Strategy Appraisal Report

Authority Scheme Reference	IMTH000913
Defra / WAG LDW Number	
Promoting Authority	Environment Agency - Thames Region
Strategy Name	Lower Thames Flood Risk Management Strategy

Aerial view of flooding at Shepperton in January 2003

Date	20th August 2010
Version	7

StAR for *Lower Thames Strategy*

Version	Status	Signed off by:	Date signed	Date issued
Version 4	Issue to Miles Jordan	SNS / MPAC	16/12/09	17/12/09
Version 5	Internal Review	SNS / MPAC	29/03/10	29/03/10
Version 6	Re-issue to NRG	JDG / MPAC	08/04/10	08/04/10
Version 7	Final Issue to NRG	GP / MPAC	20/08/10	20/08/10
Version7a	Final Issue to Dir Ops	GP/TC	27/10/10	27/10/10

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Lower Thames Flood Risk Management Strategy Appraisal Report.

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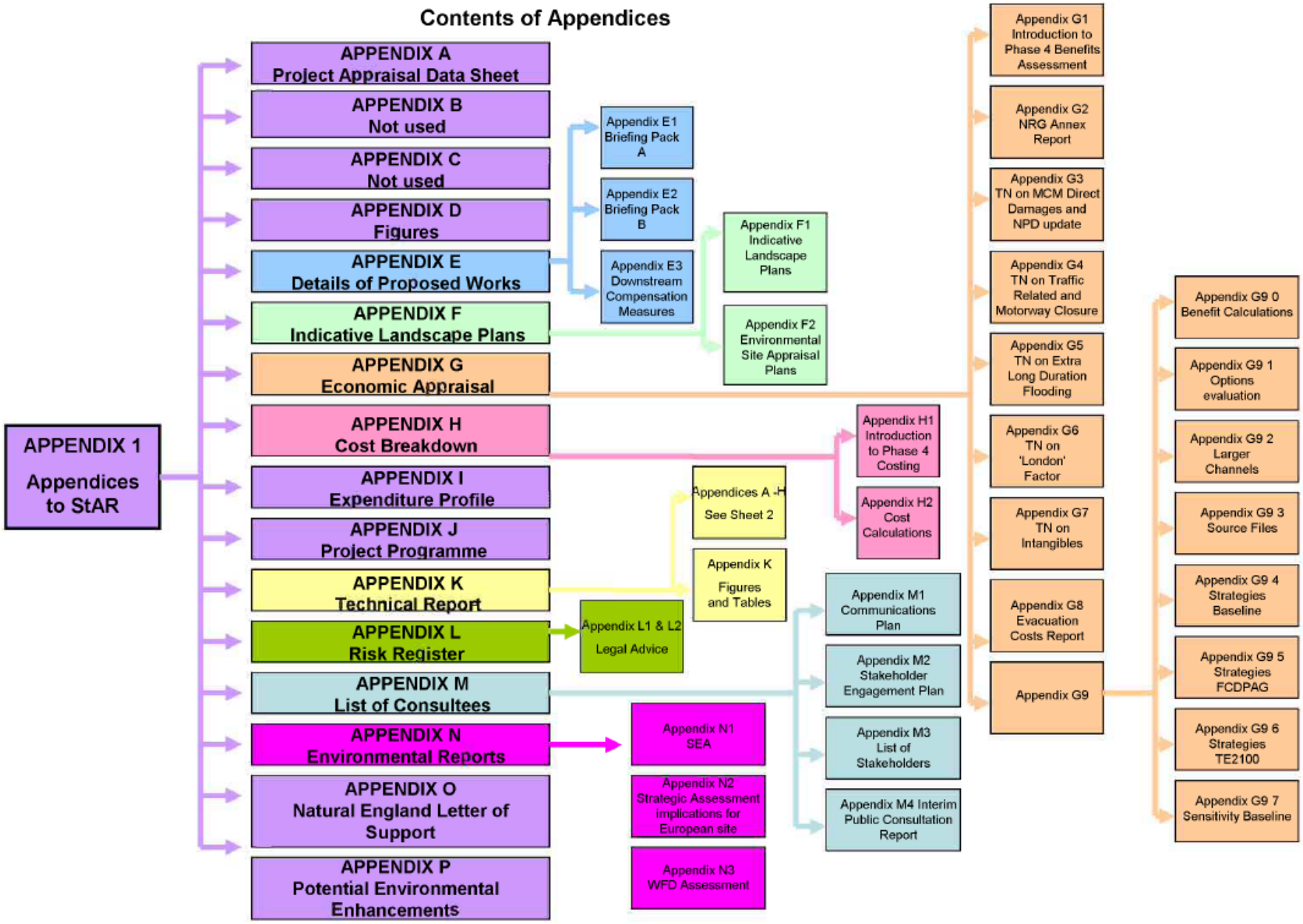

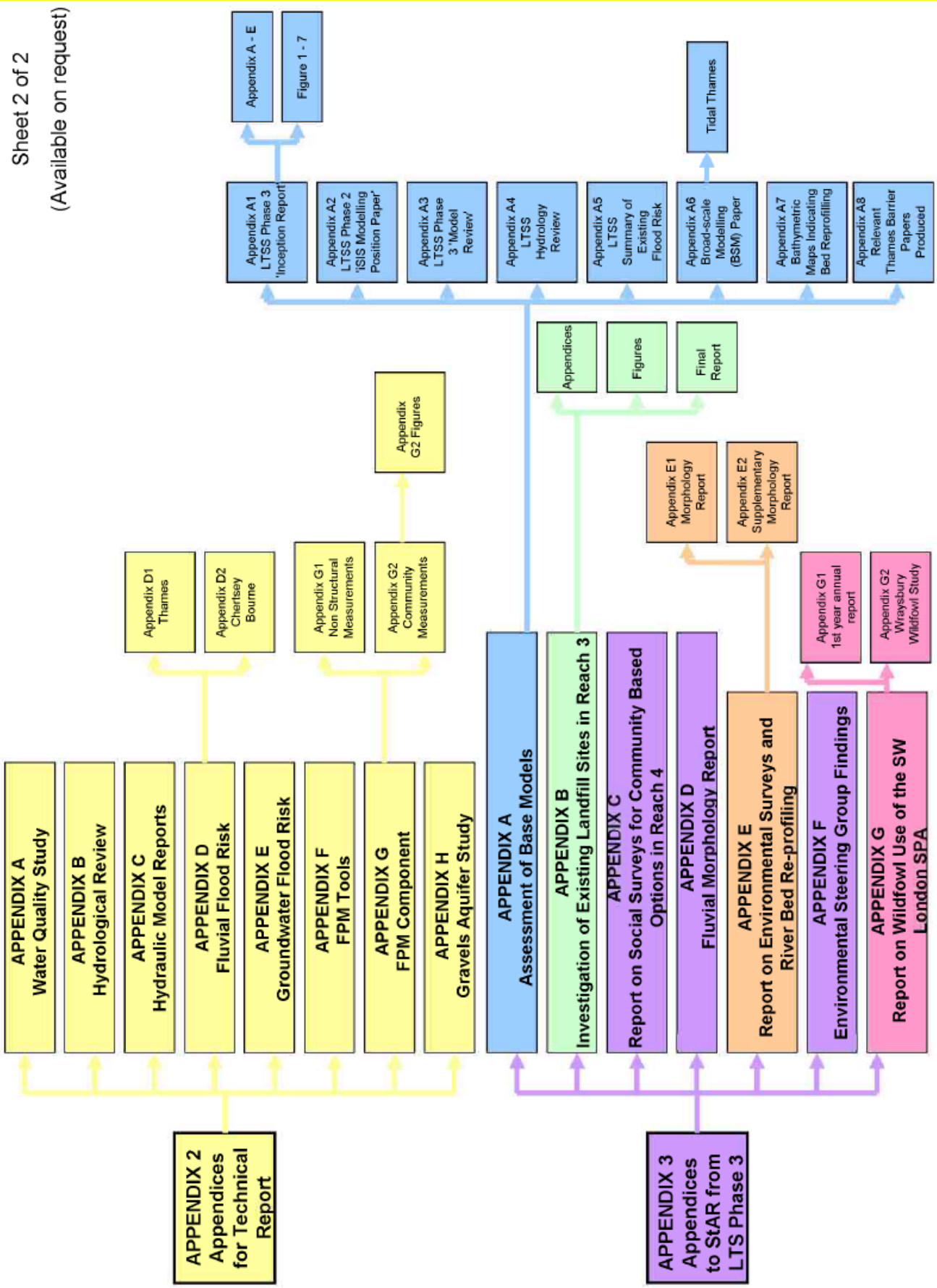
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To Commit Expenditure

Environment Agency Region: Thames

Project Name: Lower Thames Flood Risk Management Strategy

Approval Value: £538 million

Sponsoring Director: David Jordan Director of Operations

Non Financial Scheme of Delegation

The approval route of all FCERM Strategies/Complex Change Projects under the Non Financial Scheme of Delegation, following recommendation for approval from the National Review Group, is Regional Director or Director, Wales and Director of Operations.

Approval Route

National Capital Programme Manager	Miles Jordan
National Review Group	Ken Allison
Regional Director	Howard Davidson
Director of Operations	David Jordan
Defra	
Treasury	

Approval History Sheet

APPROVAL HISTORY SHEET (AHS)				
1. Submission for review				
Project Title: Lower Thames Flood Risk Management Strategy			**Project Code: IMTH000913**	
Project Manager: Graham Piper			**Date of Submission:**	
Lead Authority: Environment Agency			**Version No:**	
Consultant Project Manager: Stuart Suter			**Consultant: Halcrow/Jacobs JV**	
The following confirm that the documentation is ready for submission to PAB or NRG. The Project Executive has ensured that relevant parties have been consulted in the production of this submission.				
Position	**Name**	**Signature**	**Date**	
Project Executive	Tim Chinn			
	Job Title:	Project Team Manager		
Project Sponsor	Innes Jones			
	Job Title:	Area Manger, SE Area, Thames Region		
NEAS National Operations Manager	Mark Ross			
2. Review by: National Review Group (NRG)				
Date of Meeting(s):		**Chairman:**		
Recommended for approval: In the sum of: £538,000,000		**Date:**	**Version No:**	
3. Environment Agency NFSoD approval *Officers in accordance with the NFSoD: Specified Officer; Regional Director; Director of Operations; Chief Executive or Director of Finance: Agency Board*				
Version No:		**Date:**		
Project Approval	**By:** In the sum of: £538,000,000	**Date:**		
4. Defra approval				
Submitted to Defra		**Date:**		
Version No. (if different):				
Defra Approval:		**Date:**		
Comments:				

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

1.

Project name	Lower Thames Flood Risk Management			Start date	March 2003
				End date	January 2012
Business unit	ncpms		Programme		
Project ref.	IMTH000913	Regional SoD ref.	F/1011/1421	Head Office SoD ref.	-

2.

Role	Name	Post Title
Project Sponsor	Innes Jones	Area Manager, SE Area, Thames Region
Project Executive	Tim Chinn	Project Team Manager, ncpms
Project Manager	Graham Piper	Project Manager, ncpms

3.

Outline Risk Assessment (ORA) Category	Low	☐	Medium	☐	High	☒

4.

NFSoD value	£k
Whole Life Costs (WLC) of Strategic Plan	538,000,000

5.

Required level of Environmental Impact Assessment (EIA)	N/A	Low	Medium	High
	☐	☐	☐	☒

6.

NFSoD approver name	Post title	Signature	Date
Howard Davidson	Regional Director, Thames region	HDavidson	29/10/10
David Jordan	Director of Operations	DJ	25/11/10
NFSoD consultee name	**Post title**	**Signature**	**Date**
Ken Allison	NRG Chair	KJAllison	15/09/10
Miles Jordan	Head of ncpms	MJ	26/8/10
Innes Jones	Area Manager, SE Area, Thames	IJ	26/8/10

Executive Summary

1.1 Introduction and background

1.1.1 The Lower Thames Strategy covers one of the largest and most at risk developed but undefended flood plains in England, with 21,000 properties and 50,000 people currently at a 0.5% annual exceedance probability (AEP) flood risk or higher. The consequences of flooding in the area would be severe, with floods lasting up to two weeks. Major flooding would affect critical national infrastructure, by causing severe disruption and likely traffic grid-lock to the M25, M4 and M3 motorways along with over 200km of the local and regional road network, suspension of several major drinking water abstractions supplying London and threaten up to 20 local electricity sub-stations. It is predicted that climate change impacts will double flood damages in a 0.5% AEP flood event from the current level of £850million to some £2billion by 2055, with the number of properties at flood risk reaching 35,000.

1.1.2 This Strategy Approval Report (StAR) describes the Environment Agency's Flood Risk Management (FRM) Strategy for the 100 year period to 2110 for the Lower Thames (Reaches 3 and 4) between Datchet and Teddington. The key objective of the Lower Thames Strategy is to identify sustainable solutions to reduce flood risk to people and property. This is to be achieved by minimising disruption to infrastructure and services, protecting and enhancing sites of nature conservation and biodiversity, and by maintaining biological quality and sediment regime of rivers and protecting fisheries.

1.1.3 This StAR implements the Thames Catchment Flood Management Plan (CFMP) which characterises the Lower Thames Area as a developed flood plain with no built flood defences. The CFMP policy applied to this area is P5, to 'reduce the risk', which aims to lower the probability of exposure to flooding and/or the magnitude of consequences of a flood. It will also contribute to the key aims of the Defra-led programme 'Making Space for Water', as well as contribute to the Environment Agency's corporate strategy 'Creating a Better Place'.

1.1.4 The Study Area (outlined in the attached Figure 2.1 and defined as the area benefiting from the implementation of FRM measures as part of this Strategy) covers over a 40km length of the River Thames from Datchet to Teddington, spreading across extensive areas of River Thames flood plain as defined on the Environment Agency's 1% and 0.1% AEP flood zone maps. Upstream areas, which are not included in this StAR, are Reach 2 covering the Maidenhead, Windsor and Eton area and Reach 1 extending up to Hurley. The Reach 2 area receives a significant reduction in flood risk from the Jubilee River.

1.1.5 The catchment area of the River Thames draining to Teddington is in total approaching 10,000 km^2. Several major tributaries join the River Thames in this area. Most have existing flood defences or add little to overall flood risk, but flood risk from the lower Chertsey Bourne through Chertsey is included.

1.1.6 There are no formal raised flood defences, in the Lower Thames, except for the historic Battle Bourne embankment protecting properties in Old Windsor. Therefore the onset of flooding, and standard of protection (SoP) to properties and infrastructure, varies significantly throughout the Study Area. The area is divided into two parts because of the differing topography: Reach 3 from Datchet to Walton Bridge; and Reach 4 from Walton Bridge to Teddington. Reach 3 is characterised by a flat and wide flood plain

with many branching and converging flood routes and compartments which are mobilised under different magnitude events. Reach 4 is more confined with a less extensive area subject to flood risk. The complex overland flood flow routes mean that flooding in the key residential areas is interdependent, i.e. solving the problem in one area could lead to a greater risk of flooding in others. Therefore each Reach as defined above is considered as a single flood cell.

1.1.7 Periodic routine (and occasional reactive) maintenance is currently carried out on the river system, primarily at the eight lock and weir complexes in the Study Area. An effective flood warning service is available to properties within the flood risk area.

1.1.8 Works will be carried out under the Water Resources Act 1991 for major capital schemes. Recommendations concerning non-structural measures are to be undertaken either by the Environment Agency directly or by third parties supported by them.

1.2 Problem

1.2.1 The Lower Thames Strategy area was affected by several major flooding events through the first half of the twentieth century, with a notable extreme event in 1947, which was approximately a 1 in 50 year (2% annual exceedance probability (AEP)) event. A further large event occurred in 1968 but this largely affected only Reach 4. The most recent flood occurred in 2003, where approximately 256 properties were affected in an event which ranged from around 7% to 20% AEP, varying with location along the Thames.

1.2.2 Flood durations on the River Thames are lengthy, typically in excess of 7 days. The onset of flooding to property occurs in a 1 in 2 year (50% AEP) flood event. At a 1 in 20 year (5% AEP) event up to approximately 6,000 properties become at risk as flooding suddenly spreads out, while there are around 21,000 properties currently at risk in the 1 in 200 year (0.5% AEP) flood event. With predicted climate change impacts the number of properties at risk in this event will increase to possibly as many as 35,000 by 2055.

1.2.3 Evacuation and subsequent temporary housing of such a large number of people would be a major problem and the likelihood of avoiding injury would be remote, with the potential for loss of life possible. Critical national infrastructure, in the form of utility, rail and road, would be directly impacted and affect people living and working within an area of at least 30km^2 (0.5% AEP flood risk). Surface and groundwater flooding also occur, the former generally being high frequency but low consequence and the latter often occurring due to high river levels in the Study Area.

1.3 Options

1.3.1 Four types of management options were evaluated comprising:

- reach based structural options (river bed re-profiling, flood diversion channels, improvements to existing structures and river bank works);
- catchment wide options (storage and use of the Thames Barrier);
- non-structural options (development of flood plain management tools to improve land use planning, development control, emergency response, flood warning and public awareness); and
- community based options (local defence schemes and individual property protection).

1.3.2 A long list of over 50 options was appraised and it was concluded that:

- flood diversion channels would be effective in Reach 3;
- a community based approach should be applied in Reach 4, within a flood plain management component;
- non-structural options should be applied throughout the Study Area; and
- while sufficient upstream storage to provide any significant reduction in flood risk for the Lower Thames is not feasible or economic, flood storage solutions on key identified tributaries under other schemes should be encouraged as a general policy to assist in partly offsetting climate change impacts.

1.3.3 The proposed flood diversion channels total approximately 17km in length and involve significant engineering across a 60-70m wide landscaped corridor, with more heavily engineered and narrower structures where available space is constrained. The channel capacities have been optimised economically to a limited range of between 150m^3/s and 170m^3/s, to undergo further economic refinement during the design stage(s) alongside review of constraints following ecological, water quality, sediment and groundwater surveys. The application of community based options has been scoped out through considering typical pilot areas. This has resulted in a short list of Do Something Options (see Table 1.1) in addition to Option A: Do Nothing (cessation of all FRM activities), Option B1: Do Minimum (maintenance of flood defence assets until failure) and Option B2: Asset Replacement (AR, maintenance of assets until failure and then replacement).

Table 1.1 Short List of Do Something Options

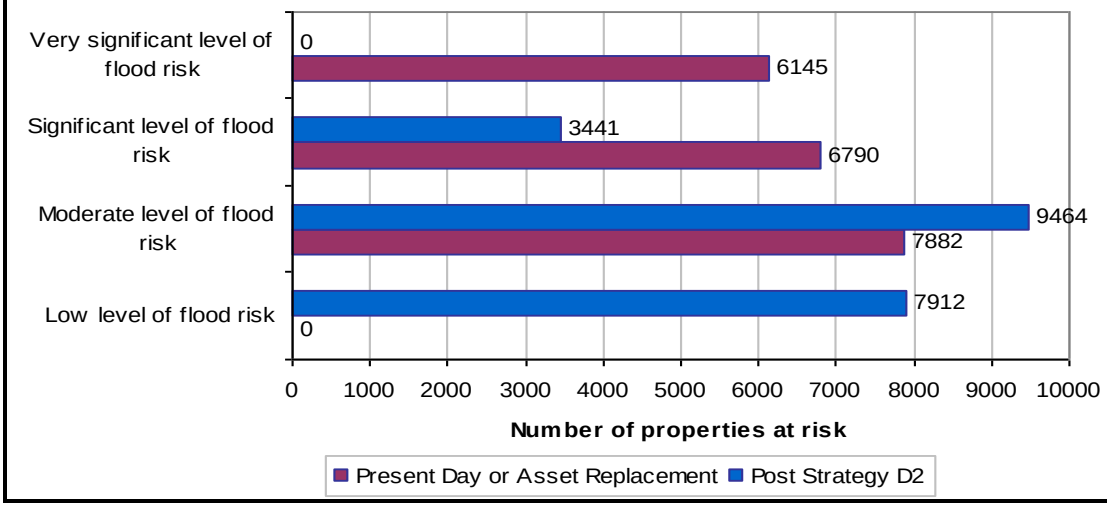
Option	Key Component(s)
C	Flood Plain Management (FPM) Making space for flood water through development of FPM tools; improved non-structural measures; and community based measures (CBMs) consisting of local defences to around 540 properties in Reach 4 with individual property protection to 700 properties in Reach 3 and at least 360 properties in Reach 4.
D2	Flood Channels 1, 2 and 3 (see Figures 6.2 and 6.3)
Option D2 includes all elements of Option C (FPM) and maintenance as defined in B2.	

1.4 Recommended strategy

1.4.1 The Preferred Strategy is D2, which as indicated from Table 1.1 involves a mix of engineering interventions and non-structural measures. It is recommended that while further detailed studies required prior to design of the flood channels are completed, the preparation of the FPM component could start immediately. Construction of the flood channels would follow once planning approval is obtained. Strategy D2 will provide some reduction in flood risk to all properties throughout Reaches 3 and 4, with the improvements in the present ('Baseline') scenario SoP being summarised in Figure 1.1 below. This illustrates the shift in property numbers between flood risk bands, taking those 20,817 properties within the present 0.5% annual exceedance probability (AEP), (or up to a moderate level of flood risk), as a result of Strategy D2 against an Asset Replacement (AR) approach. This assumes that the planned CBMs achieve the maximum possible flood risk reduction, successfully targeting those most at risk (i.e. zero households remain at a very significant level of flood risk).

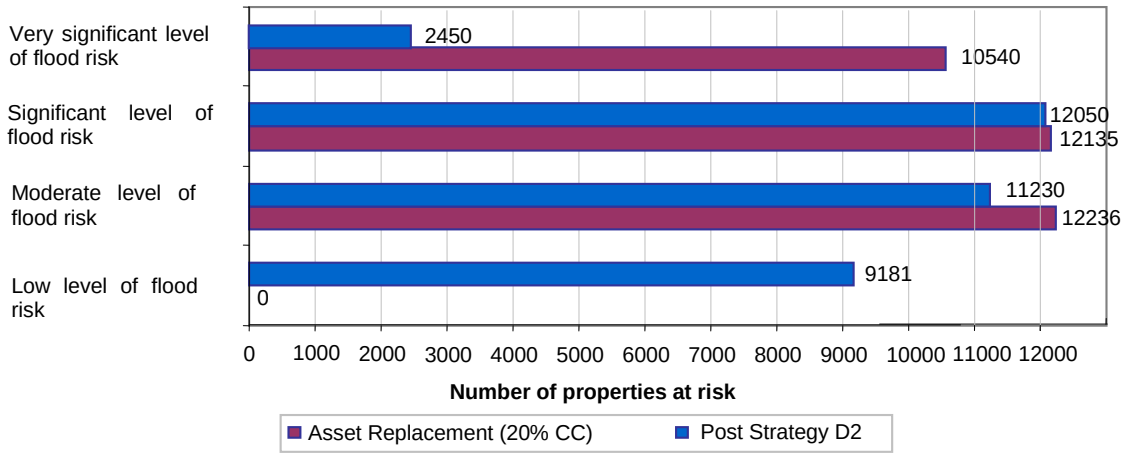
1.4.2 The flood channels will convey an in-bank design capacity of at least 150m^3/s, while the Thames carries 250-300m^3/s of in-bank flow in Reach 3.

