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Inner Thames Estuary Feasibility Study 1: ENVIRONMENTAL IMPACTS

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Executive Summary

(i) Background

In December 2013, the Airports Commission identified that while an Inner Thames Estuary location had the potential to provide a significant reduction in the noise impacts compared to most of the phase 1 options and create economic and regeneration activity in north Kent and Essex, it also presented some clear challenges on which further information was needed before a decision could be reached on whether to short-list such a proposal for phase 2.

One of these challenges included understanding further the adverse effects of constructing and operating an airport in an Inner Thames Estuary location, a location of clear and distinct nature and conservation value. In particular, identifying and understanding the issues affecting the Natura 2000 network of designated sites, and the wider environmental impacts on estuarine processes, morphology, flood risk, landscape and cultural heritage.

The purpose of this report is to fulfil the Terms of Reference (ToR) for the environmental impacts study, as set out in the final ToR published by the Airports Commission in March 2014. Comments received from both the consultation on the draft terms of reference and the call for evidence have been included as part of the study, where it has been appropriate and relevant to do so.

(ii) Baseline environment

The Inner Thames Estuary around the Hoo Peninsula comprises extensive areas of intertidal habitat including saltmarsh and mudflat, which support high numbers of internationally important bird species. These habitats provide a vital food resource for overwintering migratory birds. In addition, there are large areas of coastal floodplain grazing marsh in the north-western and eastern peripheries of the Peninsula, which support substantial populations of breeding birds.

This habitat is crossed by many drains and ditches which provide feeding opportunities and roosting grounds for birds. Saline lagoons are present in the west of the Peninsula and are also used by a wide variety of wading birds. Estuarine processes are important in supporting the habitats and species of the Thames Estuary. Fine grained sediments play an important role in ecosystem processes within the estuary as they are naturally deposited on mudflats and saltmarshes.

The Greater Thames Estuary is under pressure from development and anthropogenic disturbance as well as the longer term effects of climate change. The Environment Agency established the Thames Estuary 2100 (TE2100) project to provide a plan to manage flood risk in the estuary over the next one hundred years. A key driver for this initiative was adaptation to the uncertain effects of climate change, with the prospect of changes in sea level; storm surge height and frequency; and river flows.

As the TE2100 plan has identified a number of potential sites for managed realignment and habitat creation, it is not anticipated that the predicted plan and climate change impacts on the estuary's habitats will lead to significant long term reductions in habitat area or populations of species they support.

(iii) Potential impacts and Mitigation or Compensation

The key findings from the study on potential impacts and scope for mitigation or compensation are summarised below for each topic area.

Ecology

While there would be no direct impacts on priority habitats as defined under the Habitats Directive, all the airport options proposed would result in a large scale direct habitat loss to Thames Estuary and Marshes SPA and Ramsar sites (as a minimum 24% & 27% of designation areas). Some sites would also involve direct loss to the Medway Marshes SPA and Ramsar sites (0-4% of designation areas).

- Given the large scale of loss to the Natura 2000 sites, which would not be possible to mitigate in close proximity the sites mainly due to bird strike risk, geomorphology changes and flood risk, it is expected that any future appropriate assessment through the Habitats Regulations Assessment (HRA) would conclude that there are likely significant adverse effects on the Natura 2000 network.

- Under the steps of the HRA process, the proposals would, therefore, be required to progress to the Alternatives Solutions test. The Competent Authority (Secretary of State for Transport) would need to be certain that no alternative solutions existed, had considered the best scientific knowledge and taken into account the representations of Natural England and Environment Agency. If this test is passed it would need to be demonstrated that the proposals were needed for Imperative Reasons of Overriding Public interest (IROPI).

- In the event that the proposals were to be taken through the HRA alternative solution and IROPI steps, an acceptable package of compensatory measures would need to be developed. The compensatory measures would need to be created in advance and demonstrated to be adequate before losses occur. Key issues related to provision of adequate compensatory habitat include:

    - The compensation measures would need to allow for the full impact of the airport, including in-combination effects, on the Natura 2000 sitesThere are a range of additional sources of direct and indirect impacts, which can lead to further losses to the function of habitats in and around the Hoo Peninsula. These are difficult to measure at this stage without detailed assessment, field data or modelling and include:
        - Bird strike management to reduce risk of bird strike to acceptable levels;
        - Morphological changes to the estuary:
        - Disturbance effects from airport operations and air traffic; and
        - Compensation areas for other developments that are displaced.

    - A minimum of around 2130 hectares (ha) is likely to be needed for habitat compensation for the airport proposals and displacement of other compensatory habitat. An upper estimate of 6800ha attempts to capture some of the potential indirect losses. The road and rail links to the airport are also likely to result in additional direct losses to Natura 2000 sites and these are therefore likely to add to the total area required for compensation.

    - The compensatory habitat would need to be provided at least beyond the 13km safeguarding zone around the airport and it is recommended that habitat for birds is created beyond 20km.

- Given the uncertainty with providing compensation habitat further afield it is likely that a ratio of gain for loss of greater than 1:1 would be required. Gain for loss ratios from other studies indicate that 2:1 and 3:1 ratios might be applied and possibly higher ratios might be appropriate where uncertainty is greater.

- The Thames Estuary is part of a group of estuaries lying between the Suffolk coast and the eastern tip of the north Kent coast and is therefore the best area to focus on for potential compensation sites. There are several potential intertidal habitat creation sites associated with managed realignment policies along the Essex and Suffolk coast which would be the first area that should be considered. These potential land areas, however, are likely to reduce as constraints in terms of availability, suitability and additional impacts are considered. These would require significant study to determine realistic deliverability.

- There is potential for providing adequate compensation in that it is technically possible, but the scale required is unprecedented in the UK to date and there is a high level of uncertainty given that the full requirement is yet to be understood. There is also significant uncertainty over the ability to deliver the functional quality of habitat to meet the needs of all species that might be affected. There is an added complexity in the ability to adequately provide the like for like combination of habitats – not just the habitat types in isolation but a mosaic of habitats for the requirements of some species.

- The compensation habitat also needs to be provided in a geographic region which would support the species affected. In order to demonstrate deliverability, extensive studies would be needed over a large area and many years, including the affected site and the possible compensation sites. The uncertainty over successful compensation would remain until displacement occurs and sufficient long term monitoring data would need to be collected to demonstrate that compensation habitat had been successfully provided.

- The cost of providing compensation habitat based on experience from other projects is estimated to be in the region of £70K to £100K per ha. Applying this to the indicative lower and upper ranges of compensatory habitat requirement and ratios from 1:1 up to 3:1, total costs could amount to £149million- £2.04billion.

Estuarine processes and Geomorphology

Changes to physical processes during construction and in the operational phases could lead to consequential ecological changes, including direct and indirect impacts on Natura 2000 Sites. Some of the potential impacts on the estuary could be mitigated to a degree but there is a likelihood of long-term permanent changes, which potentially could besignificant adverse effects..

Estuarine environments are particularly sensitive to construction and therefore careful construction sequencing would be required to mitigate impact as far as possible for options built into the estuary channel. Large scale dredging in the Thames Estuary , if required to source material for the airport construction, could add significantly to impacts on the estuary.

Changes to the estuary geomorphology and hydrodynamics caused by an airport development from encroachment into the estuary are likely to arise in relation to, tidal prism, wave reflection; sediment deposition, sediment entrainment; and bank erosion. Potential consequential ecological impacts in inter-tidal and sub-tidal areas include

changed habitats and species composition. Changes to the tidal prism could also alter the duration and extent of inundation.

HR Wallingford[1] reported that there is a likelihood of only minor changes in maximum and minimum water levels due to an airport development in their scenario of airport development resulting in an inter-tidal habitat loss of about 100 ha. However the study also indicates that current speeds and directions would be altered, potentially leading to an indirect loss of 2,500 ha of inter-tidal habitats. Wave reflection could increase wave heights on the northern bank, potentially causing erosion.

There is potential for cumulative impacts on a number of Water Framework Directive water bodies, including rivers, estuaries, groundwaters and lakes, with potential for deterioration of the hydromorphological quality of those water bodies and this could impact the ecological status of the water bodies. This would invoke a series of tests to determine whether the development would be applicable for an Article 4.7 exemption, bypassing the normal WFD requirements.

Further studies including detailed hydrodynamic modelling would be needed to determine the precise nature and extent of potential impacts on the estuary and fluvial watercourses and the requirement for mitigation and compensation.

Flood Risk

The study focussed on flood risk issues related to tidal flooding. The primary policy relating to flood risk is in the Thames Estuary is the TE2100 Plan.

Before an airport development in the Inner Thames Estuary could proceed it would be necessary to undertake extensive modelling studies in order to demonstrate that the airport could be implemented without increasing flood risk elsewhere, and where possible reducing overall flood risk.

These studies would need to be similar in complexity to those carried out for TE2100 and would need to address impact risk areas including:

- Reduction in both conveyance and storage capacity in the Thames Estuary (and possibly the Medway) as a consequence of intrusion beyond the existing defence lines.
- The hydraulic consequences of long term geomorphological changes as a result of intrusion into the estuary.
- Loss of the managed realignment benefit for extreme flood events of the compensatory habitat areas on the Hoo Peninsula included in the TE2100 plan.
- Loss of the ability of other low-lying defended areas to receive flood water from overtopping in events exceeding the current design standard of the existing defences, which is lower than the likely design standard for the airport.
- A range of potential climate change scenarios, including the extreme H++ scenario to ensure that the design could be adapted in the future including, North Sea storm surges and extreme events as used for the TE2100 planning.

It is likely that there would need to be changes to tidal defences elsewhere within the Thames estuary which would need to be accommodated in the TE2100 adaptive flood management approach.

[1] HR Wallingford (2014). Inner Estuary Airport Call for Evidence. Technical submission by HR Wallingford to Airports Commission. Report No RT01.

Landscape
The sensitivity of the Thames Estuary landscape is recognised at national, regional and local scales. It is noted for its open character, sense of remoteness and relative tranquillity.

The development of an airport hub in this location would radically and irreversibly change this landscape. The airport, along with associated infrastructure, would be visible over an extensive area with potential views from the nationally designated Kent Downs AONB. Visual impacts would be relevant both during daylight and during darkness as a result of lighting. Overflight from an airport on the Hoo peninsula would also have both a visual impact and an impact on the sense of tranquillity.

Overall, all potential airport locations are likely to cause significant adverse landscape character and visual effects and loss of tranquillity.

