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Assessment of the impact of recently-built flood alleviation schemes in managing long-term residual flood risk in England

Final report

June 2017



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Contract

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Purpose

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Executive Summary

Context and purpose

The Adaptation Sub-Committee (ASC) of the Committee on Climate Change (CCC) has a statutory duty to report to Parliament on the Government's progress in implementing its National Adaptation Programme. This programme, published in July 2013, sets out the Government's objectives and policies for adaptation primarily in England, addressing the risks and opportunities identified by the UK Climate Change Risk Assessment (CCRA), first published in January 2012.

The ASC is required to produce a second progress report on the National Adaptation Programme by the end of June 2017 (the first was produced in 2015). To inform this progress report, the ASC wished to assess how recent flood defence schemes have helped contribute towards the long-term management of residual flood risk in the context of climate change. As a result, JBA Consulting was commissioned by the ASC in December 2016 to conduct this review.

The specific aims of this project were to review a sample of the major schemes contributing towards the delivery of better flood protection to 180,000 households over the 2010/11 to 2014/15 period and understand:

- The impact of the flood alleviation schemes in managing long-term flood risks, by assessing the current and future standard of protection achieved by the scheme in comparison to what was in place previously. This would include considering how climate change has been factored in to the scheme design, for example the allowances included for future sea level rise or increase in peak river flows at the outset.
- The extent to which future options to upgrade defence standards are included as an explicit element of the scheme design, for example identified upgrade paths and trigger points consistent with taking a 'managed adaptive' approach.
- The justification provided to support the choice of the particular engineering solution(s) and standard of protection against other options.
- To what extent the schemes work with natural processes and deliver co-climate change adaptation co-benefits, such as the creation or restoration of habitats that help absorb heavy rainfall or wave energy, or natural flood management techniques such as rewilding, tree-planting, more natural hydromorphology.
- The consistency of these schemes with sub-national flood risk strategies i.e. the immediate and longer-term risk management policies identified for the area within catchment management plans, shoreline management plans, and the 2014 Long-Term Investment Scenarios.

Methodology

The research approaches involved a mix of quantitative and qualitative methods to gain an overall understanding of progress against the identified Aims. The research methods deployed were as follows:

- Assessment of a large sample of the schemes in the MTP that delivered the most reported benefits over the four years
- Detailed review of 27 schemes delivered in the four-year period using Project Appraisal Report documents, Flood and Coastal Erosion Risk Management strategies and wider strategy and policy documents of relevance.
- Interviews with scheme project managers
- Stakeholder interviews with Regional Flood and Coastal Committee chairs and national and regional Environment Agency representatives.

Key findings and conclusions in relation to each of the study aims

Aim 1: Improved flood protection

Aim 1 is focused on whether, and how much, flood alleviation schemes improve current as well as future Standards of Protection (SoP). Based on an improved SoP, most of the schemes are taking households from very significant risk to low or moderate risk. This means that overall the schemes assessed are improving the SoP for households. Furthermore, most of the schemes are increasing the existing SoP and incorporated an increase in risk due to climate change in the design. Looking at the total 'households better protected' shows that 40% are not improving on the existing SoP but are maintaining the same low level of risk. This is because many of the schemes assessed are replacing or refurbishing existing assets that are in a poor condition.

However, this improved protection is not always completed in year one; the scheme may be phased over several decades, only replacing some assets when they are at the end of their

design life. This approach provides the best value for money but the reporting of households better protected can give the appearance of the protection being provided immediately whereas this may not be fully realised until all the individual work packages are implemented over a longer time period.

The schemes were assessed for evidence of OMs being incorrectly claimed. Some schemes may present the same OMs when the business case is reviewed to release more investment due to staged implementation. However, overall it appears that OM2 benefits are being claimed correctly in the sample assessed.

Aim 2: Managed adaptive approaches

Managed adaptive schemes are promoted through Government policy to encourage flexibility to respond to future uncertain climate change, during the whole life of a measure. Essentially, adaptive approaches enable schemes to maintain their SoP over time. Four of the schemes factored in climate change so the SoP will reduce but the design standard will be maintained for 50 years. Positively, 16 out of the 27 schemes factor in climate change to enable the same design standard to be maintained for 100 years.

Almost half of the schemes reviewed incorporated adaptive approaches, however most of these did not identify clear adaptive pathways and trigger points. In the main, plans to enhance/replace features were based around specific time periods and may be more focused on replacing obsolete measures than adapting functional measures. However, it is important to acknowledge the context in which investment decisions are made and recognise that a balance has to be achieved that maximises long term resilience within the constraints imposed by the availability of public funding. Consultations with strategic stakeholders revealed strong support for adaptive strategies taking forward a package of precautionary and adaptive measures to manage flood and coastal erosion risk over time.

Aim 3: Justification to support preferred option

After short-listing options, the primary justification for the selection of the preferred option in the schemes under review was quantified economics; this is in line with FCERM AG. There is evidence that the amenity and environmental benefits of some options are being overlooked due to being dismissed at the short-listing stage before the evidence can be quantified.

Option short-listing should be driven by the project objectives; if the objectives are heavily constrained, then alternative options are unlikely to progress to the short-list stage. The PAR objectives were analysed to see if they included wider considerations of the environment and amenity value. Many of the objectives included vague statements such as 'where possible enhance the environment'. But only 12 out of 27 schemes included direct, specific objectives to enhance the environment or provide amenity value.

Some schemes consulted stakeholders or undertook Multi-Criteria Analysis to provide a more detailed selection. However, only three of the schemes assessed used Multi-Criteria Analysis to reject options and to take forward the shorted listed options. Subjective reasoning in addition to pure economics can have a positive outcome if alternative options with additional benefits are taken forward although, less positively it can result in some options being rejected early in the process before a robust appraisal has been undertaken.

Some of the chosen solutions are a continuation of the existing arrangements and have a limited ambition for improved SoP at the outset, even if a more expensive, but more cost beneficial option is available. This is because the decision process considers the possible availability of funding in addition to the cost benefit ratio. There is awareness beyond the PAR approval to the funding decision i.e. in some cases the 'financial case' appears to override the 'economic case'. This can reduce a strategic approach to FCERM and thinking longer term. Schemes that do have an FCERM Strategy behind them are more likely to consider strategic, longer term schemes that are higher cost. The Strategy led PARs should follow the recommendations of the FCERM Strategy. but there may be opportunities to consider different SoPs and climate change allowances for this preferred option to increase value for money.

Aim 4: Working with natural processes

Government policy following the Pitt Review emphasised the need to 'work with natural processes' (WWNP) as part of integrated portfolios of responses to flooding and coastal erosion. 19 of the schemes reviewed considered some WWNP or habitat creation measures whilst eight did not – the definition of WWNP has been taken to include beach re-nourishment. Six schemes incorporated significant WWNP processes to manage flood risk, four included beach re-nourishment measures in the preferred option and nine included habitat creation measures that did not directly contribute to the alleviation of flood risk.

Consultees highlighted that strategic approaches are increasingly being developed involving a package of measures that include WWNP schemes. The eight schemes that identified WWNP options and discounted these through option appraisal did so on the basis of technical feasibility,

the potential to create environmental dis-benefits or due to the constraints of the site e.g. replacement of flood defence walls. The strategic consultations highlighted a need for greater evidence on the benefits that WWNP measures can achieve in the short and long term before these are adopted on a more widespread basis. Defra and the Environment Agency are currently supporting an R&D programme to consolidate, enhance and disseminate evidence to support WWNP and natural flood management (NFM).

Aim 5: Consistency with national and sub-national flood risk strategies

All coastal schemes reviewed referred to and were consistent with the relevant SMP and only two schemes do not align with the relevant SMP's aspirations for WWNP. All fluvial schemes reviewed were consistent with the relevant CFMP and only four schemes do not align with the relevant CFMP's aspirations for WWNP.

18 of the 27 schemes had been developed in the context of overarching FCERM strategies and were consistent with these. Where schemes were 'stand-alone' this was justified in relation to the independence of flood cells or where a strategy was planned, but not had yet been prepared and the scheme was considered to be of such importance that it should proceed prior to strategy development/finalisation. Consultations with strategic stakeholders revealed an increasing move towards strategic approaches involving the development of packages of measures to address flood risk now and in the future.

Recommendations

Aim 1: Improved flood protection

Whilst the findings in relation to increased SoP and building in climate change allowances are positive, coastal authorities can find it difficult to deliver affordable schemes with long term benefits and are therefore choosing to deliver a number of schemes, that in the long term will be more expensive. Even though Partnership Funding policy will show the economic benefits of a large coastal scheme, the five-case model encourages a focus on the financial case encouraging a short-term outlook that may affect the longer term resilience of flood risk management schemes. **It is recommended that Defra and the EA should consider how national funding level commitments can enable a more strategic approach to coastal risk management.**

Some inconsistencies were identified in the way that the duration of benefits are captured, particularly with schemes completed over several stages and the need to justify these at each stage. **The EA could consider reviewing how OMs are captured to provide a more accurate overview of households better protected.**

Aim 2: Managed adaptive approaches

The study identified that almost half of the schemes reviewed incorporated managed adaptive approaches, however most of these did not identify clear adaptive pathways and trigger points.

It is recommended that consideration is given to improving appraisal guidance in relation to managed adaptive approaches building on previous research and studies with a specific focus on adaptation pathways and trigger points.

In addition, **the Environment Agency should ensure that risk management authorities enable and monitor the delivery of adaptive packages of schemes in the long term. This includes ensuring that land management practices and subsequent scheme improvements are in line with an overall adaptive strategy for the management of in the long term flood risk.**

Aim 3: Justification to support preferred option

The study identified robust optioneering on economic grounds, but some concerns were identified in relation to limited option choices, an overly subjective short-listing approach and a strong bias towards economic benefits. It is suggested that appraisal guidance could be revised to address the following:

- **There should be a more consistent approach to the short-listing approach, potentially requiring new guidance, as the current one tends to be qualitative thus leading to options being discounted at an early stage without full justification.**
- **A structured and transparent short-listing process could be encouraged by shifting the focus on the wider project objectives; this will allow a wider breath of options to be taken forward, as well as increasing the emphasis on environmental and social benefits and dis-benefits whose consideration can be limited through the current approach.**

Aim 4: Working with natural processes

19 of the schemes reviewed incorporated some element of WWNP in terms of NFM, beach re-nourishment or habitat creation/enhancement; just six of these were focused on using natural

processes (not including beach re-nourishment) to manage flood risk. More quantified evidence of the benefits of WWNP is required to encourage take-up. Therefore, **it is recommended that the findings from the current Defra and EA supported WWNP R& D Programme are widely publicised potentially supported by additional capacity building activities to encourage greater take up. The method to account for co-benefits to calculated OM1 should be reviewed to ensure it is in line with the latest evidence on natural capital accounting.**

Contents

Executive Summary	4
1 Introduction and context	1
1.1 Commission purpose and details	1
1.2 Aims and Objectives	1
1.3 Target audience	2
1.4 Structure of report	2
1.5 Summary	2
2 Methodology and data	3
2.1 Overview	3
2.2 Data collection	3
2.3 Medium Term Plan Review.....	3
2.4 Selection and review of scheme reports.....	3
2.5 Scheme lead interviews.....	4
2.6 Strategic stakeholder interviews	4
2.7 Scheme characteristics.....	4
2.8 Summary	9
3 Aim 1: Improved flood protection	10
3.1 Explanation of Aim 1	10
3.2 Current level of protection provided by flood defences	11
3.3 Future level of risk (including climate change)	12
3.4 Summary	14
4 Aim 2: Managed adaptive approaches	16
4.1 Explanation of aim and context	16
4.2 Implementation of managed adaptive approaches	17
4.3 Designing for exceedance now or in the future	18
4.4 Good practice examples.....	21
4.5 Summary	22
5 Aim 3: Justification to support preferred option	23
5.1 Explanation of Aim 3.....	23
5.2 Summary data	23
5.3 Scheme examples	23
5.4 Summary	27
6 Aim 4: Working with natural processes	29
6.1 Explanation of aim and context	29
6.2 Implementation of WWNP schemes.....	29
6.3 Good practice examples.....	30
6.4 Challenges	33
6.5 Summary	34
7 Aim 5: Consistency with national and sub-national flood risk strategies	35
7.1 Explanation of aim and context	35
7.2 National Long Term Investment Scenarios (LTIS)	35
7.3 SMPs and CFMPs	35
7.4 FCERM Strategies.....	I
7.5 Strategic consultations.....	V
7.6 Summary	V
8 Recommendations	VI
Appendices	VII
A Summary data table	VII
References	VIII

List of Figures

Figure 3-1: Original SoP of the 27 schemes.....	11
Figure 3-2: Original SoP of the households in the 27 schemes	11
Figure 4-1: Precautionary and managed adaptive approaches	16
Figure 4-2: Aim 2 Taking a managed adaptive approach	17
Figure 4-3: Schemes that improve the existing SoP, of the 27	19
Figure 4-4: Households from the 27 schemes that receive an improved SoP	20

List of Tables

Table 2-1: High level summaries of the 27 schemes assessed	5
Table 3-1: How the 27 schemes moved risk banks.....	12
Table 3-2: How the 76,858 households better protected moved risk banks	12
Table 6-1 – Schemes that incorporate significant WWNP measures.....	30
Table 7-1 - Alignment between coastal schemes and relevant SMP policies.....	36
Table 7-2 - Alignment between fluvial schemes and CFMPs.....	41
Table 7-3 - Alignment between the 27 reviewed schemes and FCERM strategies	I

Abbreviations

ASC.....	Adaptation Sub-Committee
BAP.....	Biodiversity Action Plan
BCR.....	Benefit Cost Ratio
CC.....	Climate Change
CCC.....	Committee on Climate Change
CCRA.....	Climate Change Risk Assessment
CFMP.....	Catchment Flood Management Plan
Defra.....	Department of Environment, Food, and Rural Affairs
FAS.....	Flood Alleviation Scheme
FCDPAG.....	Flood and Coastal Defence Project Appraisal Guidance
FCERM AG.....	Flood and Coastal Erosion Risk Management Appraisal Guidance
FRM.....	Flood Risk Management
GiA.....	Grant in Aid
IDB.....	Internal Drainage Board
MCA.....	Multi Criterial Analysis
MTP.....	Medium Term Plan
NAP.....	National Adaptation Programme
NERC.....	Natural Environment Research Council
NFM.....	Natural Flood Management
OM.....	Outcome Measure
PAR.....	Project Appraisal Report
PLP.....	Property Level Protection
RFCC.....	Regional Flood and Coastal Committee
RMA.....	Risk Management Authorities
SMP.....	Shoreline Management Plan
SoP.....	Standard of Protection
WWNP.....	Working with Natural Processes

Definitions

ASC: The Adaptation Sub-Committee	The Adaptation Sub-Committee sets the direction for adaptation matters including independent advice on preparing for climate change. The ASC is made up of experts from the fields of climate change, science and economics and is chaired by the Baroness Brown of Cambridge.
BAP: Biodiversity Action Plan	Also, referred to as UK BAP was published in 1994, and is the UK Government's response to the Convention on Biological Diversity (CBD), which the UK signed up to in 1992 in Rio de Janeiro. The CBD called for the development and enforcement of national strategies and associated action plans to identify, conserve and protect existing biological diversity, and to enhance it wherever possible.
BCR: Benefit cost ratio	A benefit-cost ratio (BCR)/Profitability Index Rate is an indicator, used in the formal discipline of cost-benefit analysis, that attempts to summarize the overall value for money of a project or proposal.
CCC: The Climate Change Committee	The Committee on Climate Change (the CCC) is an independent, statutory body established under the Climate Change Act 2008. Our purpose is to advise the UK Government and Devolved Administrations on emissions targets and report to Parliament on progress made in reducing greenhouse gas emissions and preparing for climate change.
CFMP: Catchment Flood Management Plan	Catchment flood management plans (CFMPs) consider all types of inland flooding, from rivers, groundwater, surface water and tidal flooding. Shoreline management plans consider flooding from the sea.
FCERM AG: The Flood and Coastal Erosion Risk Management Appraisal Guidance	Produced by the Environment Agency. It provides best practice implementation guidance on appraisal and supports the Defra Policy Statement on Appraisal (June 2009). Use of the FCERM Appraisal Guidance is a requirement for all publicly funded Flood and Coastal Erosion Risk Management strategies and projects developed by operating authorities. The role of the guidance is to provide the user with the information needed to complete a FCERM appraisal in line with government policy.
FCERM: Flood and Coastal Erosion Risk Management	The term "Flood Risk Management" in place of "Flood Defence" recognises that managed flooding is essential to meet the requirements of a sustainable flood strategy.
IDB: Internal Drainage Boards	Internal drainage boards (IDB) are public bodies that manage water levels in some areas where there is a special need for drainage. These areas are known as internal drainage districts (IDD). IDBs undertake works to reduce flood risk to people and property, and manage water levels for agricultural and environmental needs.
MCA: Multi Criteria Analysis	Multi-Criteria Analysis (MCA) covers a range of appraisal techniques that have the potential to capture a wide range of impacts that may not be readily valued in monetary terms, especially those relating to social issues.
NAP: National Adaptation Programme	The National Adaptation Programme (NAP) contains a register of actions which includes all the actions agreed in the programme so far. It also aligns risks identified in the Climate Change Risk Assessment to actions being undertaken or to be undertaken and the timescales according to each theme.
NERC: Natural Environment Research Council	The Natural Environment Research Council is the UK's largest funder of independent environmental science, training and innovation, delivered through universities and research centres.

NFM: Natural Flood Management	Natural Flood Management (NFM) involves implementing a range of land management interventions. with the aim of decreasing peak flood levels experienced by properties and other assets downstream. The aim is to slow the rate of flow and / or store more flood water in the upstream catchment.
OM: Outcome Measures	The Department for Environment, Food & Rural Affairs sets outcome measures to make sure the Environment Agency and other risk management authorities achieve the aims of government FCERM policy.
PAR: Project Appraisal Report or Programme Appraisal Report	This report is a Programme Appraisal Report, documenting the appraisal and preferred option for the delivery of a programme of projects or packages of projects over the next five years, 2012 to 2017.
PLP: Property Level Protection	Property Level Protection (PLP) measures can be categorized into the following two groups: <ul style="list-style-type: none"> • Flood resistance measures, which can form a barrier against flood water • Flood resilience measures, such as replacing carpets with waterproof tiling and raising electricity sockets in order to reduce the impact of any floodwater that does enter your property may have, as well as aiding the recovery process.
RFCC: Regional Flood and Coastal Committee	The Regional Flood and Coastal Committee (RFCC) is a committee established by the Environment Agency under the Flood and Water Management Act 2010 that brings together members appointed by Lead Local Flood Authorities (LLFAs) and independent members
RMA: Risk Management Authorities	Defra has overall national responsibility for policy on flood and coastal erosion risk management (FCERM) in England. The department provides funding for flood risk management through grants to the Environment Agency, local authorities and internal drainage boards. These risk management authorities and others have their own responsibilities and powers that they can use in order to carry out these responsibilities.
SoP: Standard of Protection	In flood risk management, the annual probability of the design flood level being reached or exceeded.
TE2100: Thames Estuary 2100	The Thames Estuary 2100 strategy (TE2100) was established in 2002 with the aim of developing a long-term tidal flood risk management plan for London and the Thames estuary.
UK CCRA: UK Climate Change Risk Assessment	The UK Climate Change Risk Assessment 2017 Evidence Report is the most up-to-date and comprehensive analysis of the risks and opportunities posed by climate change to the UK.
WWNP: Working with natural processes	Working with natural processes means taking action to manage flood and coastal erosion risk by protecting, restoring and emulating the natural regulating function of catchments, rivers, floodplains and coasts.

1 Introduction and context

1.1 Commission purpose and details

The Adaptation Sub-Committee (ASC) of the Committee on Climate Change (CCC) has a statutory duty to report to Parliament on the Government's progress in implementing its National Adaptation Programme (NAP). This programme, published in July 2013, sets out the Government's objectives and policies for adaptation primarily in England, addressing the risks and opportunities identified by the UK Climate Change Risk Assessment (CCRA), first published in January 2012.