Figure 1.1 Potential Reduction in Property Flood Risk from Strategy D2



1.4.3 Widening of diversion channels is not easily undertaken without major increments in cost, thus a precautionary approach is adopted with regard to accommodating climate change. However, because there is a step change in costs as the size of diversion channels increases above the optimum size for the base case, the same optimum channel size is found with climate change. Under the ('FCDPAG' 20%) climate change scenario, the reduction in flood risk to all properties throughout Reaches 3 and 4 provided by Strategy D2 is summarised in Figure 1.2 below. This illustrates the shift in property numbers between flood risk bands, taking those 34,911 properties within the 'FCDPAG' 20% climate change 0.5% annual exceedance probability (AEP), (or up to a moderate level of flood risk), as a result of Strategy D2 against an Asset Replacement (AR) approach.

Figure 1.2 Potential Reduction in Property Flood Risk from Strategy D2 under the 'FCDPAG' 20% Climate Change Scenario



1.4.4 Opportunities will be taken to create significant additional Biodiversity Action Plan (BAP) habitat, largely comprised of wetland or wet woodland, helping to meet Environment Agency targets on Outcome Measures. The Strategy will promote the creation of at least 40 ha of (BAP) habitat, aspiring to achieve some 60 ha of (BAP) habitat dependent on land agreements and partnership working. This is not considered to conflict with proposals for recreation activities in the area, as long as the scheme is subject to sensitive masterplanning and zoning of particular uses. It is likely that most recreation

activities on and around the water would not be particularly intrusive and new habitats could be designed to deal with low levels of disturbance if required.

1.5 Economic Case and Outcome Measures

1.5.1 The appraisal period is 100 years, and the Strategy has used the Flood and Coastal Defence Project Appraisal Guidance (FCDPAG3). Table 1.2 summarises the benefits, costs, and outcome measures scores for the Preferred Strategy Option (Option D2).

Table 1.2 Economic Case and Outcome Measures Score

Present value costs	Present value benefits	Net present value	Benefit cost ratio	Cost per residential property
£256m	£1652m	£1422m	6.4	£14.4k
Project		**FPM Stage 1**	**FPM Stage 2**	**Total OM Scores**
Flood Plain Management (FPM)		3.63	4.14	3.96
Flood Diversion Channels Option D2				3.08

1.6 Environmental and social considerations

1.6.1 A Strategic Environmental Assessment (SEA) was carried out as part of the Strategy development. The area contains rich ecology and archaeology, and the river and surrounding gravel pits support many recreational activities including sailing and angling. These factors have been considered in the options development and appraisal.

1.6.2 The Southwest London Waterbodies Special Protection Area (SPA) is a particular constraint, as the proposed diversion channels pass through one of the designated gravel pits. A Habitats Regulations Assessment (HRA) has been undertaken which concludes that the Strategy will not adversely affect the integrity of the site subject to appropriate mitigation being in place, although further Habitats Regulations Assessments will be undertaken for component projects arising from the Strategy. Natural England has provided a letter of support to this effect. There are a large number of existing lakes in the area, which present many opportunities for mitigation and compensation to be developed. There is also likely to be loss of a small part of SSSI habitat at Thorpe Hay Meadow, for which mitigation and/or compensation measures will need to be developed.

1.6.3 The diversion channels require considerable land take, much of which is through areas of landfill and open water. Diversion Channels 1, 2 and 3 would cross extensive areas of landfill and costs for all aspects related to this have been allowed for within the Strategy. There will be impacts on private property, including an area of Crown Estate land and three private residences. Discussions are on-going with the three directly affected property owners, with an offer for the Environment Agency to buy. One of these is already proceeding and the others are under discussion.

1.6.4 Other key impacts that will need further consideration at the next stage are management of the water quality, fish and other aquatic species in the diversion channels and lakes that they pass through; and management of water flows in the channels to balance the conflicting needs of the river and its ecology, public water supply abstractions, and the ecology and fisheries of the diversion channels. There will be a need for extensive archaeological mitigation work where the channels pass through virgin gravels, and the need to manage works through areas of landfill, so as to prevent the risk of pollution of the channels and wider environment. Heathrow Airport lies very close to the Study Area, so the channels will need to be designed so as not to attract birds of concern in relation

to bird strike. Early discussions with the airport authorities have been positive and suggest that a solution will be available.

1.6.5 We anticipate that the diversion channels will provide significant environmental enhancements, with benefits to the local landscape and biodiversity. We are keen that the channels provide a new recreational resource for the area, with footpaths and other facilities where possible and appropriate. For example the channels could be used by small craft such as canoes, though frequency of structures would hinder larger vessels.

1.6.6 Extensive consultation has been undertaken with key stakeholders and the general public. Meetings and workshops have been held with interested parties and landowners, and ten public consultation meetings have been held, with over 1,300 people attending. Consultation on the SEA Environmental Report has taken place with internal functions, statutory consultees, wider external stakeholders and the public. It is envisaged that Strategy D2 will receive strong all round support, whereas there would be significant resistance to the exclusion of Channel 1 (Option D4).

1.7 Key Delivery Risks

1.7.1 The most significant risks to strategy implementation have been identified and scoped through detailed consultations and discussions during Phases 3 and 4 of the Lower Thames study, and are summarised together with their mitigations in Table 1.3.

Table 1.3 Risks and Mitigations

Risk	Mitigation
Changes in flow and nutrient regimes, eg increase in nutrient loading to lakes. This could be contrary to the Water Framework Directive (WFD) and will require an article 4.7 test. Developing WFD requirements could also result in the need for more extensive mitigation to be developed.	Undertake ecological and water quality surveys. Design flexible scheme to permit flushing flows. Design package of mitigation measures. Work closely with WFD implementation team. Provide additional data collection and re-scope mitigation packages. Prepare case for overriding public interest if mitigation is deemed inadequate. An initial WFD 4.7 test is provided in appendix N3
Habitat Regulations Assessment for the Southwest London Waterbodies SPA does not identify sufficient mitigation.	Work closely with Natural England and RSPB to prepare compensation as well as mitigation packages. Prepare case for overriding public interest if mitigation is deemed inadequate.
BAA object to channel because of increased risk of bird strike.	Maintain close consultation with BAA. Design package of mitigation measures. Early consultation suggests a solution will be viable
Design of channel will need to comply with Landfill Directive as a result of proximity of new watercourse to landfill.	Robust scheme design to separate diversion channels from groundwater. Channel lining is designed on a similar basis to a landfill liner with excavated waste taken off-site for disposal to licensed site.
Crown Estates do not accept flood channels. As land cannot be subject to CPO, an alternative location for Channel 1 off-take would be required.	Continue close consultation with Crown Estates to agree mutually acceptable alignments and design for this critical section of Channel 1.
Scale of funding required is considered unaffordable.	Regular liaison with Environment Agency Board, Defra and Treasury to agree phasing of work.

1.8 Implementation

1.8.1 Implementation of the FPM Measures will be undertaken in two four-year stages during the first 8 years of the Strategy. Due process will be required for planning, design and funding approval of the Flood Channels, but would be expedited as far as possible, with construction planned from years 10 to 18. The capital works will be completed by 2027.

1.8.2 While the Strategy obtains formal approval, proposals will be brought forward immediately to prepare promotion and implementation of the FPM tools, pilot projects for community based measures (CBMs) elements of the FPM measures and data collection studies for the flood channels.

1.8.3 PARs for the full implementation in two stages of the community measures will be completed in 2011 and 2013. The PAR for the flood channels will commence late 2010, will be accompanied by an Appropriate Assessment and will be completed in 2013. Following this, it is intended that a Planning Application will be submitted in 2014, which is anticipated will result in a Public Inquiry in 2015. Tenders for construction will be sought late 2018/early 2019 with the start of construction in 2019.

1.8.4 The cost of the Strategy over the 100 year appraisal period is shown in Table 1.4.

Table 1.4 Summary of Whole Life Costs for Preferred Option (£m)

Item	Flood plain management	Flood channels	Total £m
Costs pre StAR			2
Environment Agency and support services costs (including surveys)	4	19	23
Construction costs	17	131	149
Environmental compensation/enhancement costs	1	7	8
Land Purchase / Compensation	1	21	22
50% Optimism Bias	12	89	101
Total capital cost (£m)	35	267	**302**
Future construction costs	4	32	36
Maintenance costs (100 years)	39	161	200
Whole life cash cost (including maintenance, but no inflation)	78	460	**538**

Note: Support services costs for FPM (£6m incl bias) are included above under 'total' capital costs'

1.9 Contributions and Funding

1.9.1 Consideration should be given to seeking contributions through abstraction of sands and gravels, local commercial interests such as marina development opportunities and EU "SANDS" funding to support restoration of old mineral workings.

1.9.2 Opportunities exist to agree long term management responsibilities for specific assets, in particular with RSPB in the Southwest London Waterbodies SPA.

1.9.3 Contributions through Local Authority grants and benefiting householders should be sought to assist funding of individual property protection, and Local Levy funds could be used to assist with the community based measures pilot projects.

1.10 Status

1.10.1 Provision of flood channels in Reach 3 and flood plain management measures, including commmunity based measures (CBMs), throughout the Study Area (to address residual risk) should be implemented to manage flood risk in the short, medium and long term. A precautionary approach to climate change should be adopted, specifically to inclusion of Channel 1 in the present planning and to enlargement of the diversion channels as far

as can then be economically justified (also environmentally and socially acceptable), as it is not practical to increase the capacity of the flood diversion channels once constructed.

1.10.2 The Strategy's environmental enhancements promote BAP habitat in line with Environment Agency Outcome Measures and Thames Area targets.

1.10.3 This Strategy requires Defra and Treasury approval.

1.11 Recommendations

1.11.1 It is recommended that the Lower Thames Flood Risk Management Strategy is approved in order to manage the risks of fluvial flooding to over 20,000 properties, around 50,000 people and associated critical infrastructure within the 0.5% AEP flood plain.

1.11.2 The Whole Life Cost (excluding inflation) is £538m including contingency of £101m.

Directors briefing paper

Region:	Thames		**Project executive:**	Tim Chinn	
Function:	Flood Risk Management		**Project manager:**	Graham Piper	
Strategy title:	Lower Thames Flood Risk Management Strategy		**Code:**	IMTH000913	
NEECA consultant:	Halcrow/Jacobs	**NCF contractor:**	n/a	**Cost consultant:**	n/a

The problem:	A very wide river flood plain with no formal raised flood defences is prone to fluvial flooding at a 1 in 20 (5% AEP) year flood event. The floodplain has been extensively developed.
People at risk: Probability of exposure: Consequence of exposure:	Around 21,000 properties are currently at risk in the 1 in 200 year (0.5% AEP) flood event. Flood durations will last up to two weeks. The onset of flooding to property occurs in a 1 in 5 year (20% AEP) flood event, placing 6,000 properties at risk.
Environmental resources at risk: Probability of exposure: Consequence of exposure:	Scheduled Monuments, listed buildings and buried archaeology, recreational resources (including navigation) and existing land uses at risk from repeat flood events. Parts of the South London Waterbodies SPA, and Dumsey Meadow SSSI can be adversely affected during large and / or prolonged flood events.
Assets at risk from flooding: Probability of exposure: Consequence of exposure:	Flooding of local and regional roads, which is likely to result in traffic grid-lock to the M25, M4 and M3 motorways. Several major drinking water abstractions supplying London would be suspended and up to 20 local electricity sub-stations would be threatened.
Description of proposed strategy:	Improvements to the management of the floodplain including local and individual protection to clusters of properties. Implementation of major flow conveyance improvements.
Outcome for people at risk:	9,494 properties (assuming no climate change) will be protected to a 1 in 75 year (1.33% AEP) flood event when all elements are implemented; in total around 20,000 properties will have an improved standard of protection.
Outcome for environmental resources at risk:	Reduction in flood risk to some cultural heritage assets, and recreational resources. There is scope to mitigate/compensate for the likely impacts on the SPA and fisheries affected. Further data collection and studies are required to assess the impact on waterbodies under the Water Framework Directive. The scheme will create a minimum of 40ha of BAP priority habitat in and adjacent to the flood channels.
Outcome for assets at risk:	A benefit to critical national infrastructure, with a reduction in traffic disruption and reduced risk to electricity and water supply facilities.

Costs (PVc): (100 year life inc. maintenance)	£256M	**Benefits: (PVb)**	£1,652M	**Ave. B: C ratio: (PVb/PVc)**	6.4
NPV:	£1,422M	**Incremental B:C ratio:**	2.0	**Whole life cost (cash value):**	£538M
Choice of preferred option:	Option D2 – Flood Channels 1, 2 and 3 and Flood Plain Management				
Total cost for which approval is sought:	**£ 538M (incl. £101M contingency)**				
Delivery programme:	Year 0 to 5 Flood Plain Management Phase 1 and Flood Channels preparation Year 5 to 10 Flood Plain Management Phase 2 Year 5 to 15 Flood Channels 1, 2 and 3				
Are funds available for the delivery of this programme?	Not confirmed				

External approvals:	Natural England – letter of support received December 2009
Defra approval:	OM Scores: Flood Plain Management = 4.0, Flood Channels 3.1.

2 Introduction and Background

2.1 Purpose of this report

2.1.1 This Strategy Appraisal Report (StAR) describes the business case for the Environment Agency's Flood Risk Management (FRM) Strategy for over 40km of the Lower River Thames comprising two separate flood cells, namely Reach 3 from Datchet to Walton Bridge and Reach 4 from Walton to Teddington (see Figure 2.1). This flood plain includes lengths of a number of tributaries (see Figure 2.2). The Strategy appraisal is in accordance with the Defra Flood and Coastal Defence Project Appraisal Guidance (FCDPAG) series of documents and 'Supplementary Notes to Operating Authorities', taking into account relevant climate change guidance. The Strategic Environmental Assessment follows both Environment Agency and government[1] best practice guidance.

2.1.2 This strategy presents a 20 years programme of works within the context of a 100 year strategic plan. This approach will enable us to effectively manage flood risk to consider the future urban growth and climate change.

2.2 Background

Strategic and Legislative Framework

2.2.1 Within our overall FRM hierarchy, the Lower Thames strategy sits within the Thames CFMP[2]. The Environment Agency's TE2100 strategy covers the downstream tidal areas, and sets out proposed flood risk management policies for the Tidal Thames.

2.2.2 The structural works identified in this strategy will be completed under the Environment Agency's permissive powers set out in Section 165 of the Water Resources Act (1991). Components of the works (such as diversion channels) will require an Environmental Impact Assessment however, under the Town and Country Planning (Environmental Impact Assessment) 1999 (as amended), and planning permission will be required.

2.2.3 Key legislative issues that will influence strategy implementation include the Habitats Directive (3.4.3), Landfill Directive (5.1.1) and Water Framework Directive (WFD) (6.3.4). These aspects are considered in more detail in the relevant sections noted here and Table 7.9.

Social and Political Background

2.2.4 The Environment Agency has a continuous engagement process with River User Groups and stakeholders, as Navigation Authority and having Water Recreation promoting duties as well as FRM interests. The Lower Thames area is high priority recreation and amenity water in South East England, and we are aware of the high public interest in river management issues. This has been reflected in high levels of attendance at the public exhibitions. Property in the area is generally of very high value, and residents and their Associations and Societies seek technical and scientific detail on FRM proposals such as this Strategy. Interest is particularly high where people have experienced recent flooding. Island communities tend to be very aware of flooding, with some adopting resistance measures and others considering raising their properties.

[1] ODPM (now DCLG) (2006) A Practical Guide to the SEA Directive
[2] Environment Agency (December 2007) Thames Region Catchment Flood Management Plan (CFMP)

Location and Designations

2.2.5 The Study Area for this StAR can be divided into two distinct reaches - Reach 3 comprises the area from Datchet to Walton Bridge, while Reach 4 is the area from Walton Bridge to Teddington. Upstream areas, which are not included in this StAR, are Reach 2 covering the Maidenhead, Windsor and Eton area and Reach 1 extending up to Hurley. The upstream boundary of the Study Area is defined by the end of the Jubilee River, a flood diversion channel constructed in the 1990s which reduces flood risk in the Reach 2 area and rejoins the Thames downstream of Black Potts' viaduct at Datchet.

2.2.6 The downstream extent is defined by Teddington Weir, the formal tidal limit of the Thames. The area downstream of this through central London is covered by the Thames Estuary 2100 (TE2100) FRM strategy (see 6.1.6).

2.2.7 There are a number of environmental sensitivities and constraints. The Southwest London Waterbodies is an SPA and Ramsar site covering many gravel pits and reservoirs. There are several SSSIs and locally designated sites. The River Thames also supports high value fisheries and aquatic communities. There are many mature parklands forming important landscape and heritage features, including Registered Parks and Gardens such as Hampton Court, and a number of Scheduled Monuments. The Thames Landscape Strategy is a local group operating from the Hampton Court area downstream, with interests in conserving the landscape and other aspects of the environment. The related constraints are discussed in greater detail in Section 3.4.

2.2.8 The Lower Thames lies at the bottom of a large, wide and relatively flat catchment area approaching 10,000km^2 in area, extending from Gloucestershire with a large number of major tributaries (see Figure 2.2). Floods on the Lower Thames therefore have large volumes, with peak flows lasting for several days, and flooding continuing for weeks before levels fall. Some tributaries can have significant impacts on flood flows in the Thames, particularly the Rivers Wey and Mole in the lower reaches of the Study Area.

Previous Studies

2.2.9 Options for managing flood risk in Reach 3 were investigated in the late 1980s and early 1990s. This looked at an extensive range of flood diversion channel options between Datchet and Walton Bridge (Reach 3). That initiative was set aside in 1992 because: (i) no structural option was economically justifiable at that time; and (ii) pending a decision by the Secretary of State into the Public Inquiry for the Jubilee River.

2.2.10 After the 2003 floods the economic viability of Reach 3 works was reviewed based on changes in Defra and Treasury guidance, and the strategy study was re-launched.

History of Flooding

2.2.11 There were several major flood events during the first half of the twentieth century, with a notable extreme event in March 1947 which had approximately a 2% annual exceedance probability (AEP), or 1 in 50 annual chance of occurrence. This flooded around 10,000 properties in the Study Area over an area of some 30km^2. A further large event also occurred in September 1968, though this was confined mainly to the Rivers Mole and Wey, impacting variably mostly between Shepperton and Teddington only.

2.2.12 The well recorded extreme event in 1947 was preceded by several flood events of note in the first half of the 20th century, extending over similar flood plain areas, with an even larger event before that in 1894. However, since 1968 there have not been any events exceeding about 5% AEP in the Lower Thames. This is not considered representative of

the long term pattern though, as flow and level records on the Thames over the last century indicate that extreme rainfall-based events are not as rare as this suggests.

2.2.13 The most recent significant flood was that of January 2003 (see Figure 2.3). Estimates of the flood flow indicate that this event had a 7-10% AEP (presently under review) at Windsor (393m^3/s flow estimate) and a more frequent 10-20% AEP at Kingston (472m^3/s) and Teddington. A total number of 256 properties are recorded as having suffered flooding during this event, including 128 flooded from the Chertsey Bourne.

2.3 Current Approach to Flood Risk Management

Measures to Manage the Probability of Flood Risk

2.3.1 There are flood defences on the Lower Mole, Ember and Colne Brook tributaries, but no major existing formal flood defences in Reaches 3 and 4 of the Lower Thames itself, though we hope to soon formalise a historic embankment defence at Old Windsor. Ongoing maintenance of rivers and streams provides some benefit, though relatively small. Weir gates are opened during times of flood to reduce their obstruction to flow. These have been continually improved over the years and now provide limited restriction to flood flows, being partially drowned out by the rising levels downstream. For 50 years the Thames was historically dredged for navigation and for flood risk purposes, following the 1947 flood. However this practice was stopped over 10 years ago. A series of recent surveys and current modelling indicate that the cessation of maintenance dredging has resulted in no clear net erosion or deposition to date.

2.3.2 The Thames Barrier is designed to operate to protect London and the tideway from the effects of tidal flood events. However, in the past it has also been operated to provide limited protection against fluvial floods in the vicinity of Teddington Lock. Stopping high tides combining with high river flows offers some benefits to properties in the downstream areas of Reach 4, particularly the island communities. However it is noted there is no obligation for the Barrier to be used in this way, with rising sea level 'tidal' barrier closure events will become much more frequent, and so the likelihood of being able to operate the Barrier in this way will significantly reduce over the next 25 years.

Measures to Manage the Consequences of Flood Risk

2.3.3 We carry out a number of activities to reduce the impacts of flooding. These include national public awareness campaigns and more localised publicity. Information is provided about what to do before and after flood events, and about any current flood warnings in place. The Floodline Warnings Direct service allows warnings to be issued to the public using various multimedia systems, and take up through the study reach is currently estimated to be about 40% (approximately twice the national average).

2.3.4 New development is controlled through Planning Policy Statement 25 (PPS25), which aims to direct developments away from areas at risk of flooding, and to ensure that they do not increase the risk of flooding elsewhere. In Lower Thames, we have developed good working relationships with the Regional and Local Planning Authorities. Subgroups of the National Flood Forum, including Thames and Chertsey Flood Forums, provide useful discussion forums for issues like PPS25 and Strategic Flood Risk Assessments.

2.3.5 Emergency response is a vital method of managing impacts and ensuring the safety of the public in the event of a flood. It is the responsibility of a number of bodies, including Local Authorities, emergency services and the Environment Agency. Plans have been developed in conjunction with Local Resilience Forums, and Multi-Agency Plans (MAPs) have now been introduced covering all aspects of flood risk management at a high level.

3 Problem Definition and Objectives

3.1 Outline of the Problem

3.1.1 The predicted extent of flooding throughout each of the two flood cells (Reaches 3 and 4) based on the strategy model, is shown in Figure 3.1 under present conditions for events with 5% AEP (1 in 20 year), 1% AEP (1 in 100 year) and 1% AEP with 20% allowance for climate change impacts. It can be seen that flooding is far more widespread in Reach 3 than Reach 4. The flood extents and levels have been well verified through two independent models, calibrated to several recent large events and validated against the major 1947 flood in broad terms, with local differences resolved.

3.1.2 Under current conditions almost 21,000 properties (dominated by residential homes) with at least a 0.5% AEP flood risk, and therefore some 50,000 people, are subjected to a moderate or greater level of risk from the River Thames and Chertsey Bourne. More than 25% of those properties, around 15,000 people, currently live under conditions of "very significant" flood risk (5% AEP, or 1 in 20 annual chance of flood damage). If the event of 2003 had been 10% larger it would have affected many more properties and people; as it was it fell just short of reaching the critical point at which flooding would spread quickly outwards to cover a much larger area of flood plain. The properties affected by flooding across flood risk bands are summarised in Table 3.1 for all property types (for further details see the Technical Report in Appendix K).