Cultural Heritage
The study area is primarily characterised by cultural heritage assets which date from the post-medieval and modern periods. These assets are related to the use of the Hoo peninsula for military and industrial purposes such as defence, salt production, brick-making, cement and gravel extraction and, more recently, the production of explosives, oil refining and electricity generation.

Across the Hoo peninsula the historic landscape is particularly distinctive for its nationally significant military heritage, reflecting the historic importance of the area in protecting London and the southeast of England from invasion by sea. The coastal defences are among the most prominent cultural heritage features of the study area. Many of these sites, including post-medieval and modern forts, gun batteries, defensive lines and explosive factories, are protected as Scheduled Monuments.

All airport options would result in the direct loss of statutory designated oron potential designations of national and regional importance along with significant changes to the settings of remaining features and the distinctive historic landscape character.

(iv) Summary

This study confirms that an airport development on the Hoo peninsula is likely to result in large scale adverse effects on international nature conservation designations, principally the Thames Estuary Marshes SPA and Ramsar sites and Medway Estuary Marshes SPA and Ramsar sites. There could also be potential impacts on other designated sites in the Inner Thames Estuary area. It is expected that an airport would need to demonstrate that there are no feasible alternative solutions for meeting development objectives in accordance with the HRA process required under the Habitat Regulations.

If an airport development was to pass the alternative solutions test and meet IROPI requirements, a large area of compensation habitat creation would be required and this would be on a scale unprecedented for any single development in Europe. There are a number of potential sites associated with proposed managed realignment along the east coast in Essex and Suffolk that could form at least part of the compensatory measures required and technically it may be possible to look beyond this area also.

While it is technically possible to create large scale habitats, there is, however, a high level of uncertainty in achieving this. The full requirements for functional quality of habitat to meet the needs of all species affected needs to be understood. The compensation habitat also needs to be provided in a geographic region which would

support the species affected. In order to demonstrate deliverability, further extensive studies would be needed over a large area and over many years, including the affected area and the possible compensation sites.

Figures

Tables

Appendices

1 Introduction

1.1 Purpose of This Report

In December 2013, after the review of the airport proposals received by the Airport Commission, the Commission reported, that options for additional runways at Gatwick and Heathrow had been short listed. They also identified that further work would be undertaken on options located within the Inner Thames Estuary before a decision was taken on whether this location would be taken forward.

The Commission identified that the Inner Thames Estuary location had some attractive benefits such as delivering a significant reduction in the noise impacts compared to most of the phase 1 options considered and had the potential to be a substantial generator of economic and regeneration activity in north Kent and Essex, but it also had some clear challenges for which further information was needed.

One of these challenges is the location of a new airport at the mouth of the Thames Estuary and the adverse effects that the construction and operation of the airport could have on the local ecology, in particular to the Natura 2000 network of designated sites and wider impacts, as well as to the geomorphology, flood risk, landscape and cultural heritage aspects.

The purpose of this report is to inform a decision by the Airports Commission on whether to continue to consider the Estuary options for short listing on the basis of the terms of reference for the environmental impacts study

This report is one of four studies being undertaken as part of the review of the feasibility of Estuary options:

- Environmental / Natura 2000 impacts (Study 1);
- Operational feasibility and attitudes to moving to a new airport (Study 2);
- Socio-economic impacts (Study 3); and
- Surface access impacts (Study 4).

The Terms of Reference (ToR) for the study were published in the Introductory Note: Inner Thames Estuary Feasibility Studies (January 2014) for consultation.[2] Comments received from this process have also informed the study tasks and scope.

This environment study reviews the potential impacts on the Natura 2000 sites and wider environment from construction and operation of a new hub airport at an Inner Thames Estuary location. The study covers:

- a review of the habitats and species affected, in particular identifying priority habitats and species;
- an analysis of the impacts, issues and risks on identified habitats and species in the short and long term;

[2] Airport Commission, (2014). *Introductory Note: Inner Thames Estuary Feasibility Study,* https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/271634/airports-intro-note.pdf *[Accessed 04/06/2014].*

- consideration of any secondary, cumulative and indirect impacts or unintended consequences to the overall stability of the eco-system and wider environmental conditions;
- an analysis of the process and issues for development affecting Natura 2000 sites;
- an analysis of the compensatory habitats necessary and costs involved for the species and habitats identified, particularly those at risk;
- a risk assessment of successful cases and outcomes being achieved and estimation of best approach and costs involved;
- identification of possible compensatory sites or locations and the potential impacts on the habitats and species as a result of moving to new sites or locations and impacts on new sites and locations; and
- a review of the landscape, historical and archaeological impacts including a risk assessment, mitigation options and cost.

This report will not make any recommendations over whether a Thames Estuary option is feasible but presents the impacts, issues, risks and precedents to allow the Commission to make a judgement about whether an Estuary option satisfies the Phase 1 criteria[3].

1.2 Structure of the Report

To address the scope of the Terms of Reference, this report covers

Section 2: Background - provides background on the Inner Thames Estuary area, the Phase 1 study[4] undertaken previously and the response to the ToR consultation.

Section 3: Scope and methodology - outlines the approach to the assessment in terms of the study area, the submissions for an airport in the Inner Thames Estuary and the likely sources of different types of impact from an airport of this proposed scale and magnitude and the main assumptions and uncertainties for this approach.

The impacts and mitigation are considered through five main topics:

Section 4: Ecology - covers internationally and nationally important designations and species and how these relate to the estuarine ecosystem and in particular outlines the process required under the UK Habitats Regulations[5] and sets out experience of this process from other schemes;

Section 5: Coastal & Estuarine Processes – considers the estuary processes and how these might be affected and the potential implications from changes for the designated sites in and around the Thames Estuary and impacts on the ecological status of water bodies protected under Water Framework Directive[6];

[3] Airports Commission (2013) Guidance Document 02:Long Term Capacity Options: Sift Criteria
[4] Airports Commission (2013) Interim Report
[5] The Conservation of Habitats and Species Regulations 2010 (as amended)
[6] Water Framework Directive (Directive 2000/60/EC)

Section 6: Flood Risk – considers the approaches likely to be required to address flood risk for a new airport in the Inner Thames Estuary and how wider flood risk might be affected;

Section 7: Landscape – covers landscape character and visual impacts in terms of national designations, character areas and tranquillity; and

Section 8: Cultural Heritage – includes effects on designated and proposed designated features and historic landscape value.

These are addressed in separate sections within this report, and for each topic the following areas are covered:

- relevant policy or legal framework;
- baseline environment covering the current environment and how this is likely to change in the future without the airport;
- approach to the assessment for the study area alongside sources of information;
- the types of environmental impacts that may occur and the significance of the effects; and
- how mitigation or compensatory measures could be approached and potential risks remaining.

Section 9: Conclusion – brings together the key findings and interactions between the sections outlined above, setting out the environmental findings of the feasibility of a new hub airport in the Inner Thames Estuary.

2 Background

2.1 The Hoo Peninsula

The Hoo Peninsula is located to the east of London on the south bank of the River Thames (Figure 2-2). It is approximately 15,000 hectares (ha) in size and is dominated by agricultural land with low densities of residential populations. The main towns are the Isle of Grain (population 1,648)[7], Allhallows (population 1,676)[8] and Cliffe. The main traffic and transport routes onto the peninsula are the A289 and A288 from the M2 and the railway line which serves London Thamesport on the south east of the Peninsula.

The periphery of the Hoo Peninsula comprises extensive areas of intertidal habitat including saltmarsh and mudflat, which support high numbers of internationally important bird species. These habitats provide a vital food resource for overwintering migratory birds. In addition, there are large areas of coastal floodplain grazing marsh in the north-western and eastern peripheries of the Peninsula which support substantial populations of breeding birds. This habitat is crossed by many drains and ditches which provide feeding opportunities and roosting grounds for birds. Saline lagoons are present in the west of the Peninsula and are also used by a wide variety of wading birds.

Estuarine processes are also important in supporting the habitats and species of the Thames Estuary. Fine grained sediments play an important role in ecosystem processes within the estuary as they are naturally deposited on mudflats and saltmarshes[9]. In the Lower Thames estuary (seaward of Barking) the channel has deepened and narrowed in the 20th Century which has resulted in an increase in the extent of intertidal habitat.

The Thames Estuary is a constantly changing environment and any plans for development should be assessed against both the current and likely future baseline to determine the environmental effects in the relevant context.

The future of the existing environment and the estuarine process that support the habitat within the Hoo Peninsula are likely to be affected by climate change. The Environment Agency established the Thames Estuary 2100 (TE2100) project to provide a plan to manage flood risk in the estuary over the next one hundred years. A key driver for this initiative was adaptation to the uncertain effects of climate change, but with the prospect of changes in sea level; storm surge height and frequency and river flows.

[7] Office of National Statistics website, 2011 census results http://neighbourhood.statistics.gov.uk/dissemination/LeadTableView.do?a=3&b=11125042&c=isle+of+grain&d=16&e=62&g=6396135&i=1001x1003x1032x1004&m=0&r=1&s=1404403297375&enc=1&dsFamilyId=2473 accessed 03/07/2014

[8] Office of National Statistics website, 2011 census results http://neighbourhood.statistics.gov.uk/dissemination/LeadTableView.do?a=3&b=11119940&c=allhallows&d=16&e=62&g=6396103&i=1001x1003x1032x1004&m=0&r=1&s=1404403484984&enc=1&dsFamilyId=2473 accessed 03/07/2014

[9] Baugh, J. V., Feates, N., Littlewood, M. A. and Spearman, J. (2012). The fine sediment regime of the Thames Estuary – A clear understanding. Journal of Ocean and Coastal Management – Special issue on coastal and estuarine sediment and their management.

Sea level rise places increased pressure on coastal defences and intertidal habitats. Today, areas of saltmarsh and mudflats that once provided natural protection are being lost to 'coastal squeeze'. This process, which results in the loss of intertidal habitat, is a consequence of rising water levels and the presence of an artificial constraint, such as reclaimed land or flood defences (Figure 2-1)**.** This is also an aspect taken into account in the plan for TE2100.