In 2015, the ASC produced its first statutory assessment of the NAP. This report used a series of indicators to identify the actions that were underway to adapt to the effects of climate change across several sectors. It also assessed how vulnerability to climate hazards is changing over time. The report also assessed the extent to which policies and programmes were set up to promote or deliver adaptation actions. The ASC assessed progress made against a series of adaptation priorities. Each priority was given a traffic light score to represent whether appropriate plans were in place, actions were occurring as set out, and trends in vulnerability were moving in the right direction. The ASC also provided a set of recommendations for further action as a result of this analysis, to which the Government subsequently responded, in line with its statutory duty.

In the first statutory assessment, the ASC considered current Government policies, plans and actions to manage flood risk in England, and their impact on reducing exposure and vulnerability to flooding. The ASC acknowledged progress in developing a six-year investment plan of flood and coastal defence schemes to be taken forward over the period 2015- 2021. The analysis also assessed the long-term investment scenarios published by the Environment Agency (EA) in 2014, considering the optimal investment path to the 2060s. The ASC concluded that even in the best-case scenario of no new development in the floodplain, optimal investment over several decades, and every cost-effective flood and coastal defence being built, there are still expected to be more homes in areas of high flood risk in the coming years than at present due to deterioration of existing assets combined with the impacts of climate change.

The ASC is required to produce a second progress report on the NAP by the end of June 2017. This report will consider any changes in policy and action since the first report was produced, and include any updates in the evidence base. To inform this second progress report, the ASC wishes to assess how recent flood defence schemes have helped contribute towards the long-term management of residual flood risk in the context of climate change.

1.2 Aims and Objectives

The objective of this project is to better understand the extent to which recently delivered flood alleviation schemes in England have been designed to support the long-term reduction in residual flood risk.

The specific aims of this project are to review a sample of the major schemes contributing towards the delivery of better flood protection to 180,000 households over the 2010/11 to 2014/15 period and understand:

1. The impact of the flood alleviation schemes in managing long-term flood risks, by assessing the current and future standard of protection achieved by the scheme in comparison to what was in place previously. This would include considering how climate change has been factored in to the scheme design, for example the allowances included for future sea level rise or increase in peak river flows at the outset.
2. The extent to which future options to upgrade defence standards are included as an explicit element of the scheme design, for example identified upgrade paths and trigger points consistent with taking a 'managed adaptive' approach.
3. The justification provided to support the choice of the particular engineering solution(s) and standard of protection against other options.
4. To what extent the schemes work with natural processes and deliver co-climate change adaptation co-benefits, such as the creation or restoration of habitats that help absorb heavy rainfall or wave energy, or natural flood management techniques such as rewilding, tree-planting, more natural hydromorphology.

5. The consistency of these schemes with sub-national flood risk strategies i.e. the immediate and longer-term risk management policies identified for the area within catchment management plans, shoreline management plans, and the 2014 Long-Term Investment Scenarios.

These five aims are the focus of the research and provide the basis for the structure of the report.

1.3 Target audience

The main audience for this report is the ASC of the CCC as it is intended to inform the ASC's progress report on the implementation of the NAP. However, this report will also be of interest to government organisations and departments responsible for flood and coastal erosion risk management (FCERM) planning, policy, programmes and funding. Other interested parties may therefore include: Defra, the Environment Agency (EA), Regional Flood and Coastal Committee (RFCC) chairs and members, Lead Local Flood Authorities (LLFAs) and Coastal Authorities and Coastal Groups

1.4 Structure of report

This report is structured as follows:

- Methodology and data – including an overview of the schemes reviewed
- Project Aims; for each project aim, the following information is included:
 - Introduction to each Aim and any issues encountered gathering the data to address the Aim
 - Simple observations from the summary data collected
 - More in depth observations from the detailed scheme analysis and the interviews.
- Recommendations.

1.5 Summary

This study has been commissioned by the Adaptation Sub-Committee (ASC) of the Committee on Climate Change (CCC) to inform the second progress report on the National Adaptation Programme (NAP). The objective of the study is to understand how recent flood defence schemes have helped contribute towards the long-term management of residual flood risk in the context of climate change. Five Aims have been set to meet this objective, the report is structured around these Aims.

2 Methodology and data

2.1 Overview

The research approaches involved a mix of quantitative and qualitative methods to gain an overall understanding of progress against the identified Aims. The research methods deployed were as follows:

- Assessment of a large sample of the schemes in the MTP that delivered the most reported benefits over the four years
- Detailed review of 27 schemes delivered in the four-year period using Project Appraisal Report (PAR) documents, Flood and Coastal Erosion Risk Management (FCERM) strategies and wider strategy and policy documents of relevance
- Interviews with scheme project managers
- Stakeholder interviews with RFCC and EA Areas Flood Risk Managers.

2.2 Data collection

We collected the following data from the Environment Agency and where publicly available from the internet:

- **PARs** - the original intention was to collect data from the schemes that provided most of the benefits but not all the PAR documents were available. Therefore, the EA provided other PARs for schemes that delivered fewer benefits. However, this did allow us to assess more fluvial schemes, see Section 2.7 for more details.
- **FCERM Strategies, Catchment Flood Management Plan (CFMP) and Shoreline Management Plan (SMP) documents** – It was not possible to collect all the FCERM Strategies as they were either not available or the scheme in question went straight to PAR without a Strategy. All schemes should be covered by either a SMP or CFMP policy and recommendations though.
- **Medium Term Plan (MTP)** - Data on most of the schemes from the EA's MTP for the 2010/11 to 2014/15 period were provided. However, only some of MTP data and part of the 2010/11 to 2014/15 programme were provided.

2.3 Medium Term Plan Review

The original intention was to conduct an initial assessment of all built schemes in the 2010/11 to 2014/15 period identified in the Environment Agency's MTP to summarise:

- Current and future Standard of Protection (SoP)
- Duration of the benefits (design life).
- Schemes that include habitat creation
- Whether the schemes were part of a strategic approach.

These data were required to identify any broad patterns and provide an overview of all schemes. However, the EA could not extract all the schemes delivered from the MTP and had to manually input the previous and new SoP. Thus, the previous and new SoP was the only information available for the schemes that delivered better protection to 93,000 out of 180,000 households in the 2010/11 to 2014/15 programme.

2.4 Selection and review of scheme reports

The main assessment of the five Aims was conducted through a review of the PARs, FCERM Strategies and policy documents (CFMP/SMPs) for 27 schemes delivered in the 2010/11 to 2014/15 programme. Rather than choose a spread of schemes (e.g. geography, urban/rural, flood source, delivery year, size, risk management authority), the top 27 schemes that contributed the most towards the 180,000 households better protected target were selected.

This means that the research sample focussed on a larger proportion of the 'households better protected' than a more representative sample would. As a result, large, coastal schemes

dominated the research although some large fluvial schemes were selected to provide a more balanced sample. Section 2.6 provides an overview of the schemes assessed.

The 27 schemes were analysed to produce the following outputs.

- A summary data table (see Appendix A)
- Detailed analysis of the individual schemes against the five Aims (Chapters 3 to 7 of this report)
- Reporting of the detailed assessments supplemented by interviews with scheme leads (Chapters 3 to 7 of this report).

2.5 Scheme lead interviews

Following the review of available documents, interviews were undertaken with EA staff who were involved in the production of the PAR business cases. These interviews were required to fill the gaps that could not be answered from the documents and to get more detailed insights, for example to identify the drivers behind the selection of the preferred option.

It was not easy to obtain contacts for all 27 schemes. There is a time gap between PAR production and scheme delivery (in some cases, up to ten years) meaning that, in some cases, the original contacts had moved on or were not able to provide extra detail. Attempts were made over several weeks to interview EA staff in relation to each scheme; 12 were available and interviewed.

2.6 Strategic stakeholder interviews

As described in Section 2.4, the ASC decided to select schemes that provided most of the benefits over the last four years. Therefore, the schemes assessed were predominantly large and coastal. To counter this, the research analysis was supplemented with interviews with five EA Area Flood Risk Managers and two RFCC chairs to obtain an overview of how recently delivered flood alleviation schemes in England have been designed to support the long-term reduction in residual flood risk. Intelligence gained from these interviews was used to supplement the evidence collected from the 27 schemes.

2.7 Scheme characteristics

A summary of the schemes reviewed is provided below, Table 2.1 provides details of each scheme.

- Of the 27 schemes reviewed for this research, 10 were fluvial schemes and 17 were tidal.
- Out of the 180,000 households better protected (moved risk bands/Outcome Measure (OM) 2 and 3) over the 2010/11 to 2014/15 period, the MTP data showed that these schemes enabled 76,860 households to be better protected. The PAR reviews showed that the same schemes contributed to 111,066 households better protected.
- From the MTP data, 19,345 (25%) households were better protected from fluvial flooding and 57,515 (75%) were protected from tidal flooding.
- From the same data, the total design and construction cost of the fluvial schemes was £179 million (30%) and £397 million (70%) for tidal schemes.
- 16 of the schemes reviewed were replacing existing assets and six were for the construction of new flood defence assets, five involved both new construction and replacement of an existing asset.

Table 2-1: High level summaries of the 27 schemes assessed

Scheme	Scheme Description	Tidal/Fluvial	Renewal/New/Both	Design and Construction Cost	PAR Date
Barking and Dagenham MEICA Package 3 (IMTH001235)	To 'Maintain and Sustain' the design standard of tidal flood defence provided by the sluices. This requires major refurbishment of the sluices to address Condition Grade, flood defence and health and safety concerns. Operationally efficiency improvements can be achieved through provision of instrumentation, telemetry, and CCTV.	Tidal	Renewal	£5,290,000	18 June 2009
Central Felixstowe Beach Management Works (AES503C-009A-001CA)	18 rock groynes along the frontage with 78000m ³ of shingle recharge in the northern section (from the Spa Gardens to Cobbold's Point), a revetment around Cobbold's Point. In future, a flood wall and maintenance recharge are proposed.	Tidal	Renewal	£10,310,000	01 April 2010
Deptford Creek Frontages Package (IMTH001230)	Critical works on failing tidal defences	Tidal	Renewal	£8,830,000	01 December 2008
Eastbourne Beach Management Study - Study to Support PAR for Eastbourne Beach Management 2010-2014	Improve standard of protection from combined marine sources. Large capital recharge (104,000m ³) to restore groyne bay volumes to the required levels followed by annual top up (11,000m ³) and recycling (5,000m ³)	Tidal	Renewal	£38,935,000	01 September 2010
Godmanchester Flood Alleviation Scheme	Construction of a line of flood defences along the eastern (right hand) bank of the River Great Ouse. A mixture of new embankments and flood walls, located mostly through private gardens.	Fluvial	Both	£10,100,000	01 June 2009
Humber Estuary Flood Defence Strategy First Five Year Package of Work (R040/0021220)	This five-year package of works includes defence improvements, managed realignment, maintenance and monitoring works, and further studies.	Tidal	Renewal	£82,940,000	01 July 2005
Ings Beck Flood Alleviation Scheme (IMNE000646)	Construction of a new dam at the site of the existing Fenton Dam and alterations to the inlet structure of a culvert in Wrenthorpe Park to create flood storage areas; local raising and strengthening where necessary of existing banks and walls; removal of a culvert in poor condition and opening up the watercourse; construction of a flood relief culvert beneath Westgate and channel improvements.	Fluvial	Both	£10,300,000	01 October 2008

Scheme	Scheme Description	Tidal/ Fluvial	Renewal/ New/Both	Design and Construction Cost	PAR Date
Lewisham and Catford Flood Alleviation Scheme	The scheme comprises of 3 main elements: construction of a Flood Storage Area in Beckenham Place Park, local defences through Lewisham and Catford, and improvements to the Honor Oak	Fluvial	New	£17,775,000	01 July 2015
Lincshore 2010 to 2015 (IMAN001844)	Beach nourishment and improvement to the existing sea walls.	Tidal	Renewal	£41,300,000	01 December 2009
Littlehampton Arun East Bank Tidal Walls	Flood defence line	Tidal	Renewal	£14,100,000	01 May 2012
Morpeth Flood Alleviation Scheme	Flood defence line and flood storage	Fluvial	Renewal	£21,100,000	01 March 2011
Nottingham Trent Left Bank Flood Alleviation Scheme (IMMI000642)	Raising or replacing only those defences that are below the standard (1%; 1 in 100) or that are likely to fail within ten years - this includes raising embankment, raising walls, new flood gates, new embankment, improvement to SW drainage, etc.	Fluvial	Renewal	£51,327,000	01 July 2006
Perry Barr and Witton Flood Risk Management Scheme	Demolition of existing flood defences and construction of new flood defences through Witton including appropriate flood risk mitigation, together with removal/redesign of hydraulic obstructions to improve channel conveyance. Replacement of existing assets in Perry Barr that are in a poor condition and difficult to maintain. The works will reduce flood risk to residential and commercial properties as well as local highways.	Fluvial	Both	£22,800,000	01 September 2012
Pevensey Outfalls Reconstruction (IMSO000737)	The preferred option is Option 4a – Rationalise (decommission Pevensey East). This includes decommissioning of the Pevensey East outfall and the maintenance requirements to the other four outfalls to extend their life for 30 years, when they are then estimated to require replacement. In addition, the option includes undertaking essential health and safety improvements.	Tidal	Renewal	£4,770,000	01 September 2009
Redcar Flood Alleviation Scheme (IMNE000524)	Seawall improvements and groyne maintenance at various standards to defend along the existing line	Tidal	Renewal	£29,200,000	01 August 2008
Ripon Flood Alleviation Scheme (IMNE000541)	Construction of an 8.6m high flood storage embankment on the River Laver, with localised defences through Ripon on the rivers Skell and Ure. Removal of existing Alma weir and river regrading works in this area.	Fluvial	New	£11,673,000	01 July 2005

Scheme	Scheme Description	Tidal/ Fluvial	Renewal/ New/Both	Design and Construction Cost	PAR Date
River Mersey, Warrington – Flood Risk Management Scheme (IMNW000699)	Linear defences along the River Mersey providing a 1% standard of protection.	Tidal	New	£23,700,000	01 June 2011
Rossall Coastal Defence Improvement Scheme	Rock revetment with new wave wall	Tidal	New	£63,200,000	01 March 2013
Salford Flood Improvement Scheme (IMNW000471)	Flood improvement scheme to the city of Salford increasing the current sop from 1 in 75year to 1 in 100year chance of flooding. The scheme involves construction of an offline storage basin with a side spill weir.	Fluvial	New	£11,749,000	01 February 2014
Sandwich Bay Sea Defences (Deal) (IMSO 001056)	Coastal defence of Sandwich bay	Tidal	Renewal	£10,300,000	01 March 2011
Shaldon and Ringmore Tidal Defence Scheme (IMSW000563)	Raise the existing defences and intervene in years 40 and 70 to respond to rising sea levels.	Tidal	Renewal	£8,529,000	01 July 2008
Shoreham Adur Tidal Walls	Reconstruct and raise the existing tidal defences over 7.2km of the River Adur, 1.8km on the east bank and 5.4km on the west bank. Defences constitute sheet piling, concrete walls, and earth embankments.	Tidal	Renewal	£26,400,000	01 January 2013
Teignmouth Estuary (Back Beach) Tidal Defence Scheme	Detailed design and construction of a tidal defence scheme for Teignmouth comprising raising existing defences (or new build where this is not possible), flood gates, access ramps and drainage works	Tidal	Both	£3,870,000	01 December 2010
Thames Tidal Frontage Programme 1 (IMTH001749)	Least cost option to bring defences up to advisory standard and reasonable condition grade. This is through a mixture of minor refurbishment, localised raising, major refurbishment, or replacement.	Tidal	Renewal	£21,000,000	01 February 2013
Upper Mole Flood Alleviation Scheme	The provision of two new flood detention reservoirs and adding flood detention capacity at two existing reservoirs upstream of Crawley.	Fluvial	Both	£14,727,000	01 April 2009
Wallasea Island Habitat Creation	Realignment and creation of tidal area.	Tidal	New	£3,935,000	01 April 2009
Walverden Water Flood	Upgrading flood defences in town.	Fluvial	Renewal	£7,024,000	01 August



Scheme	Scheme Description	Tidal/ Fluvial	Renewal/ New/Both	Design and Construction Cost	PAR Date
Alleviation Scheme					2006

2.8 Summary

To gain evidence and understanding across the five Aims of this research, a detailed review of 27 schemes delivered in the four-year period was undertaken using PAR documents, FCERM strategies and wider strategy and policy documents of relevance. To supplement this evidence, a sample of the full MTP was analysed and interviews were undertaken with 12 of the 27 scheme leads. Stakeholder interviews with RFCC and EA Areas Flood Risk Managers were also undertaken.

Rather than choose a spread of schemes, the schemes that delivered most of the 180,000 households better protected were selected. As a result, the large, coastal schemes dominated the research although some large fluvial schemes were also selected.

3 Aim 1: Improved flood protection

3.1 Explanation of Aim 1

This Aim seeks to understand how flood alleviation schemes are managing long-term flood risks, by assessing the current and future standard of protection achieved by the scheme in comparison to what was in place previously. This includes considering how climate change has been factored in to the scheme design, for example the allowances included for future sea level rise or increase in peak river flows at the outset.

The EA reports on the number of properties 'better protected' (OM2), however, these reported figures do not provide information on the current or future level of risk.

Current schemes seeking FCERM Grant in Aid (GiA) approval use the Partnership Funding calculator that subdivides households better protected into the following categories for current and future risk:

- $\geq 5\%$ AEP¹ = Very significant risk
- $< 5\%$ to $> 1.3\%$ = Significant risk
- 1.3% to $> 0.5\%$ = Moderate risk
- $\leq 0.5\%$ = Low risk

This study is looking at schemes delivered in the 2010/11 to 2014/15 period. Most of the business cases were developed before the new Partnership Funding policy so they do not provide a breakdown of OM2 against current and future levels of risk.

Therefore, this study was needed to understand the impact of flood alleviation schemes in managing long term flood risk by assessing individual PARs.

3.1.1 Schemes used

To appraise this Aim, data has been collection from the 27 individual schemes. These schemes were assessed in detail and interviews were undertaken with some of the scheme leads. This Aim was also discussed through the strategic consultations undertaken with RFCC chairs and EA Area Flood Risk Managers. These findings are integrated through the chapter and the views are of those consulted, not of JBA.

The flood risk management schemes assessed fall into two categories, those that:

1. provide a step reduction in probability of flood and coastal erosion risk through new or improved defences;
2. avoid a significant increase in flood or coastal erosion risk probability by replacing or refurbishing existing assets. These capital maintenance projects are to restore other EA priority defences in high consequence areas to target condition.

To improve the SoP and move risk bands (see 3.1 above) the PAR needs to show the risk before and after the scheme has been constructed. The 'after' risk band is the one the households are expected to be in at the end of the claimed duration of benefits period². This will include the expected impacts of climate change increasing risk over time.

For the 'before' risk, a detailed assessment (e.g. breach modelling) is needed for schemes replacing a deteriorating asset that has fallen short of its design standard (number 2 above). Where a detailed assessment is not available, the EA guidance recommends a simple approach. The guidance assumes that the 'Before' risk band is one band below the design standard of the asset once capital maintenance is completed.

Where there are no existing defences and a new asset is being built (number 1 above), this is comparable to Aim 1 which is looking at 'current and future SoPs'.

¹ Annual exceedance probability (AEP) is the inverse of the annual maximum return period. For example, the 100-year flood can be expressed as the 1% AEP flood, which has a 1% chance of being exceeded in any year.

² Calculate Grant in Aid funding for flood and coastal erosion risk management projects. Guidance for risk management authorities. Version 1 updated February 2014

3.2 Current level of protection provided by flood defences

Of the 27 schemes analysed, six were new schemes, 16 were schemes that needed replacing because they were at the end of their design life and five were a mixture of renewal and new (see box 1).

The PAR and the interviews provided information of the level of risk before the scheme was in place. If the scheme was a new asset, the existing level of risk to the community was stated. For the asset replacement schemes, some of the PARs quoted the original design standards, others estimated the levels of risk based on the conditions of the existing asset.

