MAYOR OF LONDON

Transport for London

Inner Thames Estuary Feasibility Study

Response to Airports Commission Call for Evidence

The Mayor of London's Submission:
Supporting technical documents

23 May 2014

Title: **Inner Thames Estuary Airport Option: Environmental Review**

Author: **ABP Marine Environmental Research Ltd**

Purpose of paper:

To present a high level overview of the likely compensation requirements associated with the Inner Thames Estuary Option.

Key messages:

- **Direct and indirect habitat impacts and the consequential impacts for waders and waterfowl are likely to be the most significant impacts on Natura 2000 features within the estuary. Direct losses of Natura 2000 habitats are estimated to be around 2000 hectares.**
- **Wider impacts such as those associated with disturbance, changes in habitat suitability and collision risk (with mobile marine species) may require additional compensation.**
- **Compensatory measures would need to be designed to replace the lost functions as fully as possible to ensure the overall coherence of the Natura 2000 network. The ratio of intertidal habitat provision to intertidal habitat loss would need to be greater than one.**
- **It is feasible to create the scale of compensatory habitat required for the Inner Thames Estuary Option.**

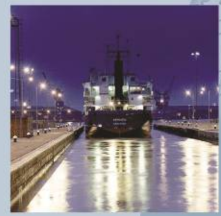
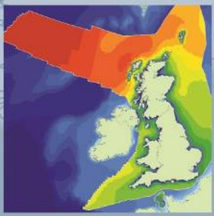
Transport for London

Inner Thames Estuary Airport Option: Environmental Review

Report R.2255

May 2014

Creating sustainable solutions for the marine environment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Inner Thames Estuary Airport Option: Environmental Review

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Summary

The Airports Commission (the Commission) was set up in 2012 to take an independent look at the UK's future airport capacity needs. As part of this process it has sought to identify a list of the most credible options for new runway capacity in the UK. In December 2013 the Commission identified two potential sites that were selected for further analysis, namely at Heathrow and Gatwick (Airport Commission, 2013). The Commission also announced that it intended to carry out additional research in respect of the Inner Thames Estuary Option in the first half of 2014.

The Mayor of London Aviation Work Programme is currently co-ordinating a work stream to provide additional information to the Airports Commission with respect to the Inner Thames Estuary Option. ABP Marine Environmental Research Ltd (ABPmer) has been contracted to undertake the following tasks as part of this programme of works:

- A baseline description and high level impact review for waders and waterfowl;
- High level impact assessment; and
- Compensation review.

This report presents an overview of the likely compensation requirements associated with the Inner Thames Estuary Option. This has been derived from an estimation of the direct footprint losses as well as the potential indirect losses associated with water level changes. The findings should therefore be treated as informative yet indicative because impacts such as disturbance, changes in habitat suitability and collision risk may also contribute to the overall impact of the development and require additional compensation. However, based on current understanding of the likely scale and nature of impacts associated with an Inner Thames Estuary Option, the direct and indirect habitat impacts are likely to be the most significant impacts on Natura 2000 features within the estuary. These will be important issues and their implications will require careful consideration. It should be noted, though, that in undertaking this review nothing has been identified that would preclude the Inner Thames Estuary Option from being considered further.

The Inner Thames Estuary Option in its current location would result in a direct loss of approximately 2,099ha of intertidal, transitional and sub-tidal habitat (including grassland and brackish standing water). The extent of overlap with internationally designated sites is approximately 1,609ha. The majority of habitat to be lost can be described as intertidal mud and sandflats, grazing marsh, sub-tidal sand/mud and to a lesser extent saltmarsh and brackish standing water. The predicted indirect losses associated with changes in water levels are estimated to be less than 5% of the direct losses of intertidal, transitional and sub-tidal habitat under the direct footprint of the Inner Thames Estuary Option. These habitats provide important functional habitat for the internationally important bird assemblage supported by the estuary.

It is considered that a compensatory package would mostly consist of intertidal and sub-tidal habitat creation, but it is possible that additional measures would be required for migratory fish, waders and sea/ marine birds. It is envisaged, based on previous experience that the ratio of intertidal habitat provision to intertidal habitat loss would be greater than one to provide the requisite certainty that the overall coherence of Natura 2000 network is protected. The opportunities for the provision of such habitat have been considered in the context of the ecological requirements of those habitats and

species (interest features) that could be impacted by an Inner Thames Estuary Option. Lessons learnt from previously implemented large scale managed realignment schemes have also been factored in to this analysis.

The site selection exercise was based on a refinement of the outputs of a number of previous investigations. The outputs of the exercise have been tailored to meet the possible requirements associated with the Inner Thames Estuary Option. Consideration has also been given to the likelihood of alternative estuaries supporting a similar bird assemblage to that which could be impacted by the footprint of the Inner Thames Estuary Option. Based on the availability of potentially suitable land for habitat creation, it is theoretically possible to create the scale of compensation required for the Inner Thames Estuary Option within the UK. A total of 73,643ha of potentially suitable land has been identified within 500km of the Inner Thames of which 2,481ha is within 50km of this location. In reality a considerable percentage of the sites may not, on further detailed investigation, prove suitable for habitat creation. In practice numerous additional site selection criteria would need to be applied to identify those sites that offer a realistic prospect of delivering suitable compensatory habitat. In this context, securing suitable sites of the large scale required will be challenging.

It is acknowledged that a full Environmental Impact Assessment would be required in support of the Inner Thames Estuary Option . Full consideration would also need to be given to any cumulative and in-combination impacts with other relevant plans or projects. This would further inform the scale of compensatory requirements as well as how these could be met. Any further assessment of the Inner Thames Estuary Airport Option would also require detailed consideration of wider coastal management initiatives. These include those related to wider marine and environmental planning and legislative requirements, strategic flood risk management strategies and initiatives designed to protect the habitats and species supported by the estuary.

Abbreviations

AA	Appropriate Assessment
ABPmer	ABP Marine Environmental Research Ltd
AtL	Advance the Line
BAP	Biodiversity Action Plan
BTO	British Trust for Ornithology
CAA	Civil Aviation Authority
CBD	Convention on Biological Diversity
CCC	Climate Change Committee
Cefas	Centre for Environment, Fisheries and Aquaculture Science
CFMP	Catchment Flood Management Plan
CHaMP	Coastal Habitat Management Plan
cSAC	candidate Special Area of Conservation
DECC	Department of Energy and Climate Change
EA	Environment Agency
EC	European Commission
EIA	Environmental Impact Assessment
ESC	Environmental Steering Committee
ESS	Essex and South Suffolk
EU	European Union
GIS	Geographic Information System
GTENA	Greater Thames Estuary Natural Area
HAT	Highest Astronomical Tide
HBU	Habitat Behaviour Unit
HFRMS	Humber Flood Risk Management Strategy
HRA	Habitat Regulations Assessment
HtL	Hold the Line
HW	High Water
IGSF	Isle of Grain to South Foreland
IROPI	Imperative Reasons of Overriding Public Interest
JNCC	Joint Nature Conservation Committee
LBAP	Local Biodiversity Action Plan
LiDAR	Light Detection and Ranging
LSE	Likely Significant Effect
LW	Low Water
MarLIN	Marine Life Information Network
MCA	Multi Criteria Analysis
MCZ	Marine Conservation Zone
MES	Medway Estuary and Swale
MHW	Mean High Water
MHWN	Mean High Water Neaps
MHWS	Mean High Water Springs
MLW	Mean Low Water
MLWS	Mean Low Water Springs

MMO	Marine Management Organisation
MR	Managed Realignment
MSL	Mean Sea Level
NAI	No Active Intervention
NERC	Natural Environment Research Council
NPPF	National Planning Policy Framework
ODPM	Office of the Deputy Prime Minister
OMREG	Online Managed Realignment
OS	Ordnance Survey
pSAC	possible Special Area of Conservation
pSPA	potential Special Protection Area
RBMP	River Basin Management Plan
RSPB	Royal Society for the Protection of Birds
RTE	Regulated Tidal Exchange
SAC	Special Area of Conservation
SCI	Sites of Community Importance
SEFRMS	Severn Estuary Flood Risk Management Strategy
SMP	Shoreline Management Plan
SPA	Special Protection Area
TE2100	Thames Estuary 2100
TEP	Thames Estuary Partnership
TfL	Transport for London
TTHAP	Tidal Thames Habitat Action Plan
UK	United Kingdom
UKBAP	United Kingdom Biodiversity Action Plan
WeBS	Wetland Bird Survey

Cardinal points/directions are used unless otherwise stated.

SI units are used unless otherwise stated.

Inner Thames Estuary Airport Option: Environmental Review

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1. Introduction

The Airports Commission (the Commission) was set up in 2012 to take an independent look at the UK's future airport capacity needs. As part of this process it has sought to identify a list of the most credible options for new runway capacity in the UK. During 2013 the Commission received 52 proposals for addressing the UK's airport capacity shortfall, over 40 of which suggested building additional runway infrastructure. These proposals were based on very different visions for the future of the aviation sector.

In December 2013 the Commission identified two potential sites that were selected for further analysis, namely at Heathrow and Gatwick (Airport Commission, 2013). The Commission also announced that it intended to carry out additional research in respect of the Inner Thames Estuary Option in the first half of 2014. On this basis, it will reach a view before the end of 2014 as to whether such an option would offer a credible proposal for consideration alongside the short-listed options. If so, it will be subject to a similar appraisal and consultation process as for those options, although not necessarily to the same timetable.

The Mayor of London Aviation Work Programme is currently co-ordinating a work stream to provide additional information to the Airports Commission with respect to the Inner Thames Estuary Option. The overall scope of works is based on the Inner Thames Estuary feasibility studies terms of reference as issued by the Commission (Airport Commission, 2014). ABP Marine Environmental Research Ltd (ABPmer) has been contracted to undertake the following tasks as part of this programme of works:

1) A baseline description and high level impact review for marine birds;

2) High level impact assessment to provide an appropriate level of information at this stage; and

3) Compensation review.

This report presents an overview of the possible compensation requirements associated with the Inner Thames Estuary Option. This is primarily in the context of the direct habitat losses in the footprint of the scheme and indirect habitat losses associated with changes in estuary water levels. It also considers where it might be feasible to provide the required scales of compensation within the UK. The report is structured according to the following main sections:

Section 1: Provides an introduction to the report;

Section 2: Provides an overview of current legislative and policy guidance;

Section 3: Outlines the potential compensation requirements associated with the Inner Thames Estuary Option;

Section 4: Outlines the methods that could be employed to create intertidal habitat in the context of the ecological requirements of the potential losses associated with the Inner Thames Estuary Option. This includes a review of lessons learnt from previously implemented habitat creation schemes;

Section 5: Identifies where it might be possible to create intertidal habitat at the scale likely to be required for this project;

Section 6: Provides a review of the implications of the Inner Thames Estuary Option in the context of TE2100;

Section 7: Outlines the interaction of the Inner Thames Estuary Option with other coastal management initiatives; and

Section 8: Provides an overall summary and recommendations for further work.

2. Compensation Review

In May 2013 ABPmer outlined possible mitigation and compensatory measures that could be required under the EC Habitats and Birds Directives for an Inner Estuary Airport Option (ABPmer, 2013a). This incorporated a review of policies and precedents for delivering compensatory measures. The following section provides a summary of the key principles and an update to those policies that have been revised since May 2013. Some elements of the initial review have been re-stated for ease of reference.

2.1 Requirements of the Habitats and Wild Bird Directives

Articles 6(3) and (4) of the EC Habitats Directive (92/43/EC) establish strict procedures for the approval of plans or projects that have the potential to affect designated features associated with sites classified as Special Protection Areas (SPAs) under the Wild Birds Directive (2009/147/EC) or as Special Areas of Conservation (SACs) under the Habitats Directive. These provisions are incorporated into English law through the Conservation of Habitats and Species Regulations 2010 and the Offshore Marine Conservation (Natural Habitats, &c.) Regulations 2007 (hereafter jointly referred to as the 'Habitats Regulations').

Under the Habitats Regulations, where a plan or project is not directly connected with, or necessary for, the management of a designated European site or European offshore marine site, including SACs and SPAs, and where the possibility of a likely significant effect (LSE) on these sites cannot be excluded, either alone or in combination with other plans or projects, an Appropriate Assessment (AA) should be undertaken in view of the site's conservation objectives by the competent authority.

In addition, it is a matter of law that candidate Special Areas of Conservation (cSACs) and Sites of Community Importance (SCI) are considered in this process; furthermore in accordance with National Planning Policy Framework (NPPF) it is national policy in England that sites designated under the 1971 Ramsar Convention for their internationally important wetlands (Ramsar sites), potential Special Protection Areas (pSPAs) and possible Special Areas of Conservation (pSACs) are considered in this process.

When evaluating the effects of a proposed development on these designated sites as part of the Habitat Regulations Assessment (HRA) process, if the competent authority cannot conclude that the plan or project will not have an adverse effect on the integrity of a European/Ramsar site (either alone or in combination with other plans or projects), the plan or project can only be adopted if it has been ascertained that, there being no alternative solutions, the plan or project must be carried out for Imperative Reasons of Overriding Public Interest (IROPI), including those of a social or economic nature.

Where the site concerned hosts a priority natural habitat type (identified in Annex 1 of the Habitats Directive) or a priority species (identified in Annex 2 of the Habitats Directive), the grounds for IROPI are more restricted, being limited only to reasons relating to human health, public safety or beneficial consequences of primary importance to the environment or any other reasons which the competent authority, having due regard to the opinion of the European

Commission, consider to be imperative reasons of overriding public interest. Where a plan or project is agreed to with reference to IROPI any necessary compensation measures are to be provided to ensure that the overall coherence of Natura 2000 is protected.

2.1.1 Overview of Guidance

The key guidance documents addressing the requirements for compensation include:

- UK guidance:
  - ODPM (2005) provides useful guidance on the relative timing of compensatory measures against the commencement of the impacts;
  - Natural Environment White Paper (referenced in HM Government, 2012) sets out how an ecosystems approach will result in better informed and integrated decisions;
  - Defra (2012) provides guidance on IROPI; and
  - National Planning Policy Framework (2012).
- EU guidance:
  - Managing Natura 2000 Sites (EC, 2000) provides guidance on the scope of compensation in the context of the Natura 2000 Network;
  - EC (2001) provides guidance on the assessment of plans and projects significantly affecting Natura 2000 sites;
  - The guidance document on Article 6(4) of the Habitats Directive (EC, 2007) confirms and expands on the requirements outlined in (EC, 2000) clarifying the concepts of alternatives, IROPI and compensatory measures; and
  - Guidelines on the implementation of the Birds and Habitats Directive in Estuaries and Coastal Zones (EC, 2011).

The details contained within these guidance documents were outlined in the 'Hub for London Compensation and Mitigation Measures In Relation to Natura 2000 Sites' report (ABPmer, 2013a) with the exception of EC (2011) which is primarily focussed on port development and dredging. The key requirements of relevance to this project are summarised below.

Compensatory measures are required to maintain the coherence of the Natura 2000 network and should be of a comparable size and type to the habitats being lost or affected. The guidance recommends that 'best efforts' should be made to assure compensation is in place beforehand. Where this is not achievable, the competent authorities should consider extra compensation for the interim losses that would occur in the meantime.

A range of ratios have been applied to determine the habitat creation objectives of a particular scheme or strategy, however, a minimum ratio of at least 2:1 has typically been applied where the required habitat gains are associated with the compensatory requirements for an identified development. To date, compensatory habitat has typically been provided broadly on a like-for-like basis (i.e. delivering through compensation the same habitats that have been or will be lost through development). However, increasing consideration is now being given to moving towards a greater emphasis on ecosystem functioning. The concept behind ecosystem functioning involves considering the full range of benefits that the natural environment provides.

The ‘Managing Natura 2000 Sites’ document (EC, 2000) states that the compensatory measures proposed for a project should ‘*concern the same biogeographical region in the same Member State*’. EC (2001) further indicates that the compensatory provision should ‘*be in as close proximity as possible to the habitat that has been adversely affected by the project or plan*’. The EC 2007 guidance repeats the requirements for compensation measures to be within the same biogeographic region (for Habitat Directive sites) or within the same range, migration route or wintering area for bird species (site designated under the Birds Directive) in the Member State concerned. In addition, there is general agreement that the local conditions necessary to reinstate the ecological assets at stake are found ‘as close as possible to the area affected by the plan or project’. Therefore, locating compensation near to the Natura 2000 site concerned in a location showing suitable conditions for the measures to be successful seems the most preferred option. However, this is not always possible and it is necessary to set a range of priorities to be applied when searching locations that meet the requirements of the Habitats Directive.

These principles were tested relatively recently in the review of compensatory measures associated with the Severn Estuary Tidal Energy Feasibility studies commissioned by the Department of Energy and Climate Change. The discussions related to this project re-enforced the published guidance with respect to the requirement to create compensatory habitat as close as possible to the location(s) where the loss or damage is predicted to occur. It was further re-iterated that the creation of compensatory habitat outside of the UK was unlikely to be acceptable. The only possible exceptions related to particular species where their ecological requirements could be better met in other Member States.

In the light of the above issues, it is therefore important to develop a sufficiently robust scientific understanding about the specific ecological requirements of the affected features and consider the flexibilities of extent, timing and location to ensure that compensatory measures are adequate. In this respect, we note that there are precedents for considering not just like-for-like delivery but wider ecosystem functioning and how the offsetting measures compare against the losses in the context of the long-term projected natural evolution of a coastal ecosystem.

It is also of note that a review of coastal compensation sites in England is currently being undertaken on behalf of Natural England which aims to provide an overall assessment of whether these sites are meeting their conservation objectives. The work will aim to derive over-arching lessons learnt as well as provide recommendations for the process under which compensation is secured in the UK. The project will also include a review of Natura 2000 compensation measures in Europe to determine their effectiveness and any lessons that may have applicability in England. It is expected to be published towards the end of 2014.

3. Compensation Requirements

The focus of this section is to outline the potential scale of intertidal habitat compensation that could be required as a result of locating an airport in the Inner Thames Estuary. This has been derived from an estimation of the direct footprint losses as well as the potential indirect losses associated with water level changes. The findings should therefore be treated as indicative, yet informative, because impacts such as disturbance, changes in habitat suitability and collision risk may also contribute to the overall impact of the development and require additional compensation. However, based on current understanding of the likely scale and nature of impacts associated with an Inner Thames Estuary Option, the direct and indirect habitat impacts are likely to be the most significant impacts on Natura 2000 features within the estuary.

3.1 Direct Habitat Loss

The Inner Thames Estuary Option in its current location (Figure 1) would result in a direct loss of approximately 2,099ha of intertidal, transitional and sub-tidal habitat (including transitional grassland[1] and brackish standing water). The generic habitat types included within these areas of overlap are summarised in Table 1 (Figure 2) and a more detailed breakdown is provided in Appendix A. This is based on overlap with the Environment Agency digital habitat inventory (dated 2004) for the majority of the footprint. The remainder of the footprint, including the sub-tidal components has been derived from overlap with EUSeaMap. It should be noted that EUSeaMap is a modelled predictive map and has a relatively coarse resolution (http://jncc.defra.gov.uk/euseamap). The extent of overlap with internationally designated sites is summarised in Tables 2 to 4 (Figure 3) and a more detailed breakdown is provided in Appendix A.

Table 1. Direct overlap with airport footprint

Habitat	Area Within Footprint (ha)
Intertidal soft sediments	977
Shingle	4
Littoral hard sediments	12
Saltmarsh	46
Grazing Marsh/ grassland	680
Reedbeds	14
Eelgrass	1
Dunes	3
Brackish standing water	66
Sub-tidal sand/ mud	296
Other (non marine habitat related)	496
Total	**2,595**

[1] It should be noted that at this stage the degree of marine influence on the grassland habitats has not been assessed and as such could include areas of terrestrial habitat.

The majority of habitat to be lost can be described as intertidal mud and sandflats, grazing marsh, sub-tidal sand/ mud and to a lesser extent saltmarsh and brackish standing water. A large proportion of the intertidal habitats are also cited within the overlapping international environmental designations on the Thames and Medway estuaries. The overlapping designated habitats are predominantly intertidal mudflats and sandflats, grazing marsh, saltmarsh and brackish standing water.

Table 2. Overlap with national and international designations

Designated Site	Overlap (ha)
Thames Estuary and Marshes SPA	1,606
Thames Estuary and Marshes Ramsar site	1,603
Medway Estuary and Marshes Ramsar site	2.5
Medway Estuary MCZ	29

Table 3. Overlap with Thames Estuary and Marshes SPA*

Habitat	Area Within Footprint (ha)
Intertidal soft sediments	940
Shingle	4
Littoral hard sediments	11
Saltmarsh	45
Grazing Marsh/ grassland	506
Reedbeds	9
Eelgrass	1
Dunes	3
Brackish standing water	59
Sub-tidal sand/ mud	6
Other (non marine habitat related)	22
Total	**1,606**

* A separate calculation has not been undertaken for the Thames Estuary and Marshes Ramsar site as it is essentially the same footprint as the respective SPA

Table 4. Overlap with Medway Estuary and Marshes Ramsar site

Habitat	Area Within Footprint (ha)
Grazing Marsh/ grassland	2
Brackish standing water	<0.5
Other (non habitat related)	<0.5
Total	**2.5**

The Medway Estuary Marine Conservation Zone (MCZ) is an inshore site located on the Kent coast. It encompasses the Medway Estuary from Rochester down to its mouth, and extends seaward to include an area between Sheerness and the Isle of Grain. A total area of 60km^2 is protected by this MCZ. One species and eight different habitats and their associated wildlife are protected by the Medway Estuary MCZ including:

- Intertidal mixed sediments;
- Intertidal sand and muddy sand;
- Sub-tidal coarse sediment;
- Sub-tidal mud;
- Sub-tidal sand;
- Low energy intertidal rock;
- Estuarine rocky habitats;
- Peat and clay exposures; and
- Tentacled lagoon-worm (*Alkmaria romijni*).

The total spatial overlap with the footprint of the Medway Estuary MCZ is 29ha.

3.2 Indirect Habitat Loss

There will be indirect changes to the extent of intertidal and sub-tidal habitats as a result of changes in the hydrodynamic (water levels) and sedimentary regimes (changes in patterns of sediment erosion and accretion) associated with an Inner Thames Estuary Option. A numerical hydrodynamic modelling exercise has been undertaken to determine a possible magnitude of indirect change in habitat extent. The baseline and predicted water levels (with the inclusion of the Inner Thames Estuary Option) have been extracted from the hydrodynamic model and reviewed in the context of the estuary topography. The range of typical slopes at both high and low water have been approximated from bathymetric charts for three sections of the study area which have been defined in relation to the relative changes in high and low water with the scheme in place (Figure 4). The ranges in slopes that have been assumed are:

- Between 1:50 and 1:200 at LW; and
- Between 1:10 and 1:50 at HW.

This is an over-simplification of the range of slopes likely to occur within the study area but the results help to indicate the broad range and magnitude of the potential indirect losses associated with changes in water level.

The predicted changes in high and low water levels assumed for each section can be summarised as:

- Section 1: 0.02m reduction in high water and 0.01m increase in low water; and
- Sections 2 and 3: 0.015m reduction in high water and 0.01m increase in low water.

These estimates are based on the outputs of the numerical modelling in the context of the margins of accuracy of the numerical model. The change in width of the intertidal zone (according to the ranges in slope applied) has been extrapolated along the respective lengths of high and low water within these zones. The length of the low and high water lines has been approximated on the basis of the Ordnance Survey (OS) Terrain 50 and the OS Boundary-Line datasets respectively.

The results of this exercise are summarised in Table 5. The potential changes to intertidal extent as a result of changes in water levels with the airport in place (under the worst case assumptions assumed in this assessment) are in the order of 70ha. This is equivalent to less than 5% of the direct losses of intertidal, transitional and sub-tidal losses under the direct footprint of the Inner Thames Estuary Option.

It should be noted that to increase the confidence in this prediction there would be a requirement for better defined recent topographic data with complete estuary coverage, improved resolution within the hydrodynamic models and a fuller consideration of any associated physical/ biological changes. In addition this estimate does not take account of any indirect losses associated with any additional changes to the morphological or hydrodynamic regime of the estuary (e.g. waves, sedimentation).

Table 5. Indicative indirect intertidal losses from changes in water levels

Section	Lower Estimate of Loss at LW (ha)	Upper Estimate of Loss at LW (ha)	Lower Estimate of Loss at HW (ha)	Upper Estimate of Loss at HW (ha)
1	5	19	2	10
2	2	6	0	1
3	6	22	2	10
Total	**12**	**48**	**4**	**21**

3.3 Waders and Wildfowl

A baseline review of the wader and waterfowl populations within the Inner Thames Estuary (ABPmer, 2014a) identified the following generic impact pathways that may affect coastal marine bird species during the construction and operation of an Inner Thames Estuary Option:

- Change in habitat extent;
- Change in habitat suitability;
- Release of contaminants associated with the dispersion of suspended sediments;
- Noise/vibration disturbance;
- Visual disturbance;
- Barrier to movement;
- Collision risk (during construction);
- Bird strike (during operation); and
- Discharge and accidental spillages.

The species considered most at risk to impacts associated with the Inner Thames Estuary Option, based on the limited initial review, have been identified as:

- Dark-bellied Brent Goose;
- Shelduck;
- Oystercatcher;
- Lapwing;

- Golden Plover;
- Grey Plover;
- Knot;
- Dunlin;
- Redshank;
- Curlew;
- Black-tailed Godwit;
- Bar-tailed Godwit;
- Ringed Plover; and
- Wigeon.