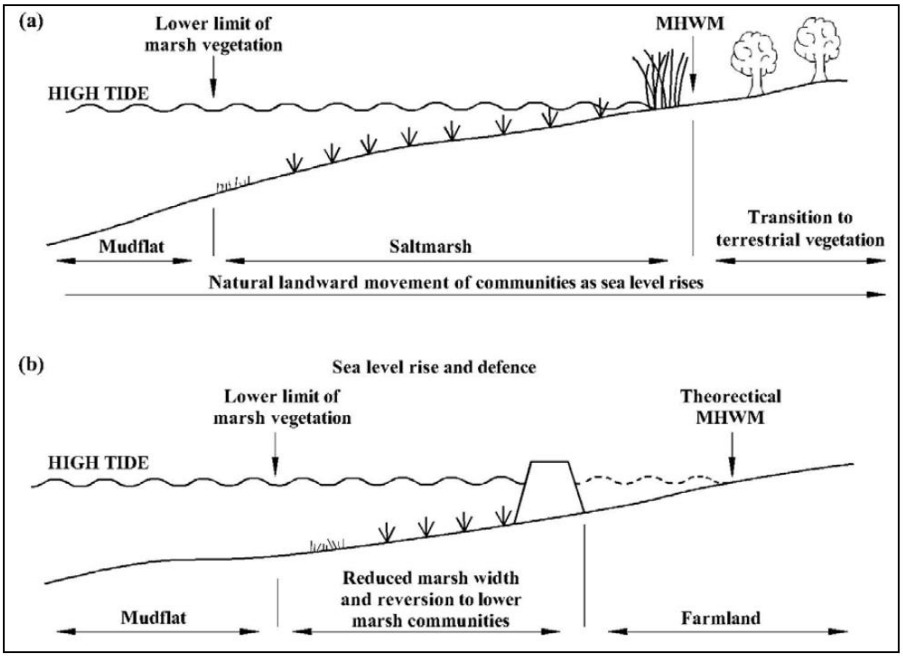


Figure 2-1 The Principle of Coastal Squeeze (from French, 1997 in Adnitt et al., 2007)[10]

2.2 Context for This Report

The Phase 1 study undertaken on the options submitted to the Airport Commission in 2013 involved an initial assessment of airport options submitted by promoters including a number within the Inner Thames Estuary area. An additional option on the Isle of Grain was developed by the Airports Commission to seek to mitigate its potential impacts. The Phase 1 analysis was undertaken against the criteria published in the Airports Commission's Guidance Document[11]. The Sift Criteria included a range of criteria covering economic, surface access, cost, risk and operational and environmental and social aspects. Environmental assessment included air quality, noise, climate change and direct impacts on designations and other issues such as flood risk. The aim was to allow a high level comparison between options.

The Commission recognised the magnitude and complexity of impacts for a new hub airport located within the Inner Thames Estuary area, rather than an expansion

[10] Adnitt, C., Brew, D., Cottle, R., Hardwick, M., John, S., Leggett, D., McNulty, S., Meakins, N. and Staniland, R. (2007) Saltmarsh management manual. Environment Agency R&D Technical Report SC030220. 123 pp.
[11] Airport Commission (2013) Guidance Document 02: Long Term Capacity Options: Sift Criteria (May 2013).

of an existing airport and that further study to understand the opportunities, implications and risks was required.

For this environment study the principal concern was the potential implications for European and International designated (Natura 2000) sites and this is reflected in the original published ToR. Consultation responses on the environmental study ToR largely supported the study scope and comments adding to the scope have been taken in to account where relevant. These included comments requesting consideration of impacts on the morphology of the Thames estuary and flood risk, impacts on landscape and likely future cultural heritage designations.

Other environmental topics such as noise and air quality were not considered to require further investigation as a part of this study, because the advantages or disadvantages of the Estuary location on these aspects, compared with the other options put forward for a new airport were sufficiently well understood for this stage of the process.

The Commission opened a call for evidence to inform the feasibility studies. The call for evidence closed on 23 May 2014. This report refers to work submitted as part of the call for evidence throughout where it has been considered appropriate and relevant.

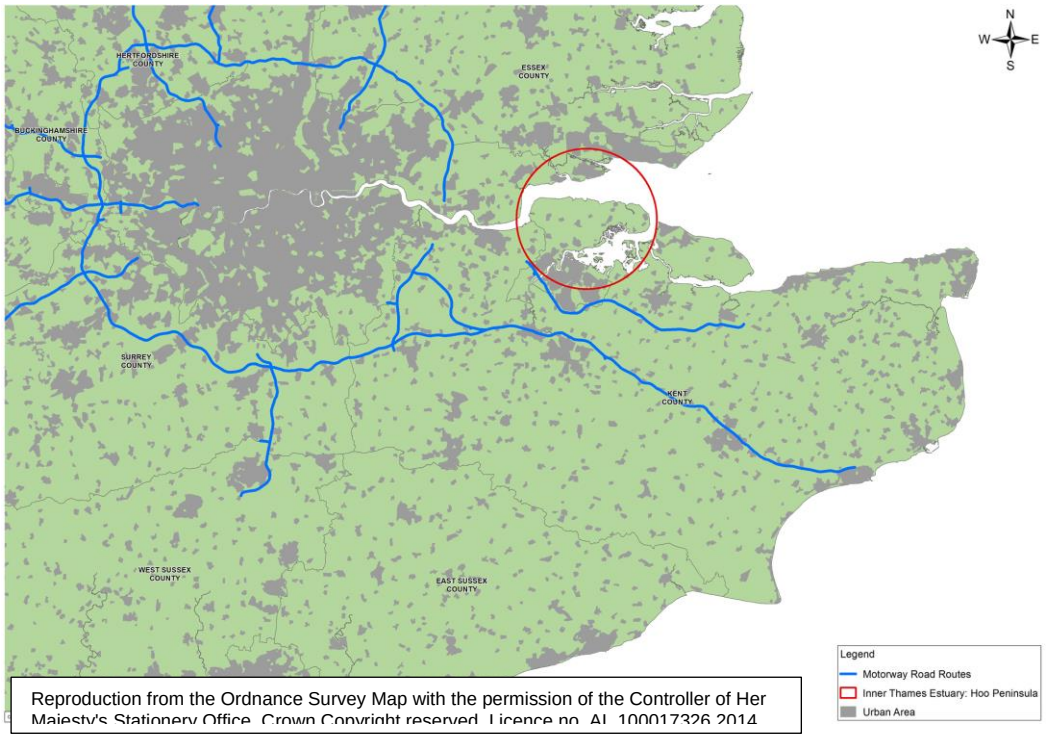


Figure 2-2 Inner Thames Estuary Airport Location

3 Scope and Methodology

3.1 General Approach

The study seeks to identify and define the general scale and magnitude of environmental impacts involved in the construction and operation of a new hub airport.

3.2 Proposed Schemes

The proposals for the Inner Thames Estuary airport are the basis for the study and these have been updated with additional information provided through the call for evidence. The options cover two main locations: on the west side of the Hoo Peninsula at Cliffe; and at Isle of Grain on the east side of the peninsula. The proposals also vary in terms of the extent to which they encroach into the estuary.

Information provided on scheme designs has varied considerably from very approximate and briefly described locations without supporting plans, to those providing a range of runway and terminal configurations. In some cases, the footprints have included space for associated airport development and run-off storage while others are unclear on the associated development allowed for.

In addition, it is recognised that the proposals and locations submitted are very preliminary and could be expected to change if the schemes are taken forward to phase 2. They are therefore considered in our assessment as examples of locations based on the information submitted in phase 1 and where this has been updated through the call for evidence. We have aimed to also comment more broadly to ensure the study is representative of the range of possible impacts.

To assist our study, we have mapped approximate footprints for the five schemes based on the information provided and these outlines have been confirmed against information where this was provided by the promoters in the call for evidence.

The following aspects will influence the airport footprint size and shape:

1. Number of runways: a three to four runway airport is assumed. This development is likely to be phased with three runways operational initially but it is assumed that ultimately a hub would be built to provide four runways by 2050.
2. Runway configuration: all runways are assumed to be aligned east/west and generally four parallel runways are proposed although the Metrotidal/Thames Reach option is for two long runways to be operated as three or four runways.
3. Airport development area: this is assumed to include all essential aircraft support and passenger infrastructure, such as terminals, air traffic control, maintenance, hangers, fuel storage, car parking, balancing ponds.
4. Air traffic movements: approximate air traffic movements for a four runway operation for 2050 are based on predictions used in the Phase 1 noise assessments and broadly consistent with the CAA Noise Analysis[12].

[12] Civil Aviation Authority (2013). Noise Analysis: Isle of Grain (Sept 2013)

3.3 Sources of Impacts

The potential sources of impacts from the development and operation of a new hub airport can be grouped as construction and operational phase impacts and can be defined as follows:

Construction Phase

- Airport construction – creation of the permanent structures such as runways, terminals and other airport buildings and facilities making up the total airport footprint;
- Construction activities – the temporary activities required to create the airport structures and buildings; and
- Sources of material for land reclamation from the estuary – where significant reclamation is required.

Operational Phase

- Use of airport buildings;
- Ground operations;
- Air traffic;
- Flood defence and estuarine morphology changes;
- Bird strike mitigation;
- Surface access; and
- Socio-economic development.

Table 3.1 below provides a breakdown of the sources of impacts which have been considered and the relevance for the different environmental topics is highlighted.

Table 3.1: Airport Development: Sources of Impact

Stage of development	Feature of development	Source of impact
Construction of footprint and flood defence	Airport footprint and flood defence structures	Land reclamation - where reclamation of area outside the current flood defences is required.
		Geomorphological changes from building into the estuary - with related habitat loss and flood risk changes.
		Site clearance - removal of features on land within current flood defences.
	Ancillary development footprint	Including for example additional footprint for car parking, hotels, balancing ponds, power supply.
	Foundations	Additional area affected below ground from , for example, piling.
	Earthworks & drainage – cut and fill to create level platform	Raising ground levels and excavation – change to drainage, land form. Potential for dredging to be required obtain fill materials from estuary or sea bed.
Construction activities	Development footprint	Land reclamation works and changes to water environment , for example, sediment release.
	Foundations	Noise, vibration and disturbance.
	Earthworks & drainage	Raising ground levels / excavation – artificial light, noise and vibration, dust generation, water pollution. Dredging activities - noise and vibration and water pollution.
	Construction traffic	Ship and HGV movements to the site.
	Building / structures & services	Construction activities on site - artificial light, air pollution, noise, waste generation and pollution risk.
Airport site - ancillary buildings and structures	All immediate airport buildings	Including for example - terminals, fuel storage, runoff storage, offices, control towers, hangars, cargo facilities and associated car parking and hotels, offices.) Layout, design and use of buildings and physical structures, ground noise and air pollution.
Ground operations – activities	Aircraft maintenance and ground traffic & taxiing	Noise impacts, emissions to air and water pollution , for example, de-icing chemicals, fuel spills.
	Lighting	24 hour lighting of runway and buildings.
Air traffic movements	Flights to and from airport	Engine noise, flaps and landing gear during take-off and landing and noise on approach and departure routes - possible 24 hour operation. Movement of planes through the sky/over-flight.
Development footprint and flood defence	Change to current and planned flood protection and change to estuary	Wider impacts from change to estuary flood risk, geomorphology / hydro- dynamic estuarine processes.
Bird strike mitigation measures	Bird strike risk	Management strategies to reduce risk including active control measures to deter birds or through planning control to limit development of bird attractants.
Surface Access	Construction footprint & traffic	New rail and road infrastructure and traffic generation.
Regional / local socio-economic development	Additional development and service requirements	Wider impacts from changes to socio – economic, population location, employment, service, resource demand.
Other	Range of operational activities	Noise impacts on people, air quality, health, carbon footprint, materials use, waste generation, water consumption .