However, three of the PARs had not undertaken a detailed assessment of risk or presented this data, so the 'simple approach' taken from the EA guidance was applied in this study to define the 'before' risk for many schemes (see 3.1.1).

3.2.1 The results

Figure 3.1 shows that 19 of the 27 scheme locations were in the highest flood risk category before the new scheme. However, Figure 3.2 shows that the households benefitting are more evenly spread across the first two categories. This means that the larger schemes are protecting households at a lower risk than the smaller schemes.

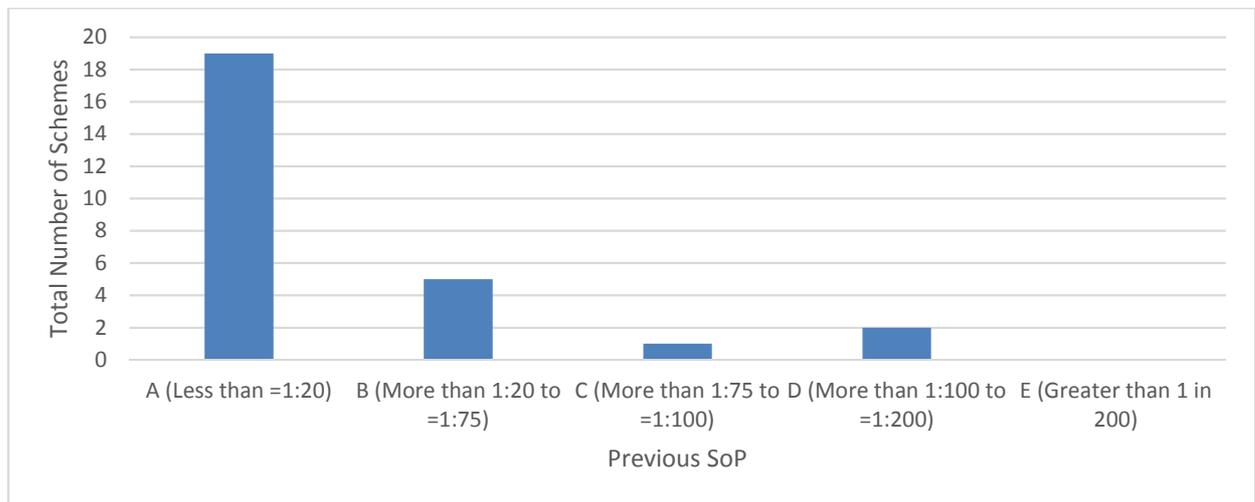


Figure 3-1: Original SoP of the 27 schemes

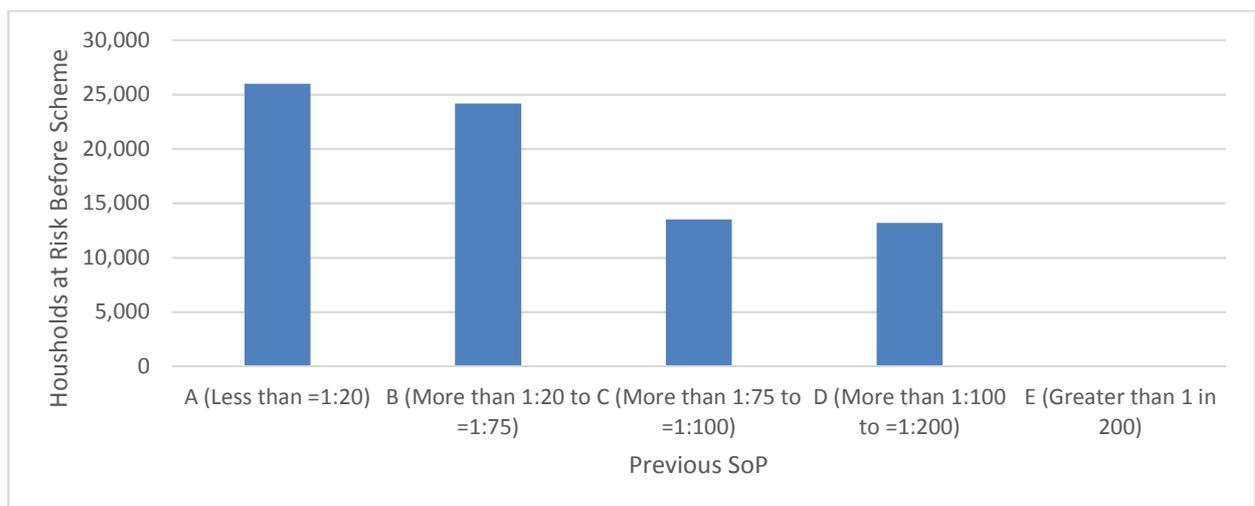


Figure 3-2: Original SoP of the households in the 27 schemes

3.3 Future level of risk (including climate change)

3.3.1 Improved SoP

Table 3.1 shows what flood risk category the 27 schemes have been moved from and to. Of the 19 schemes with the lowest SoP before a scheme, seven were provided with a scheme that will offer the highest level of protection for the design life. However, seven were only providing a moderate level of protection. 11 of the schemes will have at least a 1 in 100-year standard for the design life.

Table 3-1: How the 27 schemes moved risk banks

			New SoP of schemes				
			A	B	C	D	E
			Less than =1:20	More than 1:20 to =1:75	More than 1:75 to =1:100	More than 1:100 to =1:200	Greater than 1 in 200
Previous SoP of schemes	A	Less than =1:20		1	7	4	7
	B	More than 1:20 to =1:75			4	1	
	C	More than 1:75 to =1:100					1
	D	More than 1:100 to =1:200					2
	E	Greater than 1 in 200					

Table 3.2 shows the previous and future level of protection for the households benefitting. 69% of households will have at least a 1 in 100-year SoP for their design life. Of the households at greatest risk, 73% would now have at least a 1 in 100-year SoP for the design life. However, 20% of the households (16,657) only move one risk category and will have less than a 1 in 100-year SoP.

Table 3-2: How the 76,858 households better protected moved risk banks

			New SoP				
			A	B	C	D	E
			Less than =1:20	More than 1:20 to =1:75	More than 1:75 to =1:100	More than 1:100 to =1:200	Greater than 1 in 200
Previous SoP	A	Less than =1:20		993	6,101	10,505	8,401
	B	More than 1:20 to =1:75			16,657	7,497	
	C	More than 1:75 to =1:100					13,519
	D	More than 1:100 to =1:200					13,186
	E	Greater than 1 in 200					

Box 1: Schemes included in the analysis and how they are funded

Schemes with staged investments

The 27 schemes assessed are predominantly tidal (see Section 2.7) and tend to replicate the existing high design standard or improve it to take account of climate change.

Coastal schemes tend to be expensive and might struggle to get approval for schemes that manage long term risks. The large coastal PARs reviewed respond to this challenge in two ways:

- By developing a PAR based on a 100-year appraisal period, but seeking approval for only part of the whole life costs. The costs for approval will provide a short duration of benefits and further investment is needed for the full 100-year appraisal period (e.g. Lincshore, Littlehampton and Deptford Creek).
- By reducing the appraisal period to less than the standard 100 years. The costs for approval will be for an asset that has the same design life as the appraisal period so a lower cost scheme can be justified (e.g. Barking and Dagenham 30-year appraisal period, Thames Tidal 40-year appraisal period).

These are acceptable appraisal methods but can lead to inaccuracies in national reporting of the 'better flood protection to 180,000 households over the 2010/11 to 2014/15 period' by:

- Repeating the same households that benefit (for the full 100-year appraisal period) every time the next tranche of funding is approved (see number 1 above)
- Reporting the households that benefit for the full appraisal period even though only part of the costs have been approved (see number 2 above).

These findings are explained in more detail below.

Short term benefits

Some schemes are claiming household benefits correctly, but they may benefit in the short/medium term until more investment is required. For example, parts of the Littlehampton scheme have a 35-year duration of benefits. The Partnership Funding Policy guidance does not say that the benefits claimed need to be maintained for a specific time period. However, the Partnership Funding calculator does reduce the GiA available based on the length of time for which the benefits are maintained. Some of the 'households better protected' may therefore only keep this improved protection for a limited period.

Schemes that will require future investment

Some of the schemes are promoting the refurbishment of existing assets before future, larger scale investment. For example:

- The Barking and Dagenham scheme precedes the TE2100 plan that includes future raising of defences.
- Deptford Creek also precedes the TE2100 plan that may include more investment in this location.
- The Lincshore scheme has GiA for ongoing beach nourishment, but it is recognised that a large scheme will be required in the future

Claiming the same benefitting households for a future scheme could lead to double counting these benefits. However, it is unclear whether this is the case, as the design life of these assets would be coming to an end by the time the additional package will be delivered. An example is the Barking and Dagenham scheme.

The Barking and Dagenham PAR is for a £5.3m scheme to maintain sluices that are part of the Thames tidal defence system that protects over 12,500 residential properties and businesses. The PAR claims that a proportion of these households (5,092) will be better protected by refurbishment of the sluice gates. This intervention is in advance of the TE2100 interventions that may include future raising of defences. So, a proportion of households will be protected for up to 50 years and more work will be required at different stages to maintain this level of protection.

There is evidence that the full suite of measures required to deliver the benefits will not be built until later in the design life (and the funding is not yet approved) but the full benefits are claimed in the PAR and sometimes in the published MTP. An example is Lincshore.

The Lincshire scheme has a design life of 100 years but the economics are reviewed every five years to release the next tranche of funding. In the EA's capital investment programme, the Lincshire scheme claims part of the benefits that the scheme provides every few years. However, over the last four years Lincshire has cumulatively claimed more than the total households that will benefit over 100 years.

It is important to clarify that in this case the OM2s are not being double counted to receive more funding, but the full appraisal of the benefits is presented every time the business case for the next stage of funding is revised

Claiming OM2 benefits

This section assessed whether the PARs have claimed outcomes (particularly OM2 – households benefitting) following a method that is not in line with EA guidance³. The OM2 rules that are of relevance for this study are:

- OM2 should just account for households, not all properties.
- The households must be directly at risk of flood damage (i.e. not upper floors of apartment buildings, not houses where only gardens and outbuildings are affected)
- Properties can only show that they have moved risk bands if the new defence provides the specified SoP at the end of the design life
- There should be no double counting. Apportionment should be used for properties that are at risk from multiple sources.
- OM2 households can be claimed if there is a short design life (less than 100 years) but the Partnership Funding calculator will scale down the total benefits this provides. However, the figures presented by the EA do not differentiate between those households that will be better protected for 100 years or 25 years (for example). This could lead to one tidal scheme claiming many households benefitting under OM2, but the scheme comprises short-term repair before a larger complete scheme is implemented in the future. It is unclear what the time gap is before the same properties can be used to justify a future scheme without it being considered double counting.
- OM2 benefits can only be claimed for the portion of the scheme that has been given financial approval. This is important for large coastal schemes that may need staged investments over long periods to gain the whole life benefits. These schemes will need to submit a new PAR/business case at every stage on investment to make sure the economics still stack up and release the next tranche of funding. There is a risk that these schemes will claim all the 'homes better protected' reported by the EA every time the new funding is approved, rather than a proportion scaled to the new funding released.

From reviewing the 27 PARs overall it appears that OM2 benefits are being claimed in line with the above guidance. The only example found where it looks like OM2 benefits have been claimed incorrectly is the Lyme Regis scheme. This PAR included all property types in OM2 including commercial and included properties that would lose their gas supply but would not be directly flood damaged.

Strategic consultations

The strategic consultations highlighted that the SoP for Internal Drainage Boards (IDBs) in the Fens differ from other areas because flood risk management measures have been built to very high SoPs due to historical concerns about food security. As SoPs are now more focused on protecting households, the costs of high SoPs and the low number of households in rural areas means that schemes are being designed to a lower SoP to make them affordable and to meet Partnership Funding requirements.

3.4 Summary

Aim 1 is focused on the impact that flood alleviation schemes have in reducing flood risk particularly on whether, and how much, flood alleviation schemes maintain or improve current as

³ Calculate Grant in Aid funding for flood and coastal erosion risk management projects. Guidance for risk management authorities. Version 1 updated February 2014
2016s5344 - CCC - Impact of flood schemes - Revised Final Report 300617

well as future standards of protection.

Based on improved SoP, 15 of the 27 schemes are providing 53,108 out of 76,858 households with at least a 1 in 100-year SoP. Furthermore, 15 of the schemes are increasing the existing design standard and will maintain this standard into the future by taking account of climate change in the design. Looking at the total 'households better protected' shows that 40% are not improving on the existing SoP but are maintaining the same low level of risk. This is because 16 of the schemes assessed are replacing or refurbishing existing assets that are in a poor condition.

However, this improved protection is not always completed in year one; the scheme may be phased over several decades, only replacing some assets when they are at the end of their design life. This approach provides the best value for money, but the reporting of households better protected can give the appearance of the protection being provided immediately whereas this may not be fully realised until all the individual work packages are implemented.

When analysing the Outcomes Measures (OM2), the PARs claim more households better protected (93,033) than the official numbers presented by the EA in the MTP (76,858). From the PAR analysis, 93,033 (80%) of the 116,985 households better protected are moving properties from very significant and significant flood risk categories to moderate or low. However, considering the standard of protection of existing defences had at the time that they were built, only 44% are moving properties from very significant and significant flood risk categories to moderate or low.

The schemes were assessed for evidence of OMs being incorrectly claimed. Examples of schemes were found that present the same OMs when the business case is reviewed to release more investment due to staged investments. But overall it appears that OM2 benefits are being claimed correctly in the sample assessed.

4 Aim 2: Managed adaptive approaches

4.1 Explanation of aim and context

The updated advice contained within 'Adapting to Climate Change: Advice to Flood and Coastal Risk Management Authorities'⁴ reiterates the support identified within Defra's Policy Statement⁵ for 'managed adaptive approaches'. The Policy Statement emphasised the need to ensure that appraisals for all activity (whether strategic level plans or individual projects) give more consideration to 'risk management' and 'adaptation', as opposed to only 'protection' and 'defence';

The following graphic illustrates the difference between managed adaptive approaches and precautionary approaches. The managed adaptive approach promotes flexibility in the appraisal options to respond to future change, during the whole life of a measure, as well as future uncertainties. Ultimately, adaptive approaches enable schemes to maintain their SoP as flood risk increases as a result of climate change and deterioration of assets. The precautionary approach involves designing for exceedance now and can involve substantial additional investment that may not be required. However, not all schemes are suited to the adaptive approach on the basis of technical feasibility requiring one-off interventions instead.

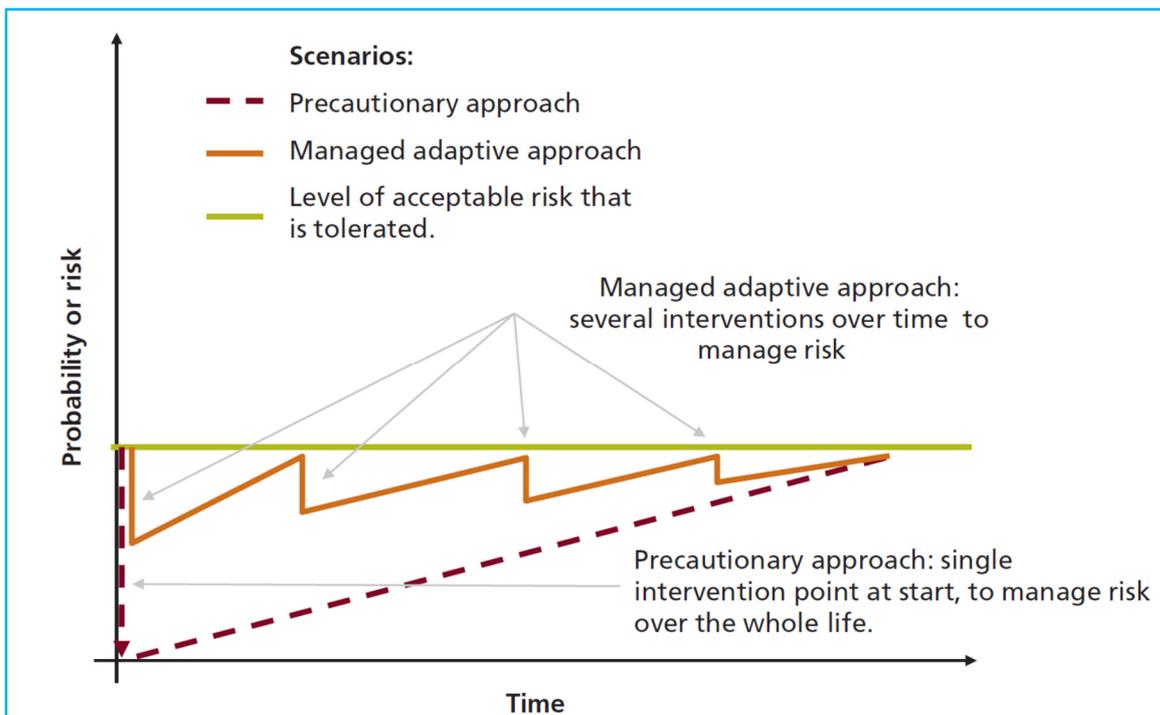


Figure 4-1: Precautionary and managed adaptive approaches (Source: Defra (2009) Appraisal of flood and coastal erosion risk management: a Defra policy statement – Figure 4-2)

In 2014, JBA produced internal supplementary guidance to the standard FCERM Appraisal Guidance for the EA regarding managed adaptive approaches.⁶ This noted that although national policy and advice for the appraisal of investment in FCERM schemes promotes the use of managed adaptive approaches to address future uncertainty, these are not being adopted extensively with a continued tendency to favour precautionary approaches. The study noted that accepting and managing uncertainty is not easy and, while there are few arguments against the benefits of affordable and flexible solutions, there can be difficulties with their justification, development, valuation and implementation in practice. This was also highlighted in previous research for Defra, 2009⁷ that identified several specific barriers to the development and

⁴ Environment Agency (2016) Adapting to Climate Change: Advice to Flood & coastal Risk Management Authorities'

⁵ Defra (2009) Appraisal of flood and coastal erosion risk management: A Defra policy statement

⁶ <http://www.icevirtuallibrary.com/doi/abs/10.1680/jwama.14.00070>

⁷ Defra (2009b) The appraisal of adaptation options in Flood and Coastal Erosion Risk Management – FD2617. Available at: [http://evidence.environmentagency.gov.uk/FCERM/en/Default/HomeAndLeisure/Floods/WhatWereDoing/IntoTheFuture/ScienceProgramme/ResearchAndDevelopment/FCRM/Project.aspx?ProjectID=f4394a7b-5e9d-4572-88feb443f5af9888&2016s5344-CCC-Impact of flood schemes - Revised Final Report 300617](http://evidence.environmentagency.gov.uk/FCERM/en/Default/HomeAndLeisure/Floods/WhatWereDoing/IntoTheFuture/ScienceProgramme/ResearchAndDevelopment/FCRM/Project.aspx?ProjectID=f4394a7b-5e9d-4572-88feb443f5af9888&2016s5344-CCC-Impact%20of%20flood%20schemes-Revised%20Final%20Report%20300617)

gramme/ResearchAndDevelopment/FCRM/Project.aspx?ProjectID=f4394a7b-5e9d-4572-88feb443f5af9888&2016s5344-CCC-Impact of flood schemes - Revised Final Report 300617

appraisal of adaptive approaches particularly highlighting the issue of culture and mind-sets where a lack of systems thinking and risk and uncertainty aversion prevails. The study also highlighted the need for both Risk Management Authorities (RMAs) to change their mind-set in relation to the development of schemes, but also for the EA to provide greater support for adaptive approaches when scrutinising FCERM appraisals. The degree to which managed adaptive approaches are being adopted and the challenges in developing, securing commitment for and implementing such schemes was investigated through the individual scheme analysis and strategic consultations with EA Area Flood Risk Managers and RFCC chairs.

4.2 Implementation of managed adaptive approaches

Scheme reviews

Of the 27 schemes reviewed, 48% incorporated an adaptive approach, for example building larger foundations than required so defences can be extended in future, 45% adopted precautionary approaches accounting for climate change now and designing for exceedance, and 7% had no provisions for climate change.