It should be noted that this list is based on the species considered most at risk to direct or indirect loss of habitat associated with the construction of the Inner Thames Estuary Option. However, it is recognised that this is based on incomplete bird data and many other potentially significant factors associated with the construction and operation of the Inner Thames Estuary Option could impact upon the bird populations within the area through the pathways outlined above. These indirect impacts and other influences are not currently well understood and at this stage there is insufficient detail regarding the Inner Thames Estuary Option design (including any associated infrastructure) and construction methodologies for a comprehensive assessment of these impacts to be made.

Should the Inner Thames Estuary Option be pursued further, detailed assessments would be required to determine a final list of potential impact pathways and their associated significance and to fill existing data gaps. Full consideration would also be given to any cumulative and in-combination impacts (with other plans or projects). In order for such detailed assessments to be made, extensive site specific surveys would need to be undertaken (see ABPmer, 2014a for more detail).

4. Compensation Provision

It is considered that a compensatory package would mostly consist of intertidal and sub-tidal habitat creation, but it is possible that additional measures would be required for migratory fish, waders and sea/ marine birds[2]. It is envisaged, based on previous experience that the ratio of intertidal habitat provision to intertidal habitat loss would be greater than one to provide the requisite certainty that the overall coherence of Natura 2000 network is protected. The opportunities for the provision of such habitat are considered further in Section 5. It is first important to understand the ecological requirements of those habitats and species (interest features) that could be impacted by an Inner Thames Estuary Option.

4.1 Intertidal Habitats

The habitat creation requirements resulting from the Inner Thames Estuary Option would include intertidal mudflat, saltmarsh, coastal grazing marsh and high level marsh lagoons. It would also be anticipated that further ecological enhancements such as raised islands and channels and ponds which remain flooded at low water for birds and fish would be inherent within the design of any such scheme. This intertidal habitat zonation relative to tidal levels is illustrated in Figure 5. The characteristics of these habitats are summarised below along with examples of species which favour a given habitat type.

4.1.1 Intertidal Mudflat

Mudflat typically develops at elevations between the levels of Mean Low Water Springs (MLWS) and Mean High Water Neaps (MHWN) which are typically inundated by the tide twice daily. These low lying sites can be opened up to a high degree of exposure and more than 450 inundations per annum will tend to form mudflat (or sandflats depending on the sedimentary environment).

The distribution of invertebrate fauna that inhabit intertidal and sub-tidal sediments is largely controlled by the tolerance of the various species to the physiological stress, predation, competition and disturbance which are influenced by physical factors, such as tidal inundation frequency (i.e. land elevation), salinity, sediment composition and structure, exposure, wave action and elevation. Much of the infauna are deposit feeders, taking advantage of the high levels of organic material in the sediment (Hiscock and Marshall, 2006). Benthic fauna and algae also provide feeding resources for overwintering and breeding bird communities (including Curlew, Dunlin, Gadwall, Redshank, Shelduck, and Teal) and fish species (e.g. bass and herring).

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2 Please note consideration of wider compensation and mitigation requirements are beyond the scope of this project.

4.1.2 Intertidal Saltmarsh

Coastal saltmarshes may be defined as areas, vegetated by herbs, grasses or low shrubs, bordering saline water bodies (Adam, 1990). Saltmarshes form in low energy or sheltered environments with shallow water, such as estuaries, behind spits and barrier islands and in protected bays where there is a supply of suspended sediment that can accrete.

Intertidal saltmarshes can form at higher elevations at the back of a mudflat, or in sheltered (breached) enclosures. Typically 300 and 450 inundations per annum will tend to form pioneer saltmarsh while less than 300 per year will allow the development of low to upper marshes. A range of saltmarsh types occur at different elevations/ inundations with saltmarsh typically developing between MHWN and Mean High Water Springs (MHWS), and upper/transitional saltmarsh between MHWS and Highest Astronomical Tide (HAT) +1 m (Figure 5). However, for the purposes of this assessment intertidal saltmarsh has been considered as a single habitat type.

Saltmarshes form wildfowl roosting/breeding/feeding areas (e.g. for Curlew, Dunlin, Lapwing, Redshank and Shelduck) as well as being important feeding and nursery areas for fish species.

4.1.3 Coastal Grazing Marsh/ Transitional Grassland

Coastal grazing marsh is a distinctive maritime habitat derived from the enclosure of saltmarsh. It is relatively flat, low lying, periodically flooded grassland, pasture or meadow drained by a network of ditches.

The ditches, which maintain the water levels, contain standing water ranging from brackish to fresh. The ditches are especially rich in plants and invertebrates. Sites may contain seasonal water-filled hollows and permanent ponds with emergent swamp communities, but not extensive areas of tall fen species like reeds; although they may abut with fen and reed swamp communities.

The marsh may grade into saltmarsh to seaward and, to landward, into other habitats of nature conservation importance, such as lowland wet grassland, reedbeds, freshwater marshes, fen meadows, wet ditches and transitions to mires and ancient woodland. These natural transitions, both within drainage ditches and on the grassland itself, are of particularly high biodiversity value.

Grazing marshes are particularly important for the number of breeding waders such as Snipe, Lapwing and Curlew they support. Internationally important populations of wintering wildfowl also occur including Bewick Swans and Whooper Swans.

4.1.4 High Level Marsh Lagoon

High level marsh lagoons are shallow ‘pans’ created in mid to upper saltmarsh that act like saline lagoons. They act as specialist invertebrate habitat and wildfowl roosting/feeding areas (e.g. for Avocet, Wigeon, Dunlin, Oystercatcher and Teal).

4.1.5 Raised Islands

Within managed realignment sites areas of high ground (above HAT) can be created within the intertidal which provide safe areas for bird roosting and breeding sites (e.g. for Oystercatcher and Terns). These areas can also attract terrestrial plant and invertebrate species.

4.2 Waders and Waterfowl

Estuaries often support substantial numbers of both waders and waterfowl, particularly during the winter and passage periods. Waders are one of the world's furthest migrating groups of birds, with many species migrating annually from Arctic breeding grounds to wintering areas as far away as South America, Africa and Australia. Many migratory species pass through Britain during spring and autumn on their way to/from breeding grounds where they feed and moult, often in coastal areas and estuaries (Adamìk and Pietruszková, 2008). For some species a proportion of the population will overwinter in Britain while others migrate further south. Waterfowl also rely on coastal estuarine habitats at various stages in their life history, particularly as important feeding and wintering areas (McKinney *et al*., 2006).

Different species of bird exhibit different physical and behavioural adaptations to allow them to exploit different feeding opportunities; they may also exploit different areas of the intertidal zone. These are summarised in Appendix B[3]. The habitat preferences of bird species relate primarily to diet and feeding behaviour, although nesting and roosting requirements are also important (Atkinson *et al*., 2001). Additional factors important in controlling wader utilisation of intertidal habitats include the area of the site, topography, habitat types, disturbance, behavioural patterns and sediment consolidation. The climate, geographical location and proximity to flyways can also be important factors in locating a suitable site.

In terms of topography, the intertidal area at mean low water springs, the ratio of area: length of shore and the coverage sequence, have all been found to affect the feeding distribution of waders (Bryant, 1979; Evans, 1979). Enclosed sites can also give birds the perception of increased risk of predation. In terms of disturbance, the close proximity of lights, noise and footpaths may affect wader use of an area. The proximity of disturbance free roost sites and other intertidal areas nearby are also important parameters determining site usage.

4.3 Compensation Options

There are a number of options that could be used to compensate for the likely impacts of an Inner Thames Estuary Option on European designated sites. These can include:

- Intertidal and sub-tidal habitat creation;
- Identification of additional sites/ areas for SAC designation; and
- Enhancement opportunities (existing habitats/ populations in designated sites not affected by the proposed developments).

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3 While not the main focus of this report details of the ecology of seabirds have also been included in Appendix B.

The focus of the current exercise is the identification of potentially suitable habitat creation opportunities within the UK. This can be achieved through:

- Managed realignment (including regulated tidal exchange); and
- Sediment reprofiling (either directly or indirectly).

A brief summary of each of these techniques is presented below, before a review of lessons learnt through the implementation of relatively large compensation schemes is provided. However, it should be noted that the specific requirements for compensation would need to be established through a thorough and detailed assessment of impacts and the identification of specific functions lost as a result of the development. In line with existing guidance (see Section 2) the compensatory measures would need to be designed to replace the lost functions as fully as possible to ensure the overall coherence of the Natural 2000 network.

4.3.1 Managed Realignment

Managed realignment is generally viewed as the main option for the creation of intertidal habitat, but it can also be used to create sub-tidal habitat in low lying areas, or in combination with sediment reprofiling. Managed realignments aim to achieve natural and morphologically-complex sites that resemble historical intertidal landscapes. It involves the deliberate breaching, or removal, of existing seawalls, embankments or dikes in order to allow the waters of adjacent coasts, estuaries or rivers to inundate the land behind.

There are essentially three different managed realignment methods which can be applied (managed breaching, defence removal or regulated tidal exchange) and these were described in detail in ABPmer, 2013a. Ultimately the technique implemented at a site is dependent on the objectives of the scheme and site specific considerations. However, the principles of identifying potential sites at the resolution required within the current study are essentially the same for each of these methods.

4.3.2 Sediment Reprofiling

Sediment reprofiling (either the deposition of sediment or removal of sediment) can be used to manipulate existing habitats. Intertidal recharge is a process by which dredged sediments are placed over or around intertidal mudflats and saltmarshes to either restore them or to protect them from ongoing erosion (Nottage and Robertson, 2005; Cefas, 2009). Recharge can also be used to create intertidal habitat on what was previously sub-tidal habitat. This approach is especially valuable for protecting habitats that are perhaps sediment starved and where the introduction of dredge arisings will allow the habitat to cope with and respond to sea level rise.

For the purposes of this project it is assumed that the same site selection principles apply as for managed realignment more widely. In practice, additional considerations associated with this method include the identification of suitable types/ volumes of material, licensing requirements as well as site specific physical and ecological constraints.

4.4 Lessons Learnt

It is essential that future habitat creation schemes are based on an understanding of lessons learnt from those that have already been implemented. Of particular relevance to the requirements associated with the Inner Thames Estuary Option are the lessons learnt from relatively large schemes.

ABPmer hosts an Online Managed Realignment (OMREG) database (ABPmer, 2014c) which documents lessons learnt from 95[4] managed realignment projects. Of these 95 schemes, two are over 500ha, both of which are in Germany. One is a regulated tidal exchange (RTE) scheme (850ha) and the second is a breach into a secondary dike (not for defence or people) to allow more effective water removal from the site following overwashing (1,750ha) (ABPmer, 2014c).

In the UK, the largest schemes are Alkborough flood alleviation scheme which is around 370ha and the Medmerry coastal realignment (on the Selsey Peninsula) which is around 300ha. In addition to these established projects there are some larger schemes in the UK that are not yet completed. Those projects which are currently underway include the RSPB's Wallasea Island Wild Coast Project (677ha) which will begin to be breached in 2016 and the Environment Agency's Steart Realignment (400ha) on the Parrett Estuary (Bristol Channel) which will be breached at the end of 2014.

There are lessons that can be learnt from a number of the largest schemes to date and these are presented in the context of the following generic headings:

- Scheme implementation costs;
- Project management and communication;
- Site selection;
- Design and assessment;
- Ecological development and monitoring;
- Wider benefits; and
- Sign-off procedure.

The following sections provide a summary of key lessons learnt under these headings with a more detailed review, illustrated with examples, provided in Appendix C.

4.4.1 Scheme Implementation Costs

One of the main hurdles in undertaking managed realignment projects is the cost of their implementation as well as the risk of these costs increasing where obstacles are encountered during the various phases (i.e. scheme design, impact assessment, planning and construction). The most significant 'known' costs are land purchase and construction, with the cost for providing new flood defences a substantial element of the construction costs in the majority of cases. Risks of increasing costs can be incurred here when managed realignment sites affect

4 Statistic correct as of 1 May 2014.

adjacent 'Habitats Regulations protected' sites or if the potential site contains protected species, archaeology assets or unexploded ordnance. Consultation with stakeholders and local communities can also be resource intensive.

Research, led by ABPmer, into the costs of managed realignment schemes has revealed that the average unit cost for all schemes that have been implemented up to and including 2011 is about £34,000 per hectare. In general there has been a clear shift over the course of two decades from initial low-cost, small-scale, and relatively inexpensive trial projects (e.g. Tollesbury, Essex created in 1995 at a cost of £14,000/ha) to high-cost, larger, projects that were designed to meet specific targets for habitat creation and flood alleviation (e.g. Medmerry (near Selsey) created in 2013 at an approximate cost of £93,000/ha). However, even in recent years, these costs have ranged greatly due to the distinct challenges and constraints faced at individual schemes (Scott *et al*., 2011).

4.4.2 Project Management and Communication

The reasons for undertaking a managed realignment need to be clearly identified at the outset, as they can influence the design and planning process but, most importantly, clarity is essential in any consultation or public engagement to promote the scheme. As managed realignments are relatively complex, having an effective, clear, honest and early, stakeholder communication strategy is essential. It is important to consult not only with the scheme promoters but also with the local community, relevant conservation bodies and consenting authorities from the outset. Local communities and authorities increasingly demand significant planning gains from managed realignment implementers (e.g. improved flood protection and public access). After breaching, and as part of the monitoring work, it is strongly recommended that communication is continued.

The timeline identified for delivering large scale compensatory habitat is estimated between 10 and 12 years for a scheme on the ground with a further period of between two and five years to develop ecological functionality. Therefore the lead in time for schemes that require large areas of compensation requires early planning, site selection, prioritisation and investigation, focusing on the ecological criteria, costs and offsite risks.

Once underway, a myriad of issues can cause significant project delays, from landowner negotiations and obtaining planning consent, to constraints on construction (due to weather, tides and protected species windows) and mitigation habitats. Significant contingencies should be incorporated into the process to allow for unexpected concerns and issues becoming unexpectedly complex (Scott *et al*., 2011).

It is recognised that there are a number of Government and public bodies which are also seeking to implement managed realignment around the country and benefits could be gained by coordinating site selection and implementation of such schemes. Managing and monitoring losses and gains in a coordinated manner could streamline the timeline for delivery of intertidal habitat as well as cost savings. Similarly, collaborative approaches with other private companies can also mutually benefit both parties.

4.4.3 Site Selection

Selecting sites for large scale intertidal habitat creation projects is challenging yet achievable. To put this into perspective, over the past 25 years, just over 1,500ha of intertidal habitat has been created in the UK through the implementation of over 55 schemes (ABPmer, 2014c). The largest UK managed realignment site to date, at Alkborough on the Humber, measures 370ha. Finding enough land for such a large scale habitat creation scheme is challenging. Much of the land that would potentially be suitable for intertidal habitat creation along the South-East and East coasts, for example, is either densely populated, highly valuable (e.g. for food production and industrial use) or already designated. In addition, any managed realignment is likely to be adjacent to coastlines or estuaries designated under the Birds and/or Habitats Directives which presents further complexities.

Land acquisition will therefore be a significant issue for any large scale managed realignment schemes. Historically the issues have focused around agricultural land purchase but it is likely that the issues of residential and commercial properties will continue to increase, with small clusters of properties or entire hamlets potentially being affected. Therefore it will be highly unlikely that any large managed realignment will be possible without significant landowner consultation, engagement, and the availability of compulsory purchase powers, potentially through an Act of Parliament.

Based on experience with larger scale UK projects (100 to 300 ha), it is estimated that it would take at least two years to find suitable site(s). The land purchase, design and assessment/ consenting phases of such schemes would also be expected to be fairly protracted for sites of a large size (Halcrow, *et al*., 2013).

As noted above, the objectives of a project need to be clearly established to allow for effective implementation and communication. These objectives, ideally, need to be underpinned by available evidence from shoreline management and flood defence strategies. In other words there has to be a clear rationale for undertaking work in a particular location and a clear recognition that the work is in keeping with the coastal and estuarine processes.

ABPmer has previously undertaken a review which identified site selection processes undertaken to find generic locations potentially suitable for managed realignment or habitat creation (Halcrow, *et al*., 2013). In most instances a two stage methodology has been applied, the first of which is generally a screening process within a Geographic Information System (GIS) framework. Most screening studies begin with a floodplain map and use a range of criteria to select the most suitable sites (e.g. by avoiding built up areas, roads or railways; identifying areas with elevations suitable for intertidal habitat creation and considering land use and land ownership issues). In this way site selection criteria should avoid those sites which are likely to pose additional programme risks. Table C1 in Appendix C lists the GIS screening criteria that have been applied by various site selection exercises.

The screening has typically been followed with a Multi Criteria Analysis (MCA) process, consultation with stakeholders, or a combination of both. MCA typically involves assigning scores to a number of criteria to establish those sites which might be more or less suitable for habitat creation. The scoring of the different parameters can also be weighted depending on the perceived importance of the respective parameters. Table C2 in Appendix C lists the MCA criteria scored and weighted by various site selection exercises.

4.4.4 Key Issues in Managed Realignment Design and Assessment

When approaching the assessment and design of managed realignment projects, an iterative and phased process is recommended, whereby there is a building up of evidence about the scale of changes and the functioning of a site. Building upon the feasibility review work that will already have been completed for the site selection work, a thorough site visit review should be seen as an essential next step in this process, following which a preliminary design should be developed and its implications assessed on a high level. At the same time, the Environmental Impact Assessment (EIA) process should be commenced, and relevant ecological surveys undertaken to ensure on-site constraints are known (and mitigated for).

The final phase should involve the detailed assessment of the scheme's hydrodynamic effects, which will then inform both the finalisation/ enhancement of the design and the assessment of the individual EIA topics. Understanding changes both within the site and along the adjacent estuary often requires detailed hydrodynamic, sediment and wave modelling/assessment exercises. Detailed investigations would be required to determine if such changes constitute a significant adverse effect on the integrity of sites as part of any project appraisal.

Overall, there are considered to be no 'new' technical barriers to large scale managed realignment over and above those already encountered in the smaller managed realignment schemes completed to date. However, the scale of larger projects may be such that the engineering costs would be higher and the risk of encountering unforeseen issues is greater and mitigation for such risks likely to be more costly than for smaller managed realignment. These could, for example, include local opposition to increased visitor numbers/ reduced tranquillity, the risk of protected species and/ or having to redirect footpaths.

4.4.5 Ecological Development and Monitoring

The ecological development of managed realignments is well studied, particularly where these were implemented as compensatory measures under the EU Habitats Regulations. For these sites there is a requirement to understand whether the created/restored habitats have offset the impacts of the plan or project which they have been designed to compensate. The final key component of a successful realignment is the implementation of an effective monitoring programme. This has two key functions to verify the impact predictions and to assess the site's development (e.g. against compensation or biodiversity targets). This monitoring usually focuses on mudflat benthos, marsh vegetation and overwintering birds, however, intertidal habitats are known to be valuable feeding and nursery grounds for many fish species such as flounder, herring and bass. As with many other aspects of managed realignment though, the detailed composition of the monitoring programme will reflect site-specific requirements.

For large scale sites, it is likely that a regulator group or steering committee will be established to review the data collected during monitoring on a regular basis. These reviews are used to evaluate the scheme against its objectives as well as re-assess what monitoring needs to be taken forward into the future.

4.4.6 Wider Benefits

In addition to enhancing flood defences and/or creating new coastal habitat managed realignments typically provide many secondary socio-economic benefits (or Ecosystem Services), such as tourism, recreational and commercial fisheries, carbon sequestration and water quality improvements.

4.4.7 Sign Off Procedure

The current procedure for determining whether managed realignment schemes have met their objectives is not well defined within the UK. Large scale managed realignments are likely to have legal agreements in place which set objectives for the scheme through which the success of the managed realignment site will be reviewed. For those managed realignment sites with specific compensation objectives it is uncertain how these sites will be signed off and the habitat deemed as acceptable compensation for that which was lost.

For most managed realignment sites to date there has been no official sign off procedure in place from the outset of the project and thus in practice there is no certainty about what will happen at these sites at the end of the defined review period. Having clear objectives in place from the outset, and a mechanism through which managed realignment sites can be signed off is of paramount importance.

5. Site Identification

A number of site selection exercises have previously been undertaken to determine potentially suitable locations for intertidal habitat creation. These have included the identification of compensatory habitats for individual developments as well as at a more strategic scale for losses typically associated with coastal squeeze. This section reviews the potential habitat creation opportunities that exist around the UK on the basis of the outputs of previous site selection exercises. The outputs of these have been tailored to meet the possible requirements associated with the Inner Thames Estuary Option. The previous studies that have been used to inform the current study include the Greater Thames Coastal Habitat Management Plan (CHaMP), Thames Estuary 2100 (TE2100), Lappel Bank and Severn Compensatory Measures. An overview of each of these projects, including the site selection criteria that were applied, is presented in Appendix D.

In summary the previous projects have initially used a number of high level criteria to define potentially suitable locations prior to a more detailed site characterisation exercise. The initial screening has typically focused on the following criteria:

- Size of the site;
- Elevation of land in the context of adjacent tidal levels;
- Exclusion of major infrastructure, railways and roads; and
- Exclusion of internationally designated sites.

The exact criteria used within each of the respective studies will have varied depending on the objectives of the original study. The minimum size for a viable option will, for example, have varied considerably.

The outputs of these previous exercises remain relevant to the current study where there is a requirement for large areas of intertidal habitat creation. In reality it is likely that multiple sites would need to be delivered as compensatory habitat for the Inner Thames Estuary Option. The relative scale of the site(s) is again likely to be related to the distance from the location of the respective adverse impacts. A minimum size criterion was applied at different distances from the location of the Inner Thames Estuary Option (see Table 6). The full list of 90 potential sites was further reviewed to remove any areas of overlap. The list was also refined to ensure that the exclusion of international designations criteria had been applied uniformly across the sites. This resulted in a total of 73 sites for further consideration.

Current Civil Aviation Authority (CAA) advice makes reference to a minimum distance of 13km from which habitat designed to support birds is created (CAA, 2008). A 13km buffer has therefore been applied to the Inner Thames Estuary Option so that these sites were not considered further in the analysis. This resulted in the removal of seven sites from the list of potential options. The application of this exclusion zone to existing airports (as mapped in OS VectorMap District) resulted in the removal of a further 22 sites.

A characterisation exercise has been undertaken to provide additional detail for each of the remaining sites according to the following generic headings:

- Size (ha);
- Location (the river/ estuary on which the site is located);
- Habitat creation feasibility (the likelihood of being able to create intertidal habitat based on land elevation and existing habitats); and
- Overall ease of implementation (based on a review of major constraints such as likely costs (e.g. length of defences required, potential compensatory/ mitigation measures), fronting designations, amount of infrastructure, flood defence requirements and agricultural land classification).

These criteria have been used to further refine the potential area that could be suitable for habitat creation. The resulting number of sites and total area available within different distances from the proposed location of the Inner Thames Estuary Option are summarised in Table 6 and Figure 6.

It can be seen from the results in Table 6 that purely in terms of the existence of suitable sites, it is possible to create the scale of compensation required for the Inner Thames Estuary Option within the UK. In reality, a proportion of these sites would not prove suitable for habitat creation. The key reasons for this have been described in the review of lessons learnt from previous schemes (see Section 4.4 and Appendix C). Thus, in practice numerous additional site selection criteria would need to be applied to identify those sites that offer a realistic prospect of delivering effective compensatory habitat.

Examples of the types of parameters that have not been included to date include proximity and overlap with waterways, airports, nature reserves, visitor centres and wider tourism and recreation attractions. Similarly at this stage no review of wider potential benefits associated with each of the respective sites has been undertaken. This could, for example, include a review of sites in the context of those locations already requiring enhancements to flood defences.

Table 6. Potential habitat creation opportunities

Distance	Minimum Size (ha)	No. of Potential Sites	Area (ha)
0-50 km	50	8	2,481
50-100 km	250	5	3,364
100-200 km	250	8	31,950
200-500 km	500	21	35,848

Consideration has also been given to the likelihood of alternative estuaries supporting a similar bird assemblage to that which could be impacted by the footprint of the Inner Thames Estuary Option. To achieve this a comparison has been made between the relative bird assemblage present at a number of alternative estuaries, based on the WeBS high water counts (5-year peak mean 2007/08 to 2011/12) and the most recent peak low water counts of the 20 most abundant species present within the Thames Estuary (see Tables E1 and E2 in Appendix E). This comparison considered eight other sites around the UK based on the locations of potentially suitable sites: the Severn Estuary; the Humber Estuary; The Wash; the Ribble Estuary; Morecambe Bay; Foryd Bay; the Inland Sea and Alaw Estuary; and Dungeness (Figure 7).

A review of the data indicates that the Severn and Humber estuaries support a comparable bird assemblage to the Thames Estuary at both high and low water and in broadly comparable numbers. The high tide counts also indicate that Morecambe Bay, The Wash and the Ribble Estuary support a similar high water assemblage to the Thames, although some species are absent in the low water data.

It should be noted, however, that the coverage of the WeBS low tide counts is often patchy and the absence of a species in the data does not necessarily imply its absence at the whole of the site. Notably, no low tide data is available for The Wash, which the high water data indicates as supporting a similar assemblage and in comparable numbers to the Thames. It is therefore acknowledged that while these data can give an indication of the likelihood of these estuaries supporting a similar bird assemblage to the Thames wider consideration must be given to a range of other factors. These include data coverage, the relative area of the site compared to the Thames and the functional use of different areas by birds. It should also be noted that the functioning of a site and its ability to support bird species will be dependent on the provision of suitable feeding and roosting features within a site. A more detailed assessment would therefore be required to undertake a comparison of the relative suitability of the different estuaries to provide suitable compensatory habitat for birds recognised through the designations on the Thames Estuary.