3.3.1 The Phase One Thames Estuary Proposals

A brief outline of the Inner Estuary options is given below[13] (these options are shown in Figure 3-1):

Transport for London / Mayor of London (TfL / MoL)
The TfL / MoL proposed airport footprint provides for 4 parallel runways, airport infrastructure such as terminals and space for ancillary supporting development such as car parks and hotels, logistics support and cargo facilities[14]. This proposal is located on the eastern, Isle of Grain side of the Hoo Peninsula and takes less of the intertidal area but a larger area of land in the southern part of the peninsula compared to the other options. For the purposes of this study, TfL / MoL are not considered to be scheme promoters.

Foster + Partners
The proposal includes four parallel runways, airport infrastructure and car parking. In addition an area on the west side of the airport is identified for ancillary development for hotels and logistics support[15] and this combined footprint is used in this study. The airport is located on the east side of the Peninsula to maximise the area of open water for the approach and also with the aim to reduce bird strike risk. The airport is located furthest east on the Isle of Grain and extends out into the estuary to the east more than the other proposals.

Metrotidal Tunnel and Thames Reach Airport Ltd
A number of airport location and layout variants were provided by Metrotidal / Thames Reach. The Mid-Range East Configuration[16] option is indicated as the preferred option through the call for evidence process and is therefore used in this study, This is for two parallel long runways operating as four runways and is located on the northern side of the Isle of Grain combined with the Metrotidal Thames tunnel crossing from Canvey to Hoo, and the footprint incorporates eastern and western tidal pools within an elliptical flood bund protection. The option extends the furthest into the Thames Estuary channel, but is understood to be flexible depending on various design factors. Ancillary supporting development is proposed to be dispersed across a number of locations on brownfield sites on the Hoo Peninsula and around the transport hubs.

IAAG
This proposal is the only option proposed on the western, Cliffe side of the Hoo Peninsula. The proposals[17] submitted for Phase 1, indicate three runways and a terminal area with a large area of woodland planting around the south and east of the airport with a range of recreation and conservation projects and supporting development. The footprint shown is indicative only and assumes the airport is largely located within the existing flood defences.

Airports Commission - Isle of Grain

[13] The London Medway Airport Inner Thames Estuary option is not considered as there was no participation in the process after the submission in phase 1
[14] New Hub Airport: Isle of Grain - Mayor of London Submission July 2013
[15] Foster + Partners Thames Hub Airport July 2013
[16] Metrotidal / Thames Reach Airport footprint: May 2014
[17] London Gateway Airport, IAAG 2013

This option was identified in Phase 1 to allow one inner Estuary representative option to be studied further and includes four parallel runways with airport terminals, cargo and car parking and some provision for ancillary development. The location is also on the eastern Isle of Grain area but does not encroach as far into the estuary to the north as the TfL / MoL and Metrotidal Tunnel and Thames Reach Airport option or to the east as the Foster + Partners option.

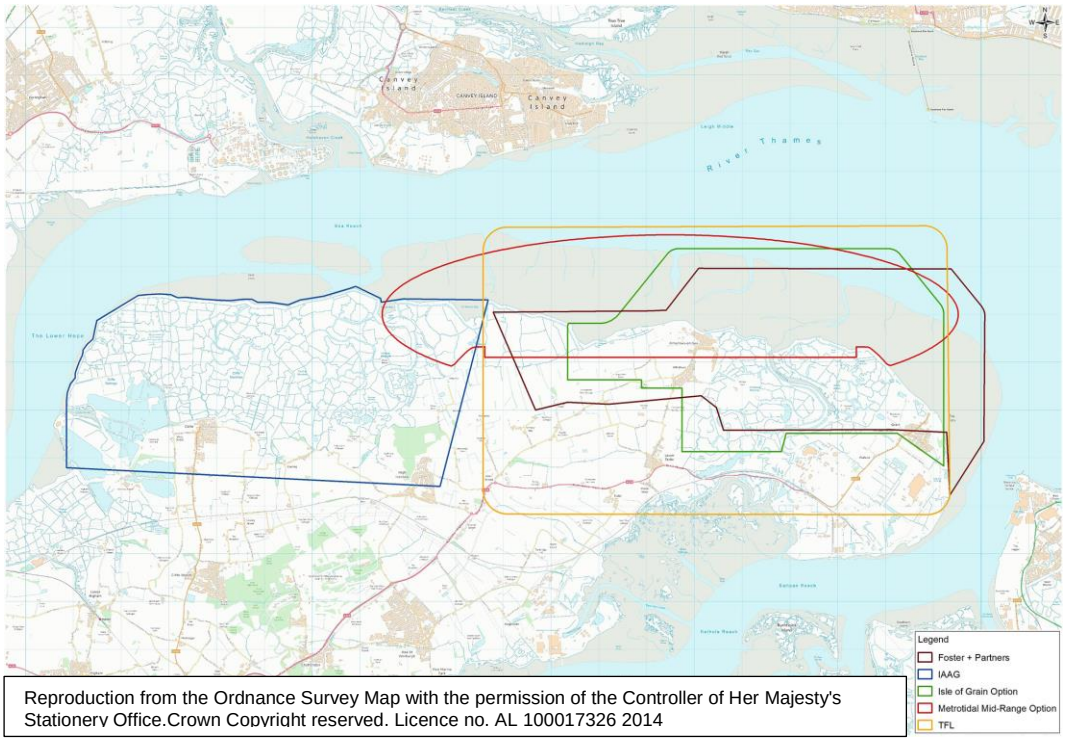


Figure 3-1 Proposal Option Footprints

3.3.2 Other Options

The proposals put forward by the proponents cover the vast majority of the Hoo Peninsula. Figure 3-1 shows that the only area not covered, is possibly a more central or a more southerly option location. A previous Cliffe proposal as considered in the SERAS report (2002)[18], was positioned centrally over St Mary Marshes with limited intrusion into the estuary.

3.3.3 Timescale for Development

The scope of the study is based on the assumption of an airport developed by 2030 operating four runways by 2050. The life of the project is 2030-2080/2100.

3.3.4 Study Area

As part of the assessment it is necessary to consider the extent over which potential impacts could occur. The concept of the zone of influence has been used to

[18] Department of Transport: The Future Development of Air Transport in the United Kingdom South East Consultation Document (July 2002)

determine the likely distance from the source that a pathway might affect a receptor. This concept is used by a number of the topics specifically, landscape and ecology although the extent of the zone of influence varies depending on the source or the pathway likely to lead to a particular impact.

A number of potential zones of influence are referred to:

- area of direct impacts within the potential footprint of the proposals;
- area of short distance local (indirect) impacts within 1km;
- area of birdstrike safeguarding 0- 13km;
- area of long distance (indirect) impacts 1 - 25km (Figure 3-2).

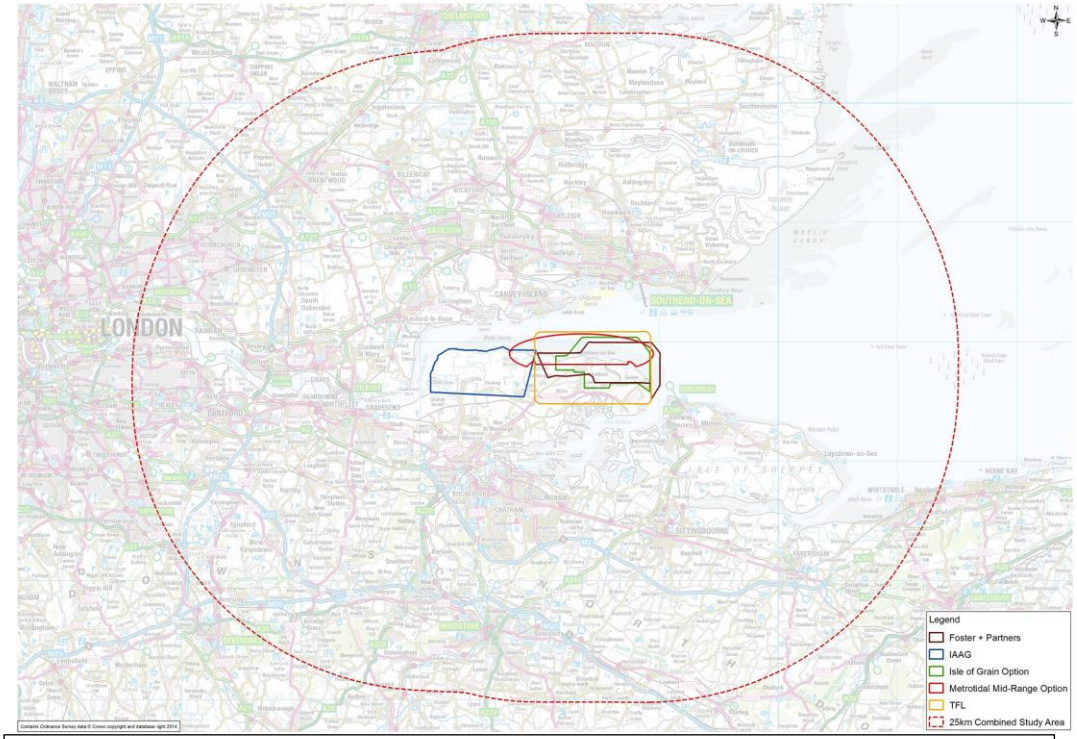
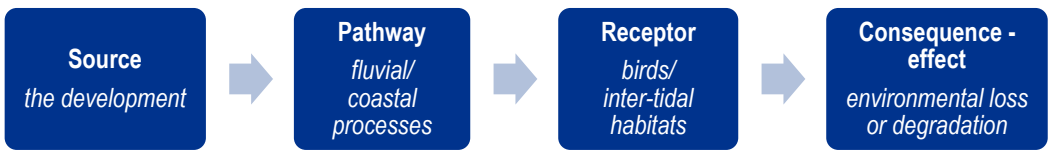


Figure 3-2 Combined 25km zone of influence

3.4 Approach

The approach for this study is based on reviewing the existing baseline information, understanding the pressures and change trends identifying the sensitive receptors of recognised importance based on designated status and focusing on identifying the large scale significant environmental effects likely to arise. This is essentially a Source - Pathway - Receptor approach.