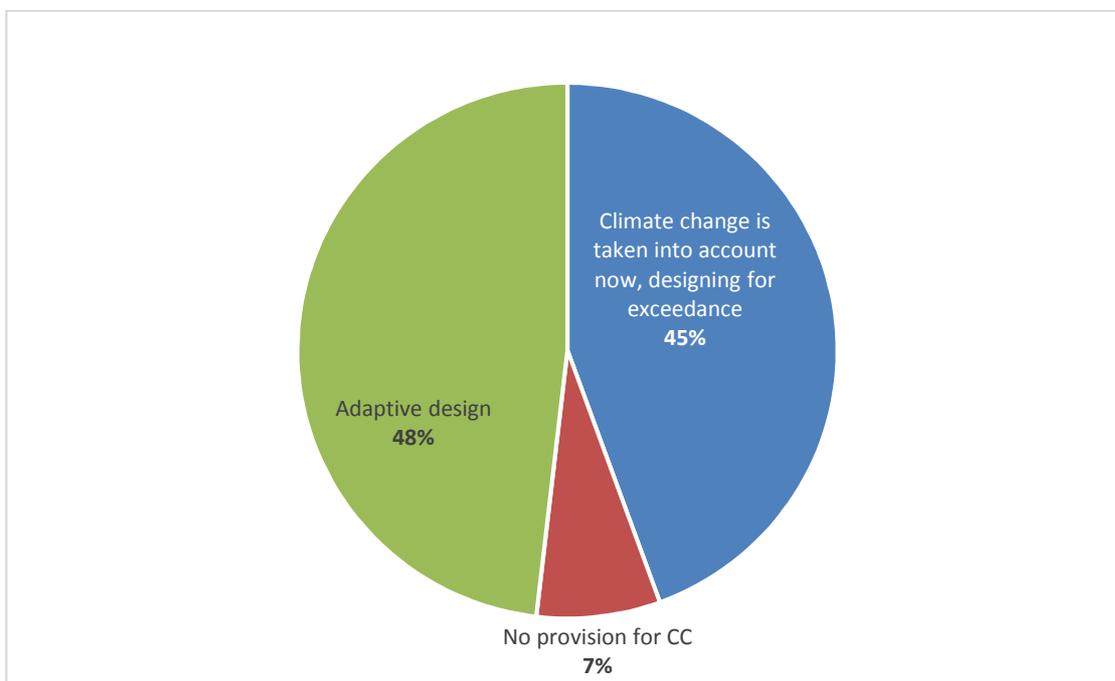


Figure 4-2: Aim 2 Taking a managed adaptive approach

Strategic consultations

Consultations with EA Area Flood and Coastal Risk Managers and RFCC Chairs revealed that for some of the larger schemes with which they are currently involved an adaptive approach is being adopted on affordability grounds due to the cost of designing for potential future exceedance now. Ultimately they are seen as a positive 'low-regrets' solution in that investment is not being made until it is required. Flexibility is factored in to enable the design to be adapted when trigger points are reached. These trigger points could be physical e.g. evidence of sea level rising or related to the availability of more certain information on climate change projections.

Consultations also revealed that there is an increasing move towards the development of adaptive approaches at the strategic level that combine a range of hard and soft structural measures that will show results over different time periods. RFCCs, such as Anglian Eastern and Northumberland recognise the need to adopt long term approaches to address future climate change impacts and appreciate the importance of planning for the long term on a catchment and multi-catchment basis. Interconnections between coastal and catchment processes were recognised as crucially important and should be addressed in a strategic and integrated manner e.g. the Broads catchment and the Norfolk coast, Fens for the Future and Northumbria Integrated Water Partnership. The need for such integrated approaches is recognised in SMPs and CFMPs, and these approaches are gaining more traction as integrated

catchment management is becoming increasingly embedded. The key point in relation to managed adaptive approaches is that whilst individual schemes may not be adaptive in themselves, they are increasingly being assembled in packages that provide an adaptive approach over time.

Innovative approaches are being employed to manage flood and coastal erosion risk in an adaptive fashion for both small and large schemes. For example, on the Norfolk coast, rollback (the physical movement of assets further inland away from the threat posed by Coastal Change) is being facilitated through spatial planning policies. North Norfolk District Council's Local Plan⁸ includes Policy EN 12 Relocation and Replacement of Development Affected by Coastal Erosion Risk. This permits the owner of a house threatened by erosion in the next 20 years to seek planning consent for a new development on land not allocated for housing. This gives new use value to the development site that can be used to augment the purchase price and give the owner of the development site an incentive to enter into a development agreement. There has been some take up of the scheme by local households (nine had taken advantage of the policy by 2012). The evaluation of the Coastal Pathfinder programme⁹, which included Happisburgh on the North Norfolk coast, suggested that this policy could be replicated elsewhere to facilitate rollback and also highlighted the potential for the private sector (i.e. developers) to use EN12 thus reducing the role of the public sector.

4.3 Designing for exceedance now or in the future

Maintaining SoPs over time

Of the 27 PARs reviewed, seven schemes did not include climate change in the design. Four factored in climate change so the SoP will reduce but the design standard will be maintained for 50 years. Positively, 16 out of the 27 schemes factor in climate change to enable the same design standard to be maintained for 100 years.

Of the schemes that integrated climate change allowances into scheme design:

- Four used the latest EA guidance on climate change¹⁰
- 10 used the previous 2006 Defra guidance¹¹
- One used pre-2006 FCDPAG guidance
- Five used other local allowances.

Over the lifetime of a scheme, the latest (2016) EA climate change guidance gives higher sea level rise and river flow allowances for climate change than the previous 2006 Defra guidance, and greater uncertainty values. Half of the schemes that integrated climate change into the design used the 2006 Defra guidance with lower estimates as this was the guidance available at the time that the schemes were designed. This means that the households being claimed as 'better protected' may not be fully resilient to climate change when compared to the latest guidance.

Some of the schemes, for example Nottingham Trent Left Bank, have used local climate change allowance data. For Nottingham, this led to a scheme that allowed for a 10% increase in fluvial flows (based on a study by CEH Wallingford) to accommodate climate change for the next 50 years, without freeboard. This scheme better protects 11,000 properties. Both the 2006 Defra and 2016 EA guidance would have recommended higher values.

Other schemes such as Rossall and Lincshire did not specify the climate change allowances used, but state that the schemes would keep pace with climate change and adapt as and when necessary. The Lincshire beach nourishment tidal scheme incrementally adds climate change allowances into the design every five years, by adding more sand to take account of increased storminess.

For PARs that are justifying schemes with staged investments (see Box 1 in Chapter 1), the climate change allowance that is designed into new schemes will reflect the business case

⁸ https://www.north-norfolk.gov.uk/media/1370/3-core_strategy_-incorporating_development_control_policies-_adopted_2008_-updated_2012.pdf

⁹ Defra (2011) Coastal Pathfinder Evaluation: An Assessment of the Five Largest Pathfinder Projects A Final Report by Regeneris Consulting

¹⁰ Adapting to Climate Change: Advice for Flood and Coastal Erosion Risk Management Authorities, EA, 2016

¹¹ Defra 2006 guidance 'Treatment of climate change impacts' using the latest science from UK Climate Projections 2009, UKCP09.

2016s5344 - CCC - Impact of flood schemes - Revised Final Report 300617

period of the new asset, or it will be adaptable so that a new replacement scheme will factor in climate change. In these cases, climate change was either not factored into the design at all, as calculations showed that the increase in risk would be small, or climate change was only factored in for the next 50 years or less.

Figure 4.3 shows the improvement in protection that the 27 schemes provide based on what was there previously. This shows that out of the 27 schemes, 15 improved the existing design standard and incorporated allowances for climate change in the design. The majority of schemes will therefore show an improvement to the design standard for the lifetime of the new flood defence asset. However, the SoP will reduce over time. It was not possible to identify the SoP that the schemes provide in year 1 compared to the end of the design life.

Only three would eventually show a reduced level of protection compared to what was there previously. Nine of the schemes will provide households with the same or less protection in the future either because they did not include climate change into the design, or they did but did not improve the SoP.

Figure 4.4 shows that nearly 26,000 (34%) of the 'households better protected' will have the same level of protection at the end of the design life.

It can be concluded that most schemes are either improving the SoP and incorporating climate change allowances into the design, or keeping the same level of low risk while taking into account climate change.

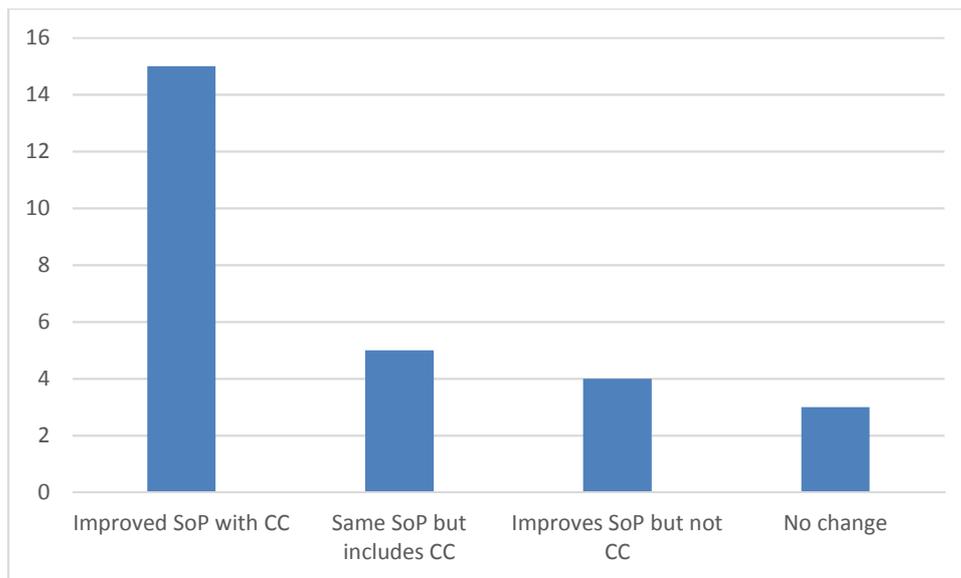


Figure 4-3: Schemes that improve the existing SoP, of the 27

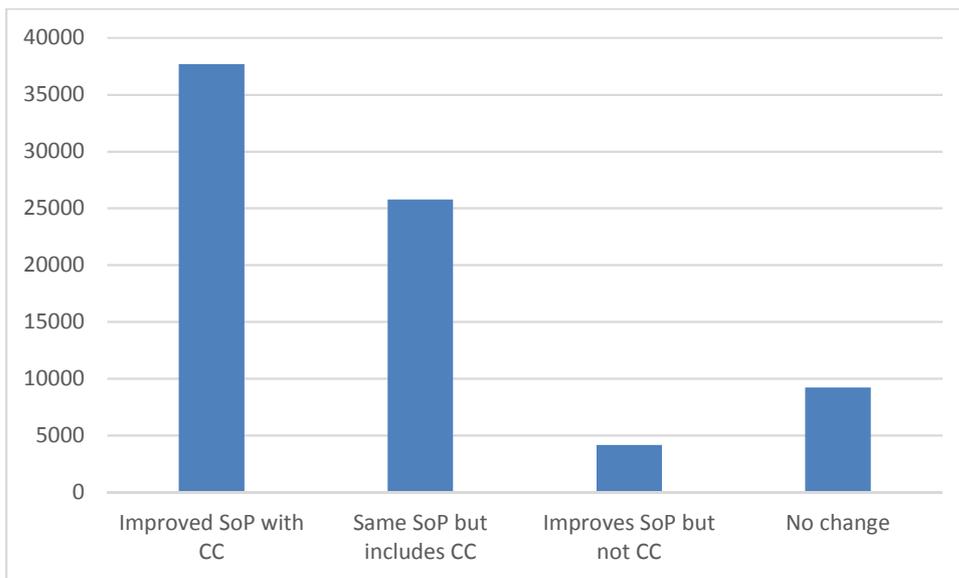


Figure 4-4: Households from the 27 schemes that receive an improved SoP

Balancing the Partnership Funding formula

Strategic consultations

Consultees identified that a key issue that influences the decision whether to progress precautionary or managed adaptive approaches is achieving a sufficiently high benefit-cost ratio (BCR) to enable a Partnership Funding score that will secure funding. With managed adaptive schemes, there appear to be different approaches adopted as to whether the full benefits are being claimed now even though schemes will only provide protection to the full climate change SoP in the future. Project managers take different approaches to reporting investment requirements and benefits in the short and longer term. Ultimately there is a need to capture the long-term costs of adaptive solutions in the business case to claim the long-term benefits. The differences in interpretation suggest that guidance may need to be clarified to ensure consistent approaches to capturing benefits are adopted.

Consultees also reported that many schemes implemented in the 1960s in the wake of the London tidal surge and issues elsewhere, are now coming to the end of their useful life. They also suggested that further work is needed on achieving the required benefits to secure funding and designing in 'upgradeability' to ensure that schemes are adaptive and not requiring unnecessary investment now as could occur through a precautionary approach.

Finally, consultees reported that it can be challenging to secure external contributions for adaptive schemes that have a high level of residual risk, possibly because external bodies are being requested to partly fund measures that will not fully protect them. In these cases, it is important to convey the message that without the scheme, the risk would be even greater. This should be evident through the option appraisal, but concerns may remain in relation to residual risk.

Implementation of adaptive pathways

Scheme reviews

A third of the schemes reviewed explicitly referred to adaptive pathways and trigger points with examples such as increasing defences as sea level rise becomes evident, frequent overtopping etc. The remaining schemes tended to state that measures would be replaced/enhanced at certain points in the future e.g. 20, 30, 50 years' time (depending on the specific measures involved) building in allowances for climate change. It is not clear whether in all cases this is a truly managed adaptive approach or simply a case of forward planning for replacement measures and identifying that these should be constructed to a level that is resilient to climate change. If measures are likely to need replacement before specific climate change impacts are realised, then there is no need for these to build in climate change allowances now.

Strategic consultations

Consultations revealed that whilst many schemes adopt a managed adaptive approach in theory, this does not generally appear to be followed through in practice in terms of identifying trigger points and adaptation pathways. The approach tends to be more focused around time periods; that is, certain interventions have a design life of 30 years and then will be replaced with a larger scheme that takes into account climate change. If conditions are not monitored and trigger points identified, there is a risk that the 'adaptive' element of the project is not progressed. However, it is important to acknowledge the context in which investment decisions are made and recognise that a balance has to be achieved that maximises long term resilience within the constraints imposed by the availability of public funding.

In addition, long term adaptive approaches over large areas (e.g. TE2100) can only be implemented effectively if the long-term planning of land management is built into all plans and policies.

Strategic adaptive approach and links with Partnership Funding

Strategic consultations

Consultees highlighted a potential disconnect between RFCCs taking a long term strategic approach and the EA being more focused on short term goals such as OMs, specifically moving households from one risk band to another on an immediate basis. RFCCs are looking at the need for 100 year strategies with sustainable approaches that incorporate adaptive approaches over several planning epochs similar to the TE2100 approach. For example, the Broads Climate Partnership commissioned a Flood Management High Level Review in 2016 to consider a more integrated approach to coastal risk management in eastern Norfolk across the existing defence strategies of Eccles to Winterton (coastal), Great Yarmouth (tidal) and Broadland (tidal and rivers).

Similarly, the strategy for the Great Ouse catchment is being refined following the introduction of Partnership Funding linking the tidal Ouse with long term plans for the fens (Fens for the Future) through a 100 to 150 year investment strategy. Again, the intention is for a package of measures delivered over time providing an overall adaptive package.

Consultees considered that strategic and integrated approaches should enable more effective management of flood and coastal erosion risk over the long term and can help capture sufficient benefits to achieve required Partnership Funding scores in less populous areas where long term strategies will ultimately be contributing to the economic prosperity and quality of life.

4.4 Good practice examples

Scheme reviews

- Central Felixstowe Beach Management Works – the scheme has been developed with the intention of constructing a flood wall at year 10. The trigger point is identified as frequent over-washing of the water and shingle onto the road below that is likely to occur more frequently with sea level rise. The BCR analysis includes an allowance of 25% of the original groyne construction in year 50 for renovation, repair and building in climate change allowance.
- Morpeth Flood Alleviation Scheme – climate change will be managed by adapting new defences in the future. Foundations are being constructed to allow the defence walls to be easily modified so that they can accommodate an increase in peak river flow of 20%. A precautionary approach is being taken to the design of new culverts through the flood storage dam, but additional capacity will be built into the flood storage area to accommodate the same potential increase. Overall this constitutes an adaptive approach comprised of precautionary and adaptive measures.
- Nottingham Trent Left Bank Flood Alleviation Scheme – the scheme is intended to maximise the flow capacity of the channel and set back defences where possible to accommodate future climate change. In places, it will be possible to raise defences or increase capacity, but this would increase flood risk to the downstream villages. Therefore, the scheme adopted partial adaptation measures to ensure best value whilst incorporating climate change. These measures include increasing foundations to allow for future defence raising and increasing the capacity of any culverts and bridges as flow increases. Future changes to wider catchment management through macro-level interventions using the Derbyshire peatland moors should help attenuate flows over time as climate change impacts are realised. Linking these two approaches has enabled

Partnership Funding to be secured for the peatland restoration scheme as it was argued that this slows the flow into the developed area of Nottingham allowing OM in terms of households protected to be captured.

- TE2100 – schemes such as the Barking and Dagenham MIEICA Package 3 Thames Tidal Frontage Programme are part of the acclaimed adaptive strategy promoted by TE2100.
- River Mersey – Warrington. The approved strategy recommended building 3.2km of embankments and 6.6km of walls to reduce flooding to a 1:100 (1%) chance of flooding in any year. The strategy recommended a managed adaptive approach to climate change. This meant the scheme was constructed so that it could be easily modified in the future to maintain the standard of protection in the face of climate change. The strategy proposed a mixture of earth embankments and steel sheet pile walls. This project has refined the defence alignment, finishes, forms of construction and looked at opportunities for cost savings. The proposed defences are located on both banks of the Mersey, but are not continuous and tie into higher ground wherever possible. At strategy stage the focus of potential environmental outcomes was those identified by the Mersey Life project and the priority was to contribute to habitat creation.

Strategic consultations

- Adaptive strategies are being developed to manage risk on the north-east Norfolk coast linked with flood risk to the Broads and to manage risk on the tidal Ouse linked with flood risk to the fens.
- Northumbria Integrated Water Partnership involving Northumbria Water, the EA and local authorities is developing a package of measures enabling a managed adaptive approach over time; many of these measures focus on working with natural processes (WWNP) e.g. swales, infiltration trenches etc. Such approaches are further investigated in Chapter 6 concerning working with natural processes.
- Oxford and Abingdon Flood Alleviation Scheme – this identifies strategic objectives requiring a series of precautionary and adaptive measures to achieve the overall desired SoP and benefits. The scheme has designed in elements that will need to be increased as climate change is realised.

4.5 Summary

- Managed adaptive schemes are promoted through Government policy to encourage flexibility to respond to future uncertain climate change, during the whole life of a measure. Essentially, adaptive approaches enable schemes to maintain their SoP over time.
- Four factored in climate change so the SoP will reduce but the design standard will be maintained for 50 years. Positively, 16 out of the 27 schemes factor in climate change to enable the same design standard to be maintained for 100 years.
- Almost half of the schemes reviewed incorporated adaptive approaches, however most of these did not identify clear adaptive pathways and trigger points. In the main, future plans to enhance/replace features were based around specific time periods and may actually be more focused on replacing obsolete measures than adapting functional measures.
- Consultations with strategic stakeholders revealed strong support for adaptive strategies taking forward a package of precautionary and adaptive measures to manage flood and coastal erosion risk over time.
- Consultations also identified particular challenges in balancing the Partnership Funding formula for adaptive strategies and securing external funding although adaptive approaches had been adopted in several cases on affordability grounds to postpone the costs of designing for future exceedance.