Table 3.1 Existing and Potential Future Numbers of Properties at Flood Risk

Flood Risk Probability Bands			Properties at Flood Risk	
			Present, no climate change	Future 20% climate change
AEP	**Annual Chance**	**Risk Band**		
Reach 3				
>5%	*>1 in 20*	*Very significant risk*	5,280	8,870
≤ 5% >1.3%	*≤ 1 in 20 >1 in 75*	*Significant risk*	5,390	8,920
≤ 1.3% >0.5%	*≤ 1 in 75 >1 in 200*	*Moderate risk*	5,120	8,050
		Total Reach 3	**15,790**	**25,840**
Reach 4				
>5%	*>1 in 20*	*Very significant risk*	860	1,675
≤ 5% >1.3%	*≤ 1 in 20 >1 in 75*	*Significant risk*	1,400	3,210
≤ 1.3% >0.5%	*≤ 1 in 75 >1 in 200*	*Moderate risk*	2,760	4,190
		Total Reach 4	**5,020**	**9,075**

3.1.3 There is inevitably some doubt about future changes in river flows as a result of climate change, and various guidance documents are available both nationally[3] and in relation to the Lower Thames Region[4]. Under what we have termed a 'FCDPAG Climate Change' scenario (see 5.5.5), an increase in peak flows of 20% has been applied as at 2055. The predicted effect this would have on the numbers of properties at risk of being affected by flooding is also shown in Table 3.1 above, suggesting a high sensitivity to such impacts. Reduction of risk due to strategy intervention is given in section 6.4.

[3] FCDPAG3 Economic Appraisal - Supplementary Note to Operating Authorities
[4] Defra/Environment Agency R&D Technical Report W5-032/TR (Impact of Climate Change on Flood Flows in River Catchments, April 2005)

3.1.4 If a 5% AEP flood, or one of greater significance, were to happen now in the Lower Thames then it would cause widespread disruption as well as damage. The likelihood that the resources of the emergency and police services would be sufficient to successfully evacuate such large numbers of people to safety throughout such an extensive area, and avoid injury and loss of life, is remote.

3.1.5 Flood hydrographs in the Lower Thames are characterised by their large volumes and as a result flood peaks extend for days, with flooding continuing for weeks before recession. The nature of this long duration flooding is explored further in Section 5.5.

3.1.6 At some confluences the contributing tributary flood flows can have localised impacts, particularly so for the lower Chertsey Bourne reaches (see Section 5.5). Alternatively impacts can be from a combined effect of Thames and tributary flood flows, though this is only significant for flood flow contributions from the Rivers Wey and Mole in the downstream reaches. Investigation of local flood risk reduction benefits has focused on the flood risk in Chertsey from the Chertsey Bourne, where both local and combined (with the Thames) flood impacts are known to be significant. The River Mole itself (as well as the Colne system in Reach 3) has significant existing flood defences in place, resulting in little residual flood risk directly from the tributary channel within the Thames flood plain. Similarly, there is little flood risk from the River Wey within the flood plain due to the weir structures near to its confluence.

3.1.7 Utility, rail and road infrastructure communications would be disrupted with direct impacts on people living and working within an immediate area of some 30km^2 of the Thames flood plain. Disruption would extend to many times this area through linkages in service supplies and transport routes. Under 0.5% AEP flood levels and conditions, impacts would include:

- the operation of a large number (up to 28 in a 1% AEP flood) of licensed abstraction points being suspended for at least 2 to 3 weeks, including major Thames Water and Veolia Water company raw water offtakes at Datchet, Staines and Abbey Meads which supply drinking water to London and surrounding areas;
- motorway traffic being halted due to severe disruption at intersections caused by long-duration flooding of feeder and access roads (Section 5.5);
- concerns about embankment stability along the Datchet-Staines railway line due to high flood levels persisting for long periods, though rail services would in fact be interrupted relatively frequently due to the direct flood risk;
- the flooding of 15-20 local electricity sub-stations, potentially causing disruption to supplies throughout the Lower Thames area;
- some 200-300km of arterial, secondary and local roads being flooded, causing acute traffic disruption and also damage due to erosive effects and long-duration saturation and softening of road embankments and sub-bases.

3.1.8 The key conclusions for future flood risk growth by 2055 are that 35,000 properties and 85,000 people will be subject to a moderate or greater level of flood risk, and that long-term (PV) flood damages could double from the current £850 million to some £2 billion.

3.2 Consequences of Doing Nothing

3.2.1 The Thames' weirs are important to maintain and control water levels. The Do Nothing approach would be a walk-away scenario under which the maintenance and operation of all weir structures would discontinue. All gates would be left shut and become fixed

crest structures, un-responsive to impacts caused by changes in river flows. During low flow conditions, no particularly significant adverse impacts would be expected. Under high flow conditions increased flooding could be expected to commence during Year 1 of this approach, as flood levels would be artificially raised by the fixed weir crests.

3.2.2 With no maintenance, structures would progressively decay and fail over an assumed period of some 50 years and the additional flooding of Year 1 would decline, though partially offset by the impacts of climate change. As weir gates fail, normal water levels would drop towards “natural” river levels, leading to increased erosion and damage to banks, infrastructure such as roads and bridges, houses, private water side property and archaeological interests. Other potential impacts would include loss of navigation, changes to habitats, loss of amenity, and operational difficulties over water abstraction.

3.2.3 The Do Nothing approach would leave approximately 33,000 properties within the 0.5% AEP flood risk, with a present value of long term damages estimated at £2 billion.

3.3 Strategic Issues

3.3.1 The Thames CFMP sets the policy for development of a flood risk management strategy for the Lower Thames. It proposes a more sustainable approach to managing the risk of fluvial flooding to people, property and the environment, and it classifies the Lower Thames as a developed flood plain with no built flood defences. The CFMP sets the policy for the Lower Thames area of the catchment as:

> **P5: Take further action to reduce flood risk (now and/or in the future)**
> Reduce the risk – lower the probability of exposure to flooding and/or the magnitude of the consequences of a flood, and hence the risk.

3.3.2 The CFMP also states that the most sustainable way of reducing flood risk will be through the development of partnerships with regional and local planning authorities and developers, and by agreeing policies and steps. The Lower Thames Strategy is the method by which this policy will be developed into a location specific framework for action, which will subsequently be implemented by a series of projects on the ground.

3.3.3 The Study Area can be considered as two distinct areas, which have different physical characteristics and act as separate flood cells. Reach 3 has a large, flat and wide flood plain, with a number of open areas. Flood mechanisms are complex throughout and the flood plain has many branching and converging flood routes and compartments, mobilised at different times under different magnitude events. Isolated areas or islands of dry land are formed with no escape routes, and areas are flooded by the backing up of water from tributaries and surface water channels. The homogeneity of flood mechanisms in Reach 3 and the need for similar option(s) to manage flood risk, mean that for planning and technical reasons this area needs to be considered as a single flood cell.

3.3.4 The flood plain of Reach 4 is more confined, with less extensive areas being subject to flood risk. Flooding mechanisms are simple, generally occurring directly from the Thames with only localised flood plain flow routes. A much narrower area becomes inundated by floodwater, and there are fewer problems with properties being cut off without safe access. There are a number of island communities within Reach 4, which experience relatively frequent flooding and have specific issues regarding access. The differences in topography and the characteristics of the flooding here mean that different solutions are required to manage risk in Reach 4 compared to Reach 3, and that Reach 4 needs to be considered as a second separate flood cell.

3.4 Key Constraints

3.4.1 As part of the Environment Agency's best practice approach to the development of strategies, we have undertaken a Strategic Environmental Assessment (SEA) in accordance with EC Directive 2001/42/EC "on assessment of the effects of certain plans and programmes on the environment" (the SEA Directive), to assess the impact of the strategy options being considered. This process is documented in the SEA Environmental Report (Appendix N), which sets out related issues in much more detail, as well as scoping out potential mitigation measures to be included in a strategy to address identified issues and constraints. Following consultation, the most significant risks to strategy implementation (and their management) are given in Section 7.4.

3.4.2 The River Thames typically has good water quality, and the fisheries and other biological communities have been improving since dredging ceased (apart from for navigational needs). Ecological surveys of 3.5km of the river were completed, to provide more information on the communities present, specifically in the section of river through Staines where there is no space to construct diversion channels. A number of protected and threatened species are known to be present in the waters of the Lower Thames, including the Depressed River Mussel, which is a UK Biodiversity Action Plan species, and on the IUCN red list as near threatened. This poses a constraint on any works to be undertaken within the River Thames itself, especially activities such as dredging. Other issues of note relate to fish migration (e.g. salmonids), potential spread of non-native, invasive aquatic flora and fauna, the risk of algal blooms and the need for a future assessment against the WFD in particular regarding water quality impacts in the lakes. Proposed further environmental surveys as part of a strategy will allow review and re-assessment of these constraints as part of preparation of outline designs.

3.4.3 The Southwest London Waterbodies Special Protection Area (SPA) is a Natura 2000 site present within the Study Area, and falls under the remit of the EU Habitats Directive. It encompasses many of the open water gravel pits and reservoirs, and receives a high level of protection due to the numbers of endangered wildfowl (Gadwall and Shoveler) that overwinter on the lakes. There are also at least three Sites of Special Scientific Interest (SSSI) potentially affected, including Thorpe Hay Meadow which is a mature hay meadow. Regular consultation with Natural England (NE) has considered the potential effects of a flood risk management strategy on the SPA, and recent studies of wildfowl numbers have been undertaken. The strategy has been subject to a Habitats Regulations Assessment (HRA), as will any future projects arising from the strategy. NE's letter of support (Appendix O) confirms their view that strategy proposals are likely to lead to an environmentally acceptable solution, and proposals under the strategy for further surveys and on-going consultation should ensure that designs are appropriate.

3.4.4 Heritage assets, including nine Scheduled Monuments and three Registered Parks and Gardens lie close to the river in several locations. These are of national historic importance and indicate a high likelihood that there is extensive buried archaeology in the area, particularly within the Thames gravels. Allowances have been made in cost estimates to cover the eventuality that such artefacts will be encountered.

3.4.5 Heathrow Airport, though not at flood risk from the Thames, lies within 3km of our Study Area. The airport operators are concerned about the risk of bird strike that could result from any change in habitats on the ground, particularly creation of new open water or marshy areas which might attract birds. Any measures included as part of the strategy will need to be designed in liaison with BAA, to ensure that they do not result in unacceptable levels of risk. We have spoken to BAA and their bird strike consultants at a number of stages through strategy development, and we are confident that designs will be able to meet their constraints as work progresses.

3.4.6 The River Thames corridor is an important feature in the landscape, and a focal point for recreation activities, including walking, cycling, boating and angling. Other important recreation assets abutting or very close to the River Thames include Thorpe Park and Hampton Court Palace, as well as many informal recreation areas such as Ankerwycke Priory National Trust land, Runnymede Pleasure Grounds, Laleham Park, Chertsey Meads and Hurst Park. Strategy proposals have sought to avoid adverse impacts on existing assets and identify opportunities to enhance or expand recreation activities.

3.4.7 The area has been subject to extensive gravel extraction over time. The resultant gravel pits have either filled with water to become lakes, or been restored as landfill. As a result, extensive areas of landfill cover the landscape. These contain various waste types and have been constructed to various standards. Historic sites are typically less engineered and have fewer records as to their contents. Site investigations were carried out to better understand the extent and content of these landfills along the proposed channel routes (5.1.1). These landfills place constraints on the type and location of engineering works. There are also legal implications (see Appendix L) where currently permitted waste sites at Hythe End need to be crossed. Strategy proposals have sought to avoid landfill sites where possible and where not possible to adopt fully costed design standards that minimise risk of adverse incidents and legal liabilities (6.3.19).

3.5 Objectives

3.5.1 The broad objective for the Lower Thames Strategy is to accord with the aims and objectives of the Thames CFMP. Based on this and other key policy documents, a number of specific objectives as shown in Table 3.2 have been developed to evaluate options and ensure a robust decision making process to identify a preferred strategy.

Table 3.2 Objectives for Evaluating Capital Scheme Options and Alternative Strategies

Category	Objective
Economic and Financial	Cost effective reduction of flood damage to property; now and in the future
	Justified investment compared with other options
	Ensure that flood risk management measures are economically viable
Social	Reduce the risk of flooding to society
	Protect and enhance recreational and amenity opportunities
Technical	Minimise engineering risks
	Minimise disruption to infrastructure and services
Environmental	Protect and enhance sites of nature conservation importance and biodiversity
	Maintain biological quality and sediment regime of rivers and protect fisheries
	Prevent damage to scheduled monuments and protect and enhance landscape character
	Seek environmental gain and enhancement
Institutional	Avoid potential adverse public perception
	Avoid conflict with legislation and at Public Inquiry
	Provide opportunities for partnering with other organisations
	Avoid potential conflict of policies within the Environment Agency

3.5.2 Based on the nature of flood risk in the Study Area, we should also seek in the long-term to better enable Local Authorities to provide a more robust service to plan and regulate future development here in a sustainable manner. Development has changed and increased by some 15-20% in the past 20 years; ensuring that such levels of development take good account of the complex flood risk issues here will help ensure that it is appropriate and well planned and compliant with PPS25.

3.5.3 A series of environmental objectives were also identified as part of the SEA (Appendix N1), expanding on those noted above. These were consulted on externally as part of the scoping report, and were used to assess alternative strategy options.

4 Options for Managing Flood Risk

4.1 Potential Flood Risk Management Approaches

4.1.1 A large number of management approaches have been considered during the strategy to reduce flood risk in the Lower Thames area. In addition to Do Nothing and Do Minimum (with and without Asset Replacement, AR) approaches, the range of flood risk management approaches considered within Reaches 3 and 4 have incorporated four broad categories of options, to varying degrees, as follows:

1. Reach based **structural options or capital schemes**. This could include:
   - **Riverbed re-profiling:** involving extensive lowering of the bed (not the sloping sides) of the Thames by about one metre in all or parts of Reaches 3 and 4;
   - **Flood diversion channels**: which would by-pass existing weir structures and improve conveyance throughout Reach 3;
   - **Capital works**: to specifically reduce flood risk in the form of river bank works, improvements to existing structures and flood defence works in Reach 4; discarded as an option for Reach 3 in LTS Phase 2 (Appendix K, Section 4.1.8).
2. **Catchment wide options,** which could include incremental storage options on key tributaries, targeted land use and development control initiatives across the catchment, and use of the Thames Barrier to help protect lower areas in Reach 4.
3. **Non-structural options** throughout Reaches 3 and 4, including increased public awareness, improved land use planning and development control, improved flood warning and emergency control plans, and promotion of flood insurance. This includes the development of flood plain management tools to support all the above by providing better information to forward planners, development controllers and emergency planners.
4. **Community based options**, including local defence schemes comprising demountable, temporary and fixed defences such as small embankments or flood walls in Reach 4, and individual property protection in both Reaches 3 and 4.

4.2 Long List of Options

4.2.1 During the preliminary stages of the strategy study the broad approaches to flood risk management, comprising a portfolio of options as noted above, were developed into a 'Long List' of options with more specific details and locations (particularly for diversion channel alignments where some options are shown in Figures 4.1, 4.2 and 4.3). Table 4.1 catalogues these options, noting whether they were short-listed or set aside (shown in grey), and with the capital scheme options categorised under sub-headings. Section 4.3 and Appendix N give more detail of the reasons for option rejection.

Table 4.1 Long List of Options

FRM Approach	Option	Taken Forward to Strategy Stage?
Do Nothing	Do Nothing (take no action, and secure gates on weir structures shut - Section 3.2)	Taken forward as the baseline comparison with other options
Do Minimum	Maintain but do not replace assets as they fail	Yes
Asset Replacement	Maintain and replace assets as they fail	Taken forward for incremental comparison with intervention options

FRM Approach	Option	Taken Forward to Strategy Stage?
Capital Schemes	**River bed re-profiling**	
	Wholesale river bed re-profiling throughout Reaches 3 and 4	No due to significant negative environmental impacts and poor economics and sustainability
	Partial and patchwork re-profiling (full width over part of a reach, and part width over part of a reach; respectively)	Not currently acceptable, but further surveys are proposed to determine future acceptability as a minor component
	Flood Diversion Channels, Reach 3 (route options and capacities)	
	Channel 1 Red (1), at 150m^3/s capacity	Yes
	Channel 1 Red (2) southerly Datchet offtake option	No, rejected due to impact on viability of Crown Estate farmland
	Channel 1 Black (1) 'River Colne' option	No, rejected due to impacts on River Colne
	Channel 1 Black (2) 'River Colne' option 2	No, rejected due to impacts on River Colne
	Channel 1 Blue 'Friary Island' option	No, rejected due to major impacts on the Thames, residential areas, historic parkland
	Channel 1 Yellow 'Ankerwycke-SPA' option	No, rejected due to major impacts on the Thames, SPA, historic parkland
	Channel 1 Green Ankerwycke' option	No, rejected due to major impacts on the Thames and historic parkland
	Channel 1 Any route option at higher 190m^3/s capacity (approx. 1 in 40 year 'Min. SoP'), requiring significant Thames works	No, rejected due to environmental impacts of much enhanced river works required to compensate for limited Thames capacity at Staines and upstream at Datchet
	Channel 2 Red southern offtake, at 150m^3/s capacity (approx. 1in 20 year 'Min. SoP')	Yes
	Channel 2 Green northern offtake	No, rejected due to major negative impact on existing landfill site and private property
	Channel 2 Yellow Egham Hythe	No, rejected as not as hydraulically efficient, and extent of river works required
	Channel 2 Blue Penton Hook option	No, rejected as not as hydraulically efficient, and extent of river works required
	Channel 2 Any route option at higher 190m^3/s capacity (approx. 1 in 40 year 'Min. SoP'), requiring significant Thames works	No, rejected due to environmental impacts of much enhanced river works required to compensate for limited M3 culvert capacities and limited Thames capacity at Staines
	Channel 3 Orange (1), at 150m^3/s capacity	Yes
	Channel 3 Orange (2)	No, rejected due to impacts on community assets in Shepperton area
	Channel 3 Any route option at higher 190m^3/s capacity (approx. 1 in 40 year 'Min. SoP'), requiring significant Thames works	No, rejected due to environmental impacts of much enhanced river works required to compensate for limited M3 culvert capacities and increasing downstream Thames influence
	Channel Works in Reach 4	
	Hurst Park fixed control weir opposite waterworks	No - these large scale structural options are not effective, either in terms of hydraulics (as indicated by the limited improvement shown in the numbers of properties protected and the shift in median Standard of Protection) or in relation to economics. Some also have significant negative environmental impacts
	Bushy Park Diversion Channel	
	Ham-Teddington Lock Diversion Channel	
	Kempton Park Racecourse Diversion Channel	
	Lower Halliford Diversion Channel	
	Walton Lane intake culverts	
	Gated weir opposite Thames Meadow	
	Tunnel under Bushy Park/Hampton Court	
	Hurst Park Diversion Channel.	
	Walton Bridge Flood Relief Channel (right bank)	
	Royal Paddocks Diversion Channel	
	Teddington Gated weir – 5 bays adjacent to gates replaced by gated weir	
	Sunbury Lock Bypass Channel	
	Relocate Sunbury Lock	
	Sunbury Lock Widening	
	Sunbury Lock Diversion Channel Approx 2.5km from gravel pits on left bank behind Sunbury Marina area to Sunbury Weir	
	Sunbury Lock Gated weir Bypassing lock at end of lock cut	

FRM Approach	Option	Taken Forward to Strategy Stage?
	Sunbury Lock Felix Lane gated culverts	
	Sunbury Lock Beasley's Ait Lane culverts/weir	
	Improve flow connection via Sunbury marina entrance and gravel pit connections (left bank)	
	On-line river bank works	
	Teddington Flood Banks (~1.2m) Fixed or demountable walls and/or earth banks on left bank from TV studios to say end Trowlock Island. Approx 0.7km length	Yes
	Bank works in Ham Lands / Hurst Park or other locations in Reach 4 e.g. localised ground lowering or modifications to banksides	Yes - whilst large scale diversion channels are not cost-effective in these locations, more limited specific local improvement works could be economically attractive and/or socially desirable within a partnership approach.
	Hampton Court Flood Berms 15-20m wide, approx 2.3km long on left bank; 20m wide, approx 0.7km long on right bank	No - these large scale structural options are not effective, either in terms of hydraulics (as indicated by the limited improvement shown in the numbers of properties protected and the shift in median Standard of Protection (SoP)) or in relation to economics
	Molesey Flood Berm On right bank adjacent to Molesey Reservoir from Swan's Rest Island to Platt's Eyot Island. Approx 1.4km long, 5-10m wide	
	Kingston Bridge Improvement Works	
	Reach 4 engineering works	
	Enhanced maintenance dredging	No
	Structural option: Works to provide additional gate structures at locks and weirs, plus widening of Desborough Cut by average 3-4 metres	Yes
	Hybrid model: combination of a reduced level of enhanced maintenance dredging and a lesser provision of additional gates at locks and weirs	Not currently acceptable, but further surveys are proposed to determine future acceptability as a minor component
	Community based measures	No
Catchment Wide Options	Upstream Storage	Yes - the strategy will not directly include any upstream storage as this has limited potential. While not economic for the Lower Thames on its own, to help offset climate change over time the strategy will encourage any incremental gain that could be achieved from flood risk strategies on key upstream tributaries.
	Land use planning at catchment scale	Yes - intensification of current activities
	Operation of Thames Barrier to retain flood storage capacity in the upstream tidal reach, reducing the backwater effect of the tidal surge at high tide, and thus reducing flood levels at Teddington and upstream. Any effect becomes small upstream of Molesey Lock.	Yes
Community Based Options	Individual building protection – dry and wet proofing of buildings	Yes, but mainly in Reach 4. No real opportunity with an acceptable level of risk is judged to exist in Reach 3 for temporary, demountable or local protection type community options. What opportunity does exist would be limited to individual property type options
	Local Protection Option - flood defences to a group of properties for example with the use of local flood walls, earth bunds, or raised kerbs, roads or footpath	
	Temporary Barriers Option – systems such as the Pallet System or Water Filled Dam types erected just prior to a flood event, as part of flood defences for groups of properties	
	Demountable Defences Option as part of flood defences for groups of properties - another form of barrier erected just prior to a flood event, requiring more preparatory work	
Non-Structural Measures	Local non-structural responses: to improve public awareness and education, enhance flood warning and emergency response, improve development control and land use planning, and improve flood insurance arrangements tied to reduced flood risk.	Yes

FRM Approach	Option	Taken Forward to Strategy Stage?
	Flood plain management tools: these would be the required mechanisms and procedures to implement flood plain management, including community based protection measures, providing flood risk data to better inform planning and regulatory bodies	Yes

4.3 Options Rejected at Preliminary stage

4.3.1 The long list of options underwent varying degrees of evaluation. The process included screening against SEA objectives; technical, hydraulic and economic analysis; and internal and external consultee workshops. Fuller details of reasons for option rejection are provided in the SEA (Appendix N1), but a summary of key points is provided below.