Assessment model



3.5 Assumptions

The assessment for this study is based on the following assumptions:

- Basic examples of outline layout and footprint range from the phase 1 promoter proposals and Isle of Grain option with updates where additional information has been provided by promoters.
- Flight path assumptions and noise / air traffic movements for 2050 are based on the noise modelling undertaken for the phase 1 Isle of Grain option. These have also been used to develop approximate flight paths and heights.
- For construction activities, the application of best practice environmental management approaches, are assumed for this stage.
- For operational activities and pollution control for runoff & water treatment, best practice design and treatment approaches are assumed including appropriate precautionary measures although it is noted that some risk will remain.
- Impacts from sourcing materials for land reclamation and creation of the airport platform and flood defences outside cut and fill within the footprint have not been considered at this stage.

3.6 Uncertainties

Key areas of uncertainty in this report are:

- Preliminary and approximate nature of the information on the size and location of possible airport footprints and airport design layout - with associated uncertainty over the extent of impacts. The approach has been comprehensive in order to consider the range of proposals on the Hoo Peninsula and their possible impacts and risks.
- Desk study nature of this report, which is largely based on existing available data and the evidence submitted, without significant field study and monitoring. This means there is considerable uncertainty over certain aspects such as:
  - movement patterns for different types of birds and how they might be affected by the loss of habitat and presence of the airport;
  - related uncertainty over the bird management required to minimise bird strike risk given that it is bird movements and numbers and types of birds that are critical to this risk; and
  - how habitats support the function of the designated site species of interest.
- Construction impacts in terms of potential for sourcing of materials through dredging and sediment (and possibly associated sediment bound contaminants) release during construction with potential to have significant possibly long term impacts on the estuary over a lengthy construction period.

- Compensatory habitat creation uncertainty and the difficulties over demonstrating effective habitat creation in advance of displacement of populations during construction.
- Although the Thames estuary is well studied in terms of hydrodynamic processes, only limited modelling has been undertaken on the airport proposals at this stage and it is anticipated that further more detailed modelling would need to be undertaken alongside airport design development and for consenting purposes.
- Inherent uncertainties over climate change including future sea level rise and extreme events and a need to consider further scenarios with potentially higher rates of seal level rise as part of more detailed hydrodynamic modelling and scenario testing.

4 Ecology

This section covers:

- Legal framework focusing on Habitats Regulations, the assessment process and case studies.
- Baseline environment – how it is currently and how it might develop in the future.
- Potential Impacts from an airport hub development.
- Secondary and cumulative impacts.
- Mitigation and Compensation.
- Relevant case studies on habitats regulations assessment.
- Summary.

This ecology section of the report reviews the potential impacts on the Natura 2000 sites and wider ecological receptors from construction and operation of a new hub airport at an Inner Thames Estuary location. For the purposes of this report, Natura 2000 sites are taken to include Special Areas for Conservation (SAC), Special Protection Areas (SPA), European Marine Sites and Ramsar sites.

The implications for consent and the processes and information required to fulfil the obligations set out by the Habitats Directive 1992 (as amended)[19] ratified in domestic legislation under the Habitats Regulations 2010 (as amended)[20] requires an analysis of the process and issues for the development affecting Natura 2000 sites. Under the Regulations, a Competent Authority may not authorise or consent a plan or project unless the tests of the Regulations are passed.

A high level review of the habitats and species affected has been undertaken. This has identified any priority habitats and species (as defined by the Habitats Directive), and informed a strategic analysis of the impacts, issues and risks on identified habitats and species in the short and long term.

Consideration has been given to any secondary, cumulative and indirect impacts on the overall stability of the eco-system and wider environmental conditions. This also draws on the discussion of impacts on the estuary process and morphology in Section 5.

These impacts have been used to evaluate the implications for the Natura 2000 sites' conservation objectives and the analysis of the compensatory habitats necessary and resources required to implement compensatory measures.

4.1 Policy and Legislative Context

The legislation and policy of particular relevance to the ecology assessment is set out in Table 4.1.

[19] Council Directive on the conservation of natural habitats and of wild fauna and flora (92/43/EEC) (as amended)
[20] The Conservation of Habitats and Species Regulations 2010 (as amended)

Table 4.1: Summary of Key International and National Legislation Relating to Ecology

International Legislation	Summary
Council Directive on the conservation of natural habitats and of wild fauna and flora (92/43/EEC) (as amended) (Known as the Habitats Directive)	Introduces protected areas. Development can only be permitted if it is shown to have no adverse effect on the integrity of the site.
Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the conservation of wild birds (Known as the Birds Directive)	Provides a framework for the conservation and management of, and human interactions with, wild birds in Europe.
The Convention on Wetlands of International Importance especially as Waterfowl Habitat (the Ramsar Convention)	Places a responsibility on the UK government to designate wetlands of international importance and promote their conservation and wise use.
The Convention on Biological Diversity 1994	Requires Member States to produce Biodiversity Action Plans to incorporate sustainable development and the environment into sectors including coastal and marine management.
National Legislation	
The Conservation of Habitats and Species Regulations 2010 (as amended)	Transposes into UK law the requirements of the Habitats and Birds Directives.
The Wildlife and Countryside Act 1981 (as amended))	Provides legislative protection for wildlife in the UK and makes it an offence to disturb, injure or kill listed species of flora and fauna.
National Environment and Rural Communities Act 2006	Designed to help achieve a rich and diverse natural environment. Section 41 of the Act provides a list of species of principal importance in England which is used as a guide to regulators in implementing their responsibilities under Section 40 “to have regard” to the conservation of biodiversity. Following devolution the Section 41 list is more regularly referred to than the UK Biodiversity Action Plan (BAP) list.
Marine and Coastal Access Act 2009	Provides for the designation of Marine Conservation Zones which together with the European Marine Sites will form a network of Marine Protected Areas.

4.2 Habitats Regulations

4.2.1 Habitats Regulations Assessment

Regulation 61 of the Habitats Regulations[21] requires the assessment of all plans or projects for implications for European sites and European offshore marine sites (referred to collectively in this report as European Sites). These Regulations transpose the European Habitats Directive (Directive 92/43/EEC on the Conservation of Natural Habitats and Wild Flora and Fauna) into domestic legislation. Such assessments are commonly known as Habitats Regulations Assessment (HRA) which demonstrate to the Competent Authority whether an

[21] The Conservation of Habitats and Species Regulations 2010 (as amended)

Appropriate Assessment in relation to maintaining the Natura 2000 network's integrity can be made. The HRA is based on the maintenance and protection of individual Natura 2000 site conservation objectives.

European sites include Special Areas for Conservation (SAC); Special Protection Areas (SPA); and European offshore marine sites. Collectively these sites are known across Europe as the Natura 2000 network. Ramsar sites are also included as Government policy in Appropriate Assessment.

The HRA process is split into 5 sequential stages that relate to the tests set within the Regulations:

Stage 1: Screening.
Is the project Likely to have Significant Effects on a European site?

Stage 2: Appropriate Assessment.
Will the project have an adverse effect on the integrity of a European site?

Stage 3: Consideration of Alternative Solutions.
Is there an absence of Alternative Solutions?

Stage 4: Consideration of Imperative Reasons of Overriding Public Interest (IROPI).
Are there IROPI?

Stage 5: Securing Compensatory Measures.
Have Compensatory Measures been secured?

The key guidance documents used for undertaking HRA are:

- Assessment of plans and projects significantly affecting Natura 2000 sites: Methodological guidance on the provisions of Article 6(3) and (4) of the Habitats Directive 92/43/EEC European;
- Managing Natura 2000 Sites, The provisions of Article 6 of the 'Habitats' Directive 92/43/EEC;
- Guidance document on Article 6(4) of the 'Habitats Directive' 92/43/EEC: clarification of the concepts of: alternative solutions, imperative reasons of overriding public interest, compensatory measures, overall coherence, opinion of the commission;
- Advice Note Ten: Habitat Regulations Assessment relevant to nationally significant infrastructure projects (IPC); and
- Guidelines on the implementation of the Birds and Habitats Directives in estuaries and coastal zones with particular attention to port development and dredging.

Regulations 62 and 66 provide a derogation process if plans or projects would have an adverse effect on the integrity of a European Site (or there is uncertainty as to the absence of such), if the plan or project must still be carried out for Imperative Reasons of Overriding Public Interest (IROPI).

4.2.2 Stage 1: Screening - Likely Significant Effects

The Stage 1 test of Likely Significant Effects (LSE) is a screening stage and is meant to identify effects on European Sites (either alone or in combination) that require more detailed assessment at stage 2. The definition of "likely" and "significant" within HRA differ from that in other environmental assessments in that they are meant to identify plausible effects rather than substantial effects that are a material matter for consideration by decision makers. Case law has established this through interpretation of the Habitats Directive in the UK and by other Member States.

Material matters for consideration by the decision maker in relation to HRA (known as the Competent Authority) are identified at stage 2 Appropriate Assessment. Stage 1 is therefore merely to screen out any plan or project for which there are no plausible effects and to scope the requirement of stage 2. The bar for passing the LSE test is therefore set very low and any identified potential pathway to an adverse effect would lead to the need for a stage 2 assessment.

4.2.3 Stage 2: Appropriate Assessment - Adverse Effects on Integrity

Stage 2 Appropriate Assessment requires the project to be assessed as to whether there will be an adverse effect on the integrity of any European Sites. The Competent Authority may not authorise a plan or project if any adverse effects on integrity (either alone or in combination) are identified or if there is uncertainty as to the absence of such. The Appropriate Assessment must be carried out using the precautionary principle. The Waddenzee ruling of the European Court of Justice (ECJ Case C-127/02) set the threshold of uncertainty to be that there must be no reasonable scientific doubt as to the absence of such effects.

The Competent Authority must undertake the Appropriate Assessment. The developer or proposers of the plan or project must provide such information as the Competent Authority may reasonably require for the purposes of the assessment. This is normally done through the publication of an HRA report accompanying any application for consent / authorisation of a plan or project. The relevant nature conservation body (Natural England) must also be consulted and regard taken of any representations they make.