5 Aim 3: Justification to support preferred option

5.1 Explanation of Aim 3

The purpose of Aim 3 is to provide evidence for and understand the justification provided to support the choice of the engineering solutions and standard of protection against other options. The data collected from PARs and consultations with project representatives were based around the following questions:

- Has there been a long list and short-listing process, how was the long list cut down to the options that were appraised in detail?
- Were different SoPs tested with different climate change allowances?
- How was the preferred option arrived at, what was driving the selection of the final option?

5.2 Summary data

The summary data on the 27 schemes shows that 22 used detailed optioneering methods to determine the preferred option and only five had a simple approach to preferred option selection. To get a summary overview of the optioneering process, the following definitions were used:

- Simple – Appraised the Do Nothing, Do Minimum and one or two other Do Something options.
- Detailed – Looked at more Do Something options and more variations of the same options e.g. different SoPs across the different options and different SoPs within the measures that make up an option.

The conclusion above is backed up by a more detailed look at the optioneering and scheme selection process. The options appraisal process was analysed in more detail; this identified that of the 27 schemes reviewed:

- 22 - used the incremental benefit cost ratio (IBCR) method in selecting the preferred option
- 3 – used multi criteria analysis (MCA) to aid option selection and short-listing
- 23 – used workshops or stakeholder consultation to short-list and/or select the preferred option
- 15 - used recommendations from FCERM Strategies for option short-listing
- 20 – appraised different SoPs for the options
- 20 – referred to and used indicative standards as a starting point for option selection and starting SoP

These data provided the basis for the analysis and examples in the rest of this chapter.

5.3 Scheme examples

5.3.1 Appraising different SoPs and using IBCR

Standard practice for schemes following FCERM Appraisal Guidance is to test several Do Something options that offer different SoPs. Following this, the guidance recommends using the incremental cost benefit ratio (IBCR) to identify the preferred option. This requires the user to list the options from lowest to highest SoP. Starting with the highest cost benefit ratio and then moving through the options will show if the IBCR is sufficient to allow for a different leading option.

22 of the schemes applied the guidance generally by selecting the option with the highest cost benefit ratio. However, to use the IBCR method effectively, options with different standards are ideally required. 20 out of the 27 schemes appraised options with different SoPs.

Seven of the schemes only appraised one SoP as the only options being considered were refurbishing existing assets e.g. Thames Tidal Frontage Programme 1, the Barking and Dagenham sluice gates and Deptford raised frontages. The assets were in a poor condition and needed investment, but no alternative options were considered, including whether an increased

SoP could be provided, e.g. raised defences, as the scope of the study was set at refurbishment and wider, more expensive new defences were ruled out.

The Warrington PAR only considered the 1 in 100-year event as this is what the FCERM Strategy recommended and no alternatives were sought.

Walverdon Water looked at different SoPs across different options but only several assessed different SoPs for the same option. For the Salford scheme, the PAR indicates that different SoPs for the same option were appraised. However, the results had not been included in the PAR because the 'solution required to achieve this is neither buildable or aesthetically acceptable'.

A potential weakness when purely relying on the economics of the IBCR is that other alternative options that offer additional benefits might get missed e.g. amenity and environmental benefits. Some of these benefits can be captured in OM1, but it can be problematic and time consuming to quantify and even if they are included, they may not increase the ratio enough to make a big difference. Some schemes will consult stakeholders or undertake an MCA to add more context to option selection.

5.3.2 Use of MCA and objective led optioneering

As noted above, 22 schemes just use economics to guide the selection of the preferred option, while three combined this with MCA. Options that use some type of MCA will weight options based on factors other than economics when short listing and selecting the preferred option. Only three of the schemes assessed used MCA to reject some options and to take forward the shorted listed options.

MCA is built on the specific project objectives that are set by the project team and/or stakeholders, most use economic, environmental and social categories. The objectives could also be set at the Strategy level and refined at PAR stage. For PARs that use MCA, a significant driver for scheme selection will be the project objectives.

After short-listing options, the primary justification for the selection of the preferred option in the schemes under review was quantified economics; this is in line with FCERM AG. There is evidence that the amenity and environmental benefits of some options are being overlooked due to being dismissed at the short-listing stage before the evidence can be quantified.

Option short-listing should be driven by the project objectives; if the objectives are heavily constrained, then alternative options are unlikely to progress to the short-list stage. The PAR objectives were analysed to see if they included wider considerations of the environment and amenity value. Many of the objectives included vague statements such as 'where possible enhance the environment'. However, only 12 out of 27 schemes included direct, specific objectives to enhance the environment or provide amenity value.

The evidence for success against objectives outside of the economics category can be qualitative and not as robust as using the IBCR. Using MCA there is a risk that some options will get rejected without fully appraising the benefits in detail e.g. schemes that use natural processes. However, the alternative to using MCA taking the long list to a short list is less transparent and not as likely to have an evidence trail to reject or take forward options. In addition, having an MCA stage could allow stakeholders to give social and environmental extra weighting and bring them forward to full appraisal.

The three schemes that used MCA for option shortlisting are Central Felixstowe, Littlehampton and Sandwich Bay. All of them used a scored and weighted analysis of the options against project specific objectives.

For the Sandwich Bay scheme, selection of the preferred option at Strategy stage was influenced by a scored and weighted MCA in addition to a conventional economic analysis. The final option was selected as the preferred option both within the MCA and the economic analysis.

Although only three of the schemes undertook a full MCA, 25 schemes considered environmental benefits when selecting the preferred option. The Godmanchester, Perry Barr, Lewisham and Eastbourne schemes say that the preferred option is the most economically beneficial and meets or exceeds the environmental objectives of the project. But there is no evidence for schemes being selected that have the most environmental benefits but a lower cost benefit score than an alternative option.

5.3.3 Stakeholder workshops and consultation

If an MCA is not undertaken, there are other ways to influence option selection including stakeholder consultations and workshops. 23 of the 27 schemes included some form of stakeholder consultation in the options short listing and/or scheme selection. This can have a positive outcome if alternative options with additional benefits are taken forward. The potential downside is that some options are rejected early based on subjective reasoning, before a robust appraisal has been undertaken. As noted above, MCA would be a more transparent way of taking stakeholder opinions into account.

The long list of options will get cut down by Project Team and stakeholder qualitative reviews rather than through a technical appraisal as it is not feasible to appraise all possible options in detail. But in some cases, the more detailed appraisal of options can be a variation on the preferred option. E.g. at the strategic stage, the Godmanchester appraisal dismissed all scheme options apart from new defences and then appraised five variations of this option. Stakeholder consultation also influenced the selection of the preferred option.

Similarly, for Nottingham Trent Left Bank, only raised defences were appraised against the baseline. Other options were dismissed through a high-level assessment. The wider options (different to raised defences) were dismissed on technical, environmental and economic grounds but the reasoning was mainly qualitative and not through a detailed appraisal. It is unclear if opportunities were missed through this.

Deptford Creek is another example where the preferred option was chosen through internal EA workshops with some external stakeholder consultation. The decision process included maintenance measures that could keep some of the existing assets in the short term, deferring larger capital expenditure.

Having informal or workshop discussions to decide which options should be short listed, can be driven by perception that certain options are too expensive without fully knowing with the economic benefits. An example is the Lewisham and Catford FAS, the reason for rejecting many of the long listed options was that they are very expensive but this was stated before a detailed economic appraisal.

Some of the PARs will initially use the FCERM AG IBCR rule to select the preferred option but then consider the implications that this option will have on the community. One example is the Teignmouth scheme. The economic and technical appraisal indicated that the best value option would be to construct the tidal defences in excess of the current day 1000-year SoP. However, the wall height required would impact excessively on sight lines and estuarine views and consultation with the Local Planning Authority indicated that, based on public opinion, planning approval would be rejected. As a result, an option with a lower SoP and lower cost benefit ratio was chosen.

Similarly, the Shaldon scheme rejected the most cost beneficial option that also offered the highest protection because the wall was deemed too high by the community, planning authority and landscape architect. A 1 in 100-year standard was therefore provided rather than a 1 in 300-year standard with a higher cost benefit ratio.

The assessment of schemes shows that cutting down the long list to the short list requires some subjective reasoning as it would not be cost effective to appraisal all possible options. When this is being done, engaging stakeholders as well as the project team provides transparency but there is a risk that alternative options that offer wider benefits are rejected early.

5.3.4 Continuing with existing arrangements

Three of the chosen solutions are a continuation of the existing arrangements or have a pre-defined scope for improved SoP at the outset.

One example is Lincshore, the preferred option is predetermined and the PAR is there to show that the status quo is still economically justifiable. The predetermined option (beach nourishment) is based on continuing a solution that meets the FCERM objectives and is affordable in the short term. A better long term option requires significant funding in year 1 that will not be realistically funded in the short term. Beach nourishment every five years will be funded but is more expensive over 100 yrs. The decision process is driven by the coastal authorities in partnership with the RFCC and is based on a realistic funding outcome.

Another example is the Barking and Dagenham scheme. Defra gave approval for the first 5-year plan of works from the FCERM Strategy and the recommended option is to “Maintain and Sustain” to address the condition grade of the defences through refurbishment. The objectives and therefore the outcomes of this scheme are to maintain the current SoP provided by the existing assets but the project objectives do not include looking at more costly options e.g. raising defences, until intervention from the later Thames Estuary 2100 (TE2100) Strategy. The costs for approval (in the 5 year works plan) were £5.3 million; going forward more funding will be required to maintain the SoP for the same properties.

5.3.5 Following FCERM Strategies

For 15 out of 27 schemes the short-listed options were heavily influenced or dictated by the overarching FCERM Strategy. Reviewing the long list at PAR stage before shortening would give a chance for new evidence and stakeholder opinions. The Felixstowe scheme did this by reconsidering the long list of options that were identified at earlier strategies and undertaking an MCA of options during stakeholder workshops.

Five of the schemes aimed for a SoP based recommendations from the Strategy rather than looking at different standards, although there is no guidance to suggest that this should be done.

The Warrington PAR just appraised the options and the SoP from the FCERM Strategy. To quote the PAR *‘It (the Strategy) recommended building walls and embankments to reduce flood risk to a 1% per year. During the development of this PAR we have not questioned this recommendation. Instead we have concentrated on selecting the best, most cost effective means of implementing the strategy’s recommendations. This meant we only had three options’.*

Similarly, the Nottingham Trent scheme cut short the appraisal process by selecting the option and standard recommended by the Strategy *‘The FTS identified that flood defences were the only viable option for flood risk management in Nottingham.....providing protection against a flood with a 1% (1 in 100) annual probability of occurring was the best option for the Nottingham Left Bank.’*

For the Thames Tidal Frontage scheme, all the options taken forward for appraisal had to meet the technical, environmental and social criteria to achieve the project objectives and the TE2100 Strategy recommendations.

This may mean that options that offer a greater level of protection now and in the future, or options that work with natural processes, could get overlooked.

5.3.6 Testing climate change allowances

The current climate change guidance¹² to be used with FCERM AG states that schemes should consider credible and reasonable climate change impacts in the design and provides climate change allowances for this purpose and sensitivity testing. There is no set requirement to provide the full climate change allowance within the scheme’s design life. It may be cost beneficial to integrate climate change allowances for the first 50 years and adapt as necessary thereafter.

Where different options and design standards are appraised only two examples could be found where different climate change allowances are used e.g. a 1 in 100 up to year 50 of the design life against up to year 100. Ripon FAS tested different design standards, but not climate change allowances.

For the Barking and Dagenham scheme, climate change was not factored in to the scheme design as modelling showed that the area at risk was not sensitive to climate change within the 50-year appraisal period. A future strategy (TE2100 Strategy) would take the impacts of climate change into account beyond year 50. But the households protected by this scheme do not integrate these future risks.

Similarly, although the appraisal period for the Warrington PAR was 100 years, the new scheme was only resilient to climate change up to year 50. This is because it was economically beneficial to make the small increases to take account of year 50, but the investment to year 100 was not cost beneficial.

¹² Adapting to Climate Change: Advice for Flood and Coastal Erosion Risk Management Authorities, Environment Agency, April 2016
2016s5344 - CCC - Impact of flood schemes - Revised Final Report 300617

The strategic consultations suggested that marginal schemes that struggle to meet Partnership Funding threshold in terms of the PF % score are even less viable if climate change modifications are brought in. Issues arise in terms of costs versus benefits over long term, if more external contributions can be found then they can build in climate change allowances, if these cannot be secured then the benefits are reduced.

5.3.7 Using set indicative standards

Some of the older PARs selected the design standard using the outdated FCDPAG3 decision rule so will have pre-judged the design SoP based on 'indicative standards' before the appraisal of the best economic solution has been calculated (e.g. Ripon FAS). Although indicative standards are no longer used, they can be used as the starting point and then lower and higher standards tested. But some schemes will still assume that, for example, a 1 in 200-year SoP is required for tidal schemes without testing others.

For Nottingham Trent Left Bank, different standards were not fully appraised through modelling and economic analysis. High level economic, technical and environmental arguments were made against an option that provided greater than a 1 in 100-year standard. The 1 in 100-year SoP was the only standard appraised for this scheme that cost £51 million and better protected nearly 12,000 properties.

The strategic consultations stated that the EA used to require all schemes to be designed to a certain SoP; if this could not be changed, schemes were not supported and did not go ahead. Through Partnership Funding Policy, greater liberation over the SoP means more schemes can be supported with lower SoP; ultimately more households are protected, but not for the long term.

5.4 Summary

After short-listing options the primary justification for the selection of the preferred option in the schemes under review was quantified economics, which is in line with FCERM AG. There is evidence that the amenity and environmental benefits of some options are being overlooked due to being dismissed at the short-listing stage before the evidence can be quantified.

Option short-listing should be driven by the project objectives, if the objectives are heavily constrained, then alternative options are unlikely to progress to the short list stage. But only 12 out of 27 schemes included direct, specific objectives to enhance the environment or provide amenity value.

. Environmental benefits can be recognised in OM4 and 5 if they fit the criteria, but social/amenity benefits need to be included in OM1 using guidance from the Multi Coloured Manual. Monetising amenity value rarely increases the benefits significantly enough to change the preferred option.

For 23 schemes, stakeholders were consulted and for three schemes MCA was undertaken to inform the option selection. Optioneering using some type of MCA will weight options based on factors other than economics when short listing and selecting the preferred option. But Only three of the schemes assessed used MCA to reject options and to take forward the short- listed options. If an MCA is not undertaken, most schemes used other ways to influence option selection including stakeholder consultations and workshops. In most cases, environmental considerations were taken into account when selecting the preferred option.

Subjective reasoning in addition to pure economics can have a positive outcome if alternative options with additional benefits are taken forward. The potential downside is that some options are rejected early based on non-quantified reasoning, before a robust appraisal has been undertaken.

Three of the chosen solutions are a continuation of the existing arrangements and have a limited ambition for improved SoP at the outset, even if a more expensive but more cost beneficial option is available. This is because the decision process considers the possible availability of funding in addition to the cost benefit ratio. There is awareness beyond the PAR approval to the funding decision, for example, for the Lincshore scheme the 'financial case' appears to override the 'economic case' so that the scheme promoter gives their scheme a better chance of being delivered (better a scaled down scheme than no scheme at all). This is affirmed by the strategic consultations. Some new schemes (outside of those reviewed in this study) may protect fewer households in 30 years than immediately after construction but the

RFCC and EA representatives consulted considered this was better than not providing any protection and schemes need to be affordable. This can reduce a strategic approach to FCERM and thinking longer term. Schemes that do have an FCERM Strategy behind them are more likely to consider strategic, longer term schemes that are higher cost. The Strategy led PARs should follow the recommendations of the FCERM Strategy, but there may be opportunities to consider different SoPs and climate change allowances for this preferred option to increase value for money.

6 Aim 4: Working with natural processes

6.1 Explanation of aim and context

Following the flooding of summer 2007, the Pitt Review concluded that flooding from a range of sources can no longer be managed by building ever higher, lengthier and heavier defences in urban and rural areas. The review emphasised the need to ‘work with natural processes’ as part of integrated portfolios of responses to flooding and coastal erosion.

Working with natural processes (WWNP) means ‘taking action to manage fluvial and coastal flood and coastal erosion risk by protecting, restoring and emulating the natural regulating function of catchments, rivers, floodplains and coasts’ (EA, 2012). It is recognised that WWNP measures are complementary to traditional flood and coastal defences, and should be considered as part of the full range of measures that risk management authorities can use to reduce the risk of flooding and coastal erosion.

In addition to providing an integrated approach that works with, rather than against nature, many WWNP measures also positively contribute to climate change adaptation in terms of FCERM objectives but also through absorbing CO₂ (increased vegetation), undertaking peatland and wetland restoration providing long term carbon sequestration opportunities, retaining or enhancing natural habitats supporting biodiversity and reducing overheating through shading and reducing the Urban Heat Island effect.

WWNP includes the following topics¹³:

- ecosystem services – including the ecosystem approach¹⁴
- fluvial and coastal geomorphology – including sediment management and restoring natural processes
- green (soft) engineering – including mitigation measures and sustainable alternatives to ‘grey’ (structural) engineering
- habitat and species management – including vegetation management, meeting biodiversity targets, fish and eel passage
- natural flood management (NFM) – including catchment land management.

Research on the take up of WWNP measures has identified several challenges that include cultural and institutional barriers as well as a lack of guidance and understanding of their benefits in relation to traditional structural solutions¹⁵. This issue was investigated through the individual scheme analysis and strategic consultations with EA national and regional contacts, and RFCC chairs.

6.2 Implementation of WWNP schemes

Scheme reviews

19 of the schemes reviewed considered some WWNP or habitat creation measures whilst eight did not.

The following six schemes incorporated significant WWNP processes to alleviate flood risk. More detail is provided on each of these schemes in Section 6.3.

- Barking and Dagenham MEICA Package 3
- Deptford Creek Frontages Package
- Ings Beck Flood Alleviation Scheme
- Lewisham and Catford
- River Mersey, Warrington – FRM Scheme
- Salford Flood Improvement Scheme.

¹³ Environment Agency (2014) Working with natural processes to reduce flood risk R&D framework: science report– SC130004/R2 - http://evidence.environment-agency.gov.uk/FCERM/Libraries/FCERM_Project_Documents/WWNP_framework.sflb.ashx

¹⁴ The ecosystem approach integrates the management of land, water and living resources and aims to balance conservation of biodiversity, sustainable use and equitable sharing of benefits

¹⁵ https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/338437/SC130004_R2.pdf
2016s5344 - CCC - Impact of flood schemes - Revised Final Report 300617

The following four schemes identified beach recharge measures that can be included as WWNP although they can have environmental impacts if implemented in inappropriate locations:

- Central Felixstowe Beach Management Works
- Eastbourne Beach Management Study - Study to Support PAR for Eastbourne Beach Management 2010-2014
- Lincshore 2010 to 2015
- Rossall Coastal Defence Improvement Scheme.

The following nine schemes identified contributions to OM4 in relation to creation of enhancement of habitat but these did not include WWNP measures to alleviate flood or coastal erosion risk:

- Humber Estuary Flood Defence Strategy First Five Year Package of Work
- Morpeth Flood Alleviation Scheme
- Nottingham Trent Left Bank Flood Alleviation Scheme
- Pevensey Outfalls Reconstruction
- Shoreham Adur Tidal Walls
- Thames Tidal Frontage Programme.
- Upper Mole Flood Alleviation Scheme
- Wallasea Island Habitat Creation
- Walverden Water Flood Alleviation Scheme.

The following eight schemes did not include any WWNP processes:

- Godmanchester Flood Alleviation Scheme
- Littlehampton Arun East Bank Tidal Walls
- Perry Barr and Witton Flood Risk Management Scheme
- Redcar Flood Alleviation Scheme
- Ripon Flood Alleviation Scheme
- Sandwich Bay Sea Defences (Deal)
- Shaldon and Ringmore Tidal Defence Scheme
- Teignmouth Estuary (Back Beach) Tidal Defence Scheme

Chapter 7 reviews the degree to which schemes were in alignment with the relevant CFMPs and SMPs with regards to the promotion of using WWNP measures.

6.3 Good practice examples

Scheme reviews

The following schemes incorporated significant natural processes that are planned to help manage flood risk.