4.3.2 Any form of **river bed re-profiling** or dredging is currently considered environmentally unacceptable due to high impact on aquatic species. Full re-profiling of an entire reach has been ruled out on this basis. Partial re-profiling, in combination with diversion channel options, has also been ruled out for environmental reasons and due to the poorer economic performance of options including re-profiling. Maintenance dredging in limited parts of Reach 4 may be considered pending findings of further environmental surveys, as works to compensate for the effects of diversion channels upstream.

4.3.3 Many alignments for **diversion channels through Reach 3** were considered and rejected. The preferred alignment for each was chosen to reduce impacts on high quality environments, designated sites, heritage sites and existing assets, and to minimise risks for private property and known landfill sites.

4.3.4 Most **large scale structural options** in **Reach 4** are not hydraulically or cost effective, and some have significant environmental impacts. Localised bank work, such as in the Teddington area, was the only option in Reach 4 that was short-listed.

4.3.5 **Upstream storage** as a sole option is not appropriate due to the unrealistically large storage capacity required, which would need to flood 200km^2 of land in Oxfordshire. However, we will seek to encourage incremental storage on tributary rivers as part of other schemes, as and when they become available. No specific projects have been identified or costed within the strategy, though the tributary strategies were reviewed.

4.4 Options Short-listed for Appraisal

4.4.1 Five alternative strategic approaches to manage flood risk in the Lower Thames have been developed from the components listed above and carried forward to evaluation. These comprise three “passive” approaches and two “intervention” approaches.

Passive Approaches

4.4.2 **Approach A: Do-Nothing** - This approach is evaluated as a baseline option for the economic appraisal, but is not considered acceptable for adoption on social, environmental, economic or political grounds (Section 3.2).

4.4.3 **Approach B**: Do-Minimum type approaches: (i) **B1: Do Minimum** - to continue to maintain existing operation and maintenance activities but without replacement of assets as they fail, and to improve current flood warning services; (ii) **B2: Asset Replacement (AR)** - to continue to maintain the existing operational capacity of the

Thames' weirs and gates through maintenance and asset replacement, and to improve current flood warning services.

Intervention Approaches

4.4.4 **Approach C:** a **Flood Plain Management (FPM)** approach that makes space for flood water by applying a portfolio of key measures throughout Reaches 3 and 4 comprising: (i) a range of community based measures including temporary, demountable and fixed defences to small groups of most-at-risk properties in Reach 4, and individual property protection in Reaches 3 and 4, targeted in Reach 3 at currently most-at-risk properties, and those with high residual risk even with diversion channels in place; (ii) intensification of existing non-structural measures including public awareness, enhanced flood warning, land use planning and regulation, and emergency response planning; (iii) development of FPM tools comprising GIS data, procedures and protocols to support all non-structural measures; and (iv) continuation of asset maintenance and replacement.

4.4.5 **Approach D:** an approach that integrates the **Flood Plain Management (FPM)** (Approach C) throughout Reaches 3 and 4, with a **Capital Scheme** component. The combination taken forward is Approach **D2**: FPM with diversion Channels 1, 2 and 3 in Reach 3, and compensation and improvement works downstream in Reach 4 (5.1.3).

4.4.6 An Approach D4 (see Figure 4.5) with FPM and diversion Channels 2 and 3 only, plus downstream works, would only offer flood risk improvements to people in the Staines to Shepperton area. Datchet, Old Windsor, Wraysbury and Hythe End, with approximately 20% of the Reach 3 flood risk, would benefit little. Based on its extensive flood plain and the continuity of the hydraulics through its length (and strategic nature of the solutions) Reach 3 should be considered as one flood cell, with Channel 1 included now to avoid issues over future downstream detriment, based on a precautionary approach (5.5.4). If it were to be introduced later, as a separate stand alone scheme, it would need to demonstrate that adequate additional compensatory measures could be found to avoid downstream detriment, with appropriate costs included. This would make the stand alone scheme economically unviable. In addition, it is highly unlikely that the D4 approach would be considered an acceptable solution at Public Inquiry.

4.4.7 Two further approaches D1 and D3 (see Figures 4.4 and 4.5), including river bed re-profiling upstream of Channel 2 together with 150m^3/s capacity diversion channels and FPM, have also been considered in some detail. We rejected D3 in Phase 3, largely for environmental reasons due to the extent of re-profiling required, but also with poor marginal economics over D4. After further assessment we have also rejected D1, again due to poor incremental economics over D2 and environmental risks (see 4.3.2).

Consequence of Above Design Level Flood Events

4.4.8 Without the construction of large and extensive diversion channels (the only acceptable major intervention approach in economic, social and environmental terms), residual flood risk is considered to be unacceptably high. This is highly sensitive to climate change impacts, which could increase flood losses two-fold or more (Section 5.5).

4.4.9 The proposed routes of diversion channels follow those areas of flood plain which would normally be activated through natural flooding at approximately 5-10% AEP floods. The smaller the channels, the more difficult it will be to operate the scheme safely and effectively in above design standard events. The channels need to be of sufficient size to minimise problems of managing excess (above design) flood flows, in order to limit flood risk along the Thames and protect the integrity of the scheme itself, and to avoid creating worse flood risk in some flood plain areas than would normally have occurred. Residual risks will require careful design of related defences and operational aspects.

4.4.10 Increasing the capacity of a channel scheme however is made more difficult by physical constraints such as the existing M3 culverts, the Thames and its bridges through Staines and past Datchet, land constraints, and rising levels from downstream, as well as a very limited hydraulic gradient. This requires River Thames works (see 5.4.16).

5 Options Appraisal and Comparison

5.1 Technical Issues

5.1.1 Diversion Channels 1, 2 and 3 would cross extensive areas of landfill. Measures to minimise risk, by ensuring robustness of design and leachate management, have included: (i) initial site investigations to determine the location, extent, depth and composition of landfill, comprising 144 trial pits, 44 boreholes and 13 window samples (in lakes), with costs allowed for further detailed site investigation at the design stage; (ii) potentially hazardous waste was encountered at sites within Royal Hythe Farm pit, but preferred channel 2 alignment should now avoid this; (iii) waste at Hythe End Pits is generally inert, with hazardous waste recorded at one location - costs have been allowed for removal and safe disposal of this to a certified site, and the Environment Agency would demand surrender of licence with due process to ensure that Hythe End pit was environmentally secure prior to adopting it as part of project; (iv) the majority of waste, either non-hazardous or inert, occurs in all three channels and the most appropriate design approach to avoid pollutant risk is considered to be by using geosynthetic liners to separate them from landfill; (v) to ensure robustness of design, costs have been allowed for liners, for "buffer" lengths of channels at the interface between landfill and "clean" land, for bentonite cut-off at (one) key location, and for parallel interceptor (French) drains and (small) stand-by pumping station to manage leachate if required.

5.1.2 The preference for diversion channel operation is to have no constant flow provided from the Thames, thus avoiding potential conflict with abstractions for water supply during low flow periods. This will also minimise problems of low flows in the Thames, and the associated water quality and ecological implications. The channels would still fill with water however, to levels controlled by weir structures to be sympathetic to surrounding groundwater levels. Close liaison would be maintained with our water resources teams and those of the water companies during detailed design preparation, to ensure relevant licence rights are protected and requirements complied with, and to formulate and agree a future form of operating agreement. This is necessary due to the possible requirement for occasional “flushing” of water through the channels and potential water quality impacts, as a result of algal blooms arising. The risks and effects of these will need to be investigated more fully during the project to collate baseline water quality and ecological data.

5.1.3 Without compensation works, the impact in Reach 4 of diversion channels in Reach 3 would potentially occur from the outfall of Channel 3, through the Desborough ‘loop’ at Shepperton, and downstream to the tidal limit at Teddington. In general, this impact would be a rise of up to approximately 20mm in peak flood levels, with the peak occurring marginally earlier (approx. 2-3hrs) due to reduced attenuation. The Strategy will address this and satisfy PPS25 requirements with compensation works, providing some incidental betterment (Appendices E3 and K), comprising: (i) widening of the south bank of Desborough Cut by an average of 3-4m; and (ii) replacement of overfall weirs at Sunbury, Molesey and Teddington with 3-6 new large gates to increase flood flow capacities at those sites. There is a co-ordinated approach with the Thames Weirs Investment Strategy, the Hydropwer project, the Paddle and Rymer Projects and TWUL.

5.1.4 The flood risk within the lower Thames flood plain is dominated by fluvial flooding from the Thames. Pluvial or groundwater flooding does occur but much less extensively and in localised areas, though on a more frequent basis. Whilst related data is limited, we have started to understand the locations where such issues occur, and where the

structural component of the strategy will bring benefit. The development of FPM tools through the Flood Plain Management (FPM) approach will allow us to investigate mechanisms and identify hot-spots and work with the local authorities to manage pluvial and groundwater flooding more effectively.

5.1.5 There are numerous tributaries and minor drainage channels in the area and many would receive some reduction in flood risk due to the diversion channels reducing flood levels generally. The Chertsey Bourne system, incorporating the Mead Lake Ditch and Moat, has been assessed as receiving significant benefits from diversion Channel 2.

5.1.6 Upstream areas would receive some additional benefit from reduced flood levels (i.e. 0.3m reduction at Romney Weir), improving residual flood risk from the Jubilee River in Reach 2 of the Lower Thames. Downstream of Teddington Weir standards of flood protection are much higher than in Reach 4 and dominated by tidal influences and barrier operation, so would not be affected by the strategy.

5.2 Environmental Assessment

5.2.1 Although not required by law, a Strategic Environmental Assessment (SEA) was carried out as part of the Strategy in accordance with EC Directive 2001/42/EC, and has formed a central part of Strategy development. Key environmental constraints in the Study Area are reported in Section 3.4 and are shown, including the boundaries of designated sites, in the Strategic Environmental Site Appraisal Plans (ESAPs) in Figures 5.1a-c.

5.2.2 We have carried out extensive consultation as part of the Strategy development. We engaged with many local groups and landowners, and held a workshop in April 2009 with key external stakeholders. These consultations have helped to guide the assessment of options and approaches, and therefore the form of the preferred Strategy. Public consultation was undertaken between September and December 2009. Ten public exhibitions were held at various locations through the Study Area, and these were very well attended by over 1,300 local people. A summary table of the strategy consultation is provided within Appendix M, which contains a ‘Strategic Communications Plan’ (M1), ‘Stakeholder Engagement Plan’ (M2), ‘Listing of Stakeholders’ (M3) and an ‘Interim Consultation Responses Report’ (M4) which highlights the strength of support from the Local Planning Authorities (LPAs) to date.

5.2.3 Natural England (NE) has been closely involved throughout development of the Strategy and has been a key consultee as the proposed diversion Channel 1 passes through the Southwest London Waterbodies SPA and Channel 2 could result in the loss of a small part of Thorpe Hay Meadow SSSI. We carried out a strategic level Habitats Regulations Assessment in relation to impacts on Natura 2000 sites. This concluded that Approaches A and D would require detailed assessment, whereas Approaches B and C would have no likely significant effects. Approach D2 incorporates diversion Channel 1, which passes directly though an SPA lake, and all diversion channels impact on lakes that were considered through a PhD study to be “relevant” to the SPA.

5.2.4 Whilst recognising that proposals for constructing diversion channels could have significant impacts on the designated sites compared to non-structural approaches, Natural England understands the rationale for the scheme in terms of reduced flood risk, compared with the other approaches offering lesser benefits. We discussed alternative alignments for Channel 1, and agreed that the chosen alignment has the least impact on areas of ecological value (see Appendix O for NE letter of support). Mitigation and/or compensatory proposals will need to be developed, but it is considered that there is scope to do this, given the large number of existing waterbodies already present in the

area which could be improved. Other opportunities exist if there is a requirement to create new waterbodies by linking in with minerals operators in the area, although the risk that this will be required is considered to be low. The alignment of Channel 2 in relation to the SSSI has yet to be determined, but a loss of a portion of the hay meadow habitat is likely in order to avoid loss of private property. Mitigation and/or compensatory habitat would need to be provided for any habitat loss.

5.2.5 Other key impacts that will need further consideration at the next stage are management of the water quality in the diversion channels and lakes that they pass through; and management of flows in the channels to balance the conflicting needs of the river and its ecology, public water supply abstractions, and the ecology of the diversion channels. There will be a need for extensive archaeological mitigation work where the channels pass through virgin gravels, and the need to manage works through areas of landfill, so as to prevent the risk of pollution of the channels and wider environment. Heathrow Airport lies very close to the Study Area, so the channels will need to be designed so as not to attract birds of concern in relation to bird strike. Early discussions with the airport authorities have been positive and suggest that a solution will be available.

5.2.6 The Strategy will comply with the Water Framework Directive; it is possible that all Approaches could have adverse effects with regards to the Water Framework Directive water bodies. Approaches A, B and C (allowing for probable climate change impacts) will all increase the level of flooding to gravel pits and the River Thames, and could therefore change the characteristics of the waterbodies and levels of nutrients. Approach D2 would increase the modification of the River Thames (already Heavily Modified), and alter the characteristics of some of the gravel pits (artificial waterbodies), although lowering the frequency of flooding of the main river and other gravel pit areas. In compliance with the Water Framework Directive we would seek to include measures to ensure no deterioration of waterbodies but it is recognised that this may not be possible due to the intrusive nature of the strategy and the requirement for some of the waterbodies to be encompassed into the diversion channels. Where this deterioration is proven to be the case, we will comply with the Water Framework Directive. Further surveys are proposed to further clarify the nature of the impacts, and if the schemes proposed in the Strategy were to compromise the ability of any waterbody to reach Good status, this would need to be documented and explained in the River Basin Management Plan, and justified based on compliance with article 4(7) of the Water Framework Directive. It is considered that this can be avoided through ongoing engagement with the Environment Agency's Water Framework Directive team and development of a comprehensive package of mitigation measures. An initial assessment with regards to the Water Framework Directive is presented in Appendix N3.

5.2.7 We anticipate that the diversion channels will provide significant environmental enhancements, with benefits to the local landscape and biodiversity. We are keen that the channels provide a new recreational resource for the area, where agreement with riparian owners allows, with footpaths and other facilities where possible and appropriate. It is possible that the channels could be used by small craft such as canoes, although the frequency of structures would hinder larger vessels. There are few significant opportunities for enhancements with Strategies A, B and C.

5.2.8 Table 5.1 below details the key environmental impact, mitigation measures and opportunities associated with the various strategy approaches taken forward to the appraisal. More detail can be found in Chapter 8 of the SEA.

Table 5.1 Key Environmental Impacts, Mitigation and Opportunities

Key Positive Impacts and Enhancements	Key Negative Impacts	Mitigation
Approach A: Do Nothing		
Potential improvement in bankside and wetland habitats as banks erode and more natural channel forms.	Conflicts with the CFMP.	No funding for mitigation would be available.
	Likely to result in strong objections from public and statutory bodies.	
	Increased flooding of designated sites (heritage, ecological) and assets (e.g. recreational sites).	
More natural channel morphology and aquatic environment would develop over time.	Health and safety hazards associated with weir collapse/likely total loss of navigation.	
	Would compound the problems that climate change is expected to bring.	
Approach B1: Do Minimum (no asset replacement)		
In the long term, impacts (both positive and negative) would be the same as for Strategy A. However they would take longer to materialise, as assets would be maintained until they reach the end of their life.		
Approach B2: Asset Replacement (AR)		
	Conflicts with the CFMP.	No funding for mitigation would be available.
	Likely to result in objections from public and local groups.	
	Increased flooding of designated sites (heritage, ecological) and assets (e.g. recreational sites) over time due to climate change.	
	Would not assist in reducing or alleviating the problems that climate change is expected to bring.	
Approach C: Flood Plain Management (FPM)		
Possible reduced level of flooding to people and built assets (e.g. heritage sites) as and where protected by community measures.	No change in flood risk, over Asset Replacement, to the natural environment and key infrastructure such as roads.	
Complies with the CFMP aim to “reduce the risk” and with ‘Making Space for Water’ guidance.	The effectiveness of this strategy would be to decrease the rate of increase of future flood risk, as well as moderate existing risk in the long term.	
Approach D2: Flood Plain Management (FPM) + Channels 1, 2 and 3		
Significantly reduced level of flooding to people.	Temporary disturbance to people and wildlife (terrestrial and aquatic) during construction of the channels.	Best practice construction methods, good communications and public relations.
Reduction of flooding to the natural environment, including reduction in flooding to designated sites such as SPA lakes and heritage sites.	Potential adverse impact on aquatic species, fish passage, possible impacts from spread of invasive species.	Careful design of channels to ensure that they are appropriate for fish movement and do not result in spread of invasive species.
Significant new recreation opportunities associated with the diversion channels.	Impacts on recreation activities in existing gravel pits such as angling and sailing, though these are largely manageable or can be compensated for elsewhere.	Use of bunds to minimise impacts on existing lakes and lake users. Bunds offer opportunities to create new habitats such as reedbeds on the lake side, locally lowering the lake depths, as well as new recreational facilities.
Complies with the CFMP aim to “reduce the risk” and Making Space for Water guidance.	Change in water quality of still waters due to input of more nutrient rich Thames water.	Additional surveys to further clarify impacts and allow appropriate mitigation to be developed.

Key Positive Impacts and Enhancements	Key Negative Impacts	Mitigation
Creation of extensive new areas of BAP habitat (40-60ha) along the diversion channel routes.	Long term impacts on Southwest London Waterbodies SPA and Thorpe Hay Meadow SSSI, including potential direct loss of the south-east portion of the SSSI.	Mitigation required to the SPA will be developed as part of project level Habitat Regulations Assessments. Opportunity to work with NE and RSPB to improve the long term management of the SPA. Mitigation opportunities on other waterbodies in the area. Mitigation required for loss of part of SSSI through Regional BAP Habitat Creation Programme.
Health benefits due to reduced risk of flooding, including reduced anxiety and risk of injury or death.	Need to manage flow regime to ensure no impact on drinking water abstraction points.	To minimise impacts on abstractions, it is likely that there would be no constant flow through the channels, rather they would become a stillwater extension of the lakes for most of the year.
Long term opportunity to enhance the landscape with new planting and sensitive design.	Loss of habitats in the line of the diversion channel and potential disturbance to protected species.	Creation of BAP habitat in association with the diversion channels e.g. reedbed.
	The potential permanent loss of archaeological sites.	Avoidance or excavation leading to preservation by record.

5.3 Social and Community Impacts

5.3.1 Approach D2 offers the greatest social benefits of all approaches, providing significant reductions in flood risk to the majority of properties in Reach 3 (between Datchet and Shepperton) and improving flood management overall. Flood risk would reduce for around 15,000 properties in Reach 3 (25,000 or more allowing for future climate change impacts) and over 35,000 people. In addition, it would target the most at risk properties remaining with various community based measures. It would reduce the health impacts associated with flooding, including risk of loss of life, as well as the risks of being hit by debris, waterborne diseases and people living in damp houses. It would also reduce the levels of worry and anxiety experienced by locals when there is heavy rainfall or forecast flooding. The diversion channels require considerable land take, much of which is through areas of landfill and open water. However there will be impacts on private property, including an area of Crown Estate land and two or three private residences.

5.3.2 Approach C would help to reduce the consequences of flooding, but there would still be significant numbers of properties and people at risk, with residual health risks. Approaches A and B would have adverse social and community effects as the level of flood risk would increase. Approaches A and B would have particularly severe community impacts due to the likely loss of navigation on the Thames, and potential collapse of river banks, posing a hazard to riverside property, infrastructure and community/recreational facilities. Approaches A, B and C would involve no direct loss of private property, though under A and B1 this could happen indirectly.

5.4 Option Costs

Introduction

5.4.1 Cost estimates have been prepared (see Appendix H for details) for the range of approaches discussed in Chapter 4. The base date used for cost (and benefit) estimation in this report is end-March 2009. A cost optimism bias has been applied to the baseline cost estimates (see 5.4.12 below)

5.4.2 A range of options for diversion channel size have been assessed (hydraulically, costs, benefits, economics, environmental implications) to evaluate their advantages and

disadvantages, and a 150m^3/s capacity for each of channels 1, 2 and 3 concluded as the near 'optimum' size as summarised under economic appraisal in Section 5.5 (and Appendix K). This 150m^3/s channel would provide a minimum of a 5% AEP standard of protection for over 95% of all properties. As part of the optimisation process, other channel capacities have been appraised ranging from 70m^3/s to 280m^3/s.

Costs of Do Minimum and Asset Replacement Approaches

5.4.3 For Do Minimum approaches the Thames' weirs and gates would continue to operate for both navigation and flood control. The operation, maintenance and replacement costs of the eight weir complexes in Reaches 3 and 4 were estimated from costs prepared under the Thames Weirs Investment Strategy Study (TWISS, 2004). These have been progressively updated during subsequent phases of this study to 2009 costs.

5.4.4 The Do Minimum without asset replacement (2009) cost for Reach 3 has been estimated as approximately £199k per annum, and the Asset Replacement cost at £361k per annum. The three weir complexes at Sunbury, Molesey and Teddington in Reach 4 are larger structures than those in Reach 3. Their combined costs in Reach 4 have therefore been taken as equivalent to the five weir complexes in Reach 3. This gives overall annual costs for the Lower Thames Study Area as double those for Reach 3 only; this totals £399k and £721k per annum for Do Minimum and Asset Replacement (AR) respectively (all prior to addition of cost optimism bias).

5.4.5 The above costs are based on a 30:70 division of total costs between FRM and 'other' (e.g. Navigation) functions respectively. The current TWISS will provide a refined estimation and opportunity to review the division of costs during the PAR/outline design stage for Lower Thames. A doubling (or more) of the baseline (without bias) do-minimum costs for FRM (say from £721k to £1.9m) would not alter the economic conclusions reached in this report, and details are discussed in Appendix K.

Costs of Flood Plain Management Option

Costs of Non-Structural Measures

5.4.6 These are incremental to current costs. Costs incurred for emergency services have been included as a percentage of direct damages in the economic appraisal. Incremental costs: (i) for public awareness would be small and have been taken as zero; (ii) for intensified development control activities would be institutional, assumed to be a full time officer at a cost of some £45k per year; and (iii) to double flood warning effectiveness have been taken as 50% of current costs or around £37k per annum. The total incremental costs to intensify current non-structural activities have therefore been estimated (without optimism bias) to be approximately £80k per year through to 2030.