If it cannot be demonstrated that the plan or project will not adversely affect the integrity of a European Site, then the plan or project can only be authorised if the tests within stage 3 to 5 can be passed.

4.2.4 Stage 3: Alternative Solutions

(i) The Alternatives Solutions test

The Competent Authority must be satisfied that there are no alternative solutions that would have a lesser adverse effect on the Natura 2000 Sites. Alternative Solutions are not defined in the Habitats Regulations or the Habitats Directive. They could involve alternative locations (routes in case of linear developments), different scales or designs of development, or alternative processes. The 'zero-option' should be considered too.

European Commission guidance *Assessment of plans and projects significantly affecting Natura 2000 sites: Methodological guidance on the provisions of Article 6(3) and (4) of the Habitats Directive 92/43/EEC European* states:

> *The examination of alternative solutions requires that the conservation objectives and status of the Natura 2000 site will outweigh any consideration of costs, delays or other aspects of an alternative solution. The competent authority should not, therefore, limit its consideration of alternative solutions to those suggested by the project or plan proponents. It is the Member State's responsibility to consider alternative solutions, which could be located even in different regions/countries.*

European Commission guidance document Article 6(4) of the *'Habitats Directive' 92/43/EEC: clarification of the concepts of: alternative solutions, imperative reasons of overriding public interest, compensatory measures, overall coherence, opinion of the commission* states:

> *In line with the need to prevent undesired impairment to the Natura 2000 network, the thorough revision and/or withdrawal of a proposed plan or project should be considered when significant negative effects on the integrity of a site have been identified. This should be observed especially in the case of effects on priority habitats and/or species protected under the Habitats Directive or globally endangered bird species listed in Annex I of the Birds Directive. The competent authorities have to analyse and demonstrate first the need of the plan or project concerned. Thus, the zero option should be considered at this stage. Subsequently, the competent authorities should examine the possibility of resorting to alternative solutions which better respect the integrity of the site in question. All feasible alternatives, in particular, their relative performance with regard to the conservation objectives of the Natura 2000 site, the site's integrity and its contribution to the overall coherence of the Natura 2000 Network have to be analysed. Such solutions should normally already have been identified within the framework of the initial assessment carried out under Article 6(3). They could involve alternative locations or routes, different scales or designs of development, or alternative processes.*

The Competent Authority would need to be certain that no alternative solutions existed, and that the best scientific knowledge had been considered and that the representations (and interpretations) by Natural England and Environment Agency had been taken into account.

(ii) Alternative Sites for an Airport

Phase 1 of the assessment of options for new provision for a new hub airport has identified that proposals for expansion of both Heathrow and Gatwick are feasible options. Subject to the points in the following paragraph, any Inner Thames Estuary proposal would have to address the alternative options offered by the Heathrow or Gatwick options (and possibly other Sift 1 options). They would have to be discarded as viable options for the Estuary option to address the Alternative Solutions test.

Some legal commentators have argued that, when considering Alternative Sites, it is possible to take account of Imperative Reasons of Overriding Public Importance (IROPI) (see next section). This is an issue on which legal advice will be required.

(iii) Alternative Designs for an Inner Thames Estuary Airport

If there are no Alternative Solutions, the assessment would also need to consider the alternative designs available for an estuary option. Indicative designs have been proposed and considered, and any project proposal would need to consider further these and other design options that may have lesser adverse effects.

Identifying the appropriate design would require an iterative consideration of the existing provision; study into the relative importance of each habitat in supporting species; the relative damage to different habitats; and assessment of the likely success of delivering any target habitat creation. The indicative proposals may not be the optimal design available on the peninsula and so a complex process of proposals and assessment prior to a decision on the preferred option would be necessary.

It is likely that a substantial amount of research would be required to even decide the preferred option prior to the consideration of Alternative Solutions of any project proposed for authorisation. There is therefore the potential for significant up-front costs on developing a proposal that may then be rejected on the basis of there being alternative sites available.

4.2.5 Stage 4: Imperative Reasons of Overriding Public Interest

Having ascertained there will be, or may be, an adverse effect on the integrity of a European Site; and that there are no Alternative Solutions to the objectives of the plan or project; in stage 4 the Competent Authority must demonstrate the IROPI that override the consideration of Regulation 61.

The Habitats Regulations state that IROPI can be for reasons of:

- Human health;
- Public safety;
- Beneficial consequences of primary importance for the environment; or
- Other imperative reasons of overriding public interest of social or economic nature.

There are clearly strong potential IROPI relating to health, public safety and socio-economic reasons which constitute the objectives or rationale for a new hub airport. However, the Competent Authority would need to be certain that the imperative nature of the reasons for authorising a new airport on the Hoo Peninsula were imperative only at that site. Otherwise, a project proposed on the Hoo Peninsula would be unlikely to pass the Alternative Solutions test (see section on assessment of Alternative Solutions).

Public health IROPI may be stronger in an estuary option than other options considered in Phase 1 due to the possible reductions in effects of noise and air pollution on human populations, but it would be necessary to demonstrate that the health improvements were of such a scale as to override the large scale adverse effects on the European Site. This may be difficult given the uncertainty over health effects attributable to an airport and when populations living near Heathrow and Gatwick have been subject to such existing effects for some decades.

Safety IROPI could be undermined by relatively high bird strike risk in relation to other options, although the risk of death and injury to people living near the airport may also be reduced. It would appear, however that it is unlikely that an estuary option would outperform all other options in relation to safety to the degree that it would be imperative to site any future hub airport on the Hoo Peninsula.

A prior opinion from the European Commission may be sought on socio economic reasons, but it is highly uncertain that the opinion would be positive due to the potential Alternative Solutions available (although future development of the project's objectives may support fewer Alternatives), and the range of objectives to be balanced for expanded hub airport provision.

4.2.6 Stage 5: Compensatory Measures

Regulation 66 states that the Competent Authority must secure that any necessary compensatory measures are taken to ensure that the overall coherence of Natura 2000 is protected, if they are to authorise a plan or project on the basis of IROPI.

European Commission guidance *document on Article 6(4) of the 'Habitats Directive' 92/43/EEC: clarification of the concepts of: alternative solutions, imperative reasons of overriding public interest, compensatory measures, overall coherence, opinion of the commission* states:

> *The compensatory measures constitute measures specific to a project or plan, additional to the normal practices of implementation of the "Nature" Directives. They aim to offset the negative impact of a project and to provide compensation corresponding precisely to the negative effects on the species or habitat concerned. The compensatory measures constitute the "last resort". They are used only when the other safeguards provided for by the directive are ineffectual and the decision has been taken to consider, nevertheless, a project/plan having a negative effect on the Natura 2000 site.*

In developing an acceptable package of Compensatory Measures therefore, it is necessary to identify the precise negative effects on each feature of each European Site adversely affected so that the additional Compensatory Measures can be assessed as to whether they correspond to addressing those negative effects. It is often difficult to precisely predict the effects of development proposals due to the inherent uncertainties in ecological systems, the lack of data, inability to predict the future accurately and differing interpretations of the implications of available information by stakeholders. Even if a precise assessment of the adverse effects can be made, there is more uncertainty in assessing whether proposed Compensatory Measures would effectively offset the damage caused.

The Compensatory Measures would need to provide sufficient functionality to support the designated species of the site(s) affected within the wider network of Natura 2000 sites to ensure each species affected was maintained in Favourable Conservation Status (FCS).

A Competent Authority may therefore only authorise a project where it is certain that the Compensatory Measures are sufficient to maintain each designated species of affected sites in FCS. This would require the proponents of the project to demonstrate how uncertainties in providing new habitat functionality would be overcome.

As a minimum a project has to be able to demonstrate that not only the carrying capacity of replacement habitat but also the functional supporting habitat is replaced at a like for like basis. For example for geese, a grassland resource providing grazing habitat could provide carrying capacity for feeding geese but would not be a like for like replacement for the loss of mud flat feeding areas.

In terms of habitat area created compared to lost, this may be a larger ratio of area of habitat gained to habitat lost than 1:1.

Compensation measures for adverse impact on the Natura 2000 network could consist of:

- restoration - restoring the habitat to ensure the maintenance of its conservation value and compliance with the conservation objectives of the site;
- creation - creating a new habitat on a new site or through the enlargement of the existing site;
- enhancement - improving the remaining habitat proportional to that which is lost due to the project or plan; and
- preservation of habitat stock - measures to prevent further erosion of the coherence of the Natura 2000 network[22].

It will be necessary for the promoter of the proposals to gain consensus on the adequacy of the Compensatory Measures package or to propose a package that is likely to be robust against challenge. The ability to gain consensus on the package will depend on consultation and negotiation on the proposals, but also on the contentiousness of the proposals and whether there are objections in principle to the siting of the airport in the Inner Thames Estuary.

Guidance on Article 6(4) on the Habitats Directive states that the ratios of compensatory habitat to habitat lost should be generally well above 1:1. Compensation ratios of 1:1 or below should only be considered when it is demonstrated that the measures will be 100% effective in reinstating structure and functionality within a short period of time and without compromising the preservation of the habitats or the populations of key species likely to be affected by the plan or project.

4.2.7 Dealing with Uncertainty and Differences of Opinion Within Conclusions

All ecological assessment and the legal tests that must be passed are subject to high degrees of uncertainty because of the inherent variability of ecosystems and the impossibility of accurately predicting the future (particularly true in this case due to scale and interconnectedness of sites, species, habitats, and geomorphology), but also because of interpretation of information and terminology, for example, “significance”, “integrity”, “satisfactory”, “precautionary”, “proportionate” and “reasonable scientific doubt”.

[22] Assessment of plans and projects significantly affecting Natura 2000 sites: Methodological guidance on the provisions of Article 6 (3) and (4) of the Habitats Directive 92/43/EEC, European Commission (November 2001)

It is a requirement of the Regulations to use the best available scientific knowledge to undertake the assessment. The provisions of adequate scientific data from a dynamic ecosystem such as the Thames Estuary, combined with the dynamic nature of many of its protected species will be a complex challenge. For such complex and large scale proposals, the range of expert opinions within stakeholders would be a fundamental part of the assessment.

4.3 Zone of Influence

The area over which an effect is experienced is defined as the zone of influence. The assessment of the implications of project activities will therefore not be restricted to areas close to the development footprint but will consider activities that may have wider reaching effects, as well as affecting species that may range over a large area away from the European sites of which they form a designated part.