6. TE2100

6.1 Objectives

The TE2100 project was established by the Environment Agency in 2002 with the aim of developing a strategic flood risk management plan for London and the Thames Estuary to the end of the century (Environment Agency, 2012). The TE2100 plan covers the tidal Thames and its floodplain from Teddington in the west to Shoeburyness in the east (Figure 8) and is divided into 23 policy units. The Inner Thames Estuary Option has the potential to impact on both the flood defence and habitat requirements outlined in the TE2100 plan.

6.1.1 Flood Risk

For each of the 23 policy units in the TE2100 plan area, there is a recommended flood risk management policy. The TE2100 action plan groups together policy units with similar characteristics and requiring a similar type and range of actions into local 'action zones'. There are five possible strategic levels of flood risk management:

P1. No active intervention (including flood warning and maintenance). Continue to monitor and advise.

P2. Reduce existing flood risk management actions (accepting that flood risk will increase over time).

P3. Continue with existing or alternative actions to manage flood risk. We will continue to maintain flood defences at their current level accepting that the likelihood and/or consequences of a flood will increase because of climate change.

P4. Take further action to keep up with climate and land use change so that flood risk does not increase.

P5. Take further action to reduce the risk of flooding (now or in the future).

The policies set the standard and strategic direction for flood risk management in each policy unit as summarised in Table 7.

Further to the development of the policies a series of options to manage flood risk were identified. The final four options as presented within the TE2100 plan are summarised in Table 8 (Figure 8). In summary the recommended option is to maintain and improve the existing system (Option 1.4) for the first 60 years of the Plan, with new arrangements required by 2070 (according to government climate change guidance at the time of issuing the plan). At this stage all four of the generic estuary wide-options remain under consideration with a decision required by 2050 due to the associated lead in times of alternative options. The TE2100 plan will therefore be kept under review over the coming decades.

Table 7. Flood risk management policies

Action Zone	Policy Units	Policy Number
0 Estuary-wide	All Units	-
1 West London	Richmond	3
	Twickenham	3
	Barnes and Kew	5
	Hammersmith	5
2 Central London	Wandsworth to Deptford	5
	London City	5
3 East London	Greenwich	5
	Isle of Dogs and Lea Valley	5
	Royal Docks	4
4 East London Downstream of Thames Barrier	Barking and Dagenham	4
	Rainham Marshes	4
	Thamesmead	4
5 Middle Estuary	Dartford and Erith	4
	Swanscombe and Northfleet	4
	Purfleet, Grays and Tilbury	4
6 Lower Estuary Marshes*	East Tilbury and Mucking Marshes	3
	North Kent Marshes	3
	Hadleigh Marshes	3
7 Lower Estuary, Urban/Industrial and Marshland*	Canvey Island	4
	Bowers Marshes	4
	Shell Haven and Fobbing Marshes	4
	Isle of Grain	3
8 Seaside/Fishermen's Frontage	Leigh Old Town and Southend on Sea	4
* Denotes TE2100Action Zones in the vicinity of the Inner Thames Estuary Option		

Table 8. The TE2100 generic estuary-wide options

Option	Description
Option 1	Improve the existing defences: ▪ Raise defences where needed ▪ Allow for future adaptation of defences ▪ Raise defences when they are replaced ▪ Allow for future adaptation and optimise repair and replacement
Option 2	Four potential sites have been identified which are in the right location to store tidal waters and reduce the level of storm surges. The sites identified are at: ▪ Erith Marshes; ▪ Aveley and Wennington Marshes; ▪ Dartford and Crayford Marshes; and ▪ Shorne and Higham Marshes.
Option 3	New Barrier: ▪ Tilbury location; and ▪ Long reach location. The new barrier would be designed to resist the highest surge tides predicted under government climate change guidance.
Option 4	Barrier with locks: ▪ Tilbury location; ▪ Long reach location; and ▪ Convert Thames Barrier to a barrier with locks when the operational limit of closures per year is reached.

The Inner Thames Estuary Option is predicted to result in a small reduction in the levels of HW and small increase in the levels of LW (but within the margins of accuracy of the numerical model, in close proximity to the site (ABPmer, 2014b). Whilst the effects of the scheme on water levels are likely to be small, the predicted reduction infers an overall reduction in the level of tidal flood risk as a direct result of the development. It is noted here that further assessment of the potential effect considering surge tides and under high river flows will help to provide additional information on flood risk effects as a result of the development. It should also be noted that this analysis is based on high level hydrodynamic modelling which would need to be refined to inform any more detailed flood risk assessment to support a project application. However, on this basis the Inner Thames Estuary Option would not be expected to adversely impact or change the flood risk policies or options set out in the TE2100 plan.

The TE2100 also identified a number of flood storage areas which are in the right location to store tidal waters and reduce the level of storm surges (see Option 2, Table 8). The sites identified are at Erith Marshes, Aveley and Wennington Marshes, Dartford and Crayford Marshes and Shorne and Higham Marshes. None of these sites directly overlap with the footprint of the Inner Thames Estuary Option (Figure 8)

6.1.2 Predicted Habitat Losses

It is estimated that 1,200 ha of habitat at the margins of the estuary will be lost through coastal squeeze over the next century. This was identified through the Greater Thames CHaMP (ABPmer, 2008). The study area was subdivided into a series of units, termed Habitat Behaviour Units (HBUs), based on an understanding of the geomorphology, hydrodynamics and habitat interconnectivity. The HBUs were defined as follows (Figure 9):

- Herne Bay to The Oaze (Whitstable Bay): with more typical ‘open coast’ characteristics (HBU 1);
- The Swale Estuary (HBU 2);
- Garrison Point to Shell Ness on the Isle of Sheppey: soft London clay cliff and slopes (HBU 3);
- The Medway Estuary (HBU 4);
- The Thames Estuary: with more ‘typical’ estuarine characteristics (HBU 5);
- Shoeburyness to Foulness Point: extensive intertidal mud and sandflats (HBU 6); and
- Sub-tidal bank and channel: region between north Kent open coast and south Essex Foulness area (HBU 7).

The total intertidal area within each HBU in the 2006 baseline condition of the study area, ranged from 385ha in HBU 1 to 8,335ha in HBU 6 (Table 9, Figure 9). Overall there was predicted to be a net loss of intertidal area throughout the study area as a whole over the next 100 years (Figure 9). The relative proportion of loss within each unit was, however, predicted to be different dependent on the key drivers and processes that are dominant within each HBU. The following table provides a summary of the predicted changes in extent of intertidal area over the next 100 years. The results should be viewed as the most likely direction and scale (order of magnitude) of change as opposed to a precise estimate (Table 9). It should be noted that not all of these losses are of designated habitats.

Table 9. Predicted changes in the extent of intertidal area within each HBU of the study area relative to the 2006 baseline

HBU	2006 Baseline (ha)	20 Year Change (ha)	50 Year Change (ha)	100 Year Change (ha)
1	385	-15	-65	-130
2	2,000	-20	20	200
3	1,360	-90	-320	-590
4	4,000	-50	50	-600
5	5,500	-55	-275	-1000
6	8,335	-100	-490	-1640
7	N/A	N/A	N/A	N/A

The outputs of the Greater Thames CHaMP were used to inform potential impacts on the designated sites of the respective estuaries. In recommending maintenance and improvement of the fixed defences, the TE2100 plan is likely to have a significant negative effect alone, and in combination, on the:

- Medway Estuary and Marshes SPA/ Ramsar site;
- Thames Estuary and Marshes SPA/ Ramsar site;
- Holehaven Creek proposed SPA;
- Benfleet and Southend SPA/Ramsar site; and
- Foulness (mid-Essex Coast Phase 5) SPA/ Ramsar/ SAC.

The Appropriate Assessment concluded that maintenance and improvement of the flood defences would result in an adverse effect on integrity of the following sites:

- Medway Estuary and Marshes SPA/ Ramsar site;
- Thames Estuary and Marshes SPA/ Ramsar site;
- Holehaven Creek proposed SPA; and
- Benfleet and Southend SPA/Ramsar site.

On this basis the TE2100 plan identified that there was a need to create 876ha of intertidal habitat according to current predictions and understanding of impacts associated with implementing the TE2100 plan. To offset the predicted losses and the potential adverse effects on the integrity of internationally designated sites five locations that have the right characteristics for intertidal habitat creation have been identified. The TE2100 plan identifies that there is likely to be a need for four of them to be implemented. The sites are (Figure 10):

- Grain Marshes;
- All Hallows Marshes;
- St Mary's Marsh (including a possible further expansion to the west);
- West Canvey Marshes; and
- Bowers Marsh.

This has been reduced from a longer list of possible options that were identified as the TE2100 plan was being developed (as described in Section 5 above). Early indications are that of the five sites identified, a possible extension to the west of St Marys Marsh and Bowers Marsh are most likely to be implemented first. In the timescales of the TE2100 plan it is intended that the first scheme will be introduced by 2020 with the others to follow in 2040, 2050 and 2065 (Environment Agency, 2012).

The Inner Thames Estuary Option will generate a further requirement for compensatory habitat on the Thames Estuary and will also directly impact on the locations proposed by the TE2100 plan. The extent of direct overlap of the footprint of the Inner Thames Estuary Option with each of these sites is summarised in Table 10 (Figure 10).

Table 10. TE2100 compensation sites

Site	Overlap With Footprint (ha)
Grain Marshes	236
All Hallows Marshes	516
St Mary's Marsh (including a possible further expansion to the west)	16
West Canvey Marshes	0
Bowers Marsh	0

7. Coastal Management Initiatives

A review of coastal management documents and policies that are relevant to the Thames Estuary has been undertaken to understand the potential for any linkages with the Inner Thames Estuary Option. These have been grouped under the following generic headings:

- Marine and environmental planning;
- Flood risk; and
- Protected habitats and species.

It is important to note, however, that many of the coastal management documents and policies are of relevance to all of these topics and as such any linkages should not be ignored. Additional detail relating to each of the documents is provided in Appendix F.

7.1 Marine and Environmental Planning

The coastal management documents and policies that have been reviewed in the context of marine planning include:

- South East Inshore Marine Plan; and
- Thames River Basin Management Plan.

The Inner Thames Estuary Option will need to be mindful of the requirements associated with each of these plans.

7.1.1 South East Inshore Marine Plan

The Marine and Coastal Access Act 2009 divided the UK marine areas into marine planning regions with an associated plan authority to prepare a marine plan for the area. In England, inshore and offshore waters have been split into 11 plan areas for which the Marine Management Organisation (MMO) will be producing marine plans. The marine plans will aim to provide guidance for sustainable development in English waters.

The East Inshore and East Offshore areas were the first areas in England to be selected for marine planning and the East Marine Plans were published on 2 April 2014. The Thames Estuary falls within the South East Inshore Marine Plan area which has yet to be selected for marine planning, however, the MMO have begun gathering evidence and data for the future plan areas. Where there is not currently a marine plan, the Marine Policy Statement provides the framework for decision making on marine licences (MMO, 2014). The primary goal of marine planning is to support the achievement of sustainable development, encompassing environmental social and economic factors in line with the ecosystem approach.

7.1.2 Thames River Basin Management Plan

The statutory Thames River Basin Management Plan (Environment Agency, 2009a) identifies the human pressures affecting the water environment in the Thames river basin district and the actions that will address them. It shows the current state of the water environment, and what actions will be taken to address the pressures identified. It sets out what improvements are possible by 2015 and how the actions will make a difference to the local environment – the catchments, the estuaries and coasts, and the groundwater. The Thames RBMP has been prepared under the Water Framework Directive, and is the first of a series of six-year planning cycles.

There is one coastal and 11 transitional (estuarine) water bodies within the Thames RBMP. All bar one of these water bodies are classified as heavily modified or artificial reflecting extensive hydrological and morphological modifications that have occurred in the past to support sustainable human use activities. None of the water bodies are expected to achieve 'good' status or potential by 2015, due to technically infeasibility or reasons of disproportionate cost. The aim for all water bodies is to achieve good status or potential by 2027.

7.2 Flood Risk

The coastal management documents and policies that have been reviewed in the context of flood risk include:

- TE2100;
- Greater Thames Coastal Habitat Management Plan;
- Shoreline Management Plans; and
- Catchment Flood Management Plans.

The potential changes to the physical environment associated with the implementation of the Inner Thames Estuary Option will need to be evaluated in the context of any consequences for flood risk. This includes the strategic flood risk management planning that has already been undertaken.

7.2.1 TE2100

The TE2100 project was established by the Environment Agency in 2002 with the aim of developing a strategic flood risk management plan for London and the Thames Estuary to the end of the century (Environment Agency, 2012). The TE2100 plan covers the tidal Thames and its floodplain from Teddington in the west to Shoeburyness in the east and is divided into 23 policy units. Additional detail on the potential interaction between the Inner Thames Estuary Option and the TE2100 is provided in Section 6.

7.2.2 Greater Thames Coastal Habitat Management Plan

The Greater Thames CHaMP (ABPmer, 2008) provides a high level framework to advise the management decisions that may affect sites within the Thames Estuary designated under the Habitats and Bird Directives and the Ramsar Convention (Natura 2000 sites). The Greater Thames CHaMP informed the TE2100 project, which looked to identify options for the next generation of measures required to address coastal flooding in the Thames Estuary (see Section 6 above).

The Greater Thames CHaMP provides a unified framework for considering the effect of sea level rise and other drivers of change affecting the conservation status of the Natura 2000 sites and their component habitats within the Thames Estuary, together with those of the Medway-Swale. The predicted changes, alongside more localised parameters and processes, provide a valuable resource on which to base future management practices within the designated sites and the system as a whole.

7.2.3 Shoreline Management Plans

The Environment Agency's Shoreline Management Plans (SMP) are large-scale assessments of the risks associated with coastal processes, including tidal patterns, wave height, wave direction and the movement of beach and seabed materials. SMPs also identify the preferred policies for managing these risks to people and the developed, historic and natural environments as well as the consequences of implementing the preferred policies.

There are three SMPs with which the Inner Thames Estuary Option would interact (Environment Agency, 2010 a, b, c). These include:

- Isle of Grain to South Foreland (IGSF);
- Medway Estuary and Swale (MES); and
- Essex and South Suffolk (ESS) (extending from Landguard Point in the north to Two Tree Island (just west of Southend) in the south, including the estuaries of the rivers Roach, Crouch, Blackwater, Colne, Stour and Orwell, and the tidal inlet of Hamford Water).

The southern boundary of the ESS SMP and the western boundary of the IGSF SMP also overlap with the TE2100 project boundaries, which is discussed in detail in Section 6.

7.2.3.1 Isle of Grain to South Foreland SMP

The Inner Thames Estuary Option location overlaps directly with policy unit 4a01 Allhallows-on-Sea to Grain (Environment Agency, 2010a). The preferred policy options identified in the Isle of Grain to South Foreland (IGSF) SMP at this location are Hold the Line (HtL) in the short term (2025) and Managed Realignment in the medium (2025-2055) and long term (2055-2105).

In the short term the plan is to continue protecting the low lying assets, which include properties, roads, agricultural land and coastal grazing marsh. Under rising sea levels it is anticipated that it will become increasingly difficult to defend the shoreline and maintain a beach on this frontage, due to coastal squeeze and a general lack of natural sediment inputs. This would result in a need for very substantial hard defences, if the current alignment were to be held in the long-term. Therefore, in the medium and long term the plan is to realign the defences, to realise potential environmental, engineering and coastal process benefits. No specific realignment position has been defined under the SMP, only an indicative extent. Although the approach would involve the managed loss of assets; it is intended that the villages of Allhallows and Grain, and the electricity/ railway line would be protected.

The marshland fronting this policy unit is also a designated freshwater habitat and its loss would need to be compensated for. By delaying realignment until the second epoch it is intended that this will give time for compensatory habitat to be established and allow for consistency with the TE2100 strategy.

The remaining policy units within the IGSF SMP, along the Thames Estuary frontage of the Isle of Grain and the North Kent coast, predominantly involve HtL in the short, medium and long term. HtL is considered appropriate along these sections of the coast which comprise dense urban areas that extend to the shoreline, important amenity beaches and have regionally important strategic links. The long term plan is to continue protecting the developments including the residential, commercial, industrial and infrastructural assets. Policy units 4a05, 4a06, 4a07A and 4a07B along the Isle of Grain and Swale Estuary frontage have also been identified as having Managed Realignment as the preferred policy.

7.2.3.2 Medway Estuary and Swale SMP

A small section of the policy unit E401 Grain Tower to Colemouth Creek overlaps directly with the Inner Thames Estuary Option (Environment Agency, 2010b). The preferred policy option here is HtL in all three epochs due to the nationally important industry and infrastructure in the area. As with the IGSF SMP, the Medway Estuary and Swale (MES) SMP identifies a preferred policy of HtL for most of the policy units where important urban areas, infrastructure and commercial assets exist. Some opportunities also exist for managed change to the defence line. Managed Realignment will enable more flexible estuary management and better flood and erosion risk management in the future.

7.2.3.3 Essex and South Suffolk SMP

There is no direct overlap between the Inner Thames Estuary Option and the Essex and South Suffolk (ESS) SMP (Environment Agency, 2010c). However, the general plans and policies are discussed. For most of the currently defended coast and estuaries, the intent is to continue to HtL of existing flood and coastal defences throughout the short, medium and long term.

For a number of frontages however, the ESS SMP process identified that the defences are under pressure from eroding channels or from wave attack, typically in the middle and outer reaches of the estuaries. This pressure is likely to increase with climate change and sea level rise. For these frontages a change of policy to MR is desirable, by realigning the defences to a more landward, sustainable location (while continuing to protect all dwellings and key infrastructure).

7.2.4 Catchment Flood Management Plans

There are 77 Catchment Flood Management Plans (CFMPs) which have assessed inland flood risk across all of England and Wales. The CFMP considers all types of inland flooding, from rivers, ground water, surface water and tidal flooding, but not flooding directly from the sea (coastal flooding), which is covered by the SMPs described above.

The role of the CFMP is to establish flood risk management policies which will deliver sustainable flood risk management for the long term. Policy options relate to the level of flood risk and associated action from advice and monitoring to managing existing flood risk measures to implementing further action to reduce flood risk. The CFMP should be used to inform planning and decision making by key stakeholders in the catchment.

The North Kent Rivers, South Essex and Thames CFMPs cover the area surrounding the proposed location for the Inner Thames Estuary Option, however the proposed airport location overlaps directly with only the North Kent Rivers CFMP (Environment Agency, 2009b,c,d). The flood risk management policy identified by the Environment Agency for this area is "areas of low to moderate flood risk where we are generally managing existing flood risk effectively". This policy tends to be applied where the risks are currently appropriately managed and where the risk of flooding is not expected to increase significantly in the future. This policy supports economic, social and environmental development by maintaining the current level of risk but accepting that the impacts of flooding will increase with time due to climate change. The North Kent Rivers CFMP highlights the importance of maintaining the link with the Medway and Swale Estuary and Isle of Grain to South Foreland SMPs to ensure an integrated approach for coastal defence, river drainage and biodiversity on the marshes (Environment Agency, 2009b).

7.3 Protected Habitats and Species

The coastal management documents and policies that have been reviewed in the context of protected habitats and species include:

- Managing the Land in a Changing Climate;
- Greater Thames Estuary Natural Area;
- Biodiversity Action Plans;
- Tidal Thames Habitat Action Plan; and
- Voluntary and non-statutory initiatives.

The predicted impacts to habitats and species arising from the implementation of the Inner Thames Estuary Option will need to have regard to each of these initiatives.

7.3.1 Managing the Land in a Changing Climate

The 2013 Managing the Land in a Changing Climate Report (CCC, 2013) is part of a series of annual progress reports by the Adaptation Sub-Committee to assess how the country is preparing for the major risks and opportunities from climate change. Together these reports will provide the baseline evidence for the Committee's statutory report to Parliament on preparedness due in 2015. The 2013 report extends the work of the Committee to some of the key ecosystem services provided by the land. Specifically, the report addresses the use of land to continue to deliver essential goods and services in the face of a changing climate – supplying food and timber, providing habitat for wildlife, storing carbon in the soil, and coping with sea level rise on the coast. It explores the extent to which decisions about the land are helping the country to prepare for climate change.

The 2013 Report highlights opportunities for adaptation, including realigning some flood defences on the coast to create space for habitats that provide natural defences to migrate inland. Realigning coastal defences in undeveloped locations will help to reduce risks of coastal flooding and habitat loss due to sea level rise. The Report makes clear that the Environment Agency and local authorities should work together on a clear implementation programme to speed up the pace of realignment along appropriate stretches of coastline. Improving compensation arrangements to account for the value of ecosystem services provided by coastal habitats would help the Environment Agency and local authorities to meet their policy goals for coastal realignment (CCC, 2013).

7.3.2 Greater Thames Estuary Natural Area

The Greater Thames Estuary Natural Area comprises not only the tidal Thames itself, from Tower Bridge downstream to Whitstable in Kent and Southend in Essex, but also includes most of the Essex coast, north to the mouth of the Stour (English Nature, 1997). The Greater Thames Estuary Natural Area identifies key issues and sets nature conservation objectives for the intertidal and sub-tidal habitats of the Area. Conservation objectives include:

- Minimise and compensate or mitigate habitat loss and damage due to sea defence improvement schemes and seek opportunities for habitat enhancement;
- Secure environmentally sustainable shoreline management which is as far as possible in harmony with natural coastal and estuarine processes, and secures the objectives of the Habitats Directive;
- Offset past and future critical habitat losses through habitat creation and enhancement;
- Maintain an adequate series of undisturbed feeding and roosting areas for all nationally and internationally important wildfowl and wader populations; and
- Maintain and enhance the extensive interconnected network of estuarine habitats. Where possible, extend wildlife corridors between developed areas, thereby preventing fragmentation.

7.3.3 Biodiversity Action Plans

The UK Biodiversity Action Plan (UKBAP) lists habitats and species given priority for action across the UK. Following a systematic review of the list originally published in 1994, the list of species and habitats was increased to 65 habitats and 1149 species in 2007 ('the 2007 list'). One hundred and twenty three of the species were also removed from the original list of UKBAP priorities. The 2007 UKBAP list has also been used by the Secretary of State as the basis for the list of Species and Habitats of Principal Importance for the purpose of Conserving Biodiversity under Section 41 (hereafter referred to as the S41 list) of the Natural Environment and Rural Communities Act (NERC) (Natural England, 2014).

One of the key recommendations of the UKBAP was that Local Biodiversity Action Plans (LBAPs) were needed to complement the national initiative. These have two broad functions: to ensure that the national action plans are put into practice at the local level and to establish targets and actions for species and habitats characteristic of each local area. It is of note that the species and habitats listed on LBAPs may be different from those listed on the UKBAP and may differ between areas.

The London, Kent and Essex Local Biodiversity Action Plans (LBAPs) share the UK BAP objective to: conserve biological diversity within the UK and contribute to the conservation of global diversity through all appropriate mechanisms. Providing a focus for local initiatives, the three LBAPs offer a regional framework important to habitat and species priorities on the Tidal Thames (London Biodiversity Partnership, 2007).

The new UK post-2010 Biodiversity Framework replaces the previous UK level Biodiversity Action Plan. The UK Post-2010 Biodiversity Framework covers the period 2011 – 2020. It forms the UK Government's response to the new strategic plan of the United Nations Convention on Biological Diversity (CBD), published in 2010 at the CBD meeting in Nagoya, Japan (JNCC and Defra, 2012).

7.3.4 Tidal Thames Habitat Action Plan

The Thames Estuary Partnership (TEP) Biodiversity Action Group has integrated the priorities of London, Kent and Essex to produce the Tidal Thames Habitat Action Plan (TTHAP) with an aim to:

- Conserve and enhance the wildlife habitats, species diversity and local distinctiveness of the Tidal Thames;
- Adopt a strategic approach to deliver biodiversity targets for the Tidal Thames as a whole; and
- Promote public awareness and appreciation of the Tidal Thames habitat and species diversity.

The role of the TTHAP is to co-ordinate action for the protection and enhancement of key habitats and species populations, within the Tidal Thames area (TEP Biodiversity Action Group, 2002). It also seeks to provide a link to related habitat and species action plans to promote an holistic approach to biodiversity gain within the Thames Estuary corridor. A number of Objectives, Actions and Targets are also outlined in the TTHAP including appropriate management for existing and new habitats and species and to create new areas of intertidal habitat and high tide roosts.

7.3.5 Voluntary and Non-Statutory Organisations

Voluntary and non-statutory organisations also provide a wealth of advice and undertake a number of management initiatives: these include the London Wildlife Trust, Kent Wildlife Trust, Essex Wildlife Trust, the Groundwork Trust, Thames 21, the British Trust for Conservation Volunteers, the Wildfowl and Wetlands Trust, the Royal Society for the Protection of Birds, North-west Kent Countryside Management Project and Groundwork Kent Thames-side.

8. Summary and Recommendations

This report presents an overview of the likely compensation requirements associated with the Inner Thames Estuary Option. This has been derived from an estimation of the direct footprint losses as well as the potential indirect losses associated with water level changes. In undertaking this review nothing has been identified that would preclude the Inner Thames Estuary Option from being considered further.

At this stage it is considered that direct and indirect habitat impacts are likely to be the most significant impacts on Natura 2000 features within the estuary. It should be noted, however, that wider impacts such as those associated with disturbance, changes in habitat suitability and collision risk (with mobile marine species) may require additional compensation. Further, detailed assessments would be required to determine a final list of potential impact pathways and their associated significance and to fill existing data gaps. Full consideration would also need to be given to any cumulative and in-combination impacts.