Table 6-1 – Schemes that incorporate significant WWNP measures

Scheme	WWNP measures
Barking and Dagenham MEICA Package 3	The sluice refurbishment works contribute to the Barking and Dagenham BAP Habitat Creation Project, creating over 10 hectares of habitat at Dagenham Washlands and the Goresbrook Corridor incorporating salt marsh, reed beds, lowland fens, ponds, wet woodland, floodplain grazing marsh, and naturalisation of 0.5km (min) of river channel.
Deptford Creek Frontages Package	The west bank of Deptford Creek provides flood defences to the Bermondsey Embayment and the east bank to the Deptford East Embayment. The areas behind these frontages, particularly the London suburb of Bermondsey are heavily urbanised. These areas of dense housing are protected by manmade frontages along the River Thames and adjoining Deptford Creek. The scheme includes the creation of 0.1ha UK priority BAP (reedbeds) habitat in 2010/11. In setting back the terracing to cultivate the reedbeds, the scheme increases the capacity of water within Deptford creek by 2,800 cubic metres helping to

Scheme	WWNP measures
	reduce flood risk.
Ings Beck Flood Alleviation Scheme	The beck has historically been constrained and culverted. Development alongside and over the beck is a legacy of its industrial past; this has contributed to numerous flood events including three in 2007/8. The scheme includes the creation of wetlands at Fenton Dam, improvements at Wrenthorpe Park, and the development of a mini urban park at Westgate that will create flood storage areas and reduce the need for hard engineering works downstream.
Lewisham and Catford	<p>The River Ravensbourne rises at Keston in the London Borough of Bromley and flows north through the London Borough of Lewisham to join the River Thames at Deptford Creek in the London Borough of Greenwich. In doing so it flows through an increasingly urbanised environment with numerous surface water inflows and tributaries such as the Pool and Honor Oak stream at Catford. The Thames Catchment Flood Management Plan characterises the floodplain as highly developed with little open space and modified river channels, and recognises that whilst flood risk is managed effectively, further actions may be needed to keep pace with climate change. Key environmental and WWNP measures include:</p> <ul style="list-style-type: none"> • Tree planting and maintenance to replace those lost and retention of mature trees where possible • Recreation of reedbed habitat in Beckenham Place Park (BPP). • Creation of meadow habitat within BPP and the Ladywell Green Detention Basin. • Increased connectivity between the river and floodplain within BPP. • De-canalisation at Mallyon's Road. • Realigned river channel incorporating river restoration features within BPP. • Replace Car Park (same capacity) to provide access to the park. <p>In addition, at the time of scheme development The Ravensbourne River Corridor Improvement Plan was being transferred into a Supplementary Planning Document providing planning guidance for riverside development to help prevent the problems of the constrained river channel reoccurring.</p>
River Mersey, Warrington – FRM Scheme	<p>The scheme includes the area of Padgate Twiggeries and confluence with Padgate Brook and the Mersey. During high tides or high fluvial flows, water in Padgate Brook cannot enter the Mersey because of its high water level. To prevent upstream flooding some storage of flows from Padgate Brook is required, until flows in the Mersey subside. The most suitable location for this was identified as the open land comprising the Twiggeries. The scheme proposed breaching the embankments along the canalised section of Padgate Brook allowing flooding of the adjacent land. Property flooding will be prevented by a new embankment. The canalised channel of Padgate Brook will be restored, together with pools and reed beds.</p> <p>The Twiggeries is a well used area of public open space which has a good population of water voles. Padgate Brook has been canalised through this area in the past. While providing flood defences, the environment was also enhanced by restoring reed beds and increasing water vole habitat. The project will create 0.25 Ha of new ponds, 0.25 Ha of new reedbed, and 1200metres of water vole habitat alongside 4.5 Ha of restored reedbed.</p>
Salford Flood Improvement Scheme	The proposed scheme includes the construction of a flood embankment along the right bank of the Irwell around Castle Irwell to create a flood storage basin. In order to reduce the impact on the riparian woodland the bank was set back 10m from the top of the riverbank. This measure will also preserve some of the existing floodplain. The scheme also includes tree planting to improve infiltration and flood attenuation.

Strategic consultations

Interestingly, the review of the PAR for the Nottingham Trent Left Bank Flood Alleviation Scheme did not highlight any measures that were WWNP, but consultation with the relevant EA Flood Risk Manager highlighted the Moors for the Future strategy concerning peat restoration in Derbyshire, higher up the catchment, to attenuate flows downstream including in Nottingham. It is possible that more strategic approaches involving packages of measures may not be identified within the individual PAR reviews.

WWNP measures are being considered as smaller scale interventions e.g. leaky dams in inland projects in Essex and Norfolk. Larger scale interventions such as the sand engine approach are also being considered e.g. around Bacton Gas Terminal on the north-east Norfolk coast. The Natural Environment Research Council (NERC) is investing considerable funding (£6-8m) into sediment studies on the east coast with regards to potentially adapting the Dutch sand engine approach into a scheme suitable for this coastline and its sediments. Beach recharge approaches are included within the definition of WWNP although these are an engineered approach that can have negative environmental implications if used inappropriately.

Funding (£2m GiA) has been received from a £15m Defra NFM initiative pot for a large WWNP scheme in the Wear catchment involving a large scale strategic approach and using a range of interventions – peat restoration, grazing, dam structures etc. to address the fast response watercourses. The catchment comprises several isolated communities and the approach does fit the usual partnership funding approach. However, the Defra funding under this initiative has less rigid rules allowing schemes to progress that would not be otherwise.

The following schemes/approaches were identified by stakeholders as good practice in relation to WWNP:

- Banbury FAS – following severe flooding in 1998 and further flood damage in 2007, a flood alleviation scheme was designed to increase Banbury's SoP to 1 in 200 years through the following five elements. These show a combination of WWNP measures, including NFM and structural defences to achieve the objectives of the scheme.
 - Flood storage reservoir upstream of Banbury – largely located in the natural floodplain of the River Cherwell, the flood storage area collects rainwater otherwise likely to swell the river over its banks.
 - Road-raising – raising the A361 in the flood storage area and installation of culverts to improve drainage and balance water levels on both sides of the road during flood events.
 - Localised storage defences downstream of the reservoir – defences constructed in three specific locations in Banbury to provide additional flood relief during severe storm events.
 - Pumping station at Moorfield Brook – used as a localised defence downstream of the reservoir by pumping rainwater downstream of development.
 - Creation of Biodiversity Action Plan (BAP) habitat – 12 ha BAP habitats created through conversion of a borrow pit (that supplied earth for embankment construction) into a country park, three river realignments incorporating ponds and various new and replacement plantings including trees and hedgerows.
- Lustram Beck scheme, Stockton – this scheme received support from the Defra £15m WWNP pot and one consultee stated that it would have been difficult for the scheme to achieve funding under usual Partnership Funding rules. The scheme is intended to reduce the risk of flooding to over 150 properties in Stockton-on Tees. The first phase involved the construction of hard defences in the urban area of catchment. The second phase, supported through the Defra WWNP pot, involves storing water at a range of scales in the catchment area upstream of Stockton. The key WWNP measures include storing water in the upstream catchment, SUDS and a large traditional storage area in Stockton-On-Tees. Use of WWNP required consultation with landowners within the catchment to slow and store surface run-off and peak flow from watercourses to ultimately reduce the peak flow in Lustram Beck before it reaches Stockton-on-Tees.

6.4 Challenges

6.4.1 Discounting of WWNP options

Scheme reviews

Eight schemes did not include WWNP in their preferred option. Three of these schemes (Littlehampton, Perry Barr and Sandwich) did not consider WWNP measures in their options and did not provide detailed explanation, three (Godmanchester, Redcar and Ripon) considered WWNP measures but discounted on the basis of technical feasibility or potential environmental disbenefits and two (Shaldon and Teignmouth) discounted WWNP measures on the basis of the constraints of the site in that both were concerned with replacement of flood defence walls. It is possible that three PARs did not identify any potential WWNP measures or provide justification for not doing so because the constraints of the site and the intention to implement a replacement scheme means these were not considered.

Strategic consultations

This issue was not highlighted within the discussions with stakeholders.

6.4.2 Evidence that WWNP ‘works’

Strategic consultations

Consultees considered that the key challenge with WWNP is the lack of suitable metrics to enable the support, incentivisation and justification of activities that promote NFM, making space for water and slowing the flow in urban environments. These approaches are regarded positively, but there is a need for more focus on how they can take water out of the system and slow flood progression in both urban and rural environments. Consultees suggested that it can be difficult to link such schemes to the Partnership Funding approach that is focused on households. There needs to be links to wider land management objectives and funding opportunities. It was also suggested that there is considerable investigatory work and research underway, but less action on the ground.

6.4.3 Support for WWNP

Strategic consultations

Stakeholders considered that WWNP tends to elicit polarised views with such processes either being considered with cynicism or as a solution to all FCERM challenges. It was suggested that reality is somewhere in between but it was generally agreed that there is a need for more evidence of benefits before such approaches can be extensively adopted.

The Wallasea Island Habitat Creation scheme demonstrates how local farmers did not consider investment in the local environment to be cost-effective. However, evidence has proved otherwise in terms of benefits for local businesses and amenity as well as managing flood risk. Inshore fisheries and mussel fishermen are supportive as the quality of the saltmarsh has improved. Established estuary partnerships in Suffolk are now supporting deliberate and planned breaches to encourage new saltmarsh.

The Fens for the Future strategy is considering WWNP measures in the upper catchment and continued adaptive strategic management in lower fenland. The upper catchment stakeholders are keen on discharging into the main rivers as fast as possible. It remains to be seen if it will be easy to gain support for slow the flow type approaches and the relevant consultee considered that IDBs can be cynical regarding the potential effectiveness of WWNP processes. The Defra funding should help demonstrate how WWNP works and help integrate this into mainstream decision making. The issue of farmers’ willingness to cooperate, that will be affected by post Brexit funding decisions, was also highlighted.

Another consultee highlighted that WWNP schemes are increasingly being considered although there are some concerns about their long-term effectiveness. They are becoming the ‘flavour of the month’, but there is a need to recognise they are not a panacea for all flood risk challenges. On some schemes, for example Lustrum Beck in Stockton, the first stage comprises traditional hard engineering achieving a 1 in 75-year SoP, and then the second stage builds in NFM processes intended to take protection up to 1 in 100 years plus climate change. These involve

small balancing features and tree planting upstream supported by the Forestry Commission. However, there are concerns about how the long-term maintenance of the WWNP schemes will be factored in. Often WWNP approaches focus on small interventions for this reason.

Finally, it was suggested that whilst WWNP are increasingly on the project developers' radar, a key challenge is that a lot of measures e.g. tree planting may not achieve benefits for 20-30 years. The Defra £15m pot for schemes will help build up useful evidence on the effectiveness of NFM/WWNP measures as the benefits are varied and evidence is required to help project developers understand how best to align WWNP with other methods to provide a holistic view on flood risk management solutions. In addition, Defra and the Environment Agency are currently supporting an R&D programme to consolidate, enhance and disseminate evidence to support WWNP and natural flood management (NFM). This comprises developing an evidence base, opportunity mapping and supporting the Defra £13m project on NFM by creating a monitoring and modelling guidance note on how and when to monitor and model. Two CIWEM launch events are planned later this year to disseminate the results of the project.

6.5 Summary

- Government policy following the Pitt Review emphasised the need to 'work with natural processes' as part of integrated portfolios of responses to flooding and coastal erosion.¹⁹ Of the schemes reviewed considered some WWNP or habitat creation measures whilst eight did not – the definition of WWNP has been taken to include beach renourishment.
- Six schemes incorporated significant WWNP processes to manage flood risk, four included beach re-nourishment measures in the preferred option and nine included habitat creation measures that did not directly contribute to the alleviation of flood risk.
- Consultees highlighted that strategic approaches are increasingly being developed involving a package of measures that include WWNP schemes along with more traditional structural approaches to provide an adaptive approach to managing flood and coastal erosion risk. The eight schemes that have identified WWNP options and discounted these have been on the basis of technical feasibility, the potential to create environmental dis-benefits or due to the constraints of the site e.g. replacement of flood defence walls. Three of the eight schemes did not provide any justification possibly because the constraints of the site and the intention to implement a replacement scheme means these were not considered.
- The strategic consultations have revealed that there is a need for greater evidence on the benefits that WWNP measures can achieve in the short and long term before these are adopted on a more widespread basis. This should be facilitated through the current Defra and Environment Agency R&D programme on NFM/WWNP.
- WWNP measures appear to be viewed either with cynicism or as a solution to all FCERM challenges. Essentially the reality is likely to be a balance between the two and more evidence will help make the case for more widespread consideration of these options.

7 Aim 5: Consistency with national and sub-national flood risk strategies

7.1 Explanation of aim and context

There should be a consistent and integrated approach to flood risk management from management policy and high level strategic objectives down to scheme delivery. For this study, an investigation of the degree to which this is happening in practice was conducted by assessing relevant strategies and the alignment (or not) of individual scheme objectives/activities with management policy, strategy objectives and target outcomes. Investigation of this aim was focused at three levels:

- Assessment of consistency with the national Long Term Investment Scenarios (LTIS)
- Assessment of consistency with sub-national FCERM policy documents, specifically SMPs and CFMPs
- Assessment of alignment with FCERM strategies for the larger schemes where these are in place.

This aim was mainly assessed via the review of the 27 schemes and relevant strategies. Specific questions were not asked of stakeholders with regards to alignment with national and sub-national strategies as there was not a focus on individual schemes, but where strategic approaches were discussed, these were captured and reported.

7.2 National Long Term Investment Scenarios (LTIS)

The long-term investment scenarios study (LTIS)¹⁶ is an economic assessment of future flood and coastal erosion risk management in the period 2015 to 2065. The LTIS report used the most recent available data to assess the consequences of investment choices to reduce the risks of flooding and coastal erosion in England over the coming years. It identified an approach to investing in FCERM over the long term that would achieve the greatest reduction in flood damage for any given amount invested. It also explored what actions may be necessary to cope with residual risk. The study took a long-term view of factors that affect flood and coastal erosion risks in order to explore a range of national investment scenarios. The LTIS provides an optimum profile of FCERM investments to reduce expected annual damage from flooding taking into climate change scenarios. This study initially included the aim of assessing the degree to which schemes built in 2014-15 contribute to the LTIS optimum profile. However, as there is no regional breakdown of identified investment requirements, it was not possible to investigate this element further.

7.3 SMPs and CFMPs

For SMPs and CFMPs, schemes were reviewed against catchment/coastal sub cell level policy aims e.g. 'reduce risk now' or 'hold the line' to identify the degree to which scheme objectives meet these wider strategic goals.

7.3.1 Shoreline Management Plans (SMPs)

The research identified that all coastal schemes referred to and were consistent with the relevant SMP. These are highlighted in PARs in relation to the legislative framework, informing the development of the FCERM strategy (where these are in place) and also specifically highlighted on the 'Project Appraisal Report – Data Sheet'.

The following table shows how each coastal scheme aligns with the relevant SMP in overall policy terms and specifically in relation to WWNP

¹⁶

Table 7-1 - Alignment between coastal schemes and relevant SMP policies

Scheme	SMP	SMP policy	Scheme alignment	SMP policy on WWNP	Scheme alignment
Central Felixstowe Beach Management Works	Lowestoft Ness to Felixstowe Languard SMP	Hold the Line for the next 100 years	The scheme and SMP both recommend a policy of 'Hold the Line' - The preferred option is a 100-year scheme design life with a preferred option of T-head groynes in conjunction with beach recharge	Through adapting the way in which defence is provided, the supply of sediment will continue and beaches will be sustained. The change in approach will encourage a more naturally functioning coast and this will support nature conservation interests	Alignment with SMP policy through inclusion of beach re-nourishment in the preferred option
Eastbourne Beach Management Study	South Foreland to Beachy head SMP	Hold the line for Eastbourne	This option is in accordance with the Hold the Line policy. This option is proceeding ahead of an approved strategy; however, the risk of conflict with the future strategy is negligible.	The present-day policy for Eastbourne is to hold the line, continuing to protect the densely-populated town and the substantial assets by maintaining and improving the existing sea wall, groynes and supplementing this with a recharged shingle beach	Alignment with SMP policy as the scheme comprises large capital recharge to restore groyne bay volumes to the required levels followed by annual top up and recycling
Humber Estuary	Flamborough Head to Gibraltar Point SMP	Hold the line and managed realignment (in smaller areas) for the Humber Estuary area	The proposed scheme is consistent with the SMP – the scheme avoids adverse impacts on site integrity; mainly through implementing a sequence of 'managed realignment' sites to replace habitat lost directly as a result of the proposed flood defence works or due to coastal squeeze.	Limited managed realignment may be required to ensure defence sustainability and compliance with applicable environmental legislation by creating habitats to compensate for losses due to coastal squeeze	The proposed scheme is consistent with the SMP – includes the creation of the Donna Nook managed realignment site to provide 138 ha of inter-tidal habitat.
Lincshore 2010 to 2015	Lincolnshire SMP (1996)	Hold the Line	The scheme is consistent with the SMP policy as its aims are to	The SMP supports intertidal habitats with associated benefits,	Proposed scheme is consistent with the SMP – includes beach

Scheme	SMP	SMP policy	Scheme alignment	SMP policy on WWNP	Scheme alignment
			reduce flood risk by sustaining the standard of defence at 0.5% AEP (1 in 200) and adapt to climate change by taking into account sea level rise in the design of works;	such as for fisheries, and provide compensation for intertidal habitat loss caused by coastal squeeze.	re-nourishment and removal of ineffective/redundant groynes (when exposed by natural beach erosion).
Littlehampton Arun East Bank Tidal Walls Scheme	Beachy Head to Selsey Bill Shoreline Management Plan Review (SMP2)	Hold the Line for the Littlehampton Arun East Bank area	Improving defences to the original SoP	As this stretch of coastline is so developed the SMP has not recommended any shoreline management that involves WWNP in the short-term.	Aligned in that neither the SMP nor the scheme make reference to working with natural processes
Pevensy Outfalls Reconstruction	South Foreland to Beachy Head Shoreline Management Plan (SMP) (2006).	The preferred policy for the frontage between Eastbourne and Bexhill (Cliff end to Beachy Head) is Hold the Line.	The proposed scheme is consistent Hold the Line - sustaining the tidal defences to ensure a 1 in 200 SoP. Also, the continued drainage of the Pevensy Levels to the English Channel whilst sustaining the tidal defences between Eastbourne and Bexhill.	No evidence of this. The SMP does not discuss working with natural processes in this specific area.	Scheme provides 0.03 hectares of reed bed BAP habitat at the decommissioned Pevensy East inlet, but this is not promoted by the SMP.
Redcar Flood Alleviation Scheme	The Tyne to Flamborough Head	Hold the Line over the main Redcar frontage	The policy identified in SMP2 is to hold the line over the main Redcar frontage, due to strong economic and social reasons. The specific policies include 14.1, 14.2, and 14.3 and are hold the line until 2105 for policy unit 14.3 is managed realignment.	The SMP states that "a sustainable shoreline sediment system is one that is allowed to behave as naturally as possible, without significant further intervention" but does not give specific recommendations in regard to WWNP for the area of the shoreline.	Scheme does not include any WWNP measures but these are not specifically promoted in the SMP for this area
Rossall Coastal	North West England and	Hold the Line	The scheme aligns with this policy – this is achieved by maintaining	The SMP recommends using softer defence options such as	Some natural processes were included in the preferred option.