The zone of influence is therefore effect- and pathway-driven as well as receptor-driven and is key to identifying the European sites potentially affected (see Table 4.2).

Table 4.2: Potential Zone of Influence

Sources (of impact)	***Potential Effect***					
Construction						
Site clearance	Habitat loss	Habitat fragmentation	Mortality	Disturbance	Introduce non-native species	
Land reclamation	Habitat loss	Habitat fragmentation	Mortality	Disturbance	Introduce non-native species	Geomorphological changes
Dredging	Habitat loss	Habitat degradation	Mortality	Disturbance	Geomorphological changes	
Piling	Noise / Vibration		Disturbance		Geomorphological changes	
Earthworks & Drainage	Air Pollution	Noise / Vibration	Disturbance	Introduce non-native species	Change water environment	
Construction activities	Air Pollution	Noise / Vibration	Disturbance	Lighting	Introduce non-native species	Change water environment
Operation						
Flight operations	Air Pollution	Noise / Vibration	Disturbance	Introduce non-native species	Change water environment	
Ground operations	Air Pollution	Noise / Vibration	Disturbance	Lighting	Change water environment	
Bird strike mitigation	Habitat degradation		Habitat fragmentation	Mortality	Disturbance	

	Effects within footprint only
	Effects within 1km of footprint
	Effects within 13km of footprint
	Effects within 25km of footprint

4.4 Baseline

4.4.1 Natura 2000 Sites

There are several Natura 2000 sites in the potential footprint of the Airport Hub and further afield that could be affected by the proposals as shown on Figure 4-1. Table 4.3 sets out those designated (and proposed) sites that are potentially affected by the airport hub proposals. Additional details for the designated sites and their qualifying features and conservation objectives are provided in Appendix A2 and A3.

No priority habitats (as defined under the Habitats Directive) are designated in the Thames Estuary. The estuary hosts coastal lagoon habitat that is listed as a priority habitat type in Annex I of the Habitats Directive. However, the coastal lagoon habitat has not been designated as an SAC as only near-natural lagoon sites have been selected for designation and the habitat present is artificial in origin, it is therefore not classified as priority habitat. The communities present are similar to those of more natural sites and the UK BAP habitat “Saline Lagoons”.

4.4.2 Nationally Designated Sites

There are a number of national designations such as Sites of Special Scientific Interest (SSSIs), National Nature Reserves (NNRs) and Marine Conservation Zones (MCZs). Many of these overlap in area with the Natura 2000 sites although they are designated for different features of interest. These are also listed in Appendix A2.

4.4.3 European Protected Species and Nationally Protected Species

As well as supporting a number of designated sites, the Hoo Peninsula and wider Thames estuary also supports a wide range of species that are internationally or nationally protected and/or are of conservation concern. The majority of these species are not the primary reason for the designation of the protected sites but are of equal value in many cases.

There are no mammals, reptiles or amphibians which are qualifying features for internationally or nationally designated sites within 1 km of the potential footprint, but a number of these species are protected and found on the peninsula including, but not limited to, great crested newt (*Triturus cristatus)* a European protected species.

The Hoo Peninsula has also been reported as being an important area for bats, including the serotine bats (*Eptesicus serotinus)* which are another European protected species[23]. There is also an expanding water vole (*Arvicola amphibius*) population recorded in the area of Damhead Creek and the peninsula also hosts populations of slow worm (*Anguis fragilis*) and grass snake (*Natrix natrix)*, all of which are nationally protected species[24].

[23] Kent Wildlife Trust (2009) Appendix C:BOA Maps and Statements relevant to Swale. Available at: http://www.swale.gov.uk/assets/Planning-General/Planning-Policy/Landscape-Character-Appraisal-SPD-Oct-10/Appendix-C.pdfAccessed 04/06/14.
[24] Scottish Power (2011). Damhead Creek Power Station Biodiversity Information. Available at: http://www.spenergywholesale.com/userfiles/file/DamheadBiodiversity.pdf. Accessed 04/06/14.

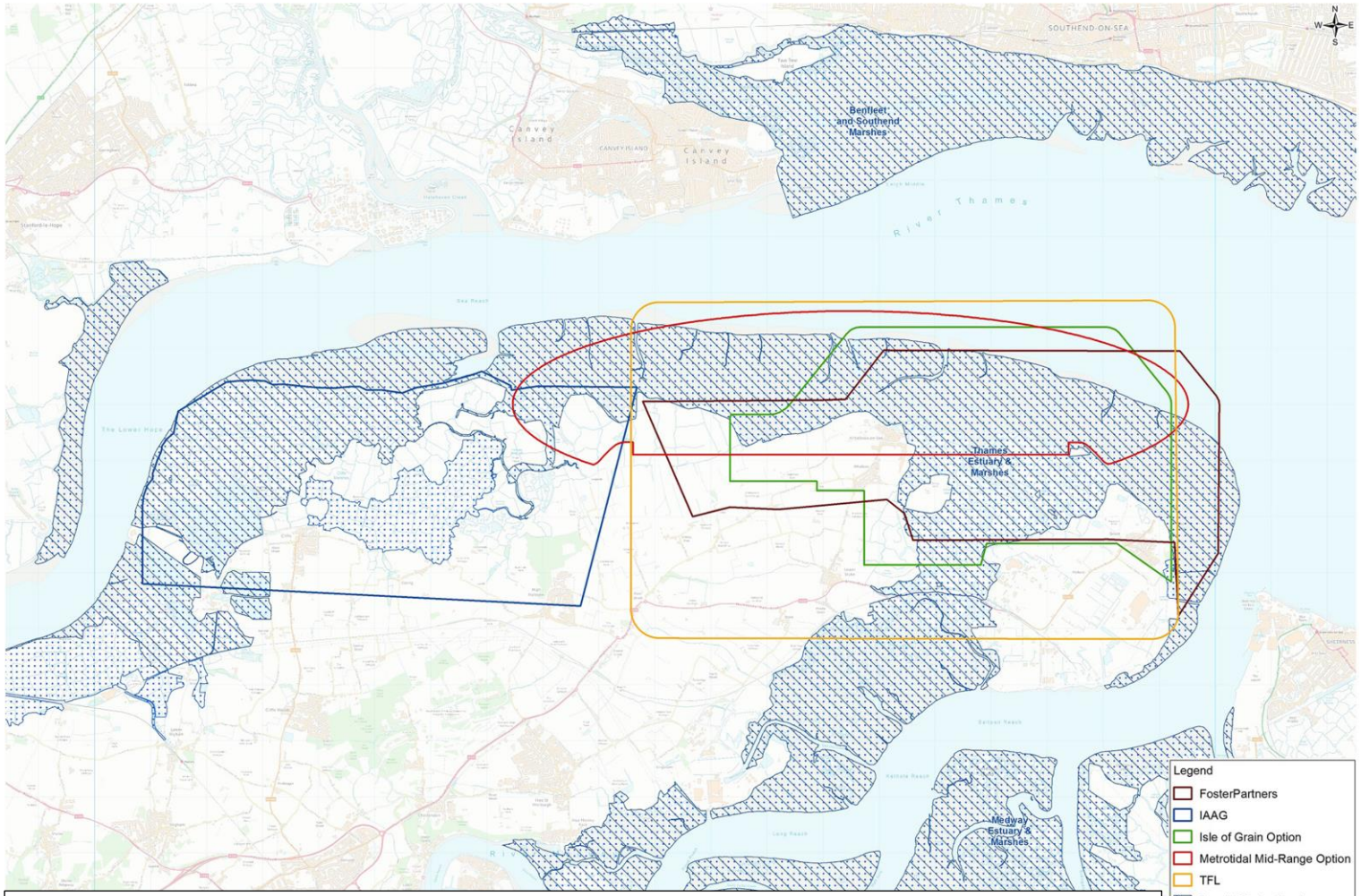


Figure 4-1: Natura 2000 Sites Directly Affected

The Thames Estuary and Marshes Ramsar site also supports one endangered plant species and at least 14 nationally scarce plants of wetland habitats. The site also supports more than 20 British Red Data Book invertebrates, such as the ground beetle (*Polystichus connexus)*, which is listed as vulnerable. The section 41 listed butterfly species, small heath (*Coenonympha pamphilus*) and white-letter hairstreak butterfly (*Strymonidia w-album*) are also present.

Table 4.3: Natura 2000 Sites within 25km of the Hoo Peninsula

SPA Site Name	Qualifying Features[25]
Thames Estuary and Marshes	Wintering and passage waterfowl
Medway Estuary and Marshes	Breeding avocet (*Recurvirostra avosetta*) and little tern (*Sterna albifrons*)
Benfleet and Southend Marshes	Wintering and passage waterfowl
The Swale	Wintering waterfowl
Foulness	Breeding avocet, marsh harrier (*Circus aeruginosus*) and Mediterranean gull (*Larus melanocephalus*)
Crouch and Roach Estuaries	Wintering and passage waterfowl
Blackwater Estuary	Breeding avocet and terns
Dengie	Wintering waterfowl and hen harrier (*Circus cyaneus*)
Outer Thames Estuary	Wintering waterfowl and hen harrier
Ramsar Site Name	
Thames Estuary and Marshes	RDB invertebrates RDB plants Wintering and passage waterfowl Coastal lagoons
Medway Estuary and Marshes	RDB invertebrates RDB plants Wintering and passage waterfowl
Benfleet and Southend Marshes	Wintering waterfowl
The Swale	RDB invertebrates RDB plants Wintering and passage waterfowl
Foulness	Saltmarsh RDB invertebrates RDB plants Wintering waterfowl
Crouch and Roach Estuaries	Coastal habitats RDB invertebrates RDB plants Wintering waterfowl
Blackwater Estuary	Coastal habitats RDB invertebrates RDB plants Breeding waterbirds Wintering waterfowl
Dengie	Coastal habitats

[25] Information from JNCC SPA citations (Available from http://jncc.defra.gov.uk/page-1401), Information sheets on Ramsar Wetlands (RIS) (Available from http://jncc.defra.gov.uk/page-1390) and SAC accounts (Available from http://jncc.defra.gov.uk/ProtectedSites/SACselection/SAC_list.asp?Country=E).

	RDB invertebrates RDB plants Wintering waterfowl
SAC Site Name	
Blean complex	Woodland
North Downs Woodlands	Woodland
Essex Estuaries	Intertidal habitats
Peter's Pit	Great crested newt (*Triturus cristatus*)
Queensdown Warren	Chalk grassland
Tankerton slopes & Swalecliffe	Fisher's estuarine moth (*Gortyna borelii lunata*)
Margate and Long Sands	Sandbanks

More details of qualifying features of Natura 2000 sites can be seen in Appendix A2.