The Inner Thames Estuary Option in its current location would result in a direct loss of approximately 2,099ha of intertidal, transitional and sub-tidal habitat (including grassland and brackish standing water). The extent of overlap with internationally designated sites is approximately 1,609ha. The majority of habitat to be lost can be described as intertidal mud and sandflats, grazing marsh, sub-tidal sand/ mud and to a lesser extent saltmarsh and brackish standing water. These habitats provide important functional habitat for the internationally important bird assemblage supported by the estuary.

It is of note considerable baseline data would need to be collected to confirm the predictions outlined above. This would include detailed habitat mapping of the intertidal zone that could be impacted by the scheme as well as the sampling of the invertebrate assemblage. The surveys would need to determine the extent of changes in habitat extent since the Environment Agency digital habitat inventory in 2004 as well as the spatial extent and condition of interest features. Similarly baseline habitat and species data would be required for sub-tidal habitats.

Extensive bird surveys would also be required to underpin any further environmental assessment work. These requirements would exist, not just for the direct footprint of the Inner Thames Estuary Option, but also in relation to the location of any other infrastructure associated with the project as well as the wider study area (i.e. the spatial extent of predicted impacts) and the locations of potential compensation sites.

To increase the confidence in the prediction of indirect impacts on intertidal and sub-tidal habitats there would be a requirement for better defined recent topographic data with complete estuary coverage, improved resolution within the hydrodynamic models and a fuller consideration of any associated physical/biological changes. In addition a more detailed assessment of any indirect losses associated with any additional changes to the morphological or hydrodynamic regime of the estuary (e.g. waves, sedimentation) would be required.

The specific requirements for compensation would need to be established through a thorough and detailed assessment of impacts and the identification of specific functions lost as a result of the development. In line with existing guidance (see Section 2) the compensatory measures would need to be designed to replace the lost functions as fully as possible to ensure the overall coherence of the Natural 2000 network. It is envisaged, based on previous experience that the ratio of intertidal habitat provision to intertidal habitat loss would be greater than one.

It is considered that a compensatory package would mostly consist of intertidal and sub-tidal habitat creation, but it is possible that additional measures could be required for migratory fish, waders and sea/ marine birds. The opportunities for the provision of compensatory habitat have been considered in the context of the ecological requirements of those habitats and species that could be impacted by an Inner Thames Estuary Option. Lessons learnt from previously implemented large scale managed realignment schemes have also been factored in to this analysis.

A site selection exercise, based on a refinement and update of the outputs of a number of previous investigations, has been undertaken to identify potentially suitable habitat creation sites. The outputs of this exercise were tailored to meet the possible requirements associated with the Inner Thames Estuary Option. Consideration has also been given to the likelihood of alternative estuaries supporting a similar bird assemblage to that which could be impacted by the footprint of the Inner Thames Estuary Option.

It has been demonstrated that it is theoretically possible to create the scale of compensation required for the Inner Thames Estuary Option within the UK. Numerous additional site selection criteria would need to be applied to identify those sites that offer a realistic prospect of delivering compensatory habitat. In this context it is recommended that further effort should be invested to further refine the areas in which suitable compensatory habitat could be provided.

Any further assessment of the Inner Thames Estuary Airport Option would require detailed consideration of other coastal management initiatives. These include those related to wider marine and environmental planning and legislative requirements, strategic flood risk management strategies and initiatives designed to protect the habitats and species supported by the estuary.

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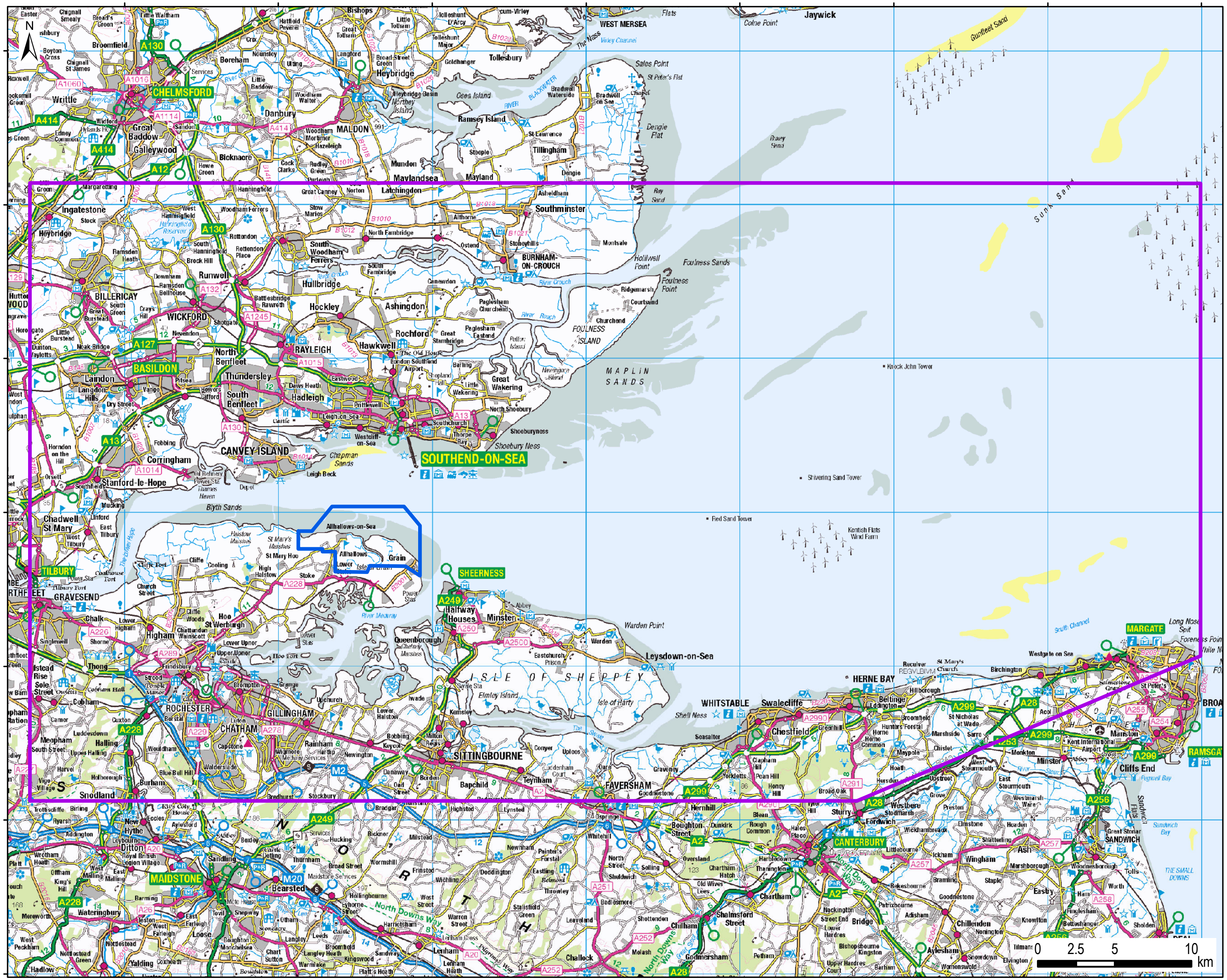
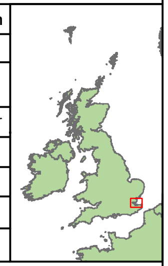
Figures



Study Area	
Inner Thames Estuary Option	



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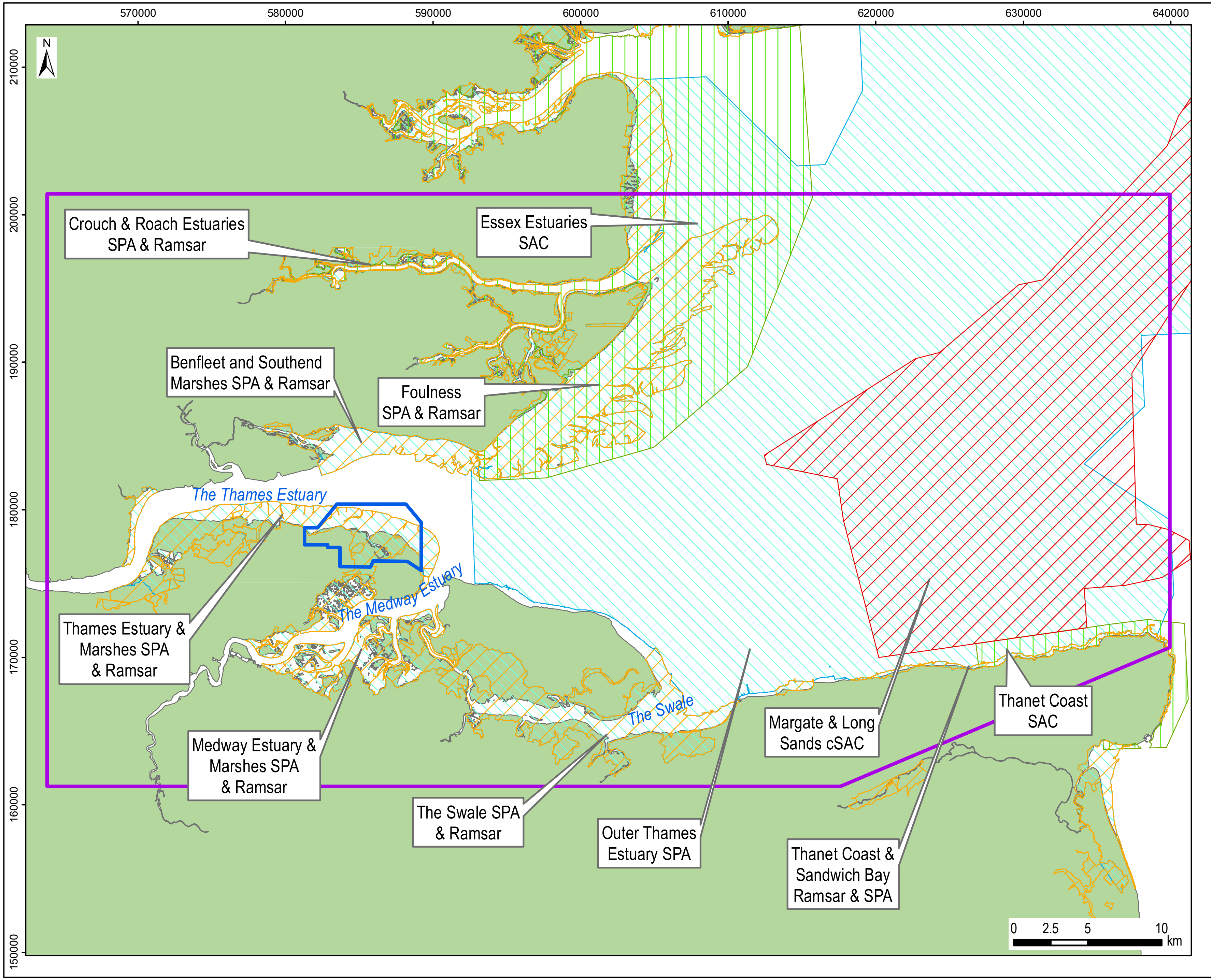
Study Area

Figure 1



Study Area
Inner Thames Estuary Option
Special Area of Conservation
Candidate Special Area of Conservation
Special Protection Area with Marine Components
Ramsar

Date	By	Size	Version
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Projection	Transverse Mercator		
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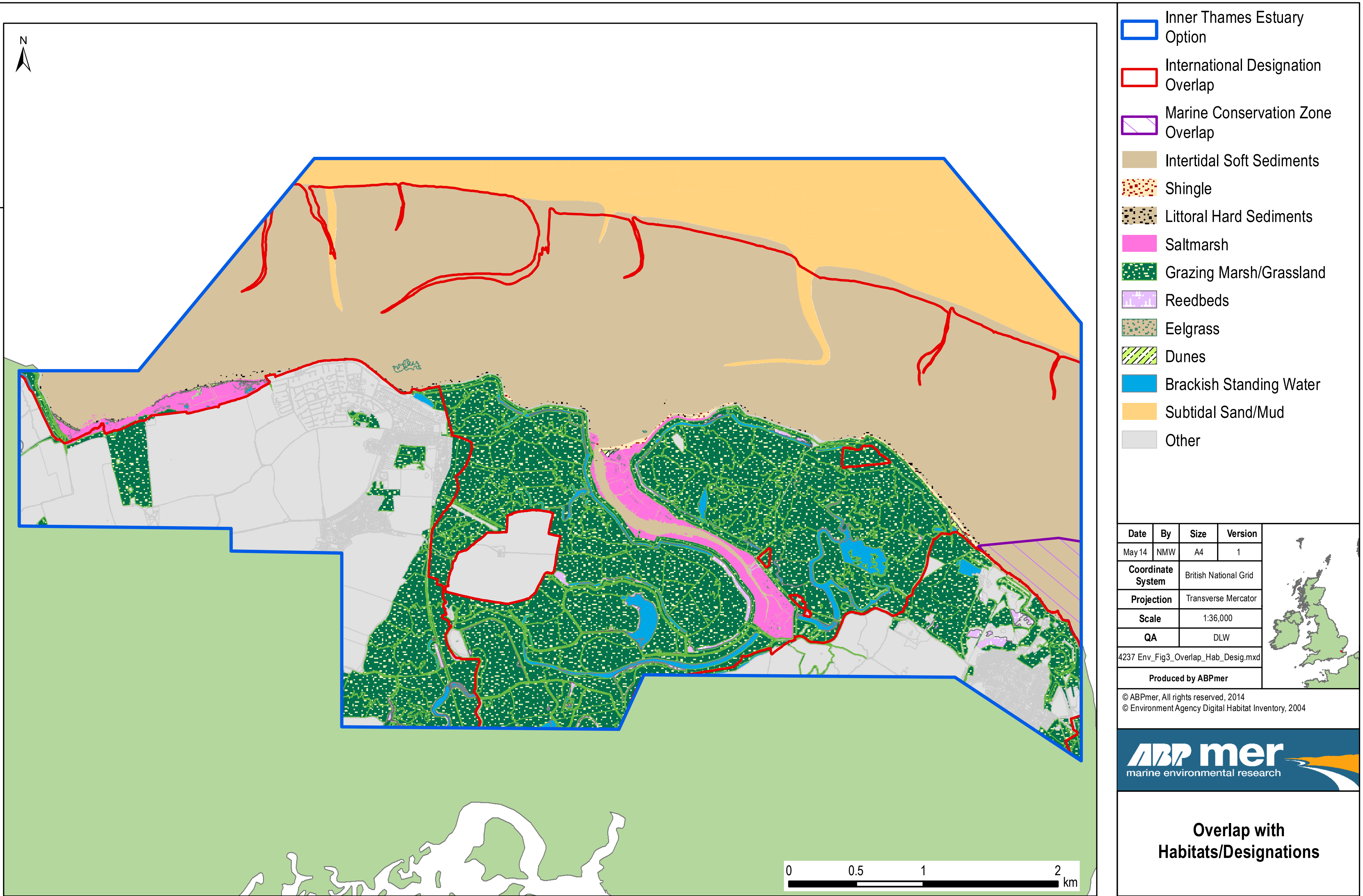
Internationally Designated Sites

Figure 2



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Projection	Transverse Mercator
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QA	DLW

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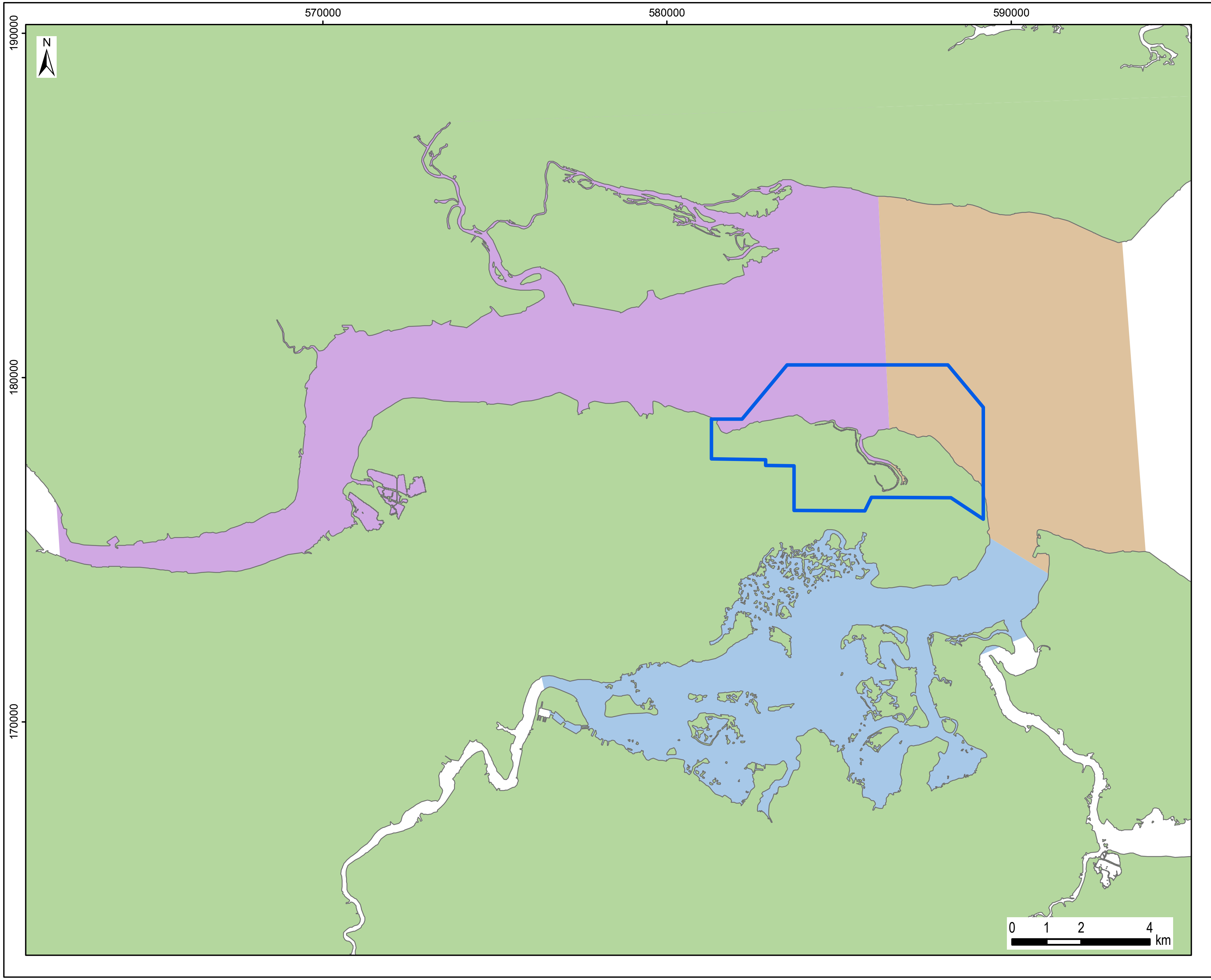
Overlap with Habitats/Designations

Figure 3



Inner Thames Estuary Option

Sections

1

2

3

Date	By	Size	Version
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Projection	Transverse Mercator
Scale	1:150,000
QA	FMM

4237 Env_Fig4_Hab_Loss.mxd

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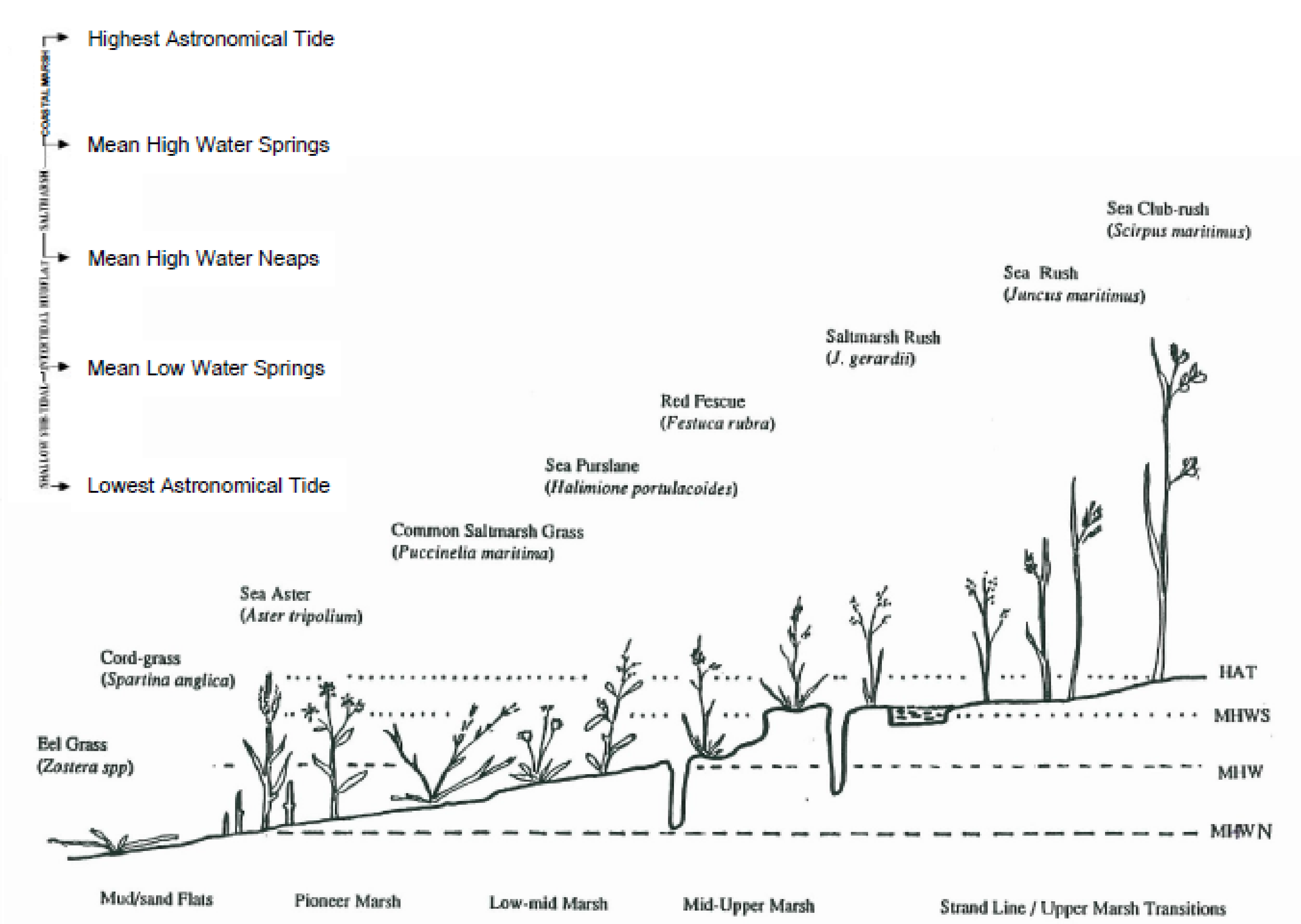
Indirect Habitat Loss Calculations

Figure 4



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Projection			
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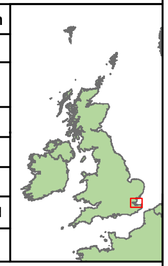

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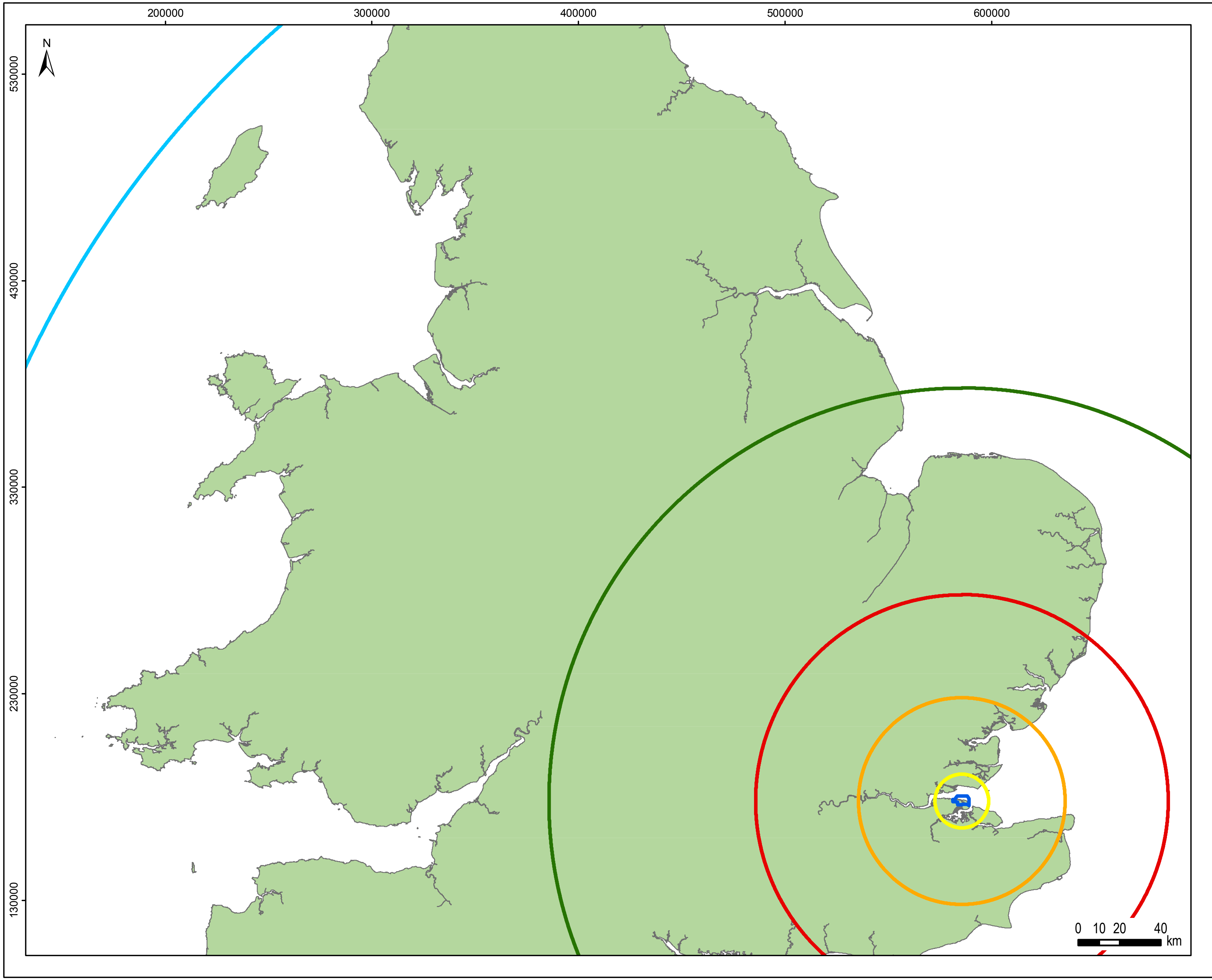
Intertidal Habitat Zonation