Costs of Managing/Implementing a FPM Option

5.4.7 These would cover planning and management activities and institutional arrangements including: (i) principally a full-time PM with access to a wide range of internal specialists; (ii) support from consultants to help promote strategy, undertake social surveys and FPM tool development, plan and design community based defence schemes; and (iii) setting up and implementing a strategy monitoring and evaluation programme. Set up costs would be incurred (see Appendix H: Cost Breakdown) in two four-year stages: (a) from 2010 to 2013 to plan and roll-out non-structural measures and FPM tools and undertake pilot community programmes; and (b) 2014 to 2017 for application of non-structural measures and FPM tools, and undertaking main programmes for community based measures; at a total cash cost (without optimism bias) for both stages of £4.1m.

Costs for Community Based Measures

5.4.8 These include flood defences for groups of properties and individual property flood proofing. Based on sample designs in Appendix K (Technical Report, TR_Appendix G2) the average investment costs for defences are estimated at £16,000 per property with O&M costs of £55 per property per year. Average costs for individual property flood proofing are estimated at £9,900 per property with recurrent annual costs for maintenance of £190 per property. A programme for implementation (Appendix J) envisages pilot programmes for up to 500 properties throughout Reaches 3 and 4 during 2012, followed by a main programme between 2014 to 2017 to give a total of 1,600 properties receiving flood defence measures at an estimated baseline investment cost of £19.1m and a recurrent annual cost of £231k after full development (both prior to inclusion of optimism bias).

5.4.9 Cost optimism bias is added to the above sums in assessing total costs below (5.4.12)

Total Costs for Flood Plain Management Option

5.4.10 The planned combined costs for the Flood Plain Management (FPM) option, above those for Asset Replacement (AR), are summarised in Table 5.2 below (including optimism bias). This shows non-structural and management measures (non-capital) and community based measures (capital) costs for the period 2010 to 2014 and beyond to 2029 and then 2110 (from values in Appendix H, Table H26).

Table 5.2 Total Present Value Costs (£million) for FPM Option

Present Value Costs (£m)	2010 - 2014	2015 - 2029	2030 - 2110	TOTAL
Capital	11.68	12.01	0	23.69
Non-Capital	3.96	6.00	5.14	15.10
Total PV Costs	**15.64**	**18.01**	**5.14**	**38.79**

5.4.11 The total cash costs of the FPM Option divided into expected capital (defences), non-capital (management and maintenance) and grant aid (individual property measures) budgets are summarised in Table 5.3 below (from values in Appendix H, Tables H1-H4).

Table 5.3 Cash Costs (£million) of FPM Option Component Stages 1 and 2

Cash Cost Category	Cash Cost (£m)			Total Cash Cost (£m)
	FPM Stage 1 2010 - 2013	FPM Stage 2 2014 - 2017	Post FPM 2018 - 2110	
Capital	2.40	10.56	0	12.96
Non-Capital	3.58	3.52	34.19	41.28
Grant Aid	5.94	9.8	0	15.74
Total Cash Cost	**11.92**	**23.88**	**34.19**	**69.98**

Derivation of Capital Works Costs

5.4.12 Cost estimates have been based on outline engineering designs and unit rates from four sources, updated as necessary using the UK Department for Business Enterprise and Regulatory Reform (BERR ex DTI) and Langdon-Everest construction cost indices. Allowances have been made of 5% for minor and 20% for general items and contingencies. A cost optimism bias of 50% has then been added to give total costs.

Costs of Special Capital Works Elements

5.4.13 Four special capital works elements are detailed in Appendix H (before adding cost bias) as: (i) large scale re-profiling works throughout Reaches 3 and 4 (Table H15) which, based on discussions with a commercial company, would have unit baseline costs of £50.4/m^3; (ii) separation and protection embankments between diversion channels and SPA and other relevant lakes, at a baseline cost of £3.6m with annual maintenance costs of £70,000 (Table H10); (iii) land-fill removal to construct diversion channels comprising 470-550,000m^3 of cover and landfill material at an estimated baseline cost for disposal of £40.5m (Table H9); and (iv) costs for land acquisition, land compensation (due to long-term restriction on use) and compensation for forgone opportunity to fill, estimated at £6.5m, £3.75m and £10.8m respectively (Tables H12-H14)

Major Costs Other than Capital Works Construction

5.4.14 Major baseline costs other than those for capital works are allowed for in Appendix H for the following elements (Table H15) prior to adding cost bias in Table H19: (i) relocation of services totalling £8.7m equivalent to 12% of all engineering works; (ii) landscaping estimated at 5% of all engineering costs totalling £3.62m; (iii) PAR/feasibility studies including all physical surveys (topo, soil, SI, groundwater, social, exploration of landfill, testing), PA and PI with all EA staff costs at 7.25% of total costs or £12.36m (iv) management, detailed design and supervision of construction at 8.5% of all engineering works totalling £6.15m; (v) diversion of Staines-Walton link main at a cost of £1.4m; (vi) archaeological monitoring/exploration during construction, totalling £1.64m; (vii) compensation for loss of fish habitats totalling £1m; and (viii) environmental compensation and mitigation measures including those for the SPA at a cost of £7.3m or 10% of engineering works.

Capital Costs of Downstream Compensation/Betterment Works

5.4.15 A number of options were considered to provide compensation for the effects of diversion channels in Reach 3, satisfy PPS25 needs and ensure some reduction in flood risk throughout Reach 4. All options involving dredging of the Thames are currently deemed unacceptable. However, the possible de-silting of shoals in Reach 4 is dependent on the findings of future environmental surveys. The most costly structural option has been adopted at this stage at an estimated baseline cost (prior to ptimism bias) of £8.75m.

Table 5.4 Present Value Capital / Non-Capital Costs (£m) for Different Size Channels

Approach Component	Option for Channel Size					
	70 m^3/s	90 m^3/s	150 m^3/s	190 m^3/s	250 m^3/s	280 m^3/s
D2 Capital (£m)	172.2	193.1	239.1	378.4	490.5	745.2
D2 Non-Capital (£m)	48.3	54.2	49.6	109.2	190.0	325.7

Costs of Diversion Channels of Different Sizes

5.4.16 Comparative costs for the economic appraisal (Section 5.5 below) have been estimated for a range of diversion channel sizes in Reach 3, ranging from 70m^3/s to 280m^3/s capacity. The capital and non-capital costs for this range of channel size options, for Approach D2 incorporating the corresponding downstream betterment and compensation works, are presented in Table 5.4 (including optimism bias). For the comparative channel sizing exercise (see paragraph 5.5.17) these costs have all been discounted, for a 100 year scheme life, to the channel construction start date. The costs of the two smaller channel sizes in Table 5.4 reflect design and operation issues (see 4.4.9). The costs of the larger channel sizes, which rise more quickly, reflect physical constraints that lead to the need for far more extensive River Thames deepening and

widening works plus river bank and structure protection (see 4.4.10). Costs here are for Reach 3 only, from the planned construction start date of 2019.

Costs of Strategy Approaches

5.4.17 Table 5.5 provides summary total costs including 50% cost optimism bias (see Appendix H) for the five strategy approaches described above, expressed as present value costs. These have been compiled from the component costs discussed in preceding sections, but are cumulative costs such that the intervention strategies incorporate costs for the Asset Replacement (AR) approach. Strategy D2 is based on construction of 150m^3/s capacity channels (see 5.4.2), together with FPM, across both Reaches 3 and 4. Detailed breakdowns of these costs are given in Appendix H.

5.4.18 Three cost periods are shown in Table 5.5. These principally relate to cost elements for strategy approach D2 viz; (i) the short-term from 2010-2014 when there would be a balance between non-capital costs for planning, managing and designing components, and capital investment in pilot works for community measures; (ii) the medium-term from 2015-2029 which would include capital costs for main programmes for community measures, but would be dominated by investment in diversion channels and downstream betterment and compensation works; and (iii) the long-term from 2030-2110 dominated by recurrent costs to maintain the strategy.

Table 5.5 Summary of Present Value Costs for Strategy Approaches

Element	Strategy Approach Costs (£m)				
	Do Nothing	Do Minimum	Asset Replacement	Flood Plain Management	Strategy D2
Years 2010-2014 inclusive (short term, first 5 years)					
Capital	0	0.00	1.78	13.46	13.46
Non-Capital	0	2.20	2.20	6.15	6.15
Sub-Total	0	2.20	3.98	19.61	19.61
Years 2015-2029 inclusive (medium term, 6-20 years)					
Capital	0	0.00	3.13	15.14	181.49
Non-Capital	0	3.62	3.87	9.87	17.78
Sub-Total	0	3.62	7.00	25.01	199.27
Years 2030-2109 inclusive (long term, 21-100 years)					
Capital	0	0.00	5.01	5.01	5.01
Non-Capital	0	2.09	5.52	10.66	32.54
Sub-Total	0	2.09	10.53	15.67	37.55
TOTAL (PV)	0	7.91	21.50	60.28	256.43

5.5 Option Benefits (Damages Avoided)

Introduction

5.5.1 The benefit assessment is discussed further in the Technical Report (Appendix K) and is set out in detail in Appendix G.

5.5.2 The two flood cells on the lower Thames (Reach 3 and Reach 4) fall within Land Use Band A (as defined in Table 6.2 of the FCDPAG3 document), and have an indicative standard of between 2.0% - 0.5% AEP (1 in 50 to 1 in 200 year) events.

5.5.3 A ‘precautionary’ approach for sea level rise is prescribed within the 2006 FCDPAG supplementary note on climate change. However, the document advocates that such an

approach can, and indeed should, be adopted in special circumstances for other climate change impacts. This use of a 'precautionary' approach in 'special' cases is targeted at large "one-off" interventions that cannot be easily modified in the future and where other multiple interventions or options are not available. In this case construction needs to lead to "no regrets" over the decisions taken during the project appraisal.

5.5.4 The adoption of a 'precautionary' approach within this strategy is considered appropriate, bearing in mind the major investment required for the proposed diversion channels. These are each major one-off interventions that cannot be cost effectively adapted (e.g. widened) after construction. There is very little scope to further alter the already flat hydraulic profile afterwards (say raising flood banks), as the channels would be excavated to bring flood water back below ground level and the structures will all be heavily drowned (as will the Thames sluices) under the design flow.

5.5.5 The results of the TE2100 analysis of climate change in the Thames catchment is summarised in Appendix K: Technical Report, Section 7. This suggests that climate change impacts on peak flood flows could in fact exceed the preceding (FCDPAG) national guidance, though TE2100 have adopted the latter as their 'Base Case' scenario. The TE2100 findings thus strongly support the decision to adopt a 'precautionary' approach for the Lower Thames Strategy. In carrying out the economic appraisal, we have therefore evaluated options and Strategies against three scenarios with a range of climate change allowances (in terms of flood flow) as follows:

- 'Baseline' scenario - no climate change' (present day hydrology);
- 'FCDPAG Climate Change' scenario (+10% now, rising to 20% from 2055 on);
- 'TE2100 Climate Change' scenario (+16% now, rising to 40% from 2085 on).

Methodology

5.5.6 Flood damages have been calculated, across a range of flood event frequencies for each option or strategy appraised, for the three scenarios set out above using the Multi Coloured Manual (MCM) (Middlesex Flood Hazard Research Centre (FHRC) 2003) and the Green Book (HM Treasury, 2003). These documents have been used in combination with the Defra FCDPAG series and Supplementary Guidance Notes (Defra: March 2003, July 2004 and October 2006). The analysis has been based on that required for a 'full scale project appraisal' as defined in the MCM.

5.5.7 Figures in the Multi Coloured Manual have been updated, as for the costs, to end-March 2009 prices using the Consumer Price Index (CPI). The 'baseline' for economic appraisal is the Do Nothing approach (Section 3.2).

5.5.8 Property information was derived from the National Property Dataset updated in 2008 (NPD 2008).

5.5.9 In the strategy economics capping of the damages has negligible effect, as a test on this for the Do Nothing approach showed less than 0.5% effect on resulting flood event damages. This is partly because flood depths for properties in the lower Thames are relatively shallow (due to the wide expanse of flood plain and the large control gates at all the locks along the river) but also as a consequence of the relatively low number of properties with a high frequency of flooding.

5.5.10 Taking account of the MCM and other appraisal guidance wherever relevant and after review with Environment Agency economic advisors and NRG members, FHRC and

other team members have assessed and incorporated the following components in the damages:

- MCM direct damage assessment: carried out for flooding of more than 12 hours through the FHRC ESTDAM model (Appendix G3);
- Flood warning reduction: an 8.5% reduction on the MCM damage value;
- Local Traffic related costs: a 17.2% addition to the MCM damage value, based on a an allowance for increased traffic volumes of 5% per annum compounded since the factor was assessed, though only for local road systems and not the motorways, at 7.5% in 1992 (Appendix G4);
- Emergency services: a 10.7% addition to the MCM direct damages (MCM, pp 131, FHRC 2003);
- 'Extra long duration flooding' (ELDF): a variable MCM uplift factor based on expert detailed review of flood durations and the related susceptibility of building fabric components to flood duration (Appendix G5);
- 'London' factor: a 10% addition to the MCM plus ELDF damage values to represent higher repair costs/wages in the London area (Appendix G6);
- Motorway closure costs: related to potential closure or gridlock of the three adjacent motorways (M4/M25/M3), based on costs assessed by FHRC for the M5 in the summer 2007 floods (Appendix G7);
- Evacuation costs: separate detailed calculation of evacuation costs based on expert knowledge, flood evidence and latest best practice (Appendix G8).

5.5.11 In addition to the components included in the event damage analysis as listed above, a separate allowance has been added to option benefits (Appendix G1) for the aspects listed below, with reference to the NRG Annex Report (Appendix G2) from the end of LTS Phase 3. It is noted that though Heathrow is not directly impacted by flooding from the Thames, and while this has not been explicitly included at present, there would be potential for significant indirect impacts based on the motorway closure impacts noted above causing gridlock on the approaches to the airport.

- Intangible losses, related to stress and bad health, updated from NRG Annex using Phase 4 MCM damages (ref. Defra FCDPAG3: Revisions to Economic Appraisal: Human Related Intangible Impacts of Flooding: July 2004);
- Local Chertsey Bourne flood benefits: through modelling of local flood events from Thorpe Park through Chertsey due to high flows purely on the Chertsey Bourne, but making allowance for the probability of combined Thames and Chertsey Bourne events;
- Service disruption costs: using the conservative estimate from the NRG Annex Report, this valuation was based upon a value of £500 per household affected under significant flood events - no further analysis has been undertaken as this is a minor addition;
- Loss of life: using the conservative estimate from the NRG Annex Report, this valuation was based upon likelihood of fatalities in accordance with the May 2008 Defra guidance, using a value of £1.3m per fatality - no further analysis has been undertaken as this is a minor addition;
- Environmental losses: using the conservative estimate from the the NRG Annex Report, based on a review of environmental gains and losses and using previous published guidance and the latest draft Economic Valuation of Environmental Effects Handbook - no further analysis has been undertaken as this is a minor addition.

5.5.12 The addition of the above components into the benefit assessment results in some 66% of the total benefits of Strategy D2 (over AR) being due to the calculated direct damages (including allowance for flood warning, emergency services and local traffic related costs). The remaining 34% is largely provided by ELDF (9%), evacuation (13%) and intangible (7%) benefits. Local Chertsey Bourne flooding, loss of life and service disruption each provide a further 1.5-2.0% of the overall benefits, with minor additions of less than 0.1-0.2% each from reduced environmental losses and motorway closures.

Table 5.6 FPM Approach Benefits

FPM Approach Component	Benefits in terms of Flood Risk Reduction Achieved
Community Based Measures • Defences for small groups of properties • Individual property protection	**Reduce existing flood risk through local defences and individual property protection** Local defences for up to an estimated 540 houses in Reach 4: Av. annual benefit per property (increment over Asset Replacement 'AR', providing target minimum 75 year SoP) = £1,030 Individual property protection to an estimated 700 houses in Reach 3 and at least 360 in Reach 4, to target minimum 75 year SoP: Av. annual benefit per property (increment over 'AR') = £930
Enhanced FPM Activities • Intensify current non-structural measures • Develop and implement FPM tools (i.e. GIS data sets) • Safeguarding flood flow routes and corridors for future diversion channels	**Reduce existing flood risk through more stringent and intensive non-structural measures, using FPM tools** Enhanced public safety is not quantified here in terms of its monetary benefits (though see Section 5.5 and Appendix G, regarding an allowance for potential 'loss of life') Reduced flood losses from enhanced public awareness, with flood action plans drafted, flood forecasting and warning and emergency response planning, giving some 10-20% additional damage reduction or £2.6m per year (£76.6m PV long-term)
	Reduce future growth in flood risk through developing and implement FPM tools Reduced flood losses from enhanced response (e.g. evidence base for development control and building regs strengthened) to development proposals and approach to land use planning, giving some 40-50% reduction in future growth in flood risk, or £340k per year (£10m PV long-term)
Strategic Measures • Develop strategic storage in key tributaries • Land use planning and regulation in upstream catchment • Thames Barrier operation	**Reduce existing flood risk through developing strategic storage upstream and the operation of the Thames Barrier** Promote the inclusion of strategic storage on key tributaries, where justified by local benefits, to give some additional reduction in flood risk the lower Thames Operate the Thames Barrier to relieve flooding to high risk properties above Teddington Lock, when appropriate to do so and when not constrained in the longer term by tidal defence operational needs for central London
	Reduce future growth in flood risk In upstream catchment both control and regulate development proposals and land use planning, and minimise runoff volumes

Flood Plain Management (FPM) Benefits

5.5.13 The average annual benefits related to the three main FPM components are summarised in Table 5.6, for the 'Baseline' scenario, and long-term present value (PV) benefits are given for enhanced FPM activities. These are described and quantified in more detail in the Technical Report (Appendix K), with the detailed economic appraisal in Appendix G.

Economic Appraisal

Introduction and Flood Cells

5.5.14 An economic appraisal period of 100 years has been used. This analysis has been undertaken using the Flood and Coastal Defence Project Appraisal Guidance (FCDPAG3) as described in the methodology above. This is set out in more detail in the Technical Report (Appendix K) and full economic appraisal (Appendix G).

5.5.15 Based on Treasury guidelines (The Green Book – Appraisal and Evaluation in Central Government), an initial discount rate of 3.5% has been used for the assessment of all present value (PV) benefits and costs for Years 0 to 30, reducing to a rate of 3.0% for Years 31 to 75 and a rate of 2.5% thereafter (Appendix G).

5.5.16 Two flood cells have been identified within the Study Area, Reach 3 and Reach 4. Given that FPM components throughout the area form the key initial strategy activities, Reaches 3 and 4 have been assessed together. Diversion channel options alone have been assessed just within Reach 3 as summarised in 'Table 5.7 Evaluation of Flood Risk Management Options' (appended), as further discussed in the Technical Report (Appendix K).

Optimum Size of Diversion Channels

5.5.17 The economic appraisal has optimised the size of diversion channels where a range of sizes have been evaluated as set out in Section 5.4. The 'optimum' size has been assessed by varying all three channels together, based on Option D2. Since benefits for each size are for comparative purposes, they have all been assessed for Reach 3 only and measured from the start date of Channel 1 construction. In contrast, strategies (evaluated later) are all assessed from a 2009 base date for Reaches 3 and 4 together.

5.5.18 For the 'Baseline' scenario, diversion channels are robustly economic within a strategy as shown in Table 5.8, for channel capacities at least up to 150m^3/s capacity. For this size of channel 'Av. BCR' and IBCR are at least approximately 5.2 and 2.24 respectively. Beyond this, the incremental benefit-cost ratios (IBCRs) over predecessor channel sizes drop below 1.0, with overall 'Av. BCRs' below the ideal target of 5.0. The IBCR for the optimum channel size (150m^3/s) against AR also shows that it is still economically robust as an option.

Table 5.8 'Baseline - no climate change' Economics for Option D2 Channel Sizes

Option D2 Channel size	70 m^3/s	90 m^3/s	150 m^3/s	190 m^3/s	250 m^3/s	280 m^3/s
Total PV Costs (£m)	**221**	**247**	**289**	**488**	**681**	**1071**
Total PV benefits (£m)	**1376**	**1408**	**1501**	**1559**	**1613**	**1659**
NPV (£m)	**1155**	**1161**	**1212**	**1072**	**932**	**588**
Av. BCR	**6.2**	**5.7**	**5.2**	**3.2**	**2.4**	**1.5**
IBCR to 'Asset Replacement'	**1.89**	**1.81**	**1.87**	**1.21**	**0.94**	**0.64**
IBCR to 'predecessor'	**-**	**1.20**	**2.24**	**0.29**	**0.28**	**0.12**

Note: Channel comparison exercise here is for Reach 3 only, from planned construction start date of 2019

5.5.19 The incremental flow of 150m^3/s over and above the bank-full capacity of the Thames, broadly corresponds with a 5% AEP (1 in 20 year) flood flow. This also corresponds with the threshold at which significant residual flood risk commences in Reach 3. It is noted that capacities in the channels can vary along their lengths, especially where Channel 3 splits into two paths. Modelling work for these channels is summarised in the Technical Report (Appendix K), with the option economics in Appendix G.

5.5.20 Results are very sensitive to climate change, with economic outcomes becoming far more positive and more than double under 'FCDPAG Climate Change' scenario. Table 5.9 below shows the 'Av BCR' to be robust at between 4.2 and 17 for all channel sizes. The IBCR over Asset Replacement peaks at the 150m^3/s size and remains strong, while over predecessor the IBCR becomes weak beyond a 150m^3/s capacity.

Table 5.9 'FCDPAG Climate Change' Economics for Option D2 Channel Sizes

Option D2 Channel size	70 m^3/s	90 m^3/s	150 m^3/s	190 m^3/s	250 m^3/s	280 m^3/s
Total PV Costs (£m)	221	247	**289**	488	681	1071
Total PV benefits (£m)	3779	3860	**4092**	4240	4374	4490
NPV (£m)	3558	3613	**3804**	3752	3693	3419
Av. BCR	17.1	15.6	**14.2**	8.7	6.4	4.2
IBCR to 'Asset Replacement'	4.32	4.17	**4.39**	2.87	2.24	1.53
IBCR to 'predecessor'	-	3.02	**5.63**	0.74	0.70	0.30

Note: Channel comparison exercise here is for Reach 3 only, from planned construction start date of 2019

5.5.21 Based on Table 5.9 and the 'precautionary' approach outlined above, an economic case could be postulated for channels up to 150m^3/s capacity and a little beyond, becoming restricted for the larger channel options due to the significant accompanying river works that become required. Based on the findings from the SEA (Appendix N) these larger options were also rejected due to unacceptable environmental and social impacts.

5.5.22 Table 5.10 indicates that strong economic results for the preferred channel size from above using the (higher) 'TE2100 Climate Change' scenario suggest a case to maximise the channel sizes as far as possible to formulate the most sustainable flood risk management solution.