Scheme	SMP	SMP policy	Scheme alignment	SMP policy on WWNP	Scheme alignment
Defences	North Wales SMP		and enhancing the current hard defences and beach management.	beach recharge as a way to manage and modify structures to prevent loss of beach.	The preferred option also does have some beach recharging
Sandwich Bay Sea Defences (Deal)	Isle of Grain to South Foreland Shoreline Management Plan Review (SMP2)	Hold the Line for the populated coastal frontages.	The preferred option identified for the frontage is to reduce flood risk by undertaking scheme improvements to a standard of 0.5% AEP.	The SMP states that although the conservation of ecological features in a changing environment remains key, in terms of environmental sustainability, future management of the coast needs to allow habitats and features to respond and adjust to change, such as accelerated sea level rise. Opportunities for maximising BAP habitats have been identified with regards to the Managed Realignment and No Active Intervention policy areas, not Hold the Line	The scheme does not include any natural processes but these are not actively promoted in areas covered by Hold the Line policies.
Shaldon and Ringmore Tidal Defence Scheme	Lyme Bay and South Devon Shoreline Management Plan	The policies for this area are to 'Hold the line' and 'Take further action to reduce flood risk (now and in the future)'.	The scheme is consistent with the recommendations of the SMP the scheme will adapt to rising sea levels by returning in about year 40 and, if justifiable nearer the time, year 70 to raise or replace the defences.	The SMP's overall objectives are to provide sustainable coastal defence options that are viable on engineering, economic and environmental grounds and where possible, to take advantage of natural forms of defence.	The scheme does not include any natural processes but this is probably because it is focused on replacement of existing defences
Shoreham Adur Tidal	Beachy Head to Selsey Bill	Hold the Line	The scheme promotes a consistent SoP of 1 in 300 to align	The SMP does not reference working with natural processes	The scheme does not include any natural processes as it is focused

Scheme	SMP	SMP policy	Scheme alignment	SMP policy on WWNP	Scheme alignment
Walls	Shoreline Management Plan Review (SMP2)		with existing defences along the frontage.	within the sub area.	on replacement of existing defences
Teignmouth Estuary (Back Beach) Tidal Defence Scheme	Lyme Bay and south Devon SMP	Hold the Line	The scheme is consistent with Hold the Line raising the defences to the 0.1% SoP	The SMP states that the core coastal defence management objectives should take advantage of natural forms of defence where possible.	The scheme does not include any natural processes as it is focused on replacement of existing defences
Thames Tidal Frontage Programme 1	TE21000 (this takes the role of the SMP for the Thames estuary)	Individual frontages have TE2100 policies of either Policy P4 Sustain (to take further action to sustain the current level of flood risk into the future) or Policy P5 Improve (to take further action to reduce the level of flood risk into the future).	The scheme is in line with the TE2100 objectives as this will improve the existing defences, optimise the defence repair/ replacement and adaptation regime. The SoP will be increased to between 0.1% and 0.01%. these	The TE2100 Action Plan suggest enhancing and restoring estuarine ecosystems to contribute to biodiversity targets and maximise the environmental benefits of natural floods.	The scheme includes the creation of additional saltmarsh/mudflat habitat and therefore is consistent with TE2100
Wallasea Island Habitat Creation	Essex and South Suffolk Shoreline Management Plan 2	Management Unit H: Crouch and Roach Estuaries – Managed Realignment	The PAR predates the SMP but the SMP confirms that the PAR has chosen the right option.	Realignment is proposed in the SMP for Wallasea Island (H10) in epoch 1.	The scheme includes moving coastal defences inland to create inter-tidal habitat and therefore is consistent with the SMP.

Aligning with recommendations to work with natural processes

SMPs are strategic by nature and therefore tend to use all-encompassing and aspirational terms such as “manage the frontage in sympathy with natural processes” (Pevensy Outfalls Reconstruction) or “a sustainable shoreline sediment system is one that is allowed to behave as naturally as possible” (Redcar Flood Alleviation Scheme). Of the 14 coastal schemes, 50% (seven) schemes include some WWNP related measures including beach re-nourishment and habitat creation and for these schemes, the SMP also promotes WWNP measures. These schemes are: Central Felixstowe, Eastbourne Beach, Humber Estuary, Lincshore, Rossall, Thames Tidal and Wallasea Island.

One scheme (Pevensy Outfalls) includes WWNP measures although these are not explicitly promoted in the SMP.

Two schemes (Shaldon and Teignmouth) do not include WWNP measures although these are promoted by the relevant SMPs. Both schemes are concerned with replacement of existing defences and therefore the constraints of the site may have prohibited the adoption of WWNP measures,

Four schemes did not include WWNP processes and they were not explicitly promoted within the SMP (Littlehampton, Redcar, Sandwich Bay and Shoreham).

In summary only two schemes do not align with the relevant SMP’s aspirations for WWNP.

7.3.2 Catchment Flood Management Plans (CFMPs)

The research identified that all the non-coastal schemes reviewed were consistent with the relevant CFMP as detailed in Table 7-2.

The six flood risk management policy options identified in CFMPs by the EA (referred to as ‘we’) are set out below; these are then referred to in the following table regarding alignment between the relevant (non-coastal) schemes and the relevant CFMPs:

- Policy 1: Areas of little or no flood risk where we will continue to monitor and advise
- Policy 2: Areas of low to moderate flood risk where we can generally reduce existing flood risk management actions
- Policy 3: Areas of low to moderate flood risk where we are generally managing existing flood risk effectively
- Policy 4: Areas of low, moderate or high flood risk where we are already managing the flood risk effectively, but where we may need to take further actions to keep pace with climate change
- Policy 5: Areas of moderate to high flood risk where we can generally take further action to reduce flood risk
- Policy 6: Areas of low to moderate flood risk where we will take action with others to store water or manage run-off in locations that provide overall flood risk reduction or environmental benefits.

Table 7-2 - Alignment between fluvial schemes and CFMPs

Scheme	CFMP	CFMP Policy	Scheme alignment	CFMP policy on WWNP	Scheme alignment
Barking and Dagenham MEICA Package 3	Thames CFMP	Policy option 5	In the Thames CFMP, the 4 sluices would fall into the Lower Roding sub-area 8, with policy option 5 that states that areas of moderate to high flood risk where can generally take further action to reduce flood risk. However, they recognise the challenge of this policy and that they will not be able to reduce the risks everywhere. Thames CFMP emphasises increasing resistance and resilience of all new development at risk of flooding and increasing the environment to be more flood resilient.	The TE2100 action plan (action zone 4) states that changes to the defences could provide opportunities for local realignment and landscaping along the Thames frontage which could reduce dependence on vertical walls where possible. The Thames CFMP states for P5 that where major flood defences are not a realistic option in the foreseeable future, the most sustainable way of reducing flood risk will be through floodplain management.	The scheme includes significant WWNP measures and therefore aligns with the CFMP and TE2100
Deptford Creek Frontages Package	TE2100 action plan	Policy Option 4	The preferred policy for the London catchments is a focus on adaptation of the urban environment through the appropriate location, layout and design of redevelopment that will make properties more resilient or resistant to flood water, therefore reducing the consequences of flooding (Thames CFMP)	The TE2100 Action Plan (action zone 2) states there may be opportunities to set back defences and improve the riverside amenity and habitats. A combination of defence realignment and floodplain management could reduce the impacts of flooding to existing properties and other assets located in the floodable areas on the river side of realigned defences, like the approach used around the Tate Modern at Bankside.	The scheme includes significant WWNP measures and therefore aligns with the CFMP and TE2100
Godmanchester Flood Alleviation Scheme	Great Ouse CFMP	Policy option 5	The Draft CFMP recommends a policy to 'take further action to reduce flood risk (now and/or in the future)' at Godmanchester. The plan also identifies this action as high priority; this aligns with the preferred scheme option. (Sub-area 3)	The CFMP suggests creating create green corridors and incorporating flood resilience measures into the location, lay-out and design of development.	No natural processes were included in the preferred option

Scheme	CFMP	CFMP Policy	Scheme alignment	CFMP policy on WWNP	Scheme alignment
Ings Beck Flood Alleviation Scheme	Calder Catchment Flood Management Plan	Policy option 5	The CFMP proposes a policy of reducing flood risk in the Calder catchment. The CFMP has recently been issued for consultation. This PAR follows the recommendations of this draft in that the CFMP will propose a policy of reducing flood risk in the lower Calder catchment. This states that a PAG 2 Flood Risk Management strategy will not be necessary for the lower River Calder, as all the problem areas are discrete and upper catchment measures will not affect the lower catchment. This scheme is included within the National Priority Programme to deliver 715 houses within the current CSR period.	The Calder CFMP policies for this area do not explicitly promote WWNP	Scheme includes significant natural processes to manage flood risk.
Lewisham and Catford	Thames CFMP	Policy option 4	The final scheme option aligns with CFMP policy options. The CFMP recommends taking further actions to 'keep pace' with cc in flood risk areas. (Sub-area 9)	The CFMP aims to look for opportunities to reduce flood risk by recreating river corridors in urban areas. The CFMP suggests that schemes should harness opportunities, allowing space for water, habitat, wildlife, and recreation.	Scheme includes significant natural processes to manage flood risk and is therefore consistent with the CFMP policy
Morpeth Flood Alleviation Scheme	Rivers Wansbeck and Blyth CFMP	Policy Option 5	The scheme aligns with the CFMP, which recommends that further action is taken to reduce flood risk in the town. (Sub-area 5)	The CFMP does not provide any recommendations to work with natural processes.	The Morpeth scheme includes limited WWNP measures in terms of habitat creation.

Scheme	CFMP	CFMP Policy	Scheme alignment	CFMP policy on WWNP	Scheme alignment
Nottingham Trent Left Bank Flood Alleviation Scheme	River Trent CFMP	Policy option 5	This scheme contributes to increasing the amount of BAP habitat in the catchment, and implementing the preferred option in the Nottingham strategy - one of the key messages in the CFMP.	Key messages for sub area 5 – Burton, Derby and Nottingham – include return watercourses to a more natural state, increasing biodiversity and opening up green river corridors, sustain and increase the amount of BAP habitat in the catchment by opening up green spaces within the built environment.	This scheme contributes to increasing the amount of BAP habitat in the catchment, and implementing the preferred option in the Nottingham strategy
Perry Barr and Witton Flood Risk Management Scheme	River Trent CFMP	Policy option 5	The Trent Catchment Flood Management Plan's (CFMP) Policy 5 for Birmingham and the Black Country is to 'take further action to reduce flood risk'. This is supported by the scheme.	Key messages for sub-area 10 – Birmingham and the Black country - sustain and increase the amount of BAP habitat in the catchment. And return watercourses to a more natural state, increasing biodiversity and opening up green river corridors throughout the policy unit, particularly through city centre regeneration projects.	The scheme does not include any WWNP measures and therefore does not align with the CFMP
Ripon Flood Alleviation Scheme	River Ouse CFMP	Policy option 5	The PAR states that "The scheme has links to the River Ouse Strategy and the CFMP, but does not compromise them." This is true to an extent, but	The CFMP promotes natural processes and alternative ways to reduce surface water flooding, (Sub-area 7)	The scheme does not include any WWNP measures and therefore does not align with the CFMP
River Mersey, Warrington – FRM Scheme	Mersey Estuary CFMP/ Upper Mersey CFMP	Policy option 5	Yes, a 20% increase in peak flow rate prediction has been used which matches the CFMP. The scheme also aligns with the preferred policy options. (Sub-area 5)	The CFMP does not give any recommendations to work with natural processes for Warrington, although does include recommendations for more rural areas.	The scheme includes significant WWNP measures to alleviate flood risk.
Salford Flood Improvement Scheme	Irwell CFMP	Policy option 5	Yes- The PAR is following the CFMP policy (number 5).	The CFMP does not give any recommendations to work with natural processes.	The scheme includes significant WWNP measures to alleviate flood risk.

Scheme	CFMP	CFMP Policy	Scheme alignment	CFMP policy on WWNP	Scheme alignment
Upper Mole Flood Alleviation Scheme	Thames CFMP	Policy option 6	The CFMP aims to look for opportunities to reduce flood risk by recreating river corridors in urban areas. The CFMP suggests that schemes should harness opportunities, allowing space for water, habitat, wildlife, and recreation.	The CFMP sub-area 5 states that the approach to flood risk management in these places uses the natural protection already provided by the river channel and the open spaces in the floodplain. The intention is to maintain, and where possible improve, the flow of water in the rivers as they pass through built up areas.	The Upper Mole includes habitat creation/enhancement that is included within the remit of WWNP but not the NFM aspirations of the CFMP
Walverden Water Flood Alleviation Scheme	River Ribble CFMP	Policy option 5	Sub-area 6 Calder highlights the need to address flood risk as a result of the heavy culverting of water courses. Key aims of the project include reducing the risk of culvert collapse and blockage showing alignment between the scheme and the CFMP.	The CFMP promotes the use of SUDS due to flood risk from sewer and surface water flooding, but does not give any recommendations to work with natural processes.	The scheme includes some elements of WWNP such as reed bed and habitat creation.

All the schemes reviewed appear to be in alignment with their relevant CFMP policies and 90% of PARs cited the relevant CFMP. For example, the Morpeth Flood Alleviation Scheme lies within the area covered by the Wansbeck and Blyth CFMP which recommends that further action is taken to reduce flood risk in the town. The initial viability report referenced in the PAR concluded there was a lack of strategic issues in the catchment, with Morpeth as the primary flood risk area. It therefore recommended that the Morpeth scheme was advanced stand-alone. The Salford Flood Improvement Scheme was also consistent with the CFMP Policy 5 for areas of moderate to high flood risk.

Aligning with recommendations to work with natural processes

Of the 13 schemes addressing fluvial flood risk, five (Barking and Dagenham, Deptford Creek, Lewisham and Catford, Nottingham Trent and Upper Mole) include WWNP processes and the relevant CFMP promotes the use of these.

Four schemes (Ings Beck, Morpeth, River Mersey – Warrington, and Salford) include WWNP measures but these are not explicitly promoted in the relevant CFMPs.

Four schemes (Godmanchester, Perry Barr, Ripon and Walverden) do not include WWNP (or NFM) processes that are explicitly promoted in the CFMP

Policy 6 of CFMPs for areas of low to moderate flood risk' should be 'applied where there may be opportunities in some locations reduce flood risk more locally or more widely in a catchment by storing water or managing run-off'. This policy only applied to the Upper Mole scheme, whilst others were considered to be at higher flood risk but still included WWNP measures.

It is important to note that CFMPs are area based and individual schemes within these areas may not meet all objectives such as those focused on WWNP. Schemes need to be viewed in a wider strategic context alongside other schemes and measures undertaken to manage flood risk to properly understand the overall context for flood risk management.

7.4 FCERM Strategies

These strategies provide a strategic approach to FCERM in a smaller area than SMP and CFMPs and present integrated, costed scheme solutions. The study investigated whether funded schemes have been identified in FCERM strategies and the role they play in reducing residual risk at the wider area level. The degree of alignment with FCERM strategies was assessed through a review of the Scheme PARs.

63% of schemes reviewed had an overarching FCERM Strategy and all were consistent with it. 37% of schemes reviewed did not refer to a FCERM strategy as one had not been produced.

The following table shows where individual schemes were linked to FCERM strategies and for those that did, the degree to which the scheme was in alignment with the relevant strategy objectives.

Table 7-3 - Alignment between the 27 reviewed schemes and FCERM strategies

Scheme	FCERM Strategy	FCERM alignment
Barking and Dagenham MEICA Package 3	Yes	This project is justified under the 5-year plan of works in the Barking and Dagenham (B&D) Embayment Strategy and the Roding West Bank (RWB) Strategy. For both Strategies, the recommended strategic option is to "Maintain and Sustain" the defences protecting these embayments. In the Thames CFMP, the 4 sluices would fall into the Lower Roding sub-area 8, with policy option 5 that states that areas of moderate to high flood risk where can generally take further action to reduce flood risk. However, they recognise the challenge of this policy and that they will not be able to reduce the risks everywhere.
Central Felixstowe Beach Management Works	Yes	This Project Appraisal Report (PAR) covers the same area as the Approved September 2007 Central Felixstowe Coastal Strategy. This PAR is the first step to implement the Approved Strategy as the studies required for the PAR were developed from the strategy, including detailed beach plan.

Scheme	FCERM Strategy	FCERM alignment
Deptford Creek Frontages Package	Yes	Objective of the scheme was to prevent the failure or breach of nine frontages protecting the Bermondsey and Deptford East Embayment, in accordance with the Strategy recommendations (Bermondsey Embayment and Deptford East Embayment strategies)
Eastbourne Beach Management Study - Study to Support PAR for Eastbourne Beach Management 2010-2014	No	There was no approved strategy in place for the frontage; a strategy was prepared in 2003 but was not agreed by Defra. The PAR states that the Environment Agency intended to prepare a strategy in 2010-11.
Godmanchester Flood Alleviation Scheme	No	This is a 'stand-alone' scheme so there is no relevant strategy,
Humber Estuary Flood Defence Strategy First Five Year Package of Work	Yes	Separate strategies were being developed for the main rivers discharging to the estuary, (the Hull, Ouse, Aire, Don and Trent) and CFMPs were under development for the Ancholme and the Grimsby area. For the purposes of the PAR, the study boundaries were amended to avoid any potential double counting of benefits. Strong links were established with the teams undertaking the neighbouring strategies to ensure that cross-boundary issues were identified and addressed.
Ings Beck Flood Alleviation Scheme	No	This scheme is outside of approved strategy since a PAG2 Flood Risk Management Strategy was not considered necessary for the lower River Calder.
Lewisham and Catford Flood Alleviation Scheme	No	The PAR states that an initial assessment of a strategy for the Ravensbourne catchment determined that a stand-alone project for the lower reaches would provide a more efficient approach to managing flood risk. This project is therefore stand alone, not being supported by a specific FRM Strategy.
Lincshore 2010 to 2015	Yes	The Lincshore Coastal Strategy encompasses the beach frontage from Mablethorpe to Skegness (see 1.13 Key Plan). The strategy was first developed in 1991 with reviews in 1998 and 2004. Both reviews recommended a continuation of the original 50-year strategy, that the Lincshore frontage and hinterland continue to be defended by beach nourishment. The project's activities are the enhancement of the sea wall and continued beach nourishment in alignment with the strategy.
Littlehampton Arun East Bank Tidal Walls	Yes	Arun District Council (Arun DC) has a number of regeneration aims outlined in the Local Development Framework Littlehampton Waterfront Strategy (Arun DC & West Sussex County Council, 2009), Littlehampton Vision (Arun DC, 2004) and Littlehampton Harbour Strategy (Littlehampton Harbour Board, 2009). This flood defence scheme provides Arun DC with foundations for its regeneration aspirations of improving the public environment.
Morpeth Flood Alleviation Scheme	No	Morpeth lies within the area covered by the Wansbeck and Blyth Catchment Flood Management Plan (CFMP) that recommends that further action is taken to reduce flood risk in the town. An initial viability report concluded there was a lack of strategic issues in the catchment, with Morpeth as the primary flood risk area. It therefore recommended that Morpeth be advanced as a stand-alone scheme.