Figure 5



Inner Thames Estuary Option
13km Buffer
50km Buffer
100km Buffer
200km Buffer
500km Buffer

Date	By	Size	Version
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Projection	Transverse Mercator		
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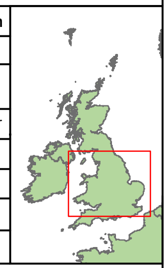

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Compensation Site Search Zones

Figure 6

Inner Thames Estuary Option

Date	By	Size	Version
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Coordinate System	British National Grid
Projection	Transverse Mercator
Scale	1:2,500,000
QA	DLW

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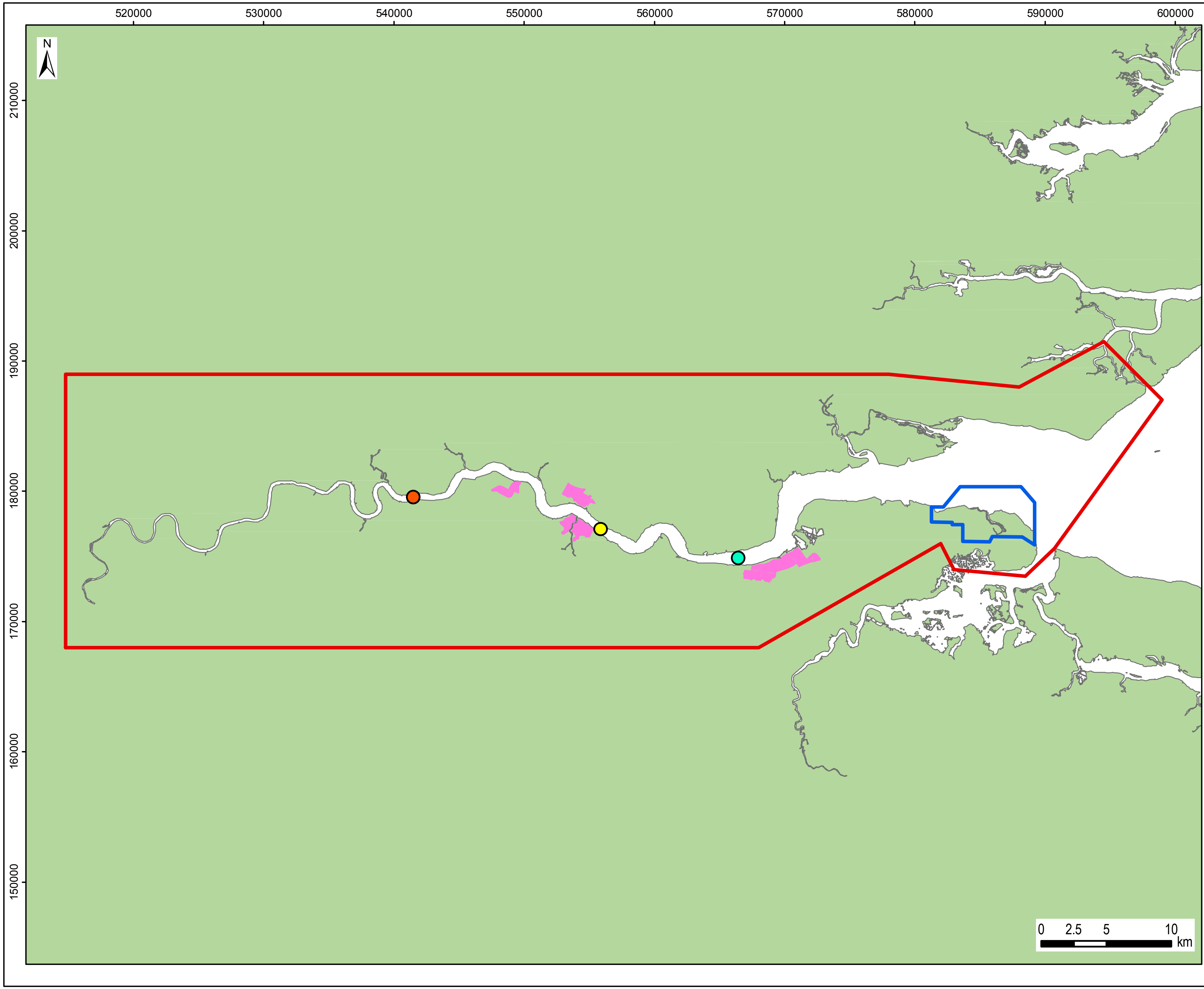
Bird Usage Inter-Estuary Comparison

Figure 7



Inner Thames Estuary Option
TE2100 Study Area
Flood Storage Areas
Thames Barrier
Long Reach Barrier
Tilbury Barrier

Date	By	Size	Version
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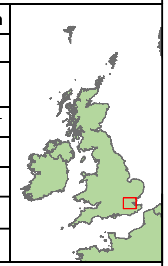

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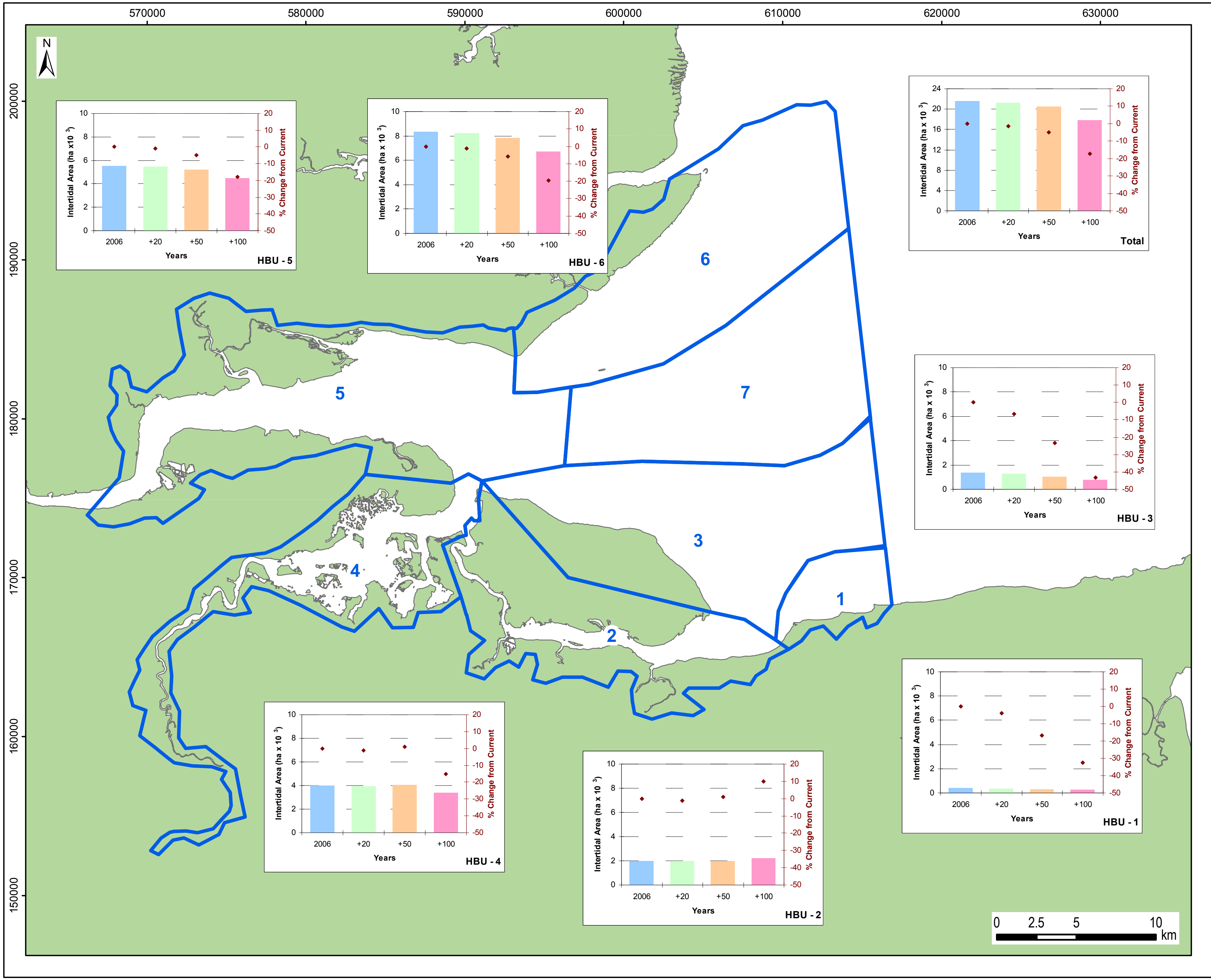
TE2100 Flood Defence Options

Figure 8



Habitat Behaviour Units

Note: 2006 Intertidal Area and Predicted Change in 20, 50 and 100 Years

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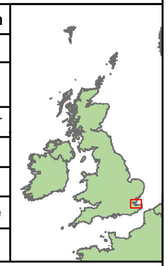

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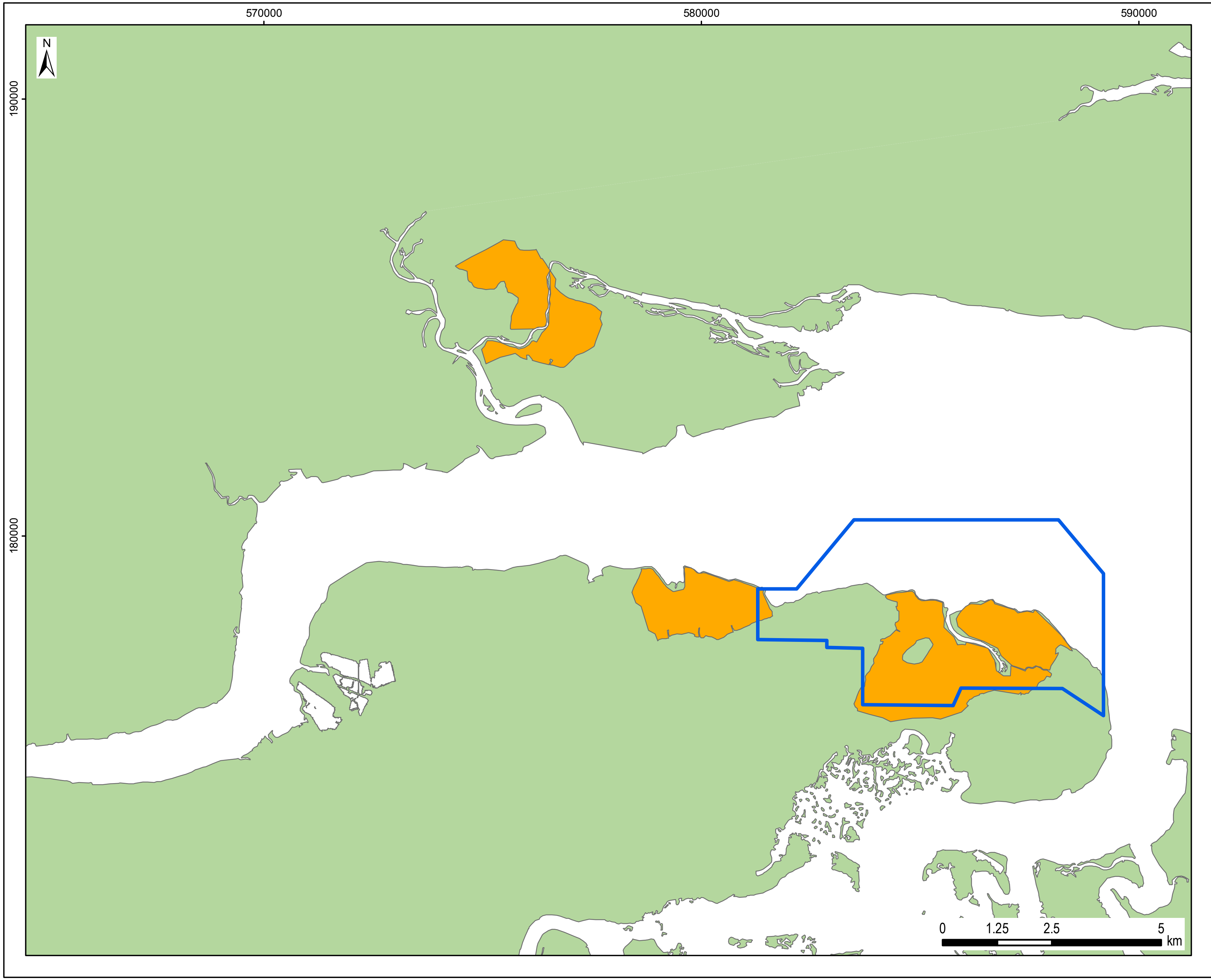
Intertidal Area Losses Predicted by the Greater Thames CHaMP

Figure 9



Inner Thames Estuary Option

TE2100 Habitat Creation Options

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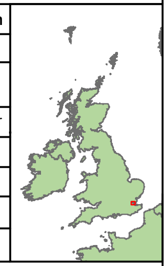

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Overlap with TE2100 Compensation Sites

Figure 10

Appendices

Appendix A

Habitats Within Airport Footprint

A. Habitats Within Airport Footprint

Table A1. Habitats within the footprint of the Inner Thames Estuary Option

Habitat	Area (ha)
Shingle	
Annual vegetation of shingle drift lines	1
Intertidal shingle	2
Other shingle above high water	1
Perennial vegetation of stony banks	<0.5
Total	**4**
Saltmarsh	
Aster tripolium low marsh [unknown management]	<0.5
Atriplex portulacoides mid-marsh [unknown management]	15
Elytrigia atherica upper saltmarsh [unknown management]	7
Pioneer saltmarsh [unknown management]	<0.5
Puccinellia maritima mid-marsh [unknown management]	11
Transitional low saltmarsh [unknown management]	6
Spartina swards [unknown management]	7
Total	**46**
Grazing Marsh/ Grassland	
Coarse grazing marsh grassland [non-amenity]	23
Grazing marsh pasture [API class]	36
Grazing marsh pasture, *Lotus/Carex divisa* sub-community	350
Grazing marsh pasture, other sub communities [cattle grazed]	62
Grazing marsh pasture, other sub communities [non-amenity]	38
Inundation grassland, brackish	4
Inundation grassland [non-amenity]	5
Sea wall grasslands [non-amenity]	15
Non-amenity grassland	90
Other neutral grassland [non-amenity]	57
Total	**680**
Dunes	
Fixed dunes, grey dunes	2
Shifting dunes, white dunes	<0.5
Unvegetated sand and dunes above high water	1
Total	**3**
Intertidal Sediments	
Littoral muds and sands	977
Total	**977**
Littoral Hard sediments	
Littoral rock and boulders	7
Marine cliffs and slopes	<0.5
Other littoral sediment	5
Supralittoral rock and boulders	<0.5
Total	**12**
Reedbeds	
Reedbeds, *Phragmites australis*	6
Bolboscheoenus maritimus	8
Total	**14**

Habitat	Area (ha)
Eelgrass	
Zostera spp.	1
Total	**1**
Brackish Standing Water	
Open standing water, brackish	60
Saline lagoon	6
Saline saltmarsh ponds	1
Total	**66**
Sub-tidal Sand/Mud	
Sub-tidal	132
Infralittoral	164
Total	**296**
Others	
Arable	314
B class road	<0.5
Buildings and structures	11
Churchyards and cemeteries [improved grassland]	1
Domestic gardens	40
General amenity	32
General built surfaces	15
Golf course	19
Littoral built structures	<0.5
Minor road	14
Mixed woodland [unknown management]	4
Open standing water, fresh	14
Quarry	3
Road verge	6
Scrub woodland [unknown management]	13
Urban parks and playing fields	2
Track	<0.5
Spoil Heap	<0.5
Total	**489**
Non CLASSIFIED	
Non classified	7
Total	**7**
Overall Total	**2595**

Table A2. Habitats within the footprint of the Inner Thames Estuary Option – overlap with Thames Estuary and Marshes SPA/Ramsar site

Habitat	Area (ha)
Shingle	
Annual vegetation of shingle drift lines	1
Intertidal shingle	2
Other shingle above high water	1
Perennial vegetation of stony banks	<0.5
Total	**4**
Saltmarsh	
Aster tripolium low marsh [unknown management]	<0.5
Atriplex portulacoides mid-marsh [unknown management]	15
Elytrigia atherica upper saltmarsh [unknown management]	6
Pioneer saltmarsh [unknown management]	<0.5
Puccinellia maritima mid-marsh [unknown management]	11
Transitional low saltmarsh [unknown management]	6
Spartina swards [unknown management]	7
Total	**45**
Grazing Marsh/ Grassland	
Coarse grazing marsh grassland [non-amenity]	18
Grazing marsh pasture [API class]	22
Grazing marsh pasture, *Lotus/Carex divisa* sub-community	340
Grazing marsh pasture, other sub communities [cattle grazed]	61
Grazing marsh pasture, other sub communities [non-amenity]	32
Inundation grassland, brackish	4
Inundation grassland [non-amenity]	3
Sea wall grasslands [non-amenity]	14
Non-amenity grassland	1
Other neutral grassland [non-amenity]	11
Total	**506**
Dunes	
Fixed dunes, grey dunes	2
Shifting dunes, white dunes	<0.5
Unvegetated sand and dunes above high water	1
Total	**3**
Intertidal Sediments	
Littoral muds and sands	940
Total	**940**
Littoral Hard Sediments	
Littoral rock and boulders	7
Other littoral sediment	4
Supralittoral rock and boulders	<0.5
Total	**11**
Reedbeds	
Reedbeds, *Phragmites australis*	1
Bolboscheoenus maritimus	8
Total	**9**
Eelgrass	
Zostera spp.	1
Total	**1**

Habitat		Area (ha)
Brackish Standing Water		
	Open standing water, brackish	53
	Saline lagoon	6
	Saline saltmarsh ponds	1
	Total	**59**
Sub-tidal Sand/Mud		
	Sub-tidal	6
	Total	**6**
Others		
	Arable	1
	Buildings and structures	<0.5
	Domestic gardens	<0.5
	General amenity	<0.5
	General built surfaces	4
	Golf course	<0.5
	Littoral built structures	<0.5
	Minor road	3
	Open standing water, fresh	5
	Road verge	<0.5
	Scrub woodland [unknown management]	1
	Track	<0.5
	Spoil Heap	<0.5
	Total	**15**
Non Classified		
	Non classified	7
	Total	**7**
	Overall Total	**1606**

Table A3. Habitats within the footprint of the Inner Thames Estuary Option – overlap with Medway Estuary and Marshes Ramsar site

Habitat	Area (ha)
Grazing Marsh/ Grassland	
Grazing marsh pasture [API class]	1.40
Non-amenity grassland	0.60
Total	**2.00**
Brackish Standing Water	
Open standing water, brackish	<0.05
Total	**<0.05**
Others	
Buildings and structures	<0.05
Domestic gardens	<0.05
General built surfaces	<0.05
Minor road	<0.05
Road verge	<0.05
Scrub woodland [unknown management]	<0.05
Total	**<0.05**
Overall Total	**2.50**

Appendix B

Bird Ecology

B. Bird Ecology

Table B1. Summary of wader and waterfowl ecology for the key species within the Thames Estuary

Species	Preferred Habitat[1]	Breeding Ecology[2,3,4]	Diet[2,3,4]	Migratory Movements[2,3,4]
Avocet	Intertidal	Nests in scrape on bare ground near water. Prefers, flat, open seashores or shallow lagoons with brackish/salt water. Wary during breeding. Loose colonies of up to 150 pairs. 1,500 UK pairs.	Benthic crustaceans and worms e.g. *Corophium* spp. and ragworm *H. diversicolor*. Insects in freshwater habitats	Breeding birds restricted to East Anglia and migrate in August/September to wintering grounds in Spain and Portugal. Numbers winter in SW England.
Dunlin	Intertidal	Breeds on low or high ground in wet, short grass or tundra. Uplands of Scotland, Wales and England. 8,600 – 10,600 UK pairs.	Insects, snails e.g. *Hydrobia* spp. and benthic worms.	Resident on the coast. Moves to breeding grounds from April to July. Non-resident migrants from Iceland winter in UK.
Knot	Intertidal	No breeding pairs in Britain.	Tellins *Macoma* spp, mussel spat *M. edulis* and cockle spat *C. edule*, and mud snails *Hydrobia* spp. They can consume several cockles per minute but only take small sized individuals (<15mm) and swallow the shell.	Large numbers of non-resident migrants occur in British estuaries during winter and on passage.
Black-tailed Godwit	Intertidal and non-tidal	Breeds in scrape on the ground in grassy tussocks. Wet meadows, grassy marshes or boggy moorland. 30-50 pairs in Britain.	Baltic tellins *M. balthica*, cockles *C. edule* and polychaete worms including ragworm *H. diversicolor*.	European race breeds here and migrates through Britain to wintering grounds in West Africa.
Grey Plover	Intertidal	No breeding pairs in Britain.	Polychaete worms *H. diversicolor*, *Nephtys hombergii*, *Lanice* spp and *A. marina*. Bivalves *C. edule*, *M. balthica*, crab *C. maenas* and marine snails e.g. *Hydrobia* spp.	Migrant adults arrive in Britain in July. Juveniles follow a month later. The Wash represents a favoured stopover site. Males winter farther north than Females and a high proportion of those wintering in Britain may be males.
Redshank	Intertidal and non-tidal	Breeds in damp places such as saltmarsh, flood meadows and around lakes. Nests in a lined scrape within rushes or other vegetation. 25,000 UK pairs.	Amphipod crustaceans Corophium spp., mud snails, *Hydrobia* spp., tellins *Macoma* spp. and ragworms *H. diversicolor*.	Northern breeding birds tend to migrate while southern breeders remain in Britain for the winter. As many as half of wintering Redshanks in Britain may be from Iceland.
Ringed Plover	Intertidal	Breeds on open coastal shores or lakes from April. Breeds on nest-scrape in the open or in short vegetation. 5,300-5,600 UK pairs.	Variety of freshwater and marine invertebrates. Insects, worms, crustaceans, marine snails such as *Hydrobia* spp. and small fish.	Long-distance migrants, although many UK birds are resident or migrate only small distances. Many migratory birds stopover or winter in Britain.

Species	Preferred Habitat[1]	Breeding Ecology[2,3,4]	Diet[2,3,4]	Migratory Movements[2,3,4]
Bewick's Swan	All coastal habitats	No breeding pairs in Britain.	Leaves, shoots and roots of aquatic and marsh plants. Visits farmland to feed on waste food.	Birds in Britain are winter migrants from Siberia. Arrive from mid-October and return before the end of March.
Pintail	All coastal habitats	Breeds in wetlands with shallow water in close proximity to grasslands and open habitats. Lakes in lowland and mountain and tundra pools. 9-33 UK pairs.	Variety of plant and animal material taken from the water. Invertebrates include insects, larvae, shrimps and marine snails such as *Hydrobia* spp.	Pintails from Iceland winter in Britain and Ireland. Migration in British pintails is unclear although some are known to reach West Africa. Some Scandinavian and Russian birds winter in the Netherlands and come to Britain in severe weather.
Shoveler	All coastal habitats	Defends established breeding territory vigorously. Breeds in marshes or lowland wet grassland close to shallow, open water. Nest is a grass-lined hollow on the ground. 1,000 to 1,500 UK pairs.	Filters surface water, eating small invertebrates such as crustaceans, small water snails, insects and larvae. Also plant matter.	Migratory. Most British birds winter in southern Europe or north Africa, leaving Britain in October. Migrants from Iceland, Russia and northern Europe winter in Britain.
Teal	All coastal habitats	Nest in hollow close to water's edge. Breeds in variety of fresh and brackish waters. Wet moorland, bogs and marshes in upland areas and shallow, well-vegetated coastal shores. 1,600-2,800 UK pairs.	Seed-bearing saltmarsh plants including glasswort *Salicornia* spp and oraches *Atriplex* spp.	Migratory species, with birds from Iceland and northern Europe wintering in Britain adding to the resident population.
Wigeon	All coastal habitats	Nests in hollow amongst thick cover. Breeds near shallow, freshwater lakes and pools or rivers. May also breed close to tundra. 300-500 UK pairs.	Terrestrial or aquatic plant species. Mainly vegetation; stems, roots and leaves of grasses, algae, pondweeds and eelgrass *Zostera* spp. in estuaries.	Breeding birds in Scotland and northern England. Wintering population includes many migrants from Iceland, Scandinavia and Russia.
Lapwing*	Intertidal and non-tidal	Breeds in scrapes on bare ground, mainly on farmland amongst crops cultivated in spring where bare soil or grass is present. 140,000 UK pairs.	Various invertebrates including earthworms, beetles, moth caterpillars, ants and other insects.	Resident in Britain and Ireland throughout the year. Some birds migrate south to winter in France or Spain. While others move west to Ireland. Russian and eastern European populations arrive for winter between June and November.
Turnstone	Intertidal	No breeding pairs in Britain.	Opportunist feeder on a wide variety of food including mussels, molluscs, crabs, insects and carrion.	Birds in Britain breed in northern Europe, Greenland and north-east Canada, arriving between August and October. North European birds pass through Britain in summer on their way to Africa.