Table 5.10 'TE2100 Climate Change' Economics for Preferred Option D2 Channel Size

Option D2 Channel size	150 m^3/s
Total PV Costs (£m)	**289**
Total PV benefits (£m)	**6684**
NPV (£m)	**6395**
Av. BCR	**23.2**
IBCR to 'Asset Replacement'	**8.98**

Note: Tabulation is for Reach 3 only, from planned construction start date of 2019

Standard of Protection and Property Flood Risk Reduction from 150 m^3/s Channels

5.5.23 The present standard of protection in the lower Thames is variable due to there being no formal flood defences. This variability would not change on completion of diversion channels, as these would simply shift the range of standards of property protection to improved flood risk bands as indicated for Reach 3 in the pie charts in Figure 5.2. The diversion channels move almost 90% of the 5,280 properties at very significant flood risk to a lower band, while those with at least a significant risk reduce from 10,670 (Table 3.1) to about 2,780 (further details in Appendix K, Section 7.4.2).

5.5.24 The 90% exceeded standard of protection, for all Reach 3 properties currently within 'moderate' flood risk (>0.5% AEP or 1 in 200 year) would shift from 1 in 12 years to 1 in

50 years for the 'Baseline' scenario, and (for those with >1% AEP under climate change) from 1 in 6 years to 1 in 40 years under the 'FCDPAG Climate Change' scenario.

Overall Damages and Strategy Benefits Taken Forward to Final Appraisal

5.5.25 The benefits of options combined for Reaches 3 and 4, from a 2009 base date and taken forward to appraisal in Section 6.1, are summarised in Tables 5.11, 5.12 and 5.13 for all three scenarios. The build up of these benefits is described above (5.5.12). Strategy D2 assumes that diversion channels would be of 150m^3/s design capacity.

Table 5.11 Present Value (PV) Damages and Benefits (£m) - 'Baseline' scenario

Strategy Approach	Damage (PVd)	Damage Avoided	FPM and Additional Benefits	Total Benefits (PVb)
Strategy A - 'Do Nothing'	2034	0	0	0
Strategy B1 - 'Do Minimum'	1142	892	0	892
Strategy B2 - 'Asset Replacement'	856	1179	0	1179
Strategy C - 'Flood Plain Management' (FPM)	856	1179	145	1324
Strategy D2 - Flood Channels 1, 2 and 3	535	1499	153	1652

Table 5.12 Present Value (PV) Damages and Benefits (£k) - 'FCDPAG Climate Change'

Strategy Approach	Damage (PVd)	Damage Avoided	FPM and Additional Benefits	Total Benefits (PVb)
Strategy A - 'Do Nothing'	3924	0	0	0
Strategy B1 - 'Do Minimum'	2275	1649	0	1649
Strategy B2 - 'Asset Replacement'	1766	2158	0	2158
Strategy C - 'Flood Plain Management' (FPM)	1766	2158	253	2411
Strategy D2 - Flood Channels 1, 2 and 3	1058	2866	264	3130

Table 5.13 Present Value (PV) Damages and Benefits (£k) - 'TE2100 Climate Change'

Strategy Approach	Damage (PVd)	Damage Avoided	FPM and Additional Benefits)	Total Benefits (PVb)
Strategy A - 'Do Nothing'	8280	0	0	0
Strategy B1 - 'Do Minimum'	4527	3753	0	3753
Strategy B2 - 'Asset Replacement'	3274	5006	0	5006
Strategy C - 'Flood Plain Management' (FPM)	3274	5006	320	5326
Strategy D2 - Flood Channels 1, 2 and 3	2061	6219	408	6627

Gains or Losses Not Quantified

5.5.26 Assets not accounted for include heritage sites, railway lines, agricultural land, water supply, electricity and damages to the structure of the road infrastructure. These losses would not provide significant further benefits. Also, flood benefits from the downstream compensation works are not quantified above as these are incidental and minor in comparison to benefits from the community based measures or diversion channels.

5.5.27 The introduction of Channel 1 within Strategy D2 would lower flood levels in Windsor and Eton by up to around 0.3m, at Romney Weir, with a reduced residual flood risk in this Reach 2 area as a result. This has been approximated as giving of the order of an additional £1-2m PV benefits, and so will not be significant to the overall LTS economics. It is alsonoted that the reduced levels here would also improve the flood conveyance capacity at Black Pott's viaduct at the downstream end of the Jubilee River diversion channel constructed previously within Reach 2.

6 Selection and Details of the preferred option

6.1 Selecting the Preferred Option

Economic Performance of Options

6.1.1 Tables 6.1 to 6.3 show results for all options in terms of PV costs and benefits at a base date of March 2009, 'Av. BCR' and IBCR ratios, for all scenarios. Strategy D2 includes the FPM Strategy C as a component, and diversion channels of approximately 150m^3/s design capacity. The incremental benefit cost ratio (IBCR) of D2 is shown below over Strategy B2, thus over and above continuing with present flood risk management levels including Asset Replacement (AR), as well as the IBCR over the FPM Strategy C. Under AR some 12,930 properties remain (in 'Baseline' scenario) at significant or higher (> 1.33% AEP) flood risk. Strategy D2 flood channels reduce this down to approximately 5,040 properties. With the CBMs (within FPM component) targeting 1,600 properties with high residual flood risk, the integrated Strategy D2 will potentially shift the 90% exceedance SoP from just above 10 years to over 50 years (see Section 6.4).

Table 6.1 Benefit-Cost Assessment - 'Baseline' scenario

Strategy Approach	PV Costs (£m)	PV Benefits (£m)	'Av. BCR'	IBCR		Option for IBCR Calculation	
Strategy A - 'Do Nothing'	0	0	-	-		-	
Strategy B1 - 'Do Minimum'	8	892	113	-		-	
Strategy B2 - 'Asset Replacement' (AR)	22	1179	55	21		Do Min	
Strategy C - 'Flood Plain Management' (FPM)	60	1324	22	3.74		AR	
Strategy D2 - Flood Channels 1, 2 and 3	256	1652	6.4	2.02	1.67	AR	FPM

Table 6.2 Benefit-Cost Assessment - 'FCDPAG Climate Change' scenario

Strategy Approach	PV Costs (£m)	PV Benefits (£m)	'Av. BCR'	IBCR		Option for IBCR Calculation	
Strategy A - 'Do Nothing'	0	0	-	-		-	
Strategy B1 - 'Do Minimum'	8	1649	209	-		-	
Strategy B2 - 'Asset Replacement' (AR)	22	2158	100	37		Do Min	
Strategy C - 'Flood Plain Management' (FPM)	60	2411	40	6.5		AR	
Strategy D2 - Flood Channels 1, 2 and 3	256	3130	12.2	4.14	3.67	AR	FPM

Table 6.3 Benefit-Cost Assessment - 'TE2100 Climate Change' scenario

Strategy Approach	PV Costs (£m)	PV Benefits (£m)	'Av. BCR'	IBCR		Option for IBCR Calculation	
Strategy A - 'Do Nothing'	0	0	-	-		-	
Strategy B1 - 'Do Minimum'	8	3753	475	-		-	
Strategy B2 - 'Asset Replacement' (AR)	22	5006	233	92		Do Min	
Strategy C - 'Flood Plain Management' (FPM)	60	5327	88	8.3		AR	
Strategy D2 - Flood Channels 1, 2 and 3	256	6627	25.8	6.90	6.63	AR	FPM

6.1.2 The economics and property flood risk numbers are summarised, with more detailed analysis and comparisons between Strategies, in 'Table 6.4 Evaluation of Flood Risk Management Strategies' (appended), as further discussed in the Technical Report (Appendix K). Appraisal details, such as FCDPAG3 spreadsheets, are in Appendix G.

6.1.3 Both the Do Minimum and Asset Replacement strategies are robust in terms of their economic outcomes, with 'Av. BCR' and IBCR of at least 50 and 20 respectively under the 'Baseline' scenario.

6.1.4 Flood plain management measures can reduce the risk of flooding now and reduce build up of flood damage potential in the future. A more stringent and targeted regime would yield estimated incremental annual benefits of £3.15m, worth some £94m in present value terms for Reaches 3 and 4 together. The FPM strategy has a NPV of £1263m, an 'Av. BCR' of 22 and an IBCR over 'Asset Replacement' of 3.74, justifying its intervention beyond present management activities.

6.1.5 Strategy D2 is robust in terms of its economic outcomes under the 'Baseline' scenario with no climate change. The best estimate of optimum channel capacities under current economic and hydrological conditions is $150m^3/s$. For these conditions the 'Av. BCR' and IBCR of D2 are 6.4 and between approximately 1.7 and 2.0 respectively.

6.1.6 Strategy D2 has a strong economic outcome and achieves good reductions in flood risk levels throughout the majority of the Reach 3 flood cell. It is therefore economically viable in terms of current economic indicators. D2 is even more robust under climate change conditions, with an approximate doubling of Av. BCR and IBCRs under 'FCDPAG Climate Change'; to approximately 12 and 4 respectively.

6.1.7 Further discussion of the Strategy economics and option comparison is contained in Chapter 7 of the Technical Report in Appendix K.

6.1.8 For the downstream tidal area from Teddington Weir through Richmond into central London, covered by the Thames Estuary 2100 (TE2100) FRM strategy, a "flood plain management" approach is being proposed with no major new capital works, consistent with Lower Thames Strategy through Reach 4.

Economically Preferred Option

6.1.9 Strategy D2 is the preferred economically qualifying option, taking into account the two flood cells as a whole and the high consequences of flooding throughout Reach 3 in particular. D2 achieves the greatest amount of reduction in flood risk on an equitable basis whilst meeting current economic tests robustly. Major capital investment in Reach 3 would be backed-up by enhanced flood plain management to exploit investment and ensure sustainable management into the future. Flood risk downstream in Reach 4, and high residual flood risk areas in Reach 3, would benefit from community based measures again supported into the future by the non-structural FPM aspects. The approach considered complies with current Operating Instructions and sets out a Joint Action Plan within Appendix K (Technical Report, TR_Appendix G2) after discussions with the LPAs. It is intended to use demountables only where permanent defences are not feasible. Detailed risk assessments for each area will be carried out at PAR stage.

6.1.10 Based on the results of the consultation process, a long-term strategy to implement all three diversion channels, supported by FPM, would be likely to receive strong all round support.

6.1.11 The predicted extent of flooding through Reach 3, with Strategy D2 in place, is shown in Figure 6.1 for events with 5% AEP (1 in 20 year), 1% AEP (1 in 100 year) and 1% AEP with 20% allowance for climate change impacts. Flooding is much reduced in Reach 3 as a result of the diversion channels, though this is more in terms of frequency and depths than overall extents of flood plain.

6.2 Sensitivity Testing

6.2.1 A key sensitivity is future change in the UK climate. While there is much uncertainty over climate change impacts on peak flood flows, these have been studied in great detail for the Thames catchment by TE2100, adding to the existing Defra FCD PAG guidance. Therefore two climate change scenarios have been included in the option appraisal, in addition to a 'Baseline' with no allowance, as described in Section 5.

6.2.2 Further sensitivity tests have been undertaken on the 'Baseline' scenario, to assess strategy robustness, to test residual uncertainties in the analysis, and check sensitivity to cost estimates. These include :

- Uncertainty in level assessment (i.e. property thresholds);
- Recent concerns raised over the assumed flood frequency relationship at Windsor, represented by a shift in flood event probability;
- An increase in the cost optimism bias applied from 50% (calculated) to 60%.

6.2.3 A description of the tests and the assumptions made are summarised in Table 6.5 below, together with the resulting 'Av. BCR' and IBCR (over 'Asset Replacement') for Strategy D2 for Reaches 3 and 4 together.

6.2.4 In all the test cases shown the economics of Strategy D2 worsen as expected, on the basis of the test assumptions used. However, the 'Av. BCR' (assessed above as 6.4) stays close to or above 5 in all cases. Equally the IBCR over 'Asset Replacement' (assessed above as 2.02) stays above 1.5 and so remains robustly above 1 (>1.5).

Table 6.5 Sensitivity Testing of Economics for Strategy D2

<table>
<tr><th rowspan="2">Test No.</th><th rowspan="2">Sensitivity Test - Purpose and Assumptions</th><th colspan="2">Strategy D2 Economics</th></tr>
<tr><th>Av. BCR</th><th>IBCR (>AR)</th></tr>
<tr><td colspan="2">Strategy D2 'Baseline' Scenario Lower Thames Strategy Phase 4 economics</td><td>6.4</td><td>2.02</td></tr>
<tr><td>1</td><td>To address uncertainty in water levels, the damages for high and medium frequency events as modelled have been reduced to the percentage of Phase 4 calculated damages as shown below:
<table>
<tr><td>Event Annual Probability</td><td>20%</td><td>10%</td><td>5%</td><td>2%</td><td>1.3%</td><td>1%</td><td>0.5%</td></tr>
<tr><td>Test case damage as % of Phase 4 economics</td><td>40%</td><td>40%</td><td>70%</td><td>100%</td><td>100%</td><td>100%</td><td>100%</td></tr>
</table></td><td>4.8</td><td>1.81</td></tr>
<tr><td>2</td><td>To address uncertainty in flood flow estimates from Windsor gauge, the damages for modelled flood event frequencies were reduced by amounts equivalent to the shifts in event probability as shown below:
<table>
<tr><td>Event Annual Probability</td><td>20%</td><td>10%</td><td>5%</td><td>2%</td><td>1.3%</td><td>1%</td><td>0.5%</td></tr>
<tr><td>Test case donor event</td><td>20%</td><td>15%</td><td>10%</td><td>2.5%</td><td>2.2%</td><td>2%</td><td>1%</td></tr>
</table></td><td>5.3</td><td>1.56</td></tr>
<tr><td>3</td><td>To address general uncertainty in costs, the cost optimism bias was increased from the calculated 50% to an upper limit 60%.</td><td>6.1</td><td>1.89</td></tr>
</table>

6.3 Details of the Preferred Option

Technical Aspects

6.3.1 A summary of all FRM components and elements of Strategy D2 is given in Table 6.6, which also indicates the scope of each element in terms of whether it is applied just in either Reach 3 or Reach 4, both study reaches, or across the upstream catchment (or downstream at Thames Barrier). The proposed routes of flood diversion Channel 1, and for Channels 2 and 3, are shown in Figures 6.2 and 6.3 respectively (Appendix D).

Table 6.6 Summary of FRM Components and Elements of Strategy D2

COMPONENT	ELEMENT	SCOPE
1. Flood Plain Management		
Non-structural measures	Development of FPM tools; to enable: intensified public awareness programmes; intensified flood warning/emergency response planning; intensified land use planning/development control; and conjunctive planning for fluvial flooding and surface water drainage	R3+R4
Community based measures	Community defences to groups of properties; comprising fixed, temporary and demountable defences targeted at over 500 of the most vulnerable properties	R4
	Individual property protection targeted at over 1000 of the most vulnerable properties	R3+ R4
2. Capital Works Component		
Diversion Channels	Channels 1, 2 and 3 Datchet-Shepperton, including property purchase and land acquisition, excavation of channels, construction of intakes, culverts and other structures, removal of landfill, relocation of services, lake separation embankments, local defences to control residual risks where necessary and ensure no detriment in exceedance events, and landscaping, environmental mitigation and compensation works	R3
Compensation/Betterment Works	Widening of Desborough Cut by 3-4 metres and increased capacity at Sunbury, Molesey and Teddington Weirs (new gates)	R4
3. Thames Weirs	Continued operation/maintenance and asset replacement of weirs	R3+R4
4. Additional Surveys/Studies	Strategy Monitoring and evaluation programmes	R3+R4
	Aquatic Ecology surveys (3 years)	R3+R4
	Water Quality and ecology of gravel pits surveys (3 years)	R3
	Groundwater Survey and Modelling study	R3

Environmental Aspects

6.3.2 Structural projects that arise out of the Lower Thames Strategy will be subject to further environmental assessment, to ensure that environmental implications continue to be taken on board as the Strategy progresses. It is likely that most projects would fall under Schedule 2 part 10 (h) of the Town and Country Planning (Environmental Impact Assessment) Regulations 1999 (as amended), covering projects for inland waterway construction, canalisation and flood relief works. Although no screening has yet taken place, it is likely that Environmental Impact Assessment would be required for the engineered works, due to the sensitivities of the surrounding environment.

6.3.3 The Habitats Regulations Assessment (HRA) of the Strategy concludes that it would not adversely affect the integrity of the Southwest London Waterbodies SPA, due to the

imposition of conditions or restrictions on the way the Strategy is to be implemented that would minimise the risk of any adverse effects on the integrity of the site. The HRA outlines a framework for developing mitigation, which has been agreed with Natural England as adequate to ensure that no unacceptable impacts will occur from projects resulting from the Strategy. Projects arising out of the Strategy will need to undergo project level assessments, which would preferably establish that there is no likely significant effect. If there are possible significant effects, mitigation measures will need to be developed to ensure that there is no adverse effect on site integrity (alone or in combination), as required under the Habitats Regulations. There are many opportunities for this on the numerous SPA lakes, relevant lakes and other waterbodies present in the area. Natural England's letter of support to this approach can be found in Appendix O.

6.3.4 The Strategy will comply with the Water Framework Directive (WFD) as it has potential impacts in relation to WFD waterbodies. Inputs of water from the River Thames could change the quality of the water in gravel pits (artificial waterbodies), and until we have done further monitoring of the existing condition of the lakes, we cannot be sure that there will be no deterioration in their quality. There is also the potential for physical impacts, as some of the lakes will have different boundaries in the future, as they will be connected to a wider diversion channel. The Lower Thames Strategy has been noted in the current cycle of River Basin Planning, as having a potential impact on waterbodies in the area. We will need to work to develop all practical mitigation measures for any adverse impacts on the gravel pits that are identified. Where adverse impacts are identified it is possible that a derogation, in compliance with the WFD, under article 4(7), would be needed. Impacts on the River Thames (a heavily modified waterbody) will also need to be considered, assessed, and mitigated as appropriate; however the likelihood of long term impacts or the need for a derogation is considered to be less. An initial assessment with regards to the WFD is presented in Appendix N3.

6.3.5 A summary of the key impacts and proposed mitigation is provided in Table 6.77 below. Most of these relate to the construction of diversion channels and works in Reach 4. Environmental impacts of other parts of the Strategy are relatively limited.

6.3.6 In addition to the measures identified above, it is anticipated that the diversion channel corridors will include significant environmental enhancements. The channels should also provide a new recreational resource for the area, where agreement with riparian owners allows, with footpaths and other facilities where appropriate and provision for activities such as angling. It is possible that the channels could be used by small craft such as canoes, although the frequency of structures would hinder larger vessels.

6.3.7 The Study Area has a legacy of minerals working, and several areas are noted to be degraded in Local Planning documents. The channels therefore offer a mechanism for provision of landscape enhancements on the wider scale, with new planting and watercourse features. The channels will also offer extensive opportunities for new habitat creation, particularly BAP habitat. We are hoping to create BAP habitat in areas supporting wetland or wet woodland, in severed parcels of land adjacent to the channel, and along the new bunds across lakes (on the lakeward site). We anticipate that it will be possible to create at least 40ha of BAP habitat, and aspire to increasing this to some 60ha as further areas are identified as the design progresses. Some of this may be mitigation for areas of habitat to be lost. However until full surveys are carried out to characterise the existing ecological value of the area, the extent of enhancement compared to mitigation remains uncertain.

6.3.8 Consultation comments have tended to relate to concerns about local issues such as people not wanting new footpaths close to their land, maintenance of local streams and about potential downstream effects.

Table 6.7 Summary of Key Impacts and Mitigation Measures

Key Impact	Mitigation Measures
Disruption during construction	Good practice working methods, exclusion of public from working areas, alternative access routes, phasing of works
Visual impact of diversion channels	High quality landscaping design and planting scheme. Channels designed to be natural looking where possible and with geomorphological design considerations taken into account
New water areas attract birds of concern to BAA	Channels to be designed in accordance with BAA guidance to ensure they do not increase the numbers of large flocking birds in the area. Ongoing consultation
Potential decline in water quality in lakes, associated with mixing Thames and lake water	Bunding of channel from existing lakes, further studies in relation to water quality and conditions (e.g. macrophyte cover) in existing lakes, to determine the likely impacts on biodiversity and requirement for further mitigation
Loss of private property	Negotiation with landowner, provision of alternative facilities, financial compensation (as appropriate depending on individual circumstances
Disposal of spoil from excavated channels, including potentially contaminated material	Identification of areas where soil can be re-used on site, with treatment if necessary (for inert and non-hazardous material). It is intended that only hazardous waste would be transported off site, and this would be disposed of in an appropriately licensed landfill site
Potential contamination from excavation close to landfill sites	Appropriate controls during construction, and design of channels to include lining or other appropriate measures to make the channel waterproof and prevent leachate of contaminants into the watercourse
Potential reduction of water flows in the River Thames, with impacts on abstraction	It is currently proposed to have no constant flow in the channels, and this would mitigate this impact. However, a full operating regime will need to be developed for management of the flows in the channels
Impact on SPA	Impacts on the SPA will be managed through the Habitats Regulations process, with provision of mitigation measures or compensatory habitat if required, likely to be on other lakes in the area.
Impact on SSSIs (primarily Thorpe Hay Meadow) and other designated and undesignated ecology	A full strategy for the SSSI site will need to be agreed, as there is a balance between loss of residential property and loss of SSSI. Compensatory habitat (in a ratio at least 1:1) will need to be provided for loss of SSSI; this could be achieved through the Regional Habitats Creation Programme. Other important habitats will also need to be fully considered and mitigated. It is anticipated that this would largely be done within the channel corridor.
Archaeological finds in gravels	It is likely that extensive pre-construction surveys (both intrusive and non-intrusive) would be required. This may take the form of trial trenching and geophysical survey. Pre-construction mitigation, such as strip map and record or excavation, may also be required. Other mitigation may include watching brief or excavation within the construction phase.
Impacts on fish, e.g. entrainment, migration, fish passage, mixing of species	Detailed design of channels to provide features for fish, e.g. fish passes, screens, escape channels. Design should conform to the General Principles of Fish Passage (England and Wales) Regulation 2009
Impacts on or loss of fisheries, which provide a nationally important angling resource	Discussions with the fisheries concerned, to identify appropriate solutions depending on the location and impacts concerned. Bunding reduces these impacts in several lakes, and screening is another possibility. Financial compensation via CPO is a worst case scenario
Impacts on the River Thames (e.g. sedimentation, habitat loss) from works connecting the diversion channels, and works through Reach 4	Extensive programme of monitoring to fully establish the quality of habitats and species present and determine sensitive areas. This will also allow review of the decision that dredging is unacceptable. The monitoring will allow a detailed programme of mitigation to be developed. Works should be timed sensitively and appropriate control measures for release of sediment put in place. Compensatory habitats may need to be provided.

6.3.9 The proposals for recreation activities and new habitat creation are not considered to conflict, as long as the scheme is subject to sensitive masterplanning and zoning of particular uses. It is likely that most recreation activities on and around the water would not be particularly intrusive and new habitats could be designed to deal with low levels of disturbance if required. Areas of BAP habitat could also be designed to cope with the proposed flow regime of the channel, for example reedbeds would be suited to areas of no constant flow.