Scheme	FCERM Strategy	FCERM alignment
Nottingham Trent Left Bank Flood Alleviation Scheme	Yes	The PAR (July 2006) adopted the recommendations from the Nottingham Strategy (EA Board Approved Strategy in November 2005). The strategy and scheme are further referenced in the River Trent CFMP.
Perry Barr and Witton Flood Risk Management Scheme	Yes	The River Tame Strategy provided recommendations for managing flood risk within 70 flood cells spread over 9 reaches along the full length of the River Tame. It investigated the effects of climate change on flood risk and business justification and recommended that a Managed Adaptive approach be adopted for Cells 19 and 20 and the acceptance of a lower SoP for the remainder of Perry Barr and Witton (Cells 17, 18, 21 and 22). The scheme has followed this approach.
Pevensey Outfalls Reconstruction	Yes	The Redoubt Gardens to Cooden Coastal Defence Strategy (CDS) 2003 and Cuckmere Haven to Redoubt Gardens CDS provide the strategic context for the scheme. The proposed scheme is consistent with the strategic preferred options, which recommend a policy of improving or sustaining the tidal defences to ensure a 1 in 200 SoP. Also, the continued drainage of the Pevensey Levels to the English Channel whilst sustaining the tidal defences between Eastbourne and Bexhill.
Redcar Flood Alleviation Scheme	Yes	The scheme aligns with the Redcar Coastal Defence Strategy, which was accepted by Defra in 2003 as a feasibility study. It is the preferred option identified within the strategy and aligns with the climate change adaptation recommendations of the strategy.
Ripon Flood Alleviation Scheme	No	Ripon is a stand-alone flood alleviation scheme, as recommended by the River Ure Catchment Preliminary Strategic Review (PSR) produced in 2001. The PSR forms the first formal stage in the development of an overall FCDPAG2 compliant flood defence strategy for the Ure catchment, and a precursor to the River Ouse Catchment Flood Management Plan (CFMP).
River Mersey, Warrington – Flood Risk Management Scheme	Yes	The Warrington Strategy was approved. This recommended reducing flood risk in 5 flood cells, continuing with maintenance in 6 cells and continuing doing nothing in 3 others. Of the 4,000 houses at risk over half are in one flood cell; “M2 - Woolston to Lower Walton, River Mersey”. This scheme provides the flood risk management scheme for this cell.
Rossall Coastal Defence Improvement Scheme	Yes	The Wyre Urban Core Strategy (WUCS) was completed in Summer 2012 and considered FCERM to the northern Fylde headland, which under extreme events contains a single 16km ² flood cell protected by a series of coastal defences. This project, the first arising from the WUCS, is for improvement works to the coastal defence in WUCS Sub-Unit (SU) 3, Rossall North.
Salford Flood Improvement Scheme	Yes	The long list of options was taken from the draft Lower Irwell Strategy produced in 2003. Following a review of the original long list of options, the PAR for the scheme adopted the shortlist presented by the Draft Lower Irwell Strategy and focuses on the different mechanisms of delivering the flood storage. Online storage had previously been ruled out; however, updates to the model showed that this, as well as offline storage, was technically possible by using a weir structure.

Scheme	FCERM Strategy	FCERM alignment
Sandwich Bay Sea Defences (Deal)	Yes	The project is supported by the approved Pegwell Bay to Kingsdown Flood and Erosion Risk Management Strategy (PeKs). The PeKs Strategy confirms the SMP2 policies, of 'Hold the Line' for the populated coastal frontages. The PeKs preferred option for this frontage (Sandwich Bay Estate to Deal Castle) is improve to 1:200 (0.5%) chance of flooding each year through beach re-nourishment with annual recycling, rock armour scour protection and a new wave wall. These are reflected in the scheme design.
Shaldon and Ringmore Tidal Defence Scheme (IMSW000563)	No	The PAR provides the following justification for the scheme being stand-alone. This project is a stand-alone scheme. Options for a combined solution for different flood cells of the estuary are limited to a tidal barrier, which would contravene the management objectives in the SMP. Flood cells are clearly separated so there is no risk of double counting benefits. Defending Shaldon and Ringmore will not increase flood risk elsewhere. There is no need to provide compensatory habitat for coastal squeeze because there is no internationally designated site. A flood risk management strategy is therefore not required.
Shoreham Adur Tidal Walls	Yes	The approved FCRM Strategy covers 32km of defences protecting the coastline and tidal frontages between the River Arun at Littlehampton and the River Adour at Shoreham by Sea. The Strategy recommended raising and replacing defences along the River Adur West Bank frontage to achieve a 1 in 300 standard of protection (SoP) as a priority action. The East Bank frontage is also recommended for raising and replacing to achieve a 1 in 200 by 2013. This scheme aligns with the FCERM strategy.
Teignmouth Estuary (Back Beach) Tidal Defence Scheme	No	The PAR states that the strategy decision making process detailed in FCDPAG 2, 'Strategic Planning and Development' has been followed and this confirms that the project should proceed as a stand-alone scheme. Flood cells are clearly separated so there is no risk of double counting benefits. Defending Teignmouth will not increase flood risk elsewhere. A flood risk management strategy is therefore not required.
Thames Tidal Frontage Programme 1	Yes	The project aligns with the strategic objectives set out in the Thames Estuary 2100 Strategic Appraisal Report (StAR). The preferred option is the most cost efficient option to meet the recommendation of the TE2100 Strategy, Option 1.4, which is defined as: "Improve the existing defences, optimise the defence repair/replacement and adaptation regime."
Upper Mole Flood Alleviation Scheme	Yes	The River Mole Flood Risk Management (FRM) Strategy that encompasses this project included six structural options, from which two were combined to form this project – Gatwick stream flood storage and culvert enhancement and bunds to address surface water issues at Gatwick airport.
Wallasea Island Habitat Creation	Yes	The preferred option in the Roach and Crouch Strategy was a combination of hold the line and managed realignment. Managed realignment was subject to further studies and resolution of landowner issues. The project complies with the Roach and Crouch Strategy and Phase 1 of this project will contribute 155 ha of new intertidal habitat.
Walverden Water Flood Alleviation Scheme	No	The Burnley, Nelson and Colne Strategy identified Walverden Water as a priority for investment and appropriate for a standalone project, as it is hydraulically independent of other areas at flood risk.

Table 7-3 shows that the majority of the 27 schemes were developed within the context of a bespoke FCERM strategy. There were no cases where there was any departure from the FCERM strategy to the PAR in relation to scheme design, incorporation for climate change allowances or WWNP.

Where schemes were not developed within the context of a FCERM strategy (such as Eastbourne Beach Management Study, Godmanchester Flood Alleviation scheme and Teignmouth Estuary (Back Beach) Tidal Defence Scheme), this was well justified within the PARs on the basis that the flood cells were independent from others and would not impact other areas in relation to flood risk.

7.5 Strategic consultations

Whilst specific questions regarding alignment with strategies were not included within the interviews with stakeholders, the discussions revealed numerous strategic approaches being taken adopted to manage fluvial, surface water and tidal flood risk across the country. These strategies, such as TE2100, the Great Ouse Tidal Strategy, Fens for the Future and ongoing work by the Northumbria Integrated Water Partnerships demonstrated that packages of schemes are being adopted across catchments that incorporate a range of measures – structural defences, managed adaptive approaches and WWNP actions. These packages are being developed to maximise optimal solutions to managing flood risk now, and in the future incorporating allowances for climate change or enabling flexibility to allow these to be addressed in the future, whilst also looking to maximise Partnership Funding scores and obtain resources where these are needed most.

7.6 Summary

- All coastal schemes reviewed referred to and were consistent with the relevant SMP.
- Of the 14 coastal schemes, 50% (seven) schemes include some WWNP related measures including beach re-nourishment and habitat creation and for these schemes, the SMP also promotes WWNP measures, one scheme includes WWNP measures although these are not explicitly promoted in the SMP. Two schemes do not include WWNP measures although these are promoted by the relevant SMPs. Four schemes did not include WWNP processes and they were not explicitly promoted within the SMP. In summary, only two schemes do not align with the relevant SMP's aspirations for WWNP.
- All fluvial schemes reviewed were consistent with the relevant CFMP.
- Of the 13 schemes addressing fluvial flood risk, five include WWNP processes and the relevant CFMP promotes the use of these, four schemes include WWNP measures but these are not explicitly promoted in the relevant CFMPs and four schemes do not include WWNP (or NFM) processes that are explicitly promoted in the CFMP. In summary, only four schemes do not align with the relevant CFMP's aspirations for WWNP.
- 18 of the 27 schemes had been developed in the context of overarching FCERM strategies and were consistent with these. Where schemes were 'stand-alone' this was justified in relation to the independence of flood cells or where a strategy was planned, but not had yet been prepared and the scheme was considered to be of such importance that it should proceed prior to strategy development/finalisation.
- Consultations with strategic stakeholders revealed an increasing move towards strategic approaches involving the development of packages of measures to address flood risk now and in the future.

8 Recommendations

Overall, the study findings are positive: most of the schemes are taking households from very significant risk to low or moderate risk and have built climate change considerations into the design; managed adaptive approaches are increasingly being adopted as ‘low regrets’ solutions; selection of the preferred options are largely well justified; schemes showed evidence of WWNP measures being adopted and there was a strong degree of alignment between the selected schemes and the policy imperatives of overarching strategies.

However, there are a number of recommendations across the first four aims of the study that could enable greater long term resilience in flood risk management across England. There are no

Aim 1: Improved flood protection

Whilst the findings in relation to increased SoP and building in climate change allowances are positive, coastal schemes can find it difficult to deliver affordable schemes with long term benefits and are therefore choosing to deliver repeated short term schemes, that in the long term will be more expensive. Even though Partnership Funding policy will show the economic benefits of a large coastal scheme, the five-case model encourages a focus on the financial case encouraging a short-term outlook that may affect the longer term resilience of flood risk management schemes. It is recommended that Defra and the EA should review how national funding level commitments can enable a more strategic approach to coastal risk management.

Some inconsistencies were identified in the way that the duration of benefits are captured, particularly with schemes completed over several stages and the need to justify these at each stage. The EA could consider reviewing how OMs are captured to provide a more accurate overview of households better protected.

Aim 2: Managed adaptive approaches

The study identified that almost half of the schemes reviewed incorporated managed adaptive approaches, however most of these did not identify clear adaptive pathways and trigger points.

It is recommended that consideration is given to improving appraisal guidance in relation to managed adaptive approaches building on previous research and studies with a specific focus on adaptation pathways and trigger points.

In addition, the Environment Agency should ensure that risk management authorities enable and monitor the delivery of adaptive packages of schemes in the long term. This includes ensuring that land management practices and subsequent scheme improvements are in line with an overall adaptive strategy for the management of in the long term flood risk.

Aim 3: Justification to support preferred option

The study identified robust optioneering on economic grounds, but some concerns were identified in relation to limited option choices, an overly subjective short-listing approach and a strong bias towards economic benefits. It is suggested that appraisal guidance could be revised to address the following:

- **There should be a more consistent approach to the short-listing approach, potentially requiring new guidance, as the current one tends to be qualitative thus leading to options being discounted at an early stage without full justification.**
- **A structured and transparent short-listing process could be encouraged by shifting the focus on the wider project objectives; this will allow a wider breath of options to be taken forward, as well as increasing the emphasis on environmental and social benefits and dis-benefits whose consideration can be limited through the current approach.**

Aim 4: Working with natural processes

19 of the schemes reviewed incorporated some element of WWNP in terms of NFM, beach re-nourishment or habitat creation/enhancement; just six of these were focused on using natural processes (not including beach re-nourishment) to manage flood risk. More quantified evidence of the benefits of WWNP is required to encourage take-up. Therefore, it is recommended that **the findings from the current Defra and EA supported WWNP R& D Programme are widely**

publicised potentially supported by additional capacity building activities to encourage greater take up. The method to account for co-benefits to calculated OM1 should be reviewed to ensure it is in line with the latest evidence on natural capital accounting.

Appendices

A Summary data table

Provided separately

References

Arun District Council & West Sussex County Council. 2009. Local Development Framework Littlehampton Waterfront Strategy

Arun District Council. 2004. Littlehampton Vision

Brisley, R., Wylde, R., Lamb, R., Cooper, J., Sayers, P., & Hall, J. (2016, April). Techniques for valuing adaptive capacity in flood risk management. *Proceedings of the Institution of Civil Engineers - Water Management*, 169(2), 75-84.

Climate Change Act. 2008. <http://www.legislation.gov.uk/ukpga/2008/27/contents>.

Committee on Climate Change (CCC). 2015. Progress in preparing for climate change 2015 Report to Parliament

Committee on Climate Change (CCC). 2017. UK Climate Change Risk Assessment 2017: Evidence Report. Available at: <https://www.theccc.org.uk/uk-climate-change-risk-assessment-2017/>

Defra. 2009. Appraisal of flood and coastal erosion risk management: A Defra policy statement. Available at: <https://www.gov.uk/government/publications/appraisal-of-flood-and-coastal-erosion-risk-management-a-defra-policy-statement-june-2009>

Defra. 2009. Appraisal of flood and coastal erosion risk management: A Defra policy statement

Defra. 2009. The appraisal of adaptation options in Flood and Coastal Erosion Risk Management – FD2617. Available at: <http://evidence.environmentagency.gov.uk/FCERM/en/Default/HomeAndLeisure/Floods/WhatWereDoing/IntoTheFuture/ScienceProgramme/ResearchAndDevelopment/FCRM/Project.aspx?ProjectID=f4394a7b-5e9d-4572-88feb443f5af9888&>

Defra. 2010. Flood and Water Management Act. Available at: <http://www.legislation.gov.uk/ukpga/2010/29/contents>

Defra. 2011. Coastal Pathfinder Evaluation: An Assessment of the Five Largest Pathfinder Projects

Defra. 2012. UK Climate Change Risk Assessment: Government Report. Available at: <https://www.gov.uk/government/publications/uk-climate-change-risk-assessment-government-report>

Defra. 2013. The National Adaptation Programme. Available at: <https://www.gov.uk/government/publications/adapting-to-climate-change-national-adaptation-programme>

Environment Agency – Thames Region. 2014. London Tidal Defences: Roding West Bank Embayment Strategy Study

Environment Agency (2014) Working with natural processes to reduce flood risk R&D framework: science report – SC130004/R2 - http://evidence.environment-agency.gov.uk/FCERM/Libraries/FCERM_Project_Documents/WWNP_framework.sflb.ashx

Environment Agency. 1996. Lincolnshire Shoreline Management Plan (1996)

Environment Agency. 2001. River Ure Catchment Preliminary Strategic Review (PSR)

Environment Agency. 2002. Barking and Dagenham Embayment - Strategic Environmental Assessment

Environment Agency. 2003. Redcar Coastal Defence Strategy

Environment Agency. 2003. The Redoubt Gardens to Cooden Coastal Defence Strategy (CDS)

Environment Agency. 2004. Lincshire Coastal Strategy

2016s5344 - CCC - Impact of flood schemes - Revised Final Report 300617

Environment Agency. 2005. Humber Estuary Flood Defence Strategy First Five Year Package of Work (R040/0021220)

Environment Agency. 2005. Nottingham Strategy

Environment Agency. 2005. Ripon Flood Alleviation Scheme (IMNE000541)

Environment Agency. 2006. Nottingham Trent Left Bank Flood Alleviation Scheme (IMMI000642)

Environment Agency. 2006. South Foreland to Beachy Head Shoreline Management Plan (SMP)

Environment Agency. 2006. Walverden Water Flood Alleviation Scheme

Environment Agency. 2007. Central Felixstowe Coastal Strategy

Environment Agency. 2008. Deptford Creek Frontages Package (IMTH001230)

Environment Agency. 2008. Ings Beck Flood Alleviation Scheme (IMNE000646)

Environment Agency. 2008. Redcar Flood Alleviation Scheme (IMNE000524)

Environment Agency. 2008. Shaldon and Ringmore Tidal Defence Scheme (IMSW000563)

Environment Agency. 2009. Barking and Dagenham MEICA Package 3 (IMTH001235)

Environment Agency. 2009. Beachy Head to Selsey Bill Shoreline Management Plan 2(SMP2)

Environment Agency. 2009. Calder Catchment Flood Management Plan (CFMP)

Environment Agency. 2009. Essex and South Suffolk Shoreline Management Plan 2 (SMP2)

Environment Agency. 2009. Flamborough Head to Gibraltar Point Shoreline Management Plan 2 (SMP2)

Environment Agency. 2009. Godmanchester Flood Alleviation Scheme

Environment Agency. 2009. Great Ouse Catchment Flood Management Plan (CFMP)

Environment Agency. 2009. Irwell Catchment Flood Management Plan (CFMP)

Environment Agency. 2009. Isle of Grain to South Foreland Shoreline Management Plan Review 2 (SMP2)

Environment Agency. 2009. Lincshore 2010 to 2015 (IMAN001844)

Environment Agency. 2009. Lowestoft Ness to Felixstowe Languard Shoreline Management Plan 2 (SMP2)

Environment Agency. 2009. Lyme Bay and South Devon Shoreline Management Plan 2 (SMP2)

Environment Agency. 2009. Mersey Estuary Catchment Flood Management Plan (CFMP)

Environment Agency. 2009. North West England and North Wales Shoreline Management Plan 2 (SMP2)

Environment Agency. 2009. Pevensey Outfalls Reconstruction (IMSO000737)

Environment Agency. 2009. River Ouse Catchment Flood Management Plan (CFMP)

Environment Agency. 2009. River Ribble Catchment Flood Management Plan (CFMP)

Environment Agency. 2009. River Trent Catchment Flood Management Plan (CFMP)

Environment Agency. 2009. Rivers Wansbeck and Blyth Catchment Flood Management Plan (CFMP)

Environment Agency. 2009. Thames Catchment Flood Management Plan (CFMP)

Environment Agency. 2009. The Tyne to Flamborough Head Shoreline Management Plan 2 (SMP2)

Environment Agency. 2009. Upper Mersey Catchment Flood Management Plan (CFMP)

Environment Agency. 2009. Upper Mole Flood Alleviation Scheme

Environment Agency. 2009. Wallasea Island Habitat Creation

- Environment Agency. 2010. Central Felixstowe Beach Management Works (AES503C-009A-001CA)
- Environment Agency. 2010. Eastbourne Beach Management Study - Study to Support PAR for Eastbourne Beach Management 2010-2014
- Environment Agency. 2010. Flood and Coastal Erosion Risk Management appraisal guidance. Available at: <https://www.gov.uk/government/publications/flood-and-coastal-erosion-risk-management-appraisal-guidance>
- Environment Agency. 2010. Teignmouth Estuary (Back Beach) Tidal Defence Scheme
- Environment Agency. 2010. Working with Natural Processes to Manage Flood and Coastal Erosion Risk
- Environment Agency. 2011. Morpeth Flood Alleviation Scheme
- Environment Agency. 2011. River Mersey, Warrington – Flood Risk Management Scheme (IMNW000699)
- Environment Agency. 2011. River Tame Flood Risk Management Strategy
- Environment Agency. 2011. Sandwich Bay Sea Defences (Deal) (IMSO 001056)
- Environment Agency. 2012. Littlehampton Arun East Bank Tidal Walls
- Environment Agency. 2012. Perry Barr and Witton Flood Risk Management Scheme
- Environment Agency. 2012. Thames Estuary 2100 (TE2100 Plan). Available at: <https://www.gov.uk/government/publications/thames-estuary-2100-te2100>
- Environment Agency. 2013. Rossall Coastal Defence Improvement Scheme
- Environment Agency. 2013. Shoreham Adur Tidal Walls
- Environment Agency. 2013. Thames Tidal Frontage Programme 1 (IMTH001749)
- Environment Agency. 2014. Calculate Grant in Aid funding for flood and coastal erosion risk management projects: Guidance for risk management authorities. Available at: <https://www.gov.uk/government/publications/calculate-grant-in-aid-funding-flood-risk-management-authorities>
- Environment Agency. 2014. Flood and coastal erosion risk management Long-term investment scenarios. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/381939/FCRM_Long_term_investment_scenarios.pdf
- Environment Agency. 2014. Salford Flood Improvement Scheme (IMNW000471)
- Environment Agency. 2015. Lewisham and Catford Flood Alleviation Scheme
- Environment Agency. 2016. Adapting to Climate Change: Advice for Flood and Coastal Erosion Risk Management Authorities
- Environment Agency. 2016. Adapting to Climate Change: Advice for Flood and Coastal Erosion Risk Management Authorities
- Environment Agency. 2016. Adapting to Climate Change: Advice to Flood & coastal Risk Management Authorities. Available at: <https://www.gov.uk/government/publications/adapting-to-climate-change-for-risk-management-authorities>
- JNCC. 1994. UK Biodiversity Action Plan. Available at: <http://jncc.defra.gov.uk/page-5155>
- Littlehampton Harbour Board. 2009. Littlehampton Harbour Strategy
- Mere Oak Ecology. 2012. Fens for the Future strategy
- North Norfolk District Council. 2008. Core Strategy: Incorporating Development Control Policies. Available at: https://www.north-norfolk.gov.uk/media/1370/3-core_strategy-incorporating_development_control_policies-adopted_2008_updated_2012.pdf
- UKCP09. 2009. <http://ukclimateprojections.metoffice.gov.uk>.

United Nations. 1992. Convention on Biological Diversity. Available at:
<https://www.cbd.int/doc/legal/cbd-en.pdf>

Warrington Borough Council. 2014. The Warrington Local Pan Core Strategy

Wyre Council. 2012 The Wyre Urban Core Strategy (WUCS)

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