Species	Preferred Habitat[1]	Breeding Ecology[2,3,4]	Diet[2,3,4]	Migratory Movements[2,3,4]
Dark-bellied Brent Goose	All coastal habitats	No breeding pairs in Britain.	Grazes vegetation on land or finds food in water. Especially eelgrass *Zostera* spp. within estuaries as well as saltmarsh species *Salicornia* and *Aster* spp. and algae.	Breeding birds leave the Arctic and migrate to wintering sites in Britain, generally arriving throughout October.
Oystercatcher	Intertidal	Breeds in bare scrapes on open, flat coasts. Prefers pebbly patches, sand or rocky ground to grassy meadows. 110,000 UK pairs.	Mainly cockles *C. edule*, mussels *Mytilus edulis* and worms, although some crabs *C. maenas* and lugworms *A. marina*. Also crustaceans and insects.	Resident in UK although migratory over most of its range. Birds in southern UK may migrate north to breed in northern England or Scotland.
Curlew	Intertidal and non-tidal	Breeds in scrapes on the ground in upland boggy, grassy and heather moorland, hill pastures, hay meadows and coastal marshes. Some nest in lowland areas on agricultural land. 68,000 UK pairs.	The shore crab *Carcinus maenas* and polychaete worms such as the ragworm *H. diversicolor*. Also small shellfish, cockles *C. edule,* marine snails such as *Hydrobia* spp. and earthworms in pastures.	Resident species in Ireland and south east England. Migrants from Scandinavia, Russia and western Europe winter in Britain, arriving from June onwards. Some British birds migrate south west to France and Spain.
Shelduck	All coastal habitats	Breeds along seashores, at larger lakes and rivers. Prefers open, unvegetated areas. 15,000 UK pairs annually.	The amphipod crustaceans *Corophium* spp, mud snails, *Hydrobia* spp., tellins *Macoma* spp. and ragworms *Hediste diversicolor*.	Resident in UK. Population increases during winter as many migrants from N and E Europe winter in the UK.
Greenshank	Intertidal and non-tidal	Breeds mainly on dry ground in northern mature pine forests near bogs or water from April to August. UK breeding population of 700-1,500 pairs annually.	Benthic worms e.g. *Hediste diversicolor*, gastropods such as *Hydrobia* spp. and small fish.	Non-resident migrants on passage between African wintering grounds. Wintering birds present from October to March.
Gadwall*	All coastal habitats	Nests on the ground, often on small islands in dense vegetation near to water. Lowland lakes or slow-flowing rivers with vegetated edges and islands. 690-1,730 UK pairs.	Mainly vegetarian, eating plant material in the water. Stems, leaves and seeds of weed, rushes, sedges and grasses, although some insects may be taken incidentally.	Resident in Britain although population increases as migrants from Iceland and northern Europe arrive for winter. Some British birds winter in southern Europe.
White-fronted Goose*	All coastal habitats	No breeding pairs in Britain.	Vegetarian. Eats shoots, leaves stems and roots of various terrestrial plants.	European birds arrive in Britain for winter between October and December. Notable wintering grounds include the Swale Estuary.
Bar-tailed Godwit	Intertidal	No breeding pairs in Britain.	Polychaete worms such as *H. diversicolor* as well as bivalves, shrimps, *A. marina* and *H. diversicolor* and marine snails such as *Hydrobia* spp.	Migrants from Arctic breeding grounds arrive in Britain between July and October. Some birds moult in British estuaries and move on while others overwinter here.

Species	Preferred Habitat[1]	Breeding Ecology[2,3,4]	Diet[2,3,4]	Migratory Movements[2,3,4]
Green Sandpiper*	Intertidal	Does not usually breed in Britain. 1-2 UK pairs nest in trees, unusually for a wader. Often in old nests of other species.	Insects and larvae in winter, mainly flies and beetles. Also freshwater shrimps, worms, small snails and small fish.	Most birds in Britain are overwintering migrants, mostly in SE and central England. Migrate from breeding grounds from June onwards and return mainly in March.
Pochard*	All coastal habitats	Breeds on lowland lakes, large ponds and reservoirs with plenty of vegetation. Nest is a shallow cup of reed stems close to water and amongst reeds. 350-630 UK pairs.	Aquatic plants including leaves, stems, seeds of various plants including pondweed, sedges and grasses. Also water snails, tadpoles, insects and small fish.	Most birds in Britain are migratory but some resident. Most arrive for winter from NE Europe and Russia and some from the Netherlands in cold winters.
Little Egret*	Intertidal and non-tidal	Breeds in trees, bushes and sometimes in reedbeds on the ground. First sites in Britain close to nesting Grey Herons. 660-740 UK pairs.	Small fish such as sticklebacks, loaches and tench, amphibians and insects. Coastal birds take crustaceans including shrimps.	Resident in southern Britain and Ireland. Most birds migratory but in recent years have spent the winter in Britain, forming the recently established breeding population.
Sanderling*	Intertidal	No breeding pairs in Britain.	Small crabs, shrimps, shellfish, Talitrid sandhoppers and marine words such as ragworm or lugworm.	Long-distance migrants. Present in Britain on passage and overwinter in coastal areas including sandy beaches and mudflats.
Golden Plover*	Intertidal and non-tidal	Breeds on blanket bog, heather moorland and limestone grassland. 38,000-59,000 UK pairs.	Variety of invertebrates. Terrestrial insects such as beetles, earthworms, moth caterpillars, larvae, snails, spiders etc.	Most British birds are resident and move from to lowland agricultural land or the coast after breeding. Wintering population includes migrants from Iceland and northern Europe.
Greylag Goose*	All coastal habitats	Breeds near freshwater lakes, often on islands. Nest often under a tree or bush, comprised of a mound of vegetation. 46,000 UK pairs.	Mainly vegetarian. Roots, tubers, leaves, stems and seeds of grasses, sedges and rushes. Grazes on land or floating pondweed and duckweed.	Many birds resident in Britain although Icelandic birds migrate to Britain in September and October for winter and return by April or May.

Key:
* Not listed in any SPA citations within the region but present in significant numbers or numbers of national/international importance.
Derived From:
1 Port of London Authority, 2014;
2 Holden and Cleeves, 2002;
3 Mullarney *et al.*, 1999;
4 RSPB, 2012.

Table B2. Summary of seabird ecology within the Thames Estuary

Taxonomic Group	Species	Max. Foraging Range From Colony[1, 2]	Diet	Foraging Behaviour, Dive Depth	Sightings in the Southern North Sea and Thames Estuary[3, 4]
Alcidae - Auks	Atlantic Puffin	200, 200	Sandeel, sprat, herring, rockling and small gadoids.	Pursuit diver Max 70 m, mean 37.03 m.	Occasional
	Razorbill	51, 95	Sandeel, sprat, herring and rockling	Max 140 m, mean 41.09 m.	Common
	Common Guillemot	200, 135	Sandeel, sprats herring and small gadoids	Pursuit diver. Max 200 m, mean 90.06 m	No data available
Laridae – Gulls, (excluding Kittiwake)	Herring Gull	-, 92	Omnivorous-fish, discards, offal	Splash diver, kleptoparasitism (will also prey on other seabirds and small mammals)	Common
	Black-headed Gull	-, 40	Worms, insects, small fish, crustacea and carrion	Surface feeder	Common
	Lesser Black-backed Gull	-, 181	Omnivorous- fish, discards, offal	Feeds on the surface or shallow plunge dives. Mainly coastal foraging range in summer	Common
	Common Gull	-, 50	Worms, insects, carrion, fish, small birds, small mammals, eggs, berries.	Surface feeder	No data available
	Great Black-backed Gull	-, -	Carrion, seabirds, small mammals, fish and shellfish.	Surface feeder, theft and also other seabirds.	Common
Kittiwake	Black-legged Kittiwake	200, 120	Sandeel and clupeids	Surface feeder using dipping or shallow plunge diving.	Common
Sternidae - Terns	Little Tern	11, 11	Small fish such as clupeids and sandeel. Small invertebrates	Shallow plunge diver and dipper	Common
	Common Tern	37, 30	Small marine and freshwater fish and aquatic invertebrates	Shallow plunge diver	Common
	Sandwich Tern	70, 54	Clupeids, gadoids and sandeel	Plunge diver. Max 20 m, mean 20 m	Common

Taxonomic Group	Species	Max. Foraging Range From Colony[1, 2]	Diet	Foraging Behaviour, Dive Depth	Sightings in the Southern North Sea and Thames Estuary[3, 4]
Phalacrocoracidae - Cormorants	Great Cormorant	50, 35	Feeds on fish such as flatfish, blennies, gadoids, sandeel, salmonid and eels.	Pursuit diver. Max 35 m, mean 12.07 m.	Common
Procellariidae – Petrels and Shearwaters	Northern Fulmar	664, 580	Sandeel, sprat, zooplankton, squid, fish discards and offal.	Surface feeder. Also splash dives	Common
	Northern Gannet	640, 590	Mackerel, herring, sandeel, gadoids, fish discards.	Plunge diver. Max 34 m, mean 8.8 m.	No data available

Derived from:
1 BirdLife International, 2014;
2 Thaxter *et al*., 2012;
3 OBIS-SEAMAP, 2014;
4 Holt *et al*., 2012.

Appendix C

Lessons Learnt from Previous Large-Scale Managed Realignment

C. Lessons Learnt from Previous Large-Scale Managed Realignment

It is essential that the process of selecting suitable site locations and implementing future coastal habitat creation schemes is based on an understanding of lessons learnt from those that have already been completed. This is because the lessons from these completed projects highlight the issues and challenges that are relevant. However, and more importantly, the evidence from past work helps with identifying the solutions that have been found and successes that have been achieved when it comes to project implementation.

Of particular relevance to the requirements associated with the Inner Thames Estuary Option are the lessons learnt from relatively large schemes. ABPmer hosts an Online Managed Realignment (OMREG) database (ABPmer, 2014c) which documents lessons learnt from 95 managed realignment projects. Of these 95 schemes, two are over 500 ha, both of which are in Germany. One is a regulated tidal exchange (RTE) scheme (850 ha) and the second is a breach into a secondary dike (not for defence or people) to allow more effective water removal from the site following over-washing (1750 ha) (ABPmer, 2014c). In the UK the largest schemes are Alkborough flood alleviation scheme which is around 370ha and the Medmerry coastal realignment (on the Selsey Peninsula) which is around 300ha.

In addition to these completed projects there are some larger schemes in the UK that are not yet completed. Those projects which are currently underway include the RSPB's Wallasea Island Wild Coast Project (677 ha) which will begin to be breached in 2016 and the Environment Agency's Steart Realignment (400 ha) on the Parrett Estuary (Bristol Channel) which will be breached at the end of 2014.

Although the number of such large projects is very limited at the present time, there are many lessons that can be learnt from a number of the largest schemes to date and these are presented in the context of the following generic headings:

- Scheme implementation costs;
- Project management and communication;
- Site selection;
- Design and assessment;
- Ecological development and monitoring;
- Wider benefits; and
- Sign-off procedure.

C.1 Scheme Implementation Costs

One of the main hurdles in undertaking managed realignment projects is the cost of their implementation as well as the risk of these costs increasing where obstacles are encountered during the various phases (i.e. scheme design, impact assessment, planning and construction). The most significant 'known' costs are land purchase and construction, with the cost for providing new flood defences being a substantial element of the construction costs in the majority of cases.

Research, led by ABPmer, into the costs of managed realignment schemes has revealed that the average unit cost for all schemes that have been implemented up to and including 2011 is about £34,000 per hectare. In general there has been a clear shift over the course of two decades from initial low-cost, small-scale, and relatively inexpensive trial projects (e.g. Tollesbury, Essex created in 1995 at a cost of £14,000/ha) to high-cost, larger, projects that were designed to meet specific targets for habitat creation and flood alleviation (e.g. Medmerry was created in 2013 at an approximate cost of £93,000/ha). However, even in recent years, these costs have ranged greatly due to the distinct challenges and constraints faced at individual schemes (Scott *et al*., 2011).

There appears to be little evidence of larger managed realignment schemes having economies of scale. In other words they do not have a lower cost per hectare because of their size and instead they can often be more costly per unit area than smaller schemes. A contributory factor to the higher costs of recent large scale schemes is increasing land prices, but also greater costs are being incurred for licensing, assessment, engineering and mitigation requirements. As mentioned above the amount and scale of 'set-back' defences is a critical consideration in cost; with site preparation and landward defence construction on average accounting for over 60% of the cost of a realignment.

The next biggest cost tends to be the pre-implementation fees (i.e. for planning, assessing, consulting) accounting for just over 20% of overall scheme costs. Risks of increasing costs can be incurred here when managed realignment sites affect adjacent Habitats Regulations protected sites or if the potential site contains protected species, archaeology assets or unexploded ordnance.

Consultation with stakeholders and local communities can also be resource intensive. For example, for the Wallasea Island Wild Coast Project (which is expected to be completed in 2025) it has been estimated that costs of between £1 million and £2 million for the large and complex site may not be unreasonable, particularly in support of land purchase negotiations (DECC, 2010). Post-scheme management and monitoring tend to account for around 5% of the overall cost. Project objectives are also a factor, with compensatory scheme costs (e.g. those undertaken to offset impacts from port developments such as Welwick (Humber)) being typically much higher, at £70,000/ha on average, than others (Scott *et al*., 2011).

C.2 Project Management and Communication

There may be a number of reasons for wanting to undertake a managed realignment and it is important that these are clearly identified at the outset, as they can influence the design and planning process but, most importantly, clarity is essential in any consultation or public engagement to promote the scheme. The schemes that have been successfully promoted have usually benefited from having clarity behind the objectives of the scheme.

As noted above, there has been a shift from relatively straightforward, smaller managed realignments to larger, more complex and costly sites that require significant project management to bring them to fruition. Having committed and enthusiastic implementers on board who learn from previous experience and ensure good cooperation with regulators and wider stakeholders can also be important. The timeline identified for delivering large scale compensatory habitat is estimated between 10 and 12 years for a scheme on the ground with a further period of between two and five years to develop ecological functionality. Therefore the lead in time for schemes that require large areas of compensation requires early planning, site selection, prioritisation and investigation, focusing on the ecological criteria, costs and offsite risks. Once underway, a myriad of issues can cause significant project delays, from landowner negotiations and obtaining planning consent, to constraints on construction (due to weather, tides and protected species windows) and mitigation habitats. Significant contingencies should be incorporated into the process to allow for unexpected concerns and issues becoming unexpectedly complex (Scott *et al*., 2011).

As managed realignments are relatively complex, especially at a large scale, having an effective, clear, honest and early, stakeholder communication strategy is also important. Based on experience at recent large-scale projects, including Alkborough Flats (Humber) and Medmerry, early stakeholder engagement incorporating liaison groups, public exhibitions and individual meetings with interested parties is highly beneficial to achieving consent. It is important to consult not only with the scheme promoters but also with the local community, relevant conservation bodies and consenting authorities from the outset. Local communities and authorities increasingly demand significant planning gains from managed realignment implementers (e.g. improved flood protection and public access). Early engagement enables local stakeholders to have a genuine input into areas the public can actually influence and extol the wider benefits of schemes beyond the immediate objectives (focussing on aspects people can relate to, e.g. flood protection) (Scott *et al*., 2011).

For any large-scale managed realignment scheme issues associated with land acquisition are likely to be significant. Therefore it will be highly unlikely that any large managed realignment will be possible without significant landowner consultation, engagement, and possibly even the availability of compulsory purchase powers, potentially through an Act of Parliament. Research by Defra which reviewed all managed realignment in the UK and investigated experience overseas through literature reviews, questionnaires and workshops identified that one reason why the communities along the north bank of the Humber were broadly supportive of the realignment schemes at Paull Holme Strays and Welwick is that the landowners directly affected were perceived to have been dealt with fairly, in that their land had been acquired by agreement (Defra, 2002). At such a scale the public and stakeholder consultation and engagement process was a vital element for success.

There are also projects (e.g. on Wallasea Island) where the landowner has recognised the need for the project and the limitations associated with continuing farming and therefore has been very supportive of proposed realignment. At Tiengemeten, a 450 ha managed realignment in Holland, six tenant farmers were moved from the island, on a voluntary basis after being offered relocation arrangements. Some of the farmers decided to take the money offered and start a different business whilst others were assisted in finding alternative farms on the mainland. The process was lengthy, taking 15 years in total for the completion of the realignment site but community consultation was key to the success of the site.

At the larger scale projects farmers can continue on the terrestrial higher elevation sections of the site, even after the realignment work has been completed. This has been the case at Alkborough on the Humber Estuary where grazing has continued.

After breaching, and as part of the monitoring work, it is strongly recommended that communication is continued. This can be achieved through the circulation of annual newsletters, discussion papers, and details of specialist site visits. Furthermore, on site information boards help to inform the public about why the wetlands have been created.

It is recognised that there are a number of Government and public bodies which are also seeking to implement managed realignment around the country and benefits could be gained by coordinating site selection and implementation of such schemes. Managing and monitoring losses and gains in a coordinated manner could streamline the timeline for delivery of intertidal habitat as well as cost savings. Similarly, collaborative approaches with other private companies can also mutually benefit both parties.

A collaborative approach is proving affective at the Wallasea Island Wild Coast managed realignment which was granted planning permission in 2009 and is currently under construction. As part of the project the RSPB are working with Crossrail who are delivering material to the site to be used in landscaping. The delivery of material by vessels began formally in September 2013 and since that time over 1.7 million tonnes have been delivered to the site (up to April 2014) by Crossrail (at a peak rate of around 40,000 tonnes per week). Typically there are two or three vessels movements each day with each vessel carrying in the region of 2,100 tonnes of landscaping material.

This working arrangement benefits both Crossrail who need to dispose of the material and RSPB who will use the material for landscaping. In addition, a lot of investigative work has been done in recent years to understand whether different types of material, in particular peat and clay material, can be used for the coastal landscaping restoration work at Wallasea. The material that was tested had a high level of physical stability, a relatively low organic content, low levels of contamination and was colonised rapidly by saltmarsh plants which grew well with these soils (ABPmer, 2013b). As a result the Environment Agency confirmed that these materials are suitable for use at Wallasea but will still be subject to the pursuance of further waste acceptance procedures and quality checks at source.

C.3 Site Selection

As noted above, the objectives of a project need to be clearly established to allow for effective implementation and communication. These objectives, ideally, need to be underpinned by available evidence from shoreline management and flood defence strategies. In other words there has to be a clear rationale for undertaking work in a particular location and a clear recognition that the work is in keeping with the coastal and estuarine processes.

To select sites (especially large-scale) it is possible to use objective criteria and mapping work to review the costal landform and hinterland features. However, this must always be linked to a review of the strategic evidence base and expert evaluations of the conditions on site (including through site visits) and the hydrodynamic effects and functionality of the site. This expert review elements is the most important factors when selecting (and later designing) a site.

ABPmer has previously undertaken a review which identified objective site selection processes undertaken to find generic locations potentially suitable for managed realignment or habitat creation (Halcrow, *et al.*, 2013). In most instances a two stage methodology has been applied, the first of which is generally a screening process within a Geographic Information System (GIS) framework. Most screening studies begin with a floodplain map and use a range of criteria to select the most suitable sites (e.g. by avoiding built up areas, roads or railways; identifying areas with elevations suitable for intertidal habitat creation and considering land use and land ownership issues). In this way site selection criteria should avoid those sites which are likely to pose additional programme risks. Table C1 lists the GIS screening criteria that have been applied by various site selection exercises.

The screening can be followed with a Multi Criteria Analysis (MCA) process, consultation with stakeholders, or a combination of both. MCA typically involves assigning scores to a number of criteria to establish those sites which might be more or less suitable for habitat creation. The scoring of the different parameters can also be weighted depending on the perceived importance of the respective parameters. In most instances the criteria used are broadly similar but there is often considerable variability in the emphasis put on physical and/or anthropogenic factors as well as in the stage in the hierarchical process at which certain criteria have been used. Such flexibility is to be expected given the variability of objectives for managed realignment. Table C2 lists the MCA criteria scored and weighted by various site selection exercises.

As discussed above it is critical that, during the process of selecting a potential site for managed realignment, the hydrodynamic functionality and the physical interaction the site will have with the adjacent estuary or coastal zone is closely considered. This must underpin the selection, and form the cornerstone of the majority of the design and assessment work that follows. The consideration of short-term effects (likely to arise from introducing a new inundation area) often dominate the consulting process, with immediate impacts a prominent issue when seeking the necessary consents. However, it is also important to consider the longer-term effects given that estuaries can take decades to centuries to respond. Understanding changes both within the site and along the adjacent estuary often requires detailed hydrodynamic, sediment and wave modelling/assessment exercises. It is recommended that feasibility studies are therefore undertaken as part of the site selection process and these may well involve initial hydrodynamic modelling work and a high-level review of the likely environmental effects.

For large-scale projects, the potential effects on adjacent estuaries and coasts are inherently also larger and therefore consideration of the hydrodynamics becomes even more important. One valuable parameter for evaluating potential effect (and helping to select sites) is the extent to which a realignment will alter an estuary's tidal prism (the volume of water exchanged with the coast on each tide). To date, all projects, even the larger ones, have resulted in only up to around 2% change to the tidal prism. The new Wallasea Island Wild Coast project will cause a 12% change to the Roach Estuary when fully completed with the site being carefully designed to achieve this and the site will also accrete sediments in the future such that this change will progressively reduce over time. The lessons that are learnt from such larger projects will help provide greater confidence in the future that well designed schemes causing larger tidal prism changes are appropriate.

Selecting sites for large-scale intertidal habitat creation projects is particularly challenging because of the difficulties that exist with simply identify suitable and available land. To put this into perspective, over the past 25 years, just over 1,500 ha of intertidal habitat has been created in the UK through the implementation of over 55 schemes (ABPmer, 2014c). The largest UK managed realignment site to date, at Alkborough on the Humber, measures 370 ha. Finding enough land for such a large-scale habitat creation scheme will be challenging. Much of the land that would potentially be suitable for intertidal habitat creation along the South-East and East coasts, for example, is either densely populated, highly valuable (e.g. for food production and industrial use) or already designated.

Table C1. GIS screening criteria applied by various site selection exercises

Parameter	Humber Estuary	Environment Agency					Third Parties		
	Cherry Cobb Sands	Solent CHaMP	Greater Thames CHaMP	Atkins Tool (Southern/ Exe)	TE2100	SEFRMS	CEFAS Tool	Wallasea	Solent Dynamic Coast
Suitable elevation (based on EA floodplain)		X						X	
Suitable elevation (based on 5m contour)		X	X	X	X				
Suitable elevation (based on 10m contour)						X			
Suitable elevation (based on tidal levels)	X		X		X	X	X	X	X
Suitable slope				X			X		
Proximity to existing habitats							X		
Exclusion of contaminated land and/or landfill					X				X
Exclusion of areas within 2km of landfill site				X					
Exclusion of areas of previous pollution incidents	X								
Exclusion of buildings/infrastructure	X					X		X	X
Exclusion of urban areas	X			X	X	X		X	
Exclusion of major underground utility lines									
Exclusion of built up areas		X	X		X	X			
Inclusion of scattered buildings and 1-2 housing units					X				
Exclusion of major industry					X	X			
Exclusion of main roads	X		X	X	X	X			
Inclusion of minor dead-end roads					X				
Exclusion of railway lines			X		X				
Exclusion of areas within 25m of railway line				X					
Exclusion of areas within 13km of airports				X					
Exclusion of woods			X						
Exclusion of designated sites	X							X	
Exclusion of sites with longer defence line								X	
Exclusion of sites smaller than 0.5ha									X
Exclusion of sites smaller than 5ha					X				
Exclusion of sites smaller than 100ha	X								
Exclusion of land not owned by The Crown Estate	X								
Exclusion of main watercourses	X								

Table C2. MCA criteria scored and weighted by various site selection exercises

Parameter	HFRMS (EA)	Humber Estuary (ARUP)	CEFAS Tool	Solent Saltmarsh	Allfleet's Marsh Wallasea (ABPmer)	TE2100	Essex	Poole and Wareham
Water salinity, freshwater flows and water quality	X		X					X
Biological/ propagule supply			X					
Percentage cover of saltmarsh and grassland	X					X		X
Habitat location (in estuary/along coast)			X					X
Exposure and/or connectivity of the site	X		X			X		
Bed stability and soil type	X		X					
Volume of sediment required to fill to MHWN						X		
Presence of contaminated land			X	X				X
Need for new/secondary defences	X	X		X				X
Years embanked				X				
Current/previous land use and evidence of relict creeks		X				X		X
Total Area		X			X			X
Length of embankment	X	X						
Morphological functioning/long-term sustainability	X				X			
Potential effects on adjacent habitats/ hydrodynamics	X				X		X	X
Engineering feasibility and costs	X	X			X			
Costs							X	
Maintenance Costs	X							
Current standard of flood defence					X		X	
Site distance to main shipping channel (as proxy for ease of affecting recharge)						X		
Realignment preferred flood defence option				X	X			
Agricultural land use	X	X		X				X
Environmental improvement							X	
Urban land and other land use (incl. roads, PROW, residential properties, infrastructure)	X	X		X				X
Land ownership		X		X	X		X	X
Existing nature conservation designations	X	X		X				X
Landscape (views across area)	X	X						X
Heritage (listed building or scheduled monument)	X	X						X
Access to site	X	X						
Archaeology	X							X

In addition, any managed realignment is more likely to be adjacent to coastlines or estuaries designated under the Birds and/or Habitats Directives and therefore there is a risk that any large scale managed realignment could affect designated sites (although such effects can be offset/mitigated through careful scheme design). Detailed investigations would be required to determine if such changes constitute a significant adverse effect on the integrity of sites as part of any project appraisal. Such developments adjacent to designated sites are likely to encounter more constraints and be difficult and complex to implement (see Section C.4 below).