(i) Birds

The Hoo Peninsula and wider Thames estuary supports internationally important populations of birds all year round. Natura 2000 sites and SSSIs in the area are designated for a wide range of breeding and wintering bird species. These birds move regularly between sites (especially on passage and in winter) and can form enormous flocks at high tides.

Breeding birds

The following breeding birds are present as internationally or nationally designated features on or near the Hoo Peninsula:

Table 4.4: Breeding Birds

Species designated on Natura 2000 sites	Additional species designated on SSSIs
Common tern (*Sterna hirundo*) Little tern (*Sterna albifrons*) Sandwich tern (*Sterna sandvicensis*) Mediterranean gull (*Larus melanocaphalus*) Avocet (*Recurvirostra avosetta*) Marsh Harrier (*Circus aeruginosus*)	Grey heron (*Ardea cinerea*) Mute swan (*Cygnus olor*) Shelduck (*Tadorna tadorna*) Garganey (*Anas querquedula*) Shoveler (*Anas clypeata*) Teal (*Anas crecca*) Gadwall (*Anas strepera*) Bearded tit (*Panurus biarmicus*) Pintail (*Anas acuta*) Pochard (*Aythya ferina*) Tufted duck (*Aythya fuligula*) Black headed gull (*Chroicocephalus ridibundus*) Redshank (*Tringa totanus*) Nightingale (*Luscinia megarhynchos*)

Inland habitats on the peninsula support a range of woodland and farmland birds, as well as the largest heronry in the UK at the Northward Hill / High Halstow SSSI / NNR. This site supports breeding herons and little egrets with most recent estimates of 250 pairs nesting here[26]. As well as being protected, these species pose high bird strike risk[27]. Other species recorded include the long-eared owl.

Coastal sites adjacent to the wider Thames estuary support similar breeding waterfowl assemblages with waders, wildfowl, gulls, and terns, as well as marsh harriers.

Wintering and migratory birds

The Thames estuary is internationally important for wintering and migrating waterfowl. Within the UK, it is one of the most important estuaries for waterfowl, ranking fifth in terms of numbers of waterfowl recoded in the Wetland Bird Survey (WeBS) core counts, with a mean count between 2007 and 2012 of 159,528 (see Table 4.5). The Thames estuary complex forms a vital staging post and wintering site for a large number of migratory waterfowl, especially in harsh weather conditions where the relatively sheltered nature of the estuary provides accessible foraging (for example, mudflats) and high tide roosting sites (for example, saltmarsh). The Swale and Medway estuaries adjacent to the Hoo Peninsula are also important for waterfowl, with average waterfowl counts in the magnitude of 75,000 and 33,000, respectively.

Table 4.5: Total Numbers of Waterfowl in the Thames and adjacent Estuaries (Source: WeBS)

Estuary	2007/08	2008/09	2009/10	2010/11	2011/12	Average
Thames	190,264	159,505	141,893	152,179	153,801	159,528
Swale	91,390	67,296	88,267	77,585	51,837	75,275
Medway	37,545	41,036	18,854	35,979	30,285	32,740

Within the 13km safeguarding zone for any airport on the Hoo Peninsula therefore, there are regularly over a quarter of a million birds, often moving in large, densely packed flocks.

The following wintering or passage birds are present as internationally designated features either individually or as part of the assemblage on or near the Hoo Peninsula:

Red throated diver (*Gavia stellata);* Little Grebe (*Tachybaptus ruficollis*); Great Crested Grebe (*Podiceps cristatus*);	Teal (*Anas crecca*); Avocet (*Recurvirostra avosetta*); Ringed plover (*Charadrius hiaticula*) ; Grey Plover (*Pluvialis squatarola*);

[26] RSPB (2014). RSPB Reserve Northward Hill. Available at: http://www.rspb.org.uk/reserves/guide/n/northwardhill/star_species.aspx. Accessed 04/06/2014.

[27] Operational Viability Study 2 *Bird strike section*

Cormorant (*Phalacrocorax carbo*);	Black-tailed Godwit (*Limosa limosa*);
White-fronted goose (*Anser albifrons*);	Dunlin (*Calidris alpina*) ;
Dark-bellied brent goose (*Branta bernicla bernicla*);	Redshank (*Tringa totanus*);
Shelduck (*Tadorna tadorna*);	Knot (*Calidris canutus*);
Pintail (*Anas acuta*);	Oystercatcher (*Haematopus ostralegus*);
Wigeon (*Anas penelope*);	Lapwing (*Vanellus vanellus*);
Shoveler (*Anas clypeata*);	Whimbrel (*Numenius phaeopus*); and
Gadwall (*Anas strepera*);	Curlew (*Numenius arquata*).

Dunlin, knot and oystercatcher have been recorded as the most abundant species in the Thames Estuary WeBS low tide counts between the Medway and Crouch Estuaries, with densities of 9.35, 2.53 and 3.39 per hectare respectively (2008/09 figures). This assemblage of birds is also present throughout the coastal areas from Essex to north Kent. The estuary is also an important wintering area for hen harrier and short eared owls.

Bird species diversity and habitat requirements

The bird populations using the estuary are of considerable national and international importance. Table 4.6, adapted from the BTO call for evidence, demonstrates the diversity of bird species which the use the estuary.

The use of the estuary and the requirements of each bird species do vary both spatially and temporally. One of the most important functions of the estuary is to supply food resource to the bird species. However, although many bird species supported by the estuarine system feed on invertebrates they are often specifically adapted for feeding on only certain invertebrate prey items or guilds of prey items. This provides a complex challenge in understanding the functional equivalence of any required replacement and compensation habitat. The challenge of the design and the implementation of that habitat replacement will be its need to consider the carrying capacity of the habitat lost in terms of each individual bird species. The temporal changes in the use by bird species not only relates to the large seasonal fluctuations of the estuary by passage migrants, overwintering and breeding species but also in the provision of suitable roosting areas between tidal cycles for species that require estuarine feeding grounds to be uncovered at low tide. These requirements again provide another complexity in designing and implementing successful habitat compensation that provides the niche breadth for all species to be maintained at their current conservation status.

Population sizes of each species protected under the designations for the Thames Estuary and Marshes SPA and the Medway Estuary and Marshes SPA Adapted from BTO Research Report No. 657[28] are provided in Table 4.6.

[28] BTO Research Report No. 657 - Review of knowledge regarding the effect of major estuarine developments on bird populations with reference to proposals for an airport in the Thames Estuary

Table 4.6: Bird Populations

	Species	Thames Estuary and Marshes	Medway Estuary and Marshes	Numbers in sectors that overlap potential airport (WeBS 5 year peak mean)	Percentage of current Thames and Medway SPA populations on the potential airport site
1	Bewick's swan *Cygnus columbianus*		16 (W)	7	70
2	Dark-bellied brent goose *Branta bernicla bernicla*		3,205 (W)	973	33
3	Shelduck *Tadorna tadorna*		4,465 (W)	587	13
4	Wigeon *Anas Penelope*		4,346 (W)	290	4
5	Teal *Anas crecca*		1,824 (W)	4245	85
6	Mallard *Anas platyrhynchos*		BA, WA	1239	80
7	Pintail *Anas acuta*		697 (W)	28	3
8	Shoveler *Anas clypeata*		76 (W)	74	9
9	Pochard *Aythya farina*		BA, WA	137	7
10	Red-throated diver *Gavia stellate*		BA, WA	4	67
11	Cormorant *Phalacrocorax carbo*		BA, WA	115	28
12	Great crested grebe *Podiceps cristatus*		67 (W)	17	8
13	Hen harrier *Circus cyaneus*	7 (W)	BA	No current data	No current data
14	Avocet *Recurvirostra avosetta*	283 (W)	28 P (B), 314 (W)	24	1
15	Oystercatcher *Haematopus ostralegus*		3,672 (W)	4302	35
16	Grey plover *Pluvialis squatarola*	2,593 (W)	3,406 (W)	767	14
17	Lapwing *Vanellus vanellus*		BA, WA	1000	7
18	Bewick's swan *Cygnus columbianus*	1,324 (P)	768 (W)	289	34
19	Dark-bellied brent goose *Branta bernicla bernicla*		1,900 (W)	1969	53
20	Shelduck *Tadorna tadorna*	1,699 (W)	957 (W)	4486	50
21	Wigeon *Anas Penelope*		561 (W)	188	27
22	Teal *Anas crecca*	4,848 (W)	541 (W)	5770	18
23	Mallard *Anas platyrhynchos*	29,646 (W)	25,936 (W)	4090	12
24	Pintail *Anas acuta*		10 (W)	53	43
25	Shoveler *Anas clypeata*	3,251 (W)	3,690 (W)	1035	26
26	Pochard *Aythya farina*		28 P (B)	5	18
27	Red-throated diver *Gavia stellate*		77 P (B)	41	15
28	Cormorant *Phalacrocorax carbo*		BA	No current data	No current data
29	Great crested grebe *Podiceps cristatus*		BA	1	14
30	Hen harrier *Circus cyaneus*		BA	No current data	No current data
31	Avocet *Recurvirostra avosetta*	75,019	65,496	21,681	25

* Note that the figures given here are for the species and population sizes listed on the Natura 2000 data form, which is the information sent to the EU as part of the SPA designation process. Additional figures for the species occurring in important numbers on these SPAs are available from the SPA Review (Stroud *et al*. 2001).

(ii) Aquatic Species

European eel (*Anguilla anguilla*) (Section 41 and UKBAP species, IUCN Red List Critically endangered) is present in the main Thames Estuary, and also utilises the drainage channels and ponds on the Hoo Peninsula and Isle of Grain. Sea lamprey (*Petromyzon marinus*) and twaite shad (*Alosa fallax*) (both Section 41 and UKBAP species) have been caught at Kingsnorth Power station[29], and are therefore considered to use the waters around the area.

In addition, the Thames, Medway and Swale are described as rivers where smelt (*Osmerus eperlanus*) (a Section 41 and UKBAP Priority species) populations are thriving[30].

Other UKBAP species recorded in the waters of the Thames and Medway estuaries include: Herring (*Clupea harengus*), Short-snouted seahorse (*Hippocampus hppocampus*), Lesser sandeel (*Ammodytes marinus*), Whiting (*Merlangius merlangius*), Dover sole (*Solea solea*), Scad (*