Social and Community Aspects

6.3.10 Strategy D2 offers the best social benefits, providing significant and sustainable reductions in flood risk to the majority of properties in Reach 3 (i.e. those between Datchet and Shepperton) as well as those most at risk in Reach 4 (see Section 6.4 for summaries of property flood risk by flood cell).

6.3.11 The reduction in flood risk that can be achieved by Strategy D2 is shown in the pie charts in Figure 6.4 for the present day 'Baseline' scenario. Assuming that the strategy can be implemented fully and effectively to achieve maximum reductions in flood risk, then Strategy D2 has the potential to take all properties throughout Reaches 3 and 4 out of very significant flood risk (>5% AEP). It would also substantially reduce the numbers of properties with significant flood risk, enabling some 9,500 properties or over 20,000 affected people to qualify for flood insurance based on ABI targets (<1.33% AEP flood risk), and take nearly 8,000 properties into low (<0.5% AEP) flood risk.

6.3.12 Similarly to above, the reduction in flood risk that can potentially be achieved by Strategy D2 under the future 'Defra FCDPAG Climate Change' scenario (for all properties with at least a 1% AEP flood risk allowing for 20% climate change) is shown in the pie charts in Figure 6.5. It has the potential to take a total of up to approximately 8,800 properties out of very significant flood risk and 8,250 out of significant flood risk, with over 4,000 properties still having moved into the low flood risk band.

Costs of the Preferred Option

Table 6.8 Costs of Preferred Option for Flood Cell Reach 3

YEARS	COSTS (£m)			SCOPE
	Capital	Non-Capital	Total	
2010	0.18	0.89	1.07	Thames weirs operation
2011	0.18	0.89	1.07	Thames weirs asset replacement
2012	1.79	0.89	2.68	Non-structural measures/FPM tools
2013	1.79	0.93	2.72	Design/roll-out Community Based Measures (CBM) pilots
2014	1.79	0.81	2.60	Design/roll-out 1st year CBM main programme
				Surveys and studies
Sub-total	5.74	4.39	10.14	
2015-29	275.58	18.00	293.58	Thames weirs operation/asset replacement
				Continued FPM/non-structural measures
				Years 2,3, 4 of CBM main programme
				Diversion channels 1, 2 and 3
Sub-total	275.58	18.00	293.58	
2030-2110	14.44	150.58	165.02	Thames weirs operation/asset replacement
				Continued FPM/non-structural measures
Sub-total	14.44	150.58	165.02	
TOTAL	295.76	172.97	468.73	

Note: Capital costs for the Reach 4 compensation/betterment works are included in this table

Table 6.9 Costs of Preferred Option for Flood Cell Reach 4

YEARS	COSTS (£m)			SCOPE
	Capital	Non-Capital	Total	
2010	0.18	0.36	0.54	Thames weirs operation
2011	0.18	0.36	0.54	Thames weirs asset replacement
2012	3.04	0.36	3.40	Non-structural measures/FPM tools
2013	3.04	0.37	3.41	Design/roll-out CBM pilots
2014	3.04	0.34	3.38	Design/roll-out 1st year CBM main programme Surveys and studies
Sub-total	9.49	1.77	11.27	
2015-2029	12.47	4.93	17.40	Thames weirs operation/asset replacement Continued FPM/non-structural measures Years 2,3, 4 of CBM main programme Downstream compensation/betterment works
Sub-total	12.47	4.93	17.40	
2030-2110	14.44	25.87	40.31	Thames weirs operation/asset replacement Continued FPM/non-structural measures
Sub-total	14.44	25.87	40.31	
TOTAL	36.41	32.57	68.98	

Note: Capital costs for the Reach 4 compensation/betterment works are included in Table 6.8

6.3.13 The capital and non-capital total costs of preferred Strategy D2 are presented in Tables 6.8 and 6.9, for each of flood cells Reach 3 and Reach 4. Costs and associated FRM actions are shown for periods related to implementation of capital works (Chapter 7).

6.3.14 Total cash costs (inclusive of 50% optimism bias) are approximately £538m, of which £469m is related to Reach3 and £69m is related to Reach 4.

Contributions and Funding

6.3.15 The capital works components of the strategy would need to be funded from central budgets. However, the nature of the strategy will present a wide range of opportunities for creative co-funding between the public and private sectors. Once a firm commitment is made to promote the strategy with government funding, substantive discussions can be held with all parties to test the credibility of opportunities for co-funding in six key areas:

- Linking commercial interests in mineral deposits of sands and gravels underlying parts of Channels 1 and 2 with opportunities for planning gain, to commission channel construction at lower cash cost;

- Linking contributions to channel costs with private sector opportunities for recreation development including marinas (Channels 2 and 3) and water-transport (these opportunities may need certain parts of the channels to have a constant water flow - this does not preclude most of the area from having no constant flow, as the area is large enough to be zoned for different uses);

- Opportunities to agree long-term responsibilities for management of specific riparian assets by third parties, such as discussions to date with RSPB who have a declared aspiration to develop and manage the Southwest London Waterbodies SPA area as a future bird and wetland sanctuary;

- Opportunities for funding under any renewed EU "SANDS" project, which in the past has provided European environmental funds to support projects to restore old mineral workings, such as at Hythe End (Channel 1) and between Green Lane and Norlands Lane (Channel 2);

- Unlocking private sector funding where social surveys have shown positive public response towards proposals for community based measures in the Reach 4 area, through both local authority grants using public money to kick-start such a community based programme (particularly individual property protection measures), and incentivising ABI to reduce flood insurance premiums or excess payments;

- Considering designs for compensation works at Teddington and Sunbury weirs which accommodate a run of river hydro power generation.

Other Aspects - Materials, Land and Waste Management Plans

Introduction

6.3.16 Land and waste management, together with the handling, storage, use and transportation of excavated materials, will be complex issues to address, and critical to successful implementation. The potential approach to management is outlined below.

Integrated Land Use Plan

6.3.17 There are many economic uses of land throughout the diversion channel corridors. These include land for flood management, gravel extraction, waste management, fisheries, amenities and recreation, and land for important environmental assets. Many landowners with diverse interests will be involved. A land ownership register has been prepared and a number of major landowners contacted and consulted during the study. The planning and preparation of detailed designs for diversion channels must be prepared in the context of overall spatial land use plans prepared by local authorities. Designs should seek to integrate the need for different land uses when deciding upon final alignments of diversion channels. Such a plan would need thorough consultations with County and Local Authorities, as well as landowners and commercial operators.

6.3.18 Discussions with Thames Landscape Strategy and LPAs have identified opportunities to integrate interests in land use development, for example land lowering at Hurst Park to create wet-land and encourage biodiversity, and new raised housing development in Reach 4 in reclaimed sedimentation beds

Materials and Waste Plan

6.3.19 A construction materials and landfill (waste) disposal plan will be a key part of preparing a land use plan for the Lower Thames strategy. The following factors will be important during consultations to prepare an agreed materials plan

- Best estimates at strategy stage are that 25,000m^3 of topsoil, subsoil, sands and gravels may be surplus to construction requirements, representing 30% of the material which could be used in permanent works for items such as landscaping and shoreline environmental mitigation and enhancement works. Alternatively excess gravels and topsoil could be sold off-site at no net cost.
- There will probably be a net deficit of clean cover material to form basal and surface protective layers for lined sections of diversion channels in landfill areas. This deficit could be sourced from recycled landfill material, principally as the basal layer. There would be a net surplus of recycled material of some 44,000m^3 which could be sold off-site as topsoil substitute at no net cost.

- There would be 340,000m^3 of unusable surplus landfill material, to be returned to landfill. This should preferably be within the boundaries of the scheme as re-encapsulated material, possibly achieved through negotiations with landfill and re-cycling companies, linked with commercial opportunities to re-cycle waste material (see below). Re-encapsulation would require an area of some 8-9ha allowing for bulking and capping the material, but would need to meet all normal planning requirements.
- There will probably be a net balance of usable material throughout all three diversion channels, requiring agreements with landowners for land for stock-piling during construction, which must be in areas that do not cause increased flood risk.
- Discussions will be needed between the Environment Agency and Planning Authorities with landfill and mineral extraction and waste re-cycling operators and companies, to forge mutually agreed arrangements for managing landfill and gravel extraction. These need to seek an integrated set of agreements to: (i) establish joint venture arrangements between operators and specialist landfill recycling companies; (ii) to set up a treatment hub(s) to sort (either manually and/or using soil processing machinery) landfill into fractions suitable for recycling, energy from waste, reuse, and possible disposal. A suitable treatment hub site will need to be identified.

6.4 Summary of Preferred Strategy

6.4.1 A summary of the economics and financial requirements of Strategy D2 is set out in Table 6.10. Cost details are in Appendix H, with benefits and economics in Appendix G.

Table 6.10 Summary of Preferred Strategy

Economic and Financial (£million)	Reach 3	Reach 4	Reaches 3 and 4
Standard of Protection	See notes below		
PV Costs (£m)			
Capital	163	30	193
Non-capital	48	15	63
Total PV Costs (£m)	**211**	**45**	**256**
PV Benefits (£m) - 'Baseline'	**1379**	**273**	**1652**
Av. BCR - 'Baseline' scenario	**6.5**	**6.1**	**6.4**
PV Benefits (£m) - 'FCDPAG CC'	**2648**	**482**	**3130**
Av. BCR - 'FCDPAG CC' scenario	**12.5**	**10.7**	**12.2**
Cash Costs (£m)			
Capital	296	36	332
Non-capital	173	33	206
Total Cash Costs (£m)	**469**	**69**	**538**

Note: Capital costs for the Reach 4 compensation/betterment works are included in Reach 3

6.4.2 In Reach 3 the standard of protection (SoP) provided by diversion channels will remain varied. The betterment in SoP provided by Strategy D2 will be substantial and is best measured by exceedance parameters as shown in Table 6.11. At least 90% of properties will have a minimum SoP of 1 in 60 years or better, and 50% will have a 1 in 200 year standard or better. These numbers are for all properties at risk of flooding in the 0.05% AEP event for the 'Baseline' scenario, while those for the 'FCDPAG Climate Change' scenario correspond to those at risk under 1% AEP (+20% CC) conditions.

Table 6.11 Shift in Standard of Protection Achieved by Strategy D2 in Reach 3

Standard of Protection Parameter	'Baseline' (without climate change)		Defra FCDPAG Climate Change	
	Asset Replacement	Strategy D2	Asset Replacement	Strategy D2
Median (50% exceedance)	45 Year	200 Year	25 Year	75 Year
90% exceedance	12 Year	60 Year	6 Year	40 Year

NOTE: The Median (50% exceeedance) refers to the minimum standard of protection established for 50% of the properties lying within the existing 1 in 200 year flood plain, for that particular option.
The 90% exceedance refers to the minmum standard of protection established for 90% of the properties lying within the existing 1 in 200 year flood palin, for that particular option. Conversely, this indicates when the most vulnerable 10% of properties lying within the existing 1 in 200 year flood plain, become at risk for each option.

6.4.3 The SoP in Reach 4 will also remain highly variable, as shown in Table 6.12 for the same property flood risk groups. Betterment here would be mostly achieved through the community based measures, where viable providing a minimum 75 Year SoP to the 900 most vulnerable properties. If implemented successfully as planned, then some 500 plus properties would be taken out of very significant (>5% AEP) flood risk, and up to a further 400 properties from significant (>1.33% AEP) flood risk. Some further betterment would be gained from the proposed capital works through Reach 4. The "median" SoP for Reach 4 would only improve marginally, unless climate change impacts are included.

Table 6.12 Shift in Standard of Protection Achieved by Strategy D2 in Reach 4

Standard of Protection Parameter	'Baseline' (without climate change)		Defra FCDPAG Climate Change	
	Asset Replacement	Strategy D2	Asset Replacement	Strategy D2
Median (50% exceedance)	75 Year	75 Year +	50 Year	70 Year
90% exceedance	10 Year	50 Year	8 Year	25 Year

7 Implementation

7.1 Project Planning

Policy, Flood Cells and Objectives of Strategy

Policy

7.1.1 The Thames CFMP (Section 3.3) defines the Lower Thames as a separate policy unit. The policy for this area is (P5) viz: (i) to take further action to reduce flood risk now and/or in the future, and (ii) to reduce the risk by lowering the probability of exposure to flooding, and/or the magnitude of the consequences of flooding.

Flood Cells

7.1.2 The distinct differences in flood extents and mechanisms between Reaches 3 and 4 mean that different, specific options are needed in each reach to manage flood risk, and that they need to be considered as two separate flood cells.

Objectives

7.1.3 The objective of each component of Strategy D2 would be to deliver policy as described above, targeted at Reach 3 and/or Reach 4 flood cells as shown in Table 7.1.

Table 7.1 Objective of each Component of Strategy

Component of Strategy	Flood Cell or Reach	Component of Risk		Timing	
		Probability	Magnitude	Now	Future
Non-structural measures	**R3+R4**		✓	✓	✓
Flood plain management tools	**R3+R4**		✓	✓	✓
Community Based Measures	**R3+R4**		✓	✓	✓
Diversion channels	**R3**	✓		✓	✓
Compensation/betterment works	**R4**	✓		✓	✓
Structural improvement woks	**R4**	✓		✓	✓

Strategy Approach

7.1.4 A ***precautionary*** approach is needed, though with ***adaptive*** aspects for certain components, as summarised below:

Flood Plain Management and Non-Structural Measures

- Flood Plain Management (FPM) tools and intensified non-structural measures must precede any substantial investment in capital schemes, so as to safeguard investment by helping to prolong scheme effectiveness.
- The scope of FPM tools, their development and the protocols for their use will need to be the result of consultations with LPAs and the Environment Agency, building on the scope and agreements that have been discussed and forged to date.
- A monitoring and evaluation programme needs to be set up at the start of the strategy, to provide evidence to support future decisions about ***adapting***

certain aspects of strategy components (see below) including: (i) the size of diversion channels; (ii) the timing of construction of diversion channels; (iii) the extent of community based programmes; (iv) the scope of downstream compensation and betterment works.

Flood diversion channels

- A ***precautionary approach*** is needed by adopting diversion channels as part of the strategy and ensuring they will have sufficient capacity, now and in the future. Once built it will be neither practical nor cost-effective to increase their size, and there will be no other technical option available to respond to eventual climate change impacts.
- The currently estimated capacity for the diversion channels which optimises economic, environmental and social objectives is in the range of 150-170m^3/s A final decision on precise design and size of these channels is not needed until outline designs have been prepared and the Planning Application is ready to be submitted. During the outline design, the final size of channels should be reviewed, and ***adapted*** to accord with: (i) the findings of environmental surveys carried out in the interim; (ii) further evidence available at that time about predicted impacts of climate change; and (iii) any re-definition of economic tests and funding availability.
- The implementation and size of flood diversion channels would be reviewed and ***adapted*** within the above range, based on assessment of the level of success in implementing both FPM and non-structural measures.

Community Based Measures

- Pilot programmes are needed to confirm the approach and test public uptake of these measures. Funding arrangements will be crucial, particularly whether or not grants are offered. The extent of subsequent full community programmes in Reaches 3 and 4 then needs to be reviewed and ***adapted*** based on the findings of the pilot programmes.

Island Communities

- Intensified early warning and evacuation programmes are the only practical ways to manage flood risk for island communities at Trowlock, Thames Ditton and Sunbury. Grant aid to raise properties has been suggested by some residents.

Compensation and Betterment Works

- The effects on Reach 4 of diversion channels in Reach 3 must be compensated by capital works in Reach 4 which must be implemented first. These works should also provide some betterment in Reach 4. Based on current evidence, the preferred package of works includes widening of Desborough Cut by 3-4m on the right bank, and increasing the flow capacities of Sunbury, Molesey and Teddington Weirs with new gates.
- The scope of these works needs to be reviewed and ***adapted*** based on the findings of environmental surveys in Reach 4 into the acceptability or otherwise of (limited) river bed re-profiling.

Strategy Phasing and Dependencies

7.1.5 Strategy D2 would be implemented in 6 broad, overlapping phases over a period of 16 years from 2010 to 2026. The overall programme (see Appendix J) proposes that the planning, design and implementation of both structural and FPM components should be promoted in parallel. Implementation of a first-stage FPM component could commence in 2012. The structural component will be expedited as fast as possible, though due

process will need to be followed. This means that 8-9 years may be required to undertake the necessary planning process including PAR preparation, HRA, planning application and consent, a possible Public Inquiry, detailed design and tender award before the first phase of a structural component could commence in 2019. The phasing of the Strategy, together with the conditions and dependencies for each phase, is summarised below.

7.1.6 **Phase I:** from 2010 to 2011: (A) Planning and approval of the Strategy; (B) Approval and undertaking PAR for 1st stage FPM component comprising: (i) non-structural measures, (ii) FPM tools development, (iii) planning and design of pilot programmes for community based measures, (iv) planning, commissioning and undertaking environmental surveys including river/sediment and lake ecology, water quality and groundwater studies and surveys, and (v) initiating monitoring and evaluation programme for strategy implementation; (C) Approval and initiation for undertaking PAR and outline designs for structural component (diversion channels and downstream works).

7.1.7 Dependencies and enabling actions will be: (i) the availability of funding; (ii) establishing a strategy planning, promotion and implementation function within the Environment Agency; (iii) commissioning consultants to provide support for planning, survey, design and construction supervision activities; (iv) successful social surveys, public incentivisation and buy-in for community based measures in pilot areas; (v) the need for a grant system to be put in place to enable programme for individual property protection measures; (vi) agreements in principle with waste and re-cycling contractors regarding status and surrender of landfill sites; (vii) agreement in principle with British Airports Authority about design of channels; and (viii) agreements in principle with key land-owners about land acquisition and compensation.

7.1.8 **Phase II:** from 2012 to 2013: (A) Launching and implementation of 1st stage FPM and community based (CBM) pilot projects in Reaches 3 and 4; (B) Approval and PAR for 2nd stage FPM and CBM main programme; (C) Completion of environmental surveys and feedback to structural component design; and (D) Completion of PAR and outline designs for structural component and sizes of channels based on feedback, including EIA and Habitats Regulations Assessment and agreement with NE.

7.1.9 Dependencies and enabling actions will be: (i) successful completion of PAR, designs, public consultation and acceptance for community based measures; (ii) land acquisition for community defence projects; (iii) successful tender and award for community defence project construction; (iv) the need to match the scale and scope of capital work detailed designs to the findings of the monitoring and evaluation, environmental, water quality, archaeology and groundwater studies and surveys; and (v) concluding agreements in principle with contractors, BAA and key land-owners.

7.1.10 **Phase III:** between 2014 and 2017: (A) The launching and implementation of FPM 2nd stage comprising main programmes for community based measures in Reaches 3 and 4; (B) Approval for preparation and submission of Planning Application and CPOs for structural component, Public Inquiry and resolution, and initiation of detailed designs.

7.1.11 Dependencies and enabling actions will include: (i) community surveys, consultation, agreement and buy-in, completion of PAR and designs for main CBM programmes; (ii) funding and grant availability for CBMs; (iii) successful PA and PI, sign-off of structural component by Defra and Treasury; (iv) internal and external funding availability for structural component; and (v) matching capital works designs to environmental surveys.

7.1.12 **Phase IV:** during 2018 and 2019: (A) completion of detailed designs for structural component (Channels 1, 2 and 3 and downstream works); (B) completion of land

acquisition and CPO activities; and (C) Preparation and award of tenders for Reach 4 compensations works and Channels 2 and 3.

7.1.13 Critical dependencies and enabling actions during this phase will be: (i) funding availability for land acquisition, CPOs and construction; (ii) final legal agreements with waste and re-cycling contractors regarding status and surrender of landfill sites; (iii) final agreement with British Airports Authority about design of channels; (iv) agreements in place with key land-owners including Crown Estates about land acquisition, severance compensation; (v) agreement to the HRA for Channels 2 and 3, and about the type, scale and location of mitigation measures; (vi) acceptable archaeological surveys, and mitigation plans where required.

7.1.14 **Phase V:** 1st stage capital works construction period between 2019 and 2022, commencing at Teddington with mitigation and betterment works in Reach 4, working upstream to channel 3 and then channel 2 with completion just downstream of Staines. Conditionalities will be: (i) funding availability; and (ii) conforming and affordable bids from contractors.

7.1.15 **Phase VI:** between 2023 and 2026, finalisation of the size of Channel 1, award of tender and 2nd stage capital works construction comprising Channel 1 and associated works. Dependencies and enabling actions will be: (i) funding availability; (ii) legal agreements with waste and re-cycling contractors regarding status and surrender of landfill sites; (iii) agreement with British Airports Authority about design of channels; (iv) agreements in place with key land-owners about land acquisition and compensation; and (v) review and agreement to the HRA for Channel 1, and about the type, scale and location of mitigation measures and management of the Wraysbury Lakes.

Strategy Programme

7.1.16 An implementation programme is shown in Appendix J. It assumes that 18-24 months may be required to obtain final Defra and Treasury approval for the Strategy. In the meantime a first-stage FPM component should then be launched, and in parallel the start of a (possible) 8-9 year process to plan and prepare designs and tender and award a contract for first stage construction of capital works. Also in parallel, a house purchase project is required for those (2-3) properties on the Channel 2 alignment. The overall programme is based on key milestones and target dates as shown in Table 7.2 below. Commencement of construction at Teddington weir (1st Stage works) is shown as 2019, on the StAR programme. This could possibly come forward to 2017, at the earliest, providing that sufficient ecological and water quality data is collated to ensure a sufficiently robust case to facilitate compliance with the Water Framework Directive and for successful progression at the Public Inquiry.

Table 7.2 Implementation Programme for Strategy D2

Milestones	Target Date
• NRG recommend approval, launch PAR activities for FPM	1st quarter 2010
• NRG recommend approval, launch structural component PAR	3rd quarter 2010
• Final Strategy approval (Defra and Treasury): • FPM tools and measures in place • Launch community based pilot programmes	Late 2011
• Launch community based main programme: • Draft PAR submitted to NRG for outline designs and EIA/HRA structural component	Mid 2014
• Submit planning application, CPOs, resolution of PAR	End 2016

•Public Inquiry and final structural component PAR submission to NRG and FSoD	
•Complete community based programmes •Complete detailed designs for 1st Stage structural component	End 2018
•Award construction contract for 1st Stage •Commence construction 1st Stage works	Mid 2019
•Complete detailed designs for 2nd Stage structural component •Award construction contract for 2nd Stage •Commence construction 2nd Stage works	Late 2024
•NEW CAPITAL WORKS COMPLETE	Late 2026

Financial Profile

7.1.17 The schedule of total capital and non-capital costs of all components of Strategy D2, expressed as cash costs including optimism bias of 50%, are shown in Table 7.3 (in two consecutive parts).

7.1.18 The cash cost of Strategy D2 is estimated at approximately £538m, of which a portion of some £332m is estimated over a twenty-year period from 2010 to 2029 inclusive.