Land acquisition will be a very significant issue for any large scale managed realignment schemes. Historically the issues have focused around agricultural land purchase but it is likely that the issues of residential and commercial properties will ever increase, with small clusters of properties or entire hamlets potentially being affected. The need for, and relevance of, compulsory purchase is likely to be a key issue. Based on experience with larger scale UK projects (100 to 300 ha), it is estimated that it may take two years to find suitable site(s). The land purchase, design and assessment/ consenting phases of such schemes would also be expected to be fairly protracted for sites of a large size (Halcrow, *et al*., 2013).

C.4 Key Issues in Managed Realignment Design and Assessment

When approaching the assessment and design of managed realignment projects, an iterative and phased process is recommended, whereby there is a building up of evidence about the scale of changes and the functioning of a site. Building upon the feasibility review work that will already have been completed for the site selection, a thorough site visit review should be seen as an essential next step in this process, following which a preliminary design should be developed and its implications assessed on a high level. At the same time, the Environmental Impact Assessment (EIA) process should be commenced, and relevant ecological surveys undertaken to ensure on-site constraints are known (and mitigated for). The final phase should involve the detailed assessment of the scheme's hydrodynamic effects, which will then inform both the finalisation/enhancement of the design and the assessment of the individual EIA topics. This may need to be supported by wave and sediment transport modelling.

Design aspects requiring the most careful consideration include tidal prism, breach design (and breach flow speeds), the role of site morphology in delivering particular habitats, and how future accretion may influence site development. Breach placement should be based on insights gained from a site visit, and a review of historic charts, current elevation maps and estuarine/coastal processes. For example, at Allfleet's Marsh, the breaches were largely placed in locations that minimised the losses of fronting saltmarsh habitat. A breach needs to be sufficiently large and deep to avoid unwanted stability issues. At Allfleet's Marsh, the breaches were deliberately over-designed to ensure that they were in 'regime' with the volumes of water exchanged and, to date, no morphological changes to the breach channels have been observed (Scott *et al*., 2011).

Regarding site morphology, the extent of any landform manipulation must be justified with due consideration to project objectives, the potential gains and the likely cost. It has often been the case that clay materials that are needed to build the new walls can be sourced on site (e.g. at Medmerry), which provides valuable opportunities for environmental optimisation (e.g. on-site fish lagoons or landward ditches enhanced for freshwater species). However, the Wallasea Wild Coast Project presented a unique opportunity in that material has been transported on site to raise the land levels (back to historical levels that existed prior to the statement of the landform). As mentioned above this material has been supplied, in large part, through a collaborative approach with Crossrail.

At the majority of the implemented managed realignment sites, internal creeks have been excavated to facilitate the effective flooding and draining of the site which, in turn, helps to ensure effective tidal conveyance and habitat creation. In some instances, field drains are already available for this function (e.g. Alkborough, Allfleet's Marsh) whilst, in others, tidal waters were allowed to create their own creek network (e.g. Tollesbury, Blackwater) (Scott *et al*., 2011).

Mudflat creation has also been successfully achieved in many managed realignments, although in estuaries with a high sediment load, such as the Humber and the Severn, rapid accretion has occurred, elevating significant proportions of managed realignment sites out of the mudflat range after a few years (Halcrow *et al*., 2012). However, in estuaries with lower sediment loads, accretion rates over mudflats tend to be lower, and mudflat can thus be expected to be maintained for several decades. This is, for example, the case at Allfleet's Marsh (Crouch, Essex), where some 30cm have accreted over the mudflats over the course of five years (ABPmer, 2012).

With regards to sub-tidal habitat creation, this has to date not been required or pursued on a large scale in the UK, although there are examples in mainland Europe and the United States, and small scale lagoons are frequently incorporated into UK managed realignment design (e.g. Welwick, Humber; Abbotts Hall, Blackwater). As managed realignment sites are typically fairly sheltered, a 'settling tank' effect is often observed and sub-tidal/lagoon features in managed realignment sites tend to accrete/fill in fairly rapidly, even in estuaries with lower sediment loads (e.g. Hagge *et al*., 1998; ABPmer, 2012). This effect is generally particularly pronounced in RTE sites, where the hydrodynamic environment tends to be fairly un-dynamic, with often long slack periods, due to the restricted size of the water exchange medium(s). In Germany, the Kleinensieler Plate RTE scheme which aimed to create a sub-tidal lagoon required dredging only five years post implementation (as well as other measures aimed at reducing future sedimentation), due to rapid filling in (Schirmer *et al*., 2003).

Overall, there are considered to be no 'new' technical barriers to large scale managed realignment over and above those already encountered in the smaller managed realignment schemes completed to date. However, the scale of larger projects may be such that the engineering costs would be higher and the risk of encountering unforeseen issues is greater and mitigation for such risks likely to be more costly than for smaller managed realignment.

For example, Medmerry managed realignment site, which covers an area of approximately 300 ha, encountered significant archaeological deposits during construction. This resulted in considerable costs and programme delays. There were also major costs and design implications associated with avoiding deliberate impacts to protected species (water voles especially).

The proposed Bristol Port Company habitat creation scheme at Steart was subject to opposition from a community stakeholder group who wanted to protect the tranquillity of the local area. The project proposed to create a diverse range of habitats over approximately 190 ha of land (including 132.5 ha of dynamic intertidal habitats) as compensation for designated habitat losses resulting from the planned construction of the Bristol Deep Sea Container Terminal in Avonmouth. Considerable liaison was had with the local community to minimise potential objections to the scheme.

It must always be recognised though that local communities adjacent to the managed realignment sites can greatly benefit from increased visitor numbers to a site. This has occurred at Alkborough, for example, where a tea room has been established in close proximity to the scheme. At Freiston (on the Wash) some 50,000 visitors per year are attracted to the area (see also Sections C.6 which summarises the wider benefits). For a large-scale project such benefits could be even greater and would result in the creation of larger, more attractive and less disturbed wild areas.

These benefits need to be recognised and communicated because concerns are often expressed about the potential for impacts on recreational value where there is a reduction in access to the coast, loss of navigational access or wider enjoyment of the area. Any footpath diversion (or possibly extinguishment and creation) would require consent from the local Highways Authority (County or Unitary Council). Public and private access routes have been identified as one of the most constraining factors on managed realignment projects (Environment Agency and Royal Haskoning, 2007).

The Donna Nook managed realignment on the Humber Estuary, a site creating approximately 120 ha of intertidal habitat, received a series of setbacks through public opposition. The land was purchased by the Environment Agency in 2005/06 and the original planning application submitted was refused. However following a public enquiry the local council was advised that there was no substantial grounds for refusal and planning permission was eventually gained in 2011 (Halcrow *et al*., 2013). The site was due to be breached in 2013, however, pursued public opposition has delayed construction further. In late 2012 plans to divert the existing footpath around the site were refused.

There is a greater likelihood of encountering freshwater and terrestrial protected species at larger managed realignment sites. Typical species that could be encountered include great crested newts, badger, water voles, bats and protected hedgerows. The presence of such species further adds to a cost of a project through detailed survey requirements, assessment and the provision of mitigation measures. Recent project examples include Medmerry (as noted above), the Environment Agency Habitat creation scheme at Steart and the RSPB project at Wallasea. In these cases there are solutions to such impacts that are available and careful discussions with Natural England will be required to ensure that the measures undertaken are both appropriate and reasonable.

C.5 Ecological Development and Monitoring

To avoid progressing sites which cannot provide the necessary habitat potential it will be important to define the ecological criteria at the outset of the process and undertake habitat prediction assessments as part of site screening, unless significant intervention is the preferred option.

The ecological development of managed realignments is well studied, particularly where these were implemented as compensatory measures under the EU Habitats Regulations. For these sites there is a requirement to understand whether the created/restored habitats have offset the impacts of the plan or project which they have been designed to compensate. The final key component of a successful realignment is the implementation of an effective monitoring programme. This has two key functions to verify the impact predictions and to assess the site's development (e.g. against compensation or biodiversity targets). This monitoring usually focuses on mudflat benthos (invertebrates), marsh vegetation and overwintering birds, however, intertidal habitats are known to be valuable feeding and nursery grounds for many fish species such as flounder, herring and bass. As with many other aspects of managed realignment though, the detailed composition of the monitoring programme will reflect site-specific requirements.

It is recommended that careful consideration is given to the methodology used in monitoring programmes and the value of the information in the context, especially, of the costs that will be incurred for its collection. For instance taking and analysing benthic invertebrate samples according to standardised quantitative methods can be very costly when, for the purposes of broad-scale site evaluations, all that may be needed is a qualitative survey of community status to provide an indication of ecological functionality and waterbird prey resource levels. Thus the importance of the information must be established and a clear dissociation maintained between what is essential and what is 'nice to know'.

With regards to benthos, mudflat invertebrate monitoring undertaken at several managed realignment sites has shown that, where the tidal elevation and physical conditions are appropriate, benthic invertebrates can colonise the accreting mudflat fairly rapidly (e.g. Tollesbury, Allfleet's Marsh and the Humber sites). Site species composition generally becomes more complex and stable over time. Early colonisers such as ragworm, mud snail and mud shrimp often dominate the biomass over the first few years. For example, rapid colonisation was observed at Allfleet's Marsh where there have been 10,000 to 20,000 organisms/m^2 in each year since its breaching. The species composition, abundance and diversity can vary greatly with differences in site elevation and location, and this makes comparison between schemes very difficult. Judging assemblages in the context of fronting habitats provides an interesting context but will not necessarily allow the effectiveness of the schemes to be determined given how different the internal conditions can be from those outside (Scott *et al*., 2011).

Saltmarsh plant colonisation follows a similar successional pattern as that observed for mudflat invertebrates. Rapid colonisation occurs if the conditions are right, especially in relation to drainage and elevation (e.g. Welwick, Chowder Ness). Pioneer vegetation such as glasswort typically colonises within one year, and it may then take several years or even decades to achieve a species composition that is exactly similar to that of adjacent mature marshes (the relevance of this is something that will need to be considered when establishing the project's objectives/criteria as noted above). However, at almost all suitably designed sites particularly rapid pioneer colonisation was observed (e.g. at Freiston where 70% of the area was covered in vegetation within three years). A similar 'exponential' rate was observed at Allfleet's Marsh, where the percentage plant coverage increased over the first four years from 1% to 6% to 60% and then 100% (Scott *et al*., 2011).

Managed realignment sites can rapidly develop into important roosting and feeding sites for waterbirds. Some sites (e.g. Welwick, Allfleet's Marsh) may initially mainly be utilised as roost sites but, as prey diversity and biomass increases, so should the proportion of feeding birds. Allfleet's Marsh for example supported very good, increasing, numbers of waterbirds in the first three years of its existence; with some 7,000, 10,000 and 12,000 waterbirds observed respectively. At the Tollesbury and Orplands managed realignments (Blackwater), communities were found to be largely similar to those of surrounding mudflats within five years of the initial breach (Atkinson *et al*., 2001).

The value of managed realignment for fish and shellfish populations, as well as for associated commercial and recreational fishing activities, is an important consideration when seeking to understand the socio-economic and ecological gains/benefits that can be achieved. At Allfleet's Marsh, fish sampling undertaken just one and two months after breaching showed that even though plants and algae had yet to colonise, the lagoonal scrapes in the developing mudflat had high numbers of crustacea and were refuge and feeding areas for juvenile sea bass and herring (amongst others). Longer term surveys undertaken at Paull Holme Strays confirmed the value of managed realignments as nursery areas for economically important fish, with eel, flounder, bass and sand goby abundant, and species composition and density judged to be largely similar to that of adjacent areas (Hemingway *et al*., 2008).

Of particular note is that sites are of higher value if they provide fish habitat throughout the entire tidal cycle by including channels and ponds which remain flooded at low water. The value of such deep ponds/lagoons has been demonstrated at Abbotts Hall where up to 2000 herring/sprat were once found in one pool alone (along with 10 other species including bass, flounder and eel) (Colclough *et al*., 2005). The inclusion of these areas can also bring about additional benefits for bird species. In the UK there is increasing recognition of the potential importance of managed realignment sites for commercial fishing and food-production in their own right as well as in mitigation for losses of at-risk arable land and as a means to enhance the recruitment of fish and shellfish stocks. However, because managed realignment sites are not designed with fish/shellfish as a core objective the commercial potential of these sites is often not fully realised (Scott *et al*., 2011).

For large scale sites, it is likely that a regulator group or steering committee will be established to review the data collected during monitoring on a regular basis. For example, for the managed realignment sites on the Humber, data collected each year is reviewed against the site objectives at six monthly Environmental Steering Committee (ESC) meetings. Similarly at Wallasea (Allfleet's Marsh), it is proposed that a project steering group made, up of a technical advisory panel, will meet and review the data after the original five year monitoring period. These reviews are used to re-assess what monitoring needs to be taken forward into the future. Any changes to monitoring are agreed at these review meetings with the regulator group and typically recorded in the meeting minutes.

C.6 Wider Benefits

In addition to enhancing flood defences and/or creating new coastal habitat managed realignments can provide secondary socio-economic benefits, such as tourism, recreational and commercial fisheries, carbon sequestration and water quality improvements.

The RSPB site at Freiston is a good practical example of a site that has been justified on economic and social grounds, having led (among other aspects) to reduced sea wall maintenance and increased visitor numbers (56,000 in 2003) that have boosted the local economy. Anecdotally, businesses near the site have reported increased trade from the visitors to the site and a guesthouse has opened immediately adjacent to the reserve.

The Steart management realignment scheme on the Severn Estuary is also predicted to provide some limited long-term socio-economic benefit, through attracting some additional visitors, but also for the local community, through improved recreation and communication links. It is anticipated that at most some 29,000 additional visitors will be attracted to the Steart Peninsula. The scheme may also potentially extend the visitor season at adjacent holiday accommodations to include the overwintering bird season, with associated socioeconomic benefits (ABPmer, 2011).

Similarly, the Wallasea Island Wild Coast scheme is predicted to lead to the creation of 16 to 21 full-time equivalent jobs in the local economy, and to flood defence-related cost savings of between £0.5 and 10 million over the next 10 years (Eftec, 2008). Separate, ecosystem services review work has also informed the Alkborough scheme which identified an approximate aggregate benefit of £23 million (Everard, 2009).

C.7 Sign Off Procedure

The current procedure for determining whether managed realignment schemes have met their objectives is not well defined within the UK. Large-scale managed realignments are likely to have legal agreements in place which set objectives for the scheme through which the success of the managed realignment site will be reviewed. For most managed realignment sites with specific compensation objectives it is uncertain how these sites will be signed off and the habitat deemed as acceptable compensation for that which was lost. For most managed realignment sites to date there has been no official sign off procedure in place from the outset of the project and thus in practice there is no certainty about what will happen at these sites at the end of the defined review period. Having clear objectives in place from the outset, and a mechanism through which managed realignment sites can be signed off is of paramount importance.

It should be noted though, that once a compensatory project is completed, it will be treated in planning terms as if it is already subject to European designation (even in advance of this designation being pursued). This position is set out in the new National Planning Policy Framework (Department for Communities and Local Government, 2012).

C.8 Conclusions

Over the last 20 years a lot of projects have been completed and there is a vast amount of practical evidence which highlights the many challenges associated with the selection of sites and the implementation of projects. These challenges are inherently greater for large-scale projects. However, there is also a large amount of evidence to demonstrate how sites function, to show the many benefits that they can provide and to demonstrate the solutions to challenges. Any future projects need to draw heavily on this positive evidence base to ensure that there is effective and efficient implementation

Appendix D

Previous Site Selection Exercises

D. Previous Site Selection Exercises

ABP Marine Environmental Research Ltd (ABPmer) undertook an investigation to identify broad scale generic locations that are potentially suitable for habitat creation within the study area of the Greater Thames CHaMP (ABPmer, 2008). This screening was undertaken using geographic information system (GIS) software according to the following criteria:

- Suitable elevation (based on tidal levels; 5 m contour as upper limit);
- Exclusion of main roads;
- Exclusion of railway lines;
- Exclusion of built up areas (single buildings included); and
- Exclusion of woods.

Nature conservation designations were also considered, but they were not used to exclude potential sites within this generic screening exercise.

Whilst a MCA process was not undertaken as part of the Greater Thames CHaMP, it was suggested that the following parameters should be considered when evaluating alternative sites: archaeology, coastal defence quality, preferred flood defence option, counter wall length, access, land use and ownership, utilities and cost.

D.1 TE2100

In 2009 ABPmer were commissioned to develop an overall strategy for habitat creation in the Thames Estuary to meet environmental targets, legislative requirements and to enhance ecological function as part of the Environment Agency Thames Estuary 2100 (TE2100) project (ABPmer, 2009). The Environment Agency stated that the aim of the site selection process within the TE2100 study area was to identify where it might be possible to create sustainable saltmarsh only. Furthermore, it was also specified that the sites should require minimal engineering and maintenance to deliver this habitat. As such, the overall objective of this task was to identify opportunities for habitat creation rather than consider the implementation of such schemes.

a) Screening

The screening process was essentially composed of two stages. Firstly, a broad-scale screening of suitable sites was undertaken using a range of datasets. Secondly, the site boundaries of the short listed options were fine-tuned using more detailed datasets (all in a GIS environment, based on Environment Agency and Natural England (NE) steer).

Broad scale screening for sites was based on the following criteria:

- Suitable elevation (initially based on NEXTMAP data and 5 m contour);
- Exclusion of major industrial and urban areas – using:
    - The land use (land classification 2000) dataset to remove industrial and urban areas; and

- Ordnance Survey (1:50,000) and Aerial Photography to ensure that areas eliminated as a result of the land use dataset were correctly eliminated.

Following this exercise the site boundaries were refined using the following iterative steps:

- Buffering of derived site boundaries by 250 m (to compensate for potential inaccuracies);
- Redefining of site boundaries using (higher-accuracy) LiDAR data; and
- Further refining of site boundaries according to infrastructure presence (i.e. inclusion of minor dead end roads, exclusion of railways, exclusion of major industry, inclusion of scattered buildings and 1 or 2 housing units, exclusion of major underground lines).

b) MCA

Following the above process a total of 48 sites were identified for further review. A number of statistics were calculated for these sites to enable comparison between them:

- Distance to the main channel (GIS calculation based on Admiralty Charts) – this was to provide an indication of the effort required to apply additional sediment to a site if required;
- Volume of sediment required to increase elevation to the level of MHWN (GIS calculation) – this provided a relative statistic which could be applied and compared across all sites;
- Average percentage cover of saltmarsh and grassland (GIS calculation based on existing elevation and water levels) – this provided both an indication of habitats the sites could currently provide and also the relative sustainability in relation to future water levels;
- Degree of exposure experienced (automated GIS fetch tool calculation); and
- Current and previous land use of the sites, including evidence of historic creeks (identified from aerial photographs and LiDAR).

The scoring and ultimate ranking of individual sites was undertaken at a workshop which involved the Environment Agency, Phil Shaw, ABPmer and HR Wallingford. Essentially, each of the above factors was scored on a varying scale of 0-4, with the maximum possible score being 20. Scoring both 'volume of sediment required' and 'average percentage cover of saltmarsh and grassland' was an intentional double counting to represent the importance of elevation for the creation and sustainability of a site.

Additional factors qualitatively reviewed/considered at the workshop included:

- Designations;
- Ecological function/position in estuary; and
- Local knowledge/expert opinion (e.g. identification of existing Environment Agency/NE restoration initiatives, including sites earmarked for freshwater habitat creation; furthermore sites earmarked as potential flood storage areas or for development were identified).

The above process led to eight sites being chosen for incorporation into the subsequent morphological modelling.

D.2 Lappel Bank and Fagbury Flats Compensatory Measures

A review of potential sites for habitat replacement was undertaken in 1996/97 to identify a suitable location to compensate for the losses incurred at Lappel Bank (Medway Estuary) and Fagbury Flats (Stour and Orwell Estuaries). The preferred option for compensation was to create suitable areas of mudflat and saltmarsh through the realignment of flood defences at a location within the Greater Thames Estuary Natural Area (GTENA). The site was required to satisfy a number of specific objectives including the overall size and the ratio of saltmarsh to mudflat habitat that developed. Following the first (largely qualitative) site selection process a preferred site was identified but was later rejected by the local community. ABPmer were commissioned in 2003 to undertake a further extended site selection process.

a) Screening

The first phase in the identification of potential compensation sites included a screening exercise against the following criteria:

- Suitable elevation (based on EA floodplain);
- Exclusion of urban areas and buildings/infrastructure;
- Exclusion of nationally and internationally designated sites;
- Exclusion of sites smaller than 40 ha (compensation requirement);
- Exclusion of sites providing less than 20 ha of mudflat habitat (compensation requirement); and
- Exclusion of sites where new defence would be longer.

b) MCA

Secondly, the following criteria were scoped across a number of scales and scores (shown in brackets). Decisions were made based on a variety of sources, including expert judgement, modelling and consultation with local English Nature (EN, now NE) teams:

- Total area (0 to 5; e.g. 5 if total area exceeded 600 ha);
- Morphological functioning (based on expert judgement) (1 to 3);
- Potential effects on adjacent estuarine/coastal habitats (1 to 3);
- Potential effects on terrestrial/freshwater habitats (0 to 3);
- Engineering feasibility and costs (1 to 4);
- Current standard of flood defence (1 to 4; e.g. 4 if in poor condition);
- Preferred flood defence option (0 for hold the line, 1 for realignment);
- Amount of owners per site (0 to 3; e.g. 3 if only one owner); and
- Proximity to Lappel Bank and Fagbury Flats (0 to 3).

Prior to the MCA phase, but not influencing the process, consultation was undertaken with EN and the Environment Agency to obtain relevant information on the sites identified in the screening process, and to identify potentially significant constraints. Sites were lastly prioritised based on the findings of the MCA exercise and the presence of potential constraints. Two sites were subsequently short-listed, and preliminary modelling and public consultations undertaken. The Defra Wallasea Wetlands Creation Project was consequently realised in 2006.

D.3 Severn Compensatory Measures

In 2010 the Department of Energy and Climate Change (DECC) undertook a study of the feasibility of tidal power generation in the Severn Estuary. A review of potential habitat creation sites throughout the UK was undertaken as part of this study according to the following criteria:

- Sites larger than 500 ha;
- Tidal flood zone 3 data cut to 5 km of coastline;
- Excludes urban areas as classed under the OS Strategic data;
- Exclude International and European (Natura 2000) sites (but includes sites adjacent to designated open coast and estuaries) (These datasets are freely available);
- All sites non-continuous (i.e. hydraulically standalone); and
- Excludes railways and A roads.

The sites were further characterised and scored as high, medium or low on the following criteria:

- Size of the site;
- Potential to achieve intertidal habitat; and
- Level of technical and economic complexity/ difficulty which was further subdivided to four subcriteria; the likely level of positive and negative interactions with extant infrastructure (housing, utilities); the likelihood of negligible effect on protected species/ habitats (adjacent and within the site); and the likelihood of lower defence requirements (length, height).

