k	**BCR**	9.89

Outcome Measure 2 – Probability of Houses at Risk of Flooding

Risk Probability Zone	Households Before	Households After
Very Significant >5%	0	0
Significant	0	0
Moderate	0	0

Outcome Measure 3 – Houses better protected from erosion

	Long term loss	Medium term loss
Number of households	92	3

Outcome Measure 4 – Statutory environmental obligations met

Ha of intertidal habitat created

Environmental Impact

This option is not likely to have significant effects on any designated sites and their constituent qualifying features.

Funding of Preferred Option

Adjusted PF score	116%	**External contributions required**	£0

This option is eligible for full GiA funding.

Table 45: Summary of Economics and Outcome Measures for BA11.2

BA 11.2 - Raise (sustain) embankments, walls, flood gates, groynes and beach.

Overall Policy	2018-2038	2039-2068	2069-2118
	HTL Sustain	HTL Sustain	HTL Sustain

Details of Preferred Option

This option involves improving the SoP provided by the defences to SoP of 0.1% AEP with sea level rise; in year 3 to 5.4m AOD and then in year 50 to 6.9m AOD to continue to provide protection in line with sea level rise.

Justification

Maintain (capital) option has the highest benefits following the Do Minimum and an incremental BCR greater than 1. However, the Sustain option protects over 5,000 additional properties and therefore much better meets the Strategy objectives. Furthermore, Sustain has the highest NPV value and better environmental scoring. Under local choices, the Sustain Option will be preferred and would require and additional £6.5m funding over 100 years.

Outcome Measure 1 – Economics

PVb (£)	£607,198k	**PVc (£)**	£36,060k	**BCR**	16.84

Outcome Measure 2 – Probability of Houses at Risk of Flooding

Risk Probability Zone	Households Before	Households After
Very Significant >5%	5,809	0
Significant	232	63
Moderate	120	0

Outcome Measure 3 – Houses better protected from erosion

	Long term loss	Medium term loss
Number of households	0	0

Outcome Measure 4 – Statutory environmental obligations met

Ha of intertidal habitat created	0

Environmental Impact

There are potential adverse effects on the intertidal Medway Estuary and Marshes SPA and Ramsar and constituent qualifying features due to coastal squeeze in the south of the BA. Areas of mudflat around West Swale to the west of Queenborough and Rushenden, are likely to be reduced in size, impacting on the populations of waders and wildfowl that use this area for feeding etc. Therefore as mitigation the Strategy is looking at creating habitat in Managed Realignment sites.

Funding of Preferred Option

Adjusted PF score	354%	**External contributions required**	£0

This option is eligible for full GiA funding.

7 Strategy wide assessment

Following the assessment of the preferred option for each BA, a Strategy wide assessment has been undertaken to ensure that the preferred options work across the Strategy.

7.1 Strategy Wide Economics

To undertake this assessment a review of the total costs for all the preferred options and the strategy wide benefits was undertaken to determine the viability of the combination of options proposed within the whole of the Strategy. The economic results are outlined in Table 46.

Table 46: Summary of the Strategy wide economics

Strategy Wide Economics					
Outcome Measure 1 – Economics					
PVb (£k)	£1,203,220k	**PVc (£)**	£178,175k	**BCR**	6.75
Outcome Measure 2 – Probability of Houses at Risk of Flooding					
Risk Probability Zone		**Households Before**		**Households After**	
Very Significant >5%		6,319		63	
Significant		781		76	
Moderate		746		8	
Outcome Measure 3 – Houses better protected from erosion					
			Long term loss		**Medium term loss**
Number of households			283		71
Outcome Measure 4 – Statutory environmental obligations met					
Ha of intertidal habitat created	29.3	Note this includes only Halling MR site as the others are part of SPA/Ramsar compensation and therefore cannot be counted as OM4s.			

The Strategy wide results demonstrate that the Strategy has a BCR significantly above one, and a large number of properties to be better protected from flooding and erosion over the long term. This is a positive outcome and highlights the viability of the Strategy to undertake coastal management works to deliver the objectives of the Strategy, including improving the SoP provided to residential and commercial property, and compensating for the potential adverse impacts on intertidal and freshwater compensation.

It should also be noted that as this is a strategy level study, the optioneering and associated costing have been calculated at a high level. As such a conservative approach has been undertaken and a 60% risk allowance has been included on all the costs. The viability of the scheme could potentially increase in the future as the risk budget is reduced as more detailed information becomes available.

7.2 Funding of the Strategy

The viability of the Strategy also relies on the affordability of the Strategy. Technical Appendix R of the Strategy sets out the Funding Plan for plugging funding gaps across the different BAs.

7.3 Implementation plan

To allow the different projects that have come out of the Strategy to be developed a MEASS Implementation Plan has been developed. The aim of the implementation plan is to develop a 'programme' for when the different stages of the projects, from initial surveys through to construction, will be implemented to assist with the Environment Agency's forward planning, and to ensure that the application for GiA funding is spread across the epochs to allow the efficient delivery of the projects. The detailed MEASS Implementation Plan is available in Technical Appendix H of MEASS.