Strategy Management

7.1.19 The strategy has a wide range of inter-dependent components. Management will be time consuming, particularly during initial years. A strategy development and implementation team will be required, comprising a project manager with access to internal specialists with a range of skills and disciplines including: (i) public relations and consultation; (ii) development control and planning; (iii) environmental assessment and monitoring; (iv) public awareness and social survey programmes; (v) aquatic and terrestrial ecology; (vi) engineering; and (vii) operations and emergency response.

7.1.20 Costs for such a team are included from 2010 to 2030 in the overall strategy cost profile shown in Table 7.3. Outcome Measures (OMs) are set out in more detail in Section 7.2.

Table 7.3 Investment Profile for Strategy D2 Costs (Part 1)

Cost by Category (£m)	CALENDAR YEARS										
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Thames' Weirs Operation / Asset Replacement											
Capital & Annual in Reach 3	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36
Capital & Annual in Reach 4	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36
Non-Structural Response (NSR) Measures in Reaches 3 and 4											
Annual costs	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Flood Plain Management Component (OM Priority Score for FPM, incl. NSR = 3.96)											
Capital or physical works			4.17	4.17	5.09	5.09	5.09	5.09			
Annual costs				0.05	0.09	0.16	0.22	0.29	0.35	0.35	0.35
Management	0.76	0.76	0.76	0.76	0.57	0.57	0. 57	0.57	0.06	0.06	0.06
Diversion Channels Capital Works Component (OM Priority Score = 3.08)											
Channels 2 and 3 in Reach 3											34.54

Improvement works, Reach 4										4.37	8.75
Channel 1 in Reach 3											
Annual costs											0.02
Total Strategy Cost Profile	**1.60**	**1.60**	**5.77**	**5.82**	**6.60**	**6.66**	**6.72**	**6.78**	**1.25**	**5.62**	**44.56**

Table 7.3 Investment Profile for Strategy D2 Costs (Part 2)

	CALENDAR YEARS									
Cost by Category (£m)	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030 – 2109**
Thames' Weirs Operation / Asset Replacement										
Capital & Annual in Reach 3	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	28.88
Capital & Annual in Reach 4	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	28.88
Non-Structural Response (NSR) Measures in Reaches 3 and 4										
Annual costs	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Flood Plain Management Component (OM Priority Score for FPM, incl. NSR = 3.96)										
Capital or physical works										
Annual costs	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	27.74
Management	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Diversion Channels Capital Works Component (OM Priority Score = 3.08)										
Channels 2 and 3 in Reach 3	69.07	34.54								
Improvement works, Reach 4										
Channel 1 in Reach 3						58.05	58.05			
Annual costs	0.27	0.65	0.85	0.85	0.85	0.85	1.17	1.50	1.50	119.83
Total Strategy Cost Profile	**70.58**	**36.43**	**2.09**	**2.09**	**2.09**	**60.14**	**60.47**	**2.74**	**2.74**	**205.50**

Procurement of Support Services

7.1.21 The strategy development and implementation team will need to procure a range of services to assist plan, design and develop the strategy; and then implement strategy. A summary of the services needed and their timing are summarised below in Table 7.4.

7.1.22 Costs for procuring such services have been estimated and included in estimated overall strategy costs for 2010 to 2028.

Table 7.4 Procurement of Services to Support Planning and Implementation

Type of Supplier	Services Required	Planning (P) and Implementation (I)
Consultants in FPM	• Planning and programming • Development of FPM tools	P,I
Socio-economic consultants	• Planning social surveys • Undertaking and interpreting social surveys	P
Environmental consultants	• SEA and EIA for capital works • Environmental baseline surveys • Water quality and ecology of lakes studies • Clerk of Works during construction	P, I

Engineering consultants	• PARs for capital works programme • Detailed designs of capital works • Detailed designs of community based measures • Groundwater study and modelling • Supervision of construction	P,I
Land Agent/Land Use Planners	• Land ownership and value • Negotiation support and CPO	P,I
Cost consultants	• Cost estimation of community based measures • Cost estimation of capital works	P
Construction Contractor(s)	• Tender and construct community based measures • Tender and construct downstream capital works • Tender and construct channels 2 and 3 • Tender and construct channel 1	I

Consultation During Planning and Implementation

7.1.23 A wide range of consultations will be required during planning and design of the strategy, and to successfully promote and implement the various components. These are summarised below in Table 7.5.

Table 7.5 Consultations Required to Plan and Implement the Strategy

Organisations/Parties to be Consulted	Objective
• Defra, Treasury	• Agree scope, budget, programme and timing of strategy • Funding/grants for programme for individual property protection
• Environment Agency	• Scope, budget, programme for environmental surveys • Scope, budget, programme for social surveys
• Environment Agency and Local Planning Authorities	• Priorities and protocols for development and roll-out of Flood Plain Management Tools
• Environment Agency and Local Planning Authorities	• Programme for development and roll-out of community based measures • Funding arrangements for community based measures
• Service providers, Highways Authority and Emergency Services	• Development of flood plain management tools • Planning of community based measures
• Natural England, RSPB, Wildlife Trusts, English Heritage and other environmental bodies	• Location, type and design of all channel works in relation to the SPA and SSSIs • Scope and types of mitigation and compensation works
• General public	• Impacts and types of mitigation and compensation works acceptable
• Crown Estates and British Airports Authority	• Diversion channel alignments and land take • Diversion channel designs and geometries
• Other Landowners	• Arrangements for stockpiling material during construction • Long-term responsibilities for the management of

	specific riparian assets by third parties
• LPAs, Mineral Companies, Waste Operators, Specialist Waste Re-cycling Companies	• Planning gains linked to commercial opportunities for minerals abstraction • Planning gains linked to commercial hub opportunities for waste management, re-cycling and disposal package

7.2 Outcome Measures Contributions

7.2.1 The preferred strategy has been assessed in accordance with Defra's Outcome Measure (OM) scoring system, as detailed in the OM Prioritisation Priority Score sheets at the end of Appendix A. The OM contributions made by Strategy D2 are summarised for the 'Baseline' (no climate change) scenario below, divided between the 'Diversion Channels D2' component in Table 7.6 and the 'FPM' component in Table 7.7 (the Asset Replacement portion of the Strategy PV Benefits and PV Costs have been split by the ratio of their respective incremental benefits).

Table 7.6 Medium Term Outcome Measures Contributions - 'D2 Channels' Component

Outcome Measure	2009/10	2010/11	2011/12	2012/13	2013/14	Future Year	Total
OM1 Economic Benefit							
PV Benefits (£k)	50,790	48,180	45,690	43,320	41,050	907,770	1,136,800
PV Costs (£k)	565	545	530	510	500	208,280	210,930
OM2 Households at risk (nr)	0	0	0	0	0	12,790	12,790
OM2b Households moving Risk Bands	0	0	0	0	0	7,725	7,725
OM3 Households at risk in Deprived Areas	0	0	0	0	0	0	0
OM4 Improved condition of SSSI (ha)	0	0	0	0	0	0	0
OM5 BAP Habitat (ha)	0	0	0	0	0	60	60
Outcome Measure Prioritisation Score							**3.08**

Table 7.7 Medium Term Outcome Measures Contributions - 'FPM' Component

Outcome Measure	2009/10	2010/11	2011/12	2012/13	2013/14	Future Year	Total
OM1 Economic Benefit							
PV Benefits (£k)	22,500	2,340	20,240	20,930	22,000	407,680	514,700
PV Costs (£k)	240	1,070	1,040	4,750	4,600	33,800	45,500
OM2 Households at risk (nr)	0	0	0	250	250	1,100	1,600
OM2b Households moving Risk Bands	0	0	0	250	250	1,100	1,600

OM3 Households at risk in Deprived Areas	0	0	0	0	0	0	0
OM4 Improved condition of SSSI (ha)	0	0	0	0	0	0	0
OM5 BAP Habitat (ha)	0	0	0	0	0	0	0
Outcome Measure Prioritisation Score							**3.96**

7.2.2 Of the Super Output Areas (SOAs) identified for the Lower Thames Study Area, none were classified as 'Deprived Areas' under OM3.

7.2.3 The overall OM score is 3.08 for the 'D2 Diversion Channels' component. This dominates the OM contributions from the Strategy, but delivers no new (above Asset Replacement) benefits in the short term.

7.2.4 The overall OM score is 3.96 for the 'FPM' component as a whole. When split between Stages 1 and 2 of the FPM implementation, the separate OM scores for each stage are 3.63 and 4.14 respectively. As expected the full roll-out of FPM, in particular the community based measures, scores more highly than the initial stage. But Stage 2 is dependent on successfully completing the pilot studies within Stage 1.

7.3 Procurement Strategy

7.3.1 It is proposed to undertake the Flood Plain Management component in two stages, via separate PARs; the first stage will comprise the FPM tools, safeguarding the existing flood flow routes and the pilots for the community based measures (CBMs), whilst the second stage covers the remaining roll-out of the CBMs. The business case for the structural 'D2 Channels' component would be developed under a single PAR. All three PARs would be commissioned under the NEECA Framework, through full competition, under a NEC PSC Option C incentivised contract. It is anticipated that the NEECA2 consultants may wish to form joint ventures, in a similar manner to the current arrangement between Halcrow and Jacobs and this would be welcomed, because of the size of the future work packages. Key staff are shown in Table 7.8 below.

7.3.2 The procurement strategy shows use of conventional frameworks and this has been issued for discussion with regard to the National Procurement Strategy. Other procurement options being considered for delivering the works arising from the Structural Component include, Design and Build, PFI and PPP.

Table 7.8 Key Staff

Agency Staff		**Framework Staff**	
Client		NEECA Team	
Asset Manager	Doug Hill	Project Manager	Stuart Suter
Client Representative	Ian Tomes	M&E Team Leader	N/A
		EIA Team Leader	Sarah Jennings
NCPMS (Appraisal & Delivery)		NCF Team	
Project Executive	Tim Chinn	Contracts Manager	N/A

Project Manager	Graham Piper	M&E Co-ordinator	N/A
Technical Advisors		NCCF Team	
Procurement	Renata Streeter	Cost Consultant	N/A
M&E Engineer	N/A		
NEAS	Daniela Viveash		
Estates Officer	Richard Allen		

7.3.3 Discussions have also been held with regard to seeking commercial opportunities and external sources of funding.

7.4 Delivery Risks

7.4.1 The most significant risks to strategy implementation have been identified and scoped through detailed consultations and discussions during Phases 3 and 4 of the Lower Thames study, and are summarised in Table 7.9 below.

Table 7.9 High Level Risk Register for Strategy Implementation

Description of Risk	Metric		Management of Risk
	Likely	Impact	
Policy • As the requirements of the Water Framework Directive become clearer, more extensive mitigation than planned may be needed, or the preparation of a case for overriding public interest.	H	H	Monitor and respond as necessary with: (i) re-programming; (ii) additional data collection; (iii) modifications to designs; and (iv) re-scoping mitigation packages.
Habitats Regulations Assessment • There is residual risk it will not be possible to find sufficient mitigation for all adverse effects of diversion channels on SW London Waterbodies SPA • Need to prepare a case for overriding public interest (IROPI).	M	H	Monitor and respond with: (i) re-programme strategy design and implementation; (ii) undertake study to show scheme is necessary for reasons of overriding public interest; (iii) prepare compensation as well as mitigation measures; and (iv) re-assess costs, economics and phasing.
Water Quality and Water Use • One risk is that high nutrient Thames water will affect water quality in existing lakes and cause a shift in trophic status, and encourage algal blooms at certain times of the year • Another risk is that operating regimes for the diversion channels will compromise extraction licences of service providers, specifically Thames Water.	H M	H M	Undertake: (i) phytoplankton, invertebrate and macrophyte communities as well as water quality surveys; (ii) quantify risks (modelling and field trialling); (iii) determine impact mechanisms; and (iv) design package of mitigation measures. Maintain: (i) current design principle of no-sweetening flow; (ii) close consultation with TW during design process; to (iii) embody operational regimes appropriate for both abstraction and flood flow management.

Thorpe Hay Meadow • Objections from Natural England, Surrey Wildlife Trust and a local property owner to the alignment of Channel 2, which would take land from Thorpe Hay Meadow.	M	M	During detailed design: (i) maintain on-going consultations with property owner and NE to agree compromise alignment; and (ii) identify replacement habitat if possible as part of the Thames Region's Regional Habitats Creation Programme.
BAA Objection • BAA have indicated cautious acceptance of preliminary design concepts, but may object to detailed designs in relation to bird strike. • The risk that design details which satisfy BAA may compromise those which would minimise environmental impacts.	M	M	During detailed design stage: (i) Maintain close consultation with BA; (ii) identify compromise package with appropriate mitigation measures; and (iii) undertake bird strike risk assessment if necessary.
Landfills • The risk is that insufficient information or inappropriate designs lead to pollution incidents with the Environment Agency having to accept legal liability. • The risk of potential conflict with the Landfill Directive (LFD) which regulates the allowable proximity of new landfill sites to watercourses; and by analogy, the proximity of existing landfill sites to new watercourses (viz Channels 1, 2 and 3).	M H	H M	• During design: (i) undertake detailed site investigation and testing to determine the condition, location, type and chemical content of landfills; (ii) use robust design parameters based on conventional materials, practices and standards to contain landfill material, separate diversion channel surface water from groundwater, and control and manage leachate; and (iii) seek to ensure that designs accord with LFD requirements that landfill can be authorised provided appropriate corrective measures are included so as not to pose a serious environmental risk.
Land and Materials • Risk that it is difficult to forge collective agreement between the Agency, Local Authorities, mineral and landfill operators and specialist landfill recycling companies, for an integrated planning and commercial package to manage landfill excavated from the diversion channels.	M	M	• Extensive consultation with all parties throughout the planning period seeking creative opportunities and packages.
Crown Estates			

• Risk that Crown Estates will not accept design proposals for diversion channels; inalienable land not subject to CPO.	M	H	• Close consultation with CE throughout the planning and design process to identify mutually agreeable alignments and design.

Appendix A Project Appraisal Report Data Sheet

Entries required in clear boxes, as appropriate.

GENERAL DETAILS

Authority Project Ref. (as in forward plan):	
Project Name (60 characters max.):	Lower Thames Strategy Study
Promoting Authority: Defra ref (if known)	
Name	Environment Agency
Emergency Works:	No (Yes/No)
Strategy Plan Reference:	
River Basin Management Plan	Thames River Basin
System Asset Management Plan	
Shoreline Management Plan:	N/A
Project Type:	Strategy Plan

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

CONTRACT DETAILS

Estimated start date of works/study:	
Estimated duration in months:	
Contract type*	

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

COSTS

	APPLICATION (£000's)
Appraisal:	
Costs for Agency approval:	
Total Whole Life Costs (cash):	

For breakdown of costs see Table in Section 2.4

CONTRIBUTIONS

Windfall Contributions:	
Deductible Contributions:	
ERDF Grant:	
Other Ineligible Items:	

LOCATION - to be completed for all projects

EA Region/Area of project site (all projects):	Thames Region
Name of watercourse (fluvial projects only):	River Thames
District Council Area of project (all projects):	Royal Borough of Windsor and Maidenhead; Spelthorne BC; Elmbridge BC; Runneymede BC; London Borough of Kingston upon Thames; London Borough of Richmond upon Thames
EA Asset Management System Reference:	
Grid Reference (all projects):	TQ075675

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

DESCRIPTION

Specific town/district to benefit:	Datchet, Old Windsor, Wraysbury, Staines, Chertsey, Shepperton, Sunbury, Molesey, Kingston, Richmond

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

Construction of 3 flood diversion channels between Datchet and Walton Bridge.
Flood plain management along the Thames flood plain between Datchet and Teddington, including non-structural measures and community based defences

DETAILS

Design standard (chance per year):		Yrs
Existing standard of protection (chance per year)		Yrs
Design life of project:		Yrs
Fluvial design flow (fluvial projects only):		m^3/s
Tidal design level (coastal/tidal projects only):	N/A	M
Length of river bank or shoreline improved:	22km	M
Number of groynes (coastal projects only):	N/A	
Total length of groynes* (coastal projects only):	N/A	M
Beach Management Project?	No	Yes/No
Water Level Management (Env) Project?	No	Yes/No
Defence type (embankment, walls, storage etc)	Flood diversion channels	

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

ADDITIONAL AGREEMENTS:

Maintenance Agreement(s):		Not Applicable/Received/Awaited
EA Region Consent (LA Projects only):		Not Applicable/Received/Awaited
Non Statutory Objectors:		Yes/No
Date Objections Cleared:		
Other:		Not Applicable/Received/Awaited

ENVIRONMENTAL CONSIDERATIONS

Natural England (or equivalent) letter:	Awaited	Not Applicable/Received/Awaited
Date received		

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

Special Protection Area (SPA):	Yes	Yes/No
Special Area of Conservation (SAC):	No	Yes/No
Ramsar Site	Yes	Yes/No
World Heritage Site	No	Yes/No
Other (Biosphere Reserve etc)	No	Yes/No

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

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

OTHER ENVIRONMENTAL CONSIDERATIONS

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

COMPATIBILITY WITH OTHER PLANS

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

SEA/ENVIRONMENTAL IMPACT ASSESSMENT

SEA	Agency Voluntary	Statutory required/Agency voluntary/not applicable
EIA	N/A at this stage	Yes (schedule 1); Yes (schedule 2); SI1217; not applicable
SEA/EIA status	Draft Environmental Report out to consultation	Scoping report prepared/draft/draft advertised/final

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

Detail	Result

Costs, benefits & scoring data

(Apportion to this phase if part of a strategy)

Local authorities only: For projects done under Coast Protection Act 1949, please separately identify: FRM = Benefits from reduction of asset flooding risk; CERM = Benefits from reduction of asset erosion risk

Benefit type (DEF: reduces risk (contributes to Defra SDA 27); CM: capital maintenance; FW: improves flood warning; ST: study; OTH: other projects)

LAND AREA

Total area of land to benefit:			Ha
of which present use is:	FRM	CERM	
Agricultural:			Ha
Developed:			Ha
Environmental/Amenity:			Ha
Scheduled for development			Ha

PROPERTY & INFRASTRUCTURE PROTECTED

	Number		Value (£'000s)	
	FRM	CERM	FRM	CERM
[1]Residential				
Commercial/industrial				
Critical Infrastructure				
Key Civic Sites				
Other (description below):				
Description:				

costs and Benefits

[1]Present value of total project whole life costs (£'000s):		
Project to meet statutory requirement?	*Y/N*	

	Value (£'000s)	
	FRM	CERM
Present value of residential benefits:		
Present value of commercial/industrial benefits:		
Present value of public infrastructure benefits:		
Present value of agricultural benefits:		
Present value of environmental/amenity benefits:		
[1]Present value of total benefits (FRM & CERM)		
Net present value:		
Benefit/cost ratio:		

Base date for estimate:		
PAG Decision Rule stage 3 applied		Yes/No
PAG Decision Rule stage 4 applied		Yes/No

OTHER OUTCOME MEASURE SCORING DETAILS

Super Output Area No*: | Indicate if deprived: No Yes/No

(*as ranked by Indices of Multiple Deprivation)

Risk: VH VH, H or N/A

	Wetland	Saltmarsh/ Mudflat	
Net gain of BAP habitat:	40-60	0	Ha
SSSI protected:	Wraysbury no1 - 60ha Wraysury and Hythe End Gravel Pits - 120ha Thorpe Hay Meadow - 6.5ha St Ann's Lake - 46ha Dumsey Mead - 10ha Total = 242.5ha		Ha
Other Habitat:	Strategy aspires to creation of 60 ha BAP Habitat (min. 40 ha)		Ha
Heritage Sites:			"I or II" , "II or other" or "N/A"

Exemption Details (if exempt from OM scoring system)

Exempt from Scoring: No Yes/No

Reason (max 100 chars):

Outcome Measure Prioritisation Priority Score: ‘D2 Diversion Channels’

Stage 1 - Calculate individual scores

Ref	Description	Project contributions (including adjustments)				Targets		Individual scores
OM1	Present value of Whole Life Benefits **(£000s)**	1,144,000 **o1**			Divided by	3,700,000 **t1**	Gives OM1 individual score	0.31 **s1**
OM2	Number of households moved from any flood / coastal erosion probability category to a lower one **(households)**	12,791 **o2**	Minus o2b	7,725 **o2b**	Divided by	100,000 **t2**	Gives OM2 individual score	0.05 **s2**
OM2b	Number of households moved from the very significant or significant flood probability category to the moderate or low flood probability category; or equivalent coastal erosion probability categories **(households)**	7,725 **o2b**	Minus o3	0 **o3**	Divided by	36,000 **t2b**	Gives OM2b individual score	0.21 **s2b**
OM3	Number of households in deprived communities at reduced flood risk **(households)**	0 **o3**			Divided by	9,000 **t3**	Gives OM3 individual score	0 **s3**
OM5	The number of hectares Biodiversity Action Plan habitat created, net of compensatory habitat **(Hectares)**	60 **o5**			Divided by	800 **t5**	Gives OM5 individual score	0.08 **s5**

Stage 2 - Calculate overall OM prioritisation score

Score	Outcome Measure prioritisation score (total of individual scores divided by whole life cost)	**0.65** **(s1 + s2 + s2b + s3 + s5)**			Divided by	**210,930** **Project whole life costs**	Multiplied by 1,000,000	3.08 **OM prioritisation score**

Outcome Measure Prioritisation Priority Score: ‘FPM’

Stage 1 - Calculate individual scores

Ref	Description	Project contributions (including adjustments)			Divided by	Targets	Gives	Individual scores
OM1	Present value of Whole Life Benefits **(£000s)**	507,000 **o1**			Divided by	3,700,000 **t1**	Gives OM1 individual score	0.14 **s1**
OM2	Number of households moved from any flood / coastal erosion probability category to a lower one **(households)**	1,600 **o2**	Minus o2b	1,600 **o2b**	Divided by	100,000 **t2**	Gives OM2 individual score	0 **s2**
OM2b	Number of households moved from the very significant or significant flood probability category to the moderate or low flood probability category; or equivalent coastal erosion probability categories **(households)**	1,600 **o2b**	Minus o3	0 **o3**	Divided by	36,000 **t2b**	Gives OM2b individual score	0.04 **s2b**
OM3	Number of households in deprived communities at reduced flood risk **(households)**	0 **o3**			Divided by	9,000 **t3**	Gives OM3 individual score	0 **s3**
OM5	The number of hectares Biodiversity Action Plan habitat created, net of compensatory habitat **(Hectares)**	0 **o5**			Divided by	800 **t5**	Gives OM5 individual score	0 **s5**

Stage 2 - Calculate overall OM prioritisation score

Score	Outcome Measure prioritisation score (total of individual scores divided by whole life cost)	**0.18** **(s1 + s2 + s2b + s3 + s5)**			Divided by	**45,500** **Project whole life costs**	Multiplied by 1,000,000	3.96 **OM prioritisation score**