Appendix E

Inter-Estuary Bird Usage Comparisons

E. Inter Estuary Bird Usage Comparison

Table E1. Five-year peak means of the 20 most abundant species within the Thames and comparative abundances at different UK estuaries

	Species	Thames Estuary	Severn Estuary	Humber Estuary	The Wash	Ribble Estuary	Morecambe Bay	Foryd Bay	Inland Sea and Alaw Estuary	Dungeness
		5-year Peak Mean	5-year Peak Mean	5-year Peak Mean	5-year Peak Mean	5-year Peak Mean	5-year Peak Mean	5-year Peak Mean	5-year Peak Mean	5-year Peak Mean
1	Knot	31,283	3,200	28,192	134,468	30,159	38,072	81	273	144
2	Dunlin	29,561	27,205	15,766	25,421	47,857	25,699	310	835	444
3	Oystercatcher	24,373	900	5,202	20,177	15,398	57,204	471	403	856
4	Dark Bellied Brent Goose	17,218	30	3,024	16,480	2	47	28	-	110
5	Black-headed Gull	10,852	8,150	9,735	21,619	11,886	14,186	-	484	4,357
6	Lapwing	9,631	10,744	14,072	17,296	16,568	16,402	1,001	1,847	6,532
7	Wigeon	6,984	8,646	3,009	8,843	78,182	6,894	2,194	1,561	7,099
8	Bar-tailed Godwit	6,401	-	2,914	14,934	3,013	2,044	68	157	16
9	Black-tailed Godwit	4,776	505	3,968	8,922	4,655	1,932	4	19	43
10	Herring Gull	4,389	1,295	1,393	6,664	18,486	10,954	-	274	2,499
11	Teal	4,195	4,893	3,550	3,467	6,389	4,024	181	195	1,251
12	Curlew	3,769	3,391	3,485	9,259	1,680	11,925	293	563	587
13	Grey Plover	3,700	382	3,089	10,482	3,454	885	-	192	45
14	Redshank	3,568	2,816	3,660	7,072	3,904	9,508	366	331	181
15	Golden Plover	3,078	2,586	28,096	24,544	4,326	3,266	196	582	3,622
16	Shelduck	1,789	4,285	4,519	5,705	2,892	6,756	157	133	142
17	Avocet	1,621	103	897	570	89	37	-	-	74
18	Common Gull	1,492	758	1,571	1,207	8,253	2,355	-	61	2,863
19	Coot	1,334	744	1,254	187	262	531	1	316	2,605
20	Great Black-backed Gull	1,194	90	590	1,507	587	461	-	18	573

Derived from: WeBS Online Report (Austin *et al*., 2014) http://blx1.bto.org/webs-reporting/
5-year peak mean 2007/08 – 2011/12

Table E2. Peak monthly counts of the 20 most abundant species within the Thames Estuary at low water and comparative abundances at different UK estuaries

	Species	Thames Estuary (2008/09)	Severn Estuary (2008/09)	Humber Estuary (2011/12)	The Wash	Ribble Estuary (2009/10)	Morecambe Bay – Kent Estuary (2005/06)	Morecambe Bay –Lune Estuary (2005/06)	Foryd Bay	Inland Sea and Alaw Estuary (2006/07)	Dungeness
		Peak	Peak	Peak	Peak	Peak	Peak	Peak	Peak	Peak	Peak
1	Dunlin	32,123	27,144	13,352	N/A	18,827	8,844	96	N/A	1,144	N/A
2	Knot	17,341	4,066	15,441	N/A	9,925	160	28,012	N/A	203	N/A
3	Oystercatcher	3,208	1,046	4,416	N/A	5,538	902	604	N/A	231	N/A
4	Wigeon	1,883	8,672	4,900	N/A	-	828	2,998	N/A	848	N/A
5	Lapwing	1,623	9,081	15,099	N/A	120	80	11,610	N/A	933	N/A
6	Black-headed Gull	1,426	16,121	1,640	N/A	25,000	2,106	4,872	N/A	340	N/A
7	Grey Plover	1,181	343	1,322	N/A	708	-	2	N/A	86	N/A
8	Herring Gull	996	6,332	1,133	N/A	29,000	16	5,908	N/A	268	N/A
9	Curlew	768	2,612	1,792	N/A	347	1,256	536	N/A	544	N/A
10	Golden Plover	756	1,440	32,413	N/A	-	40	5,200	N/A	631	N/A
11	Dark-bellied Brent Goose	704	19	2,941	N/A	-	-	-	N/A	-	N/A
12	Redshank	699	2,963	1,737	N/A	171	1,260	1,136	N/A	304	N/A
13	Great Black-backed Gull	535	329	346	N/A	1,700	70	260	N/A	15	N/A
14	Black-tailed Godwit	531	646	1,979	N/A	3,419	-	-	N/A	6	N/A
15	Shelduck	285	2,450	3,409	N/A	770	658	316	N/A	80	N/A
16	Turnstone	152	629	389	N/A	1	-	8	N/A	56	N/A
17	Ringed Plover	107	127	127	N/A	-	44	10	N/A	129	N/A
18	Common Gull	101	2,430	1,109	N/A	32,000	1,204	228	N/A	106	N/A
19	Sanderling	90	163	268	N/A	453	-	-	N/A	1	N/A
20	Teal	76	4,401	6,674	N/A	2	486	198	N/A	59	N/A

N.B. Low Tide Counts are not recorded every year at all UK estuaries. The most recent data available has been presented for each estuary location.
Derived from WeBS Online Report (Austin *et al*., 2014) http://blx1.bto.org/webs-reporting/
There is no WeBS low tide coverage of Morecambe Bay as a whole and as such this has been substituted with low water data from the closest areas covered – Kent Estuary and Lune Estuary.

Table E3. Designation status of species across the SPA sites within the study area

Species	Thames Estuary and Marshes SPA	Medway Estuary and Marshes SPA	The Swale SPA	Foulness SPA	Crouch and Roach Estuaries SPA	Severn Estuary SPA	Humber Estuary SPA	The Wash SPA	Ribble and Alt Estuaries SPA	Morecambe Bay SPA	Dungeness to Pett Level SPA
Knot	W	W		W			W/P	W	W	W	
Dunlin	W	W	W			W	W/P	W	W	W	
Oystercatcher		W		W				W	W	W	
Dark Bellied Brent Goose		W	W	W	W			W			
Hen Harrier	W			W	W		W				
Bewick’s Swan		W				W		W	W		W
Wigeon		W						W	W		
Bar-tailed Godwit				W			W	W	W	W	
Black-tailed Godwit	W	W					W/P	W	W		
Pintail		W						W	W	W	
Teal		W							W		
Curlew		W						W	W	W	
Grey Plover	W	W		W					W	W	
Redshank	W	W	W	W		W	W/P	W	W	W	
Ringed Plover	P	W		B						P	
Shelduck		W				W	W	W	W	W	
Avocet	W	B/W		B/W			B/W				
Shoveler		W									
Turnstone		W						W		W	
Greenshank		W									
Common Tern		B		B				B	B		B
Little Tern		B		B			B	B			B
Sandwich Tern				B							
Gadwall						W		W			
White-fronted Goose						W					
Bittern							B/W				
Marsh Harrier							B				
Golden Plover							W		W		

Species	Thames Estuary and Marshes SPA	Medway Estuary and Marshes SPA	The Swale SPA	Foulness SPA	Crouch and Roach Estuaries SPA	Severn Estuary SPA	Humber Estuary SPA	The Wash SPA	Ribble and Alt Estuaries SPA	Morecambe Bay SPA	Dungeness to Pett Level SPA
Ruff							P		B		
Pink-footed Goose								W	W	W	
Goldeneye								W			
Sanderling								W	W		
Common Scoter								W	W		
Whooper Swan								W			
Lesser Black-backed Gull									B		
Black-headed Gull									B		
Scaups									W		
Cormorant									W		
Lapwing									W		
Sandwich Tern										B	
Mediterranean Gull											B

Derived from JNCC SPA site list http://jncc.defra.gov.uk/page-1400
Key:
W Wintering Population;
B Breeding Population;
P Passage Population.

Appendix F

Coastal Management Initiatives

F. Coastal Management Initiatives

A review of coastal management documents and policies that are relevant to the Thames Estuary has been undertaken to understand the potential for any linkages with the Inner Thames Estuary Option. The documents that have been reviewed have been grouped under the following generic headings:

- Marine and environmental planning;
- Flood risk; and
- Protected habitats and species.

It is important to note, however, that many of the coastal management documents and policies are of relevance to all of these topics and as such any linkages should not be ignored.

F.1 Marine and Environmental Planning

The coastal management documents and policies that have been reviewed in the context of marine planning include:

- South East Inshore Marine Plan; and
- Thames River Basin Management Plan.

The Inner Thames Estuary Option will need to be mindful of the requirements associated with each of these plans.

F.1.1 South East Inshore Marine Plan

The Marine and Coastal Access Act 2009 divided the UK marine areas into marine planning regions with an associated plan authority to prepare a marine plan for the area. In England, inshore and offshore waters have been split into 11 plan areas for which the Marine Management Organisation (MMO) will be producing marine plans. The marine plans will aim to provide guidance for sustainable development in English waters.

The East Inshore and East Offshore areas were the first areas in England to be selected for marine planning and the East Marine Plans were published on 2 April 2014. The Thames Estuary falls within the South East Inshore Marine Plan area which has yet to be selected for marine planning, however, the MMO have begun gathering evidence and data for the future plan areas. Where there is not currently a marine plan, the Marine Policy Statement provides the framework for decision making on marine licences (MMO, 2014).

F.1.2 Thames River Basin Management Plan

The statutory Thames River Basin Management Plan (Environment Agency, 2009a) identifies the human pressures affecting the water environment in the Thames river basin district and the actions that will address them. It shows the current state of the water environment, and what actions will be taken to address the pressures identified. It sets out what improvements are possible by 2015 and how the actions will make a difference to the local environment – the catchments, the estuaries and coasts, and the groundwater. The Thames RBMP has been prepared under the Water Framework Directive, and is the first of a series of six-year planning cycles.

There is one coastal and 11 transitional (estuarine) water bodies within the Thames RBMP. All bar one of these water bodies are classified as heavily modified or artificial reflecting extensive hydrological and morphological modifications that have occurred in the past to support sustainable human use activities. None of the water bodies are expected to achieve 'good' status or potential by 2015, due to technical infeasibility or reasons of disproportionate cost. The aim for all water bodies is to achieve good status or potential by 2027.

The estuaries and coastlines in the Thames River Basin District have been the subject of physical modification over many years. Continued development has been identified as a need within this catchment, particularly associated with the 'Thames Gateway' growth area. Future development and associated infrastructure including flood defences and provision of drinking water and sewerage, all represents further pressures on the water environment. However if this is managed well, it will also offer opportunities to improve the physical river environment via sustainable methods of planning and development. Technology and other solutions to address the pressures are also predicted to improve, but the rate at which some new solutions can be introduced will depend on the economic climate (Environment Agency, 2009a).

F.2 Flood Risk

The coastal management documents and policies that have been reviewed in the context of flood risk include:

- TE2100;
- Greater Thames Coastal Habitat Management Plan;
- Shoreline Management Plans; and
- Catchment Flood Management Plans.

The potential changes to the physical environment associated with the implementation of the Inner Thames Estuary Option will need to be evaluated in the context of any consequences for flood risk. This includes the strategic flood risk management planning that has already been undertaken.

F.2.1 TE2100

The TE2100 project was established by the Environment Agency in 2002 with the aim of developing a strategic flood risk management plan for London and the Thames Estuary to the end of the century (Environment Agency, 2012). The TE2100 plan covers the tidal Thames and its floodplain from Teddington in the west to Shoeburyness in the east and is divided into 23 policy units. Additional detail on the potential interaction between the Inner Thames Estuary Option and the TE2100 is provided in Section 6 of the Environmental Review.

F.2.2 Greater Thames Coastal Habitat Management Plan

The Greater Thames CHaMP (ABPmer, 2008) provides a high level framework to advise the management decisions that may affect sites within the Thames Estuary designated under the Habitats and Bird Directives and the Ramsar Convention (Natura 2000 sites). CHaMPs are considered necessary where such sites are located on, or adjacent to, dynamic coastlines and where other activities, such as flood and coastal defence, may significantly affect the management of the (semi-) natural system. The CHaMP is a non-statutory document intended to inform the development of Shoreline Management Plans (SMPs), flood and coastal defence strategies, together with associated planning of maintenance and capital works, based upon a consideration of the best available scientific information. The Greater Thames CHaMP informed the TE2100 project, which looked to identify options for the next generation of measures required to address coastal flooding in the Thames Estuary.

The Greater Thames CHaMP provides a unified framework for considering the effect of sea level rise and other drivers of change affecting the conservation status of the Natura 2000 sites and their component habitats within the Thames Estuary, together with those of the Medway-Swale. The Greater Thames CHaMP has two primary functions: (i) to act as an accounting system to record and predict losses and/or gains to habitat; and (ii) to set, at a high level, the direction for habitat conservation measures to address net losses. This will inform decisions on proposed flood and coastal erosion risk management activities to provide a strategic picture of habitat replacement requirements in the Greater Thames area.

The predicted morphological form of the Greater Thames CHaMP study area at 20, 50 and 100 years, was derived from numerical modelling work and the results of this analysis have been used to provide an indication of the predicted extent of the intertidal area at each time period, assuming that existing flood defences are maintained over the study period. The results indicated that the estuary is constantly evolving and that there is predicted to be a loss of intertidal habitats over the timeframe of the next 100 years which will have consequences for the species they support. This includes the loss of habitats that are currently within the boundaries of internationally designated sites. Following the broad scale review of potential opportunities for habitat creation the Greater Thames CHaMP concluded that there is sufficient area available to offset the predicted losses, however, a number of constraints exist that in reality would reduce this estimate. The predicted changes, alongside more localised parameters and processes, provide a valuable resource on which to base future management practices within the designated sites and the system as a whole.

F.2.3 Shoreline Management Plans

The Environment Agency's Shoreline Management Plans (SMP) are large-scale assessments of the risks associated with coastal processes, including tidal patterns, wave height, wave direction and the movement of beach and seabed materials. SMPs also identify the preferred policies for managing these risks to people and the developed, historic and natural environments as well as the consequences of implementing the preferred policies.

The first SMPs were produced in the mid-1990s, setting out policies to manage each length of shoreline. However, since the 1990s there have been several major studies which have provided new information on, for example, sea level rise predictions, and in light of this the first shoreline management policies were considered to no longer be practical or acceptable in the long term.

The second generation of SMPs, covering the entire 6000 km of coast in England and Wales, were finalised in 2010. Shoreline management planning is an ongoing process, so SMPs are reviewed as new information and knowledge becomes available. This review normally happens every five to ten years.

SMPs provide a 'route map' for local authorities and other decision makers to move from the present situation towards meeting future needs, and identify the most sustainable approaches to managing the risks to the coast in the short term (0-20 years), medium term (20-50 years) and long term (50-100 years). Within these timeframes, the SMPs also include an action plan that prioritises what work is needed to manage coastal processes into the future, and where it will happen. This in turn will form the basis for deciding and putting in place specific flood and erosion risk management schemes, coastal erosion monitoring and further research on how we can best adapt to change.

Sections of coastline within each SMP are broken down into management units with an SMP policy identified for each unit over the short, medium and long term. The shoreline management policies considered are those defined by the Defra (2006) report, and include:

- **Hold the Line (HtL):** means holding the existing defence line by maintaining or changing the standard of protection.
- **Advance the Line (AtL):** means building new defences seaward of the existing defence line.
- **Managed Realignment (MR):** means allowing or enabling the shoreline to move, with associated management to control or limit the effect on land use and environment. This can take various forms, depending on the nature of the shoreline and the intent of management to be achieved. All are characterised by managing change, not only technically (where management can mean breaching, building and maintaining defences) but also for land use and environment (where management can mean helping or ensuring adaptation).
- **No Active Intervention (NAI):** means no investment in coastal defences or operations. It can apply to unprotected cliff frontages and to areas where investment cannot be justified, potentially resulting in natural or unmanaged realignment of the shoreline.

There are three SMPs with which the Inner Thames Estuary Option would interact (Environment Agency, 2010a,b,c). These include:

- Isle of Grain to South Foreland (IGSF);
- Medway Estuary and Swale (MES); and
- Essex and South Suffolk (ESS) (extending from Landguard Point in the north to Two Tree Island (just west of Southend) in the south, including the estuaries of the rivers Roach, Crouch, Blackwater, Colne, Stour and Orwell, and the tidal inlet of Hamford Water).

The southern boundary of the ESS SMP and the western boundary of the IGSF SMP also overlap with the TE2100 project boundaries, which is discussed in detail in Section 6 of the Environmental Review Report.

F.2.3.1 Isle of Grain to South Foreland SMP

The Inner Thames Estuary Option location overlaps directly with policy unit 4a01 Allhallows-on-Sea to Grain of the IGSF SMP (Environment Agency, 2010a). The preferred policy options identified in the IGSF SMP at this location are HtL in the short term (2025) and MR in the medium (2025-2055) and long term (2055-2105).

In the short term the plan is to continue protecting the low lying assets, which include properties, roads, agricultural land and coastal grazing marsh. Under rising sea levels it is anticipated that it will become increasingly difficult to defend the shoreline and maintain a beach on this frontage, due to coastal squeeze and a general lack of natural sediment inputs. This would result in a need for very substantial hard defences, if the current alignment were to be held in the long-term. Therefore, in the medium and long term the plan is to realign the defences, to realise potential environmental, engineering and coastal process benefits. Managed realignment could reduce the need for hard defences, possibly creating cost savings and environmental enhancement. No specific realignment position has been defined under the SMP, only an indicative extent. Although the approach would involve the managed loss of assets; it is intended that the villages of Allhallows and Grain, and the electricity / railway line would be protected.

The marshland fronting this policy unit is also a designated freshwater habitat and its loss would need to be compensated for. By delaying realignment until the second epoch it is intended that this will give time for compensatory habitat to be established and allow for consistency with the TE2100 strategy.

The remaining policy units within the IGSF SMP, along the Thames Estuary frontage of the Isle of Grain and the North Kent coast, predominantly involve HtL in the short, medium and long term. HtL is considered appropriate along these sections of the coast which comprise dense urban areas that extend to the shoreline, important amenity beaches and have regionally important strategic links. The long term plan is to continue protecting the developments including the residential, commercial, industrial and infrastructural assets. Policy units 4a05, 4a06, 4a07A and 4a07B along the Isle of Grain and Swale Estuary frontage have also been identified as having MR as the preferred policy.

F.2.3.2 Medway Estuary and Swale SMP

A small section of the MES SMP policy unit E401 Grain Tower to Colemouth Creek overlaps directly with the Inner Thames Estuary Option (Environment Agency, 2010b). The preferred policy option here is HtL in all three epochs due to the nationally important industry and infrastructure in the area. As with the IGSF SMP, the MES SMP identifies a preferred policy of HtL for most of the policy units where important urban areas, infrastructure and commercial assets exist. Some opportunities also exist for managed change to the defence line. MR will enable more flexible estuary management and better flood and erosion risk management in the future.

F.2.3.3 Essex and South Suffolk SMP

There is no direct overlap between the Inner Thames Estuary Option and the ESS SMP (Environment Agency, 2010c). However, the general plans and policies are discussed. For most of the currently defended coast and estuaries, the intent is to continue to HtL of existing flood and coastal defences throughout the short, medium and long term.

For a number of frontages however, the ESS SMP process identified that the defences are under pressure from eroding channels or from wave attack, typically in the middle and outer reaches of the estuaries. This pressure is likely to increase with climate change and sea level rise. For these frontages a change of policy to MR is desirable, by realigning the defences to a more landward, sustainable location (while continuing to protect all dwellings and key infrastructure).

F.2.4 Catchment Flood Management Plans

There are 77 Catchment Flood Management Plans (CFMPs) which have assessed inland flood risk across all of England and Wales. The CFMP considers all types of inland flooding, from rivers, ground water, surface water and tidal flooding, but not flooding directly from the sea (coastal flooding), which is covered by the SMPs described above.

The role of the CFMP is to establish flood risk management policies which will deliver sustainable flood risk management for the long term. Policy options relate to the level of flood risk and associated action from advice and monitoring to managing existing flood risk measures to implementing further action to reduce flood risk. The CFMP should be used to inform planning and decision making by key stakeholders in the catchment.

The North Kent Rivers, South Essex and Thames CFMPs cover the area surrounding the proposed location for the Inner Thames Estuary Option, however the proposed airport location overlaps directly with only the North Kent Rivers CFMP (Environment Agency, 2009b,c,d). The flood risk management policy identified by the Environment Agency for this area is "areas of low to moderate flood risk where we are generally managing existing flood risk effectively". This policy tends to be applied where the risks are currently appropriately managed and where the risk of flooding is not expected to increase significantly in the future. This policy supports economic, social and environmental development by maintaining the current level of risk but accepting that the impacts of flooding will increase with time due to climate change. The North Kent Rivers CFMP highlights the importance of maintaining the link with the Medway and Swale Estuary and Isle of Grain to South Foreland SMPs to ensure an integrated approach for coastal defence, river drainage and biodiversity on the marshes (Environment Agency, 2009b).

F.3 Protected Habitats and Species

The coastal management documents and policies that have been reviewed in the context of protected habitats and species include:

- Managing the Land in a Changing Climate;
- Greater Thames Estuary Natural Area;
- Biodiversity Action Plans;
- Tidal Thames Habitat Action Plan; and
- Voluntary and non-statutory initiatives.

The predicted impacts to habitats and species arising from the implementation of the Inner Thames Estuary Option will need to be evaluated in the context of each of these initiatives.

F.3.1 Managing the Land in a Changing Climate

The 2013 Managing the Land in a Changing Climate Report (CCC, 2013) is part of a series of annual progress reports by the Adaptation Sub-Committee to assess how the country is preparing for the major risks and opportunities from climate change. Together these reports will provide the baseline evidence for the Committee's statutory report to Parliament on preparedness due in 2015. The 2013 report extends the work of the Committee to some of the key ecosystem services provided by the land. Specifically, the report addresses the use of land to continue to deliver essential goods and services in the face of a changing climate – supplying food and timber, providing habitat for wildlife, storing carbon in the soil, and coping with sea level rise on the coast. It explores the extent to which decisions about the land are helping the country to prepare for climate change.

The 2013 Report highlights opportunities for adaptation, including realigning some flood defences on the coast to create space for habitats that provide natural defences to migrate inland. Realigning coastal defences in undeveloped locations will help to reduce risks of coastal flooding and habitat loss due to sea level rise. The Report makes clear that the Environment Agency and local authorities should work together on a clear implementation programme to speed up the pace of realignment along appropriate stretches of coastline. Improving compensation arrangements to account for the value of ecosystem services provided by coastal habitats would help the Environment Agency and local authorities to meet their policy goals for coastal realignment (CCC, 2013).

F.3.2 Greater Thames Estuary Natural Area

The Greater Thames Estuary Natural Area comprises not only the tidal Thames itself, from Tower Bridge downstream to Whitstable in Kent and Southend in Essex, but also includes most of the Essex coast, north to the mouth of the Stour (English Nature, 1997). The intertidal zone is dominated by soft sediments, forming extensive saltmarshes and mudflats. These are separated along most of its length by man-made sea defences from the low-lying land on alluvial soils. The Greater Thames Estuary Natural Area identifies key issues and sets nature conservation objectives for the intertidal and sub-tidal habitats of the Area. Conservation objectives include:

- Minimise and compensate or mitigate habitat loss and damage due to sea defence improvement schemes and seek opportunities for habitat enhancement;
- Secure environmentally sustainable shoreline management which is as far as possible in harmony with natural coastal and estuarine processes, and secures the objectives of the Habitats Directive;
- Offset past and future critical habitat losses through habitat creation and enhancement;
- Maintain an adequate series of undisturbed feeding and roosting areas for all nationally and internationally important wildfowl and wader populations; and
- Maintain and enhance the extensive interconnected network of estuarine habitats. Where possible, extend wildlife corridors between developed areas, thereby preventing fragmentation.

F.3.3 Biodiversity Action Plans

The UK Biodiversity Action Plan (UKBAP) lists habitats and species given priority for action across the UK. Following a systematic review of the list originally published in 1994, the list of species and habitats was increased to 65 habitats and 1149 species in 2007 ('the 2007 list'). One hundred and twenty three of the species were also removed from the original list of UKBAP priorities. The 2007 UKBAP list has also been used by the Secretary of State as the basis for the list of Species and Habitats of Principal Importance for the purpose of Conserving Biodiversity under Section 41 (hereafter referred to as the S41 list) of the Natural Environment and Rural Communities Act (NERC) (Natural England, 2014).

One of the key recommendations of the UKBAP was that Local Biodiversity Action Plans (LBAPs) were needed to complement the national initiative. These have two broad functions: to ensure that the national action plans are put into practice at the local level and to establish targets and actions for species and habitats characteristic of each local area. It is of note that the species and habitats listed on LBAPs may be different from those listed on the UKBAP and may differ between areas.

The London, Kent and Essex Local Biodiversity Action Plans (LBAPs) share the UK BAP objective to: conserve biological diversity within the UK and contribute to the conservation of global diversity through all appropriate mechanisms. Providing a focus for local initiatives, the three LBAPs offer a regional framework important to habitat and species priorities on the Tidal Thames (London Biodiversity Partnership, 2007).

The new UK post-2010 Biodiversity Framework replaces the previous UK level Biodiversity Action Plan. The UK Post-2010 Biodiversity Framework covers the period 2011 – 2020. It forms the UK Government's response to the new strategic plan of the United Nations Convention on Biological Diversity (CBD), published in 2010 at the CBD meeting in Nagoya, Japan. This includes five internationally agreed strategic goals and supporting targets to be achieved by 2020 (JNCC and Defra, 2012). The five strategic goals agreed were:

- Strategic Goal A: Address the underlying causes of biodiversity loss by mainstreaming biodiversity across government and society;
- Strategic Goal B: Reduce the direct pressures on biodiversity and promote sustainable use;
- Strategic Goal C: To improve the status of biodiversity by safeguarding ecosystems, species and genetic diversity;
- Strategic Goal D: Enhance the benefits to all from biodiversity and ecosystem services; and
- Strategic Goal E: Enhance implementation through participatory planning, knowledge management and capacity building.

F.3.4 Tidal Thames Habitat Action Plan

The Thames Estuary Partnership (TEP) Biodiversity Action Group has integrated the priorities of London, Kent and Essex to produce the Tidal Thames Habitat Action Plan (TTHAP) with an aim to:

- Conserve and enhance the wildlife habitats, species diversity and local distinctiveness of the Tidal Thames;
- Adopt a strategic approach to deliver biodiversity targets for the Tidal Thames as a whole; and
- Promote public awareness and appreciation of the Tidal Thames habitat and species diversity.

The role of the TTHAP is to co-ordinate action for the protection and enhancement of key habitats and species populations, within the Tidal Thames area (TEP Biodiversity Action Group, 2002). It also seeks to provide a link to related habitat and species action plans to promote an holistic approach to biodiversity gain within the Thames Estuary corridor. A number of Objectives, Actions and Targets are also outlined in the TTHAP including appropriate management for existing and new habitats and species and to create new areas of intertidal habitat and high tide roosts.

F.3.5 Voluntary and Non-statutory Organisations

Voluntary and non-statutory organisations also provide a wealth of advice and undertake a number of management initiatives: these include the London Wildlife Trust, Kent Wildlife Trust, Essex Wildlife Trust, the Groundwork Trust, Thames 21, the British Trust for Conservation Volunteers, the Wildfowl and Wetlands Trust, the Royal Society for the Protection of Birds, North-west Kent Countryside Management Project and Groundwork Kent Thames-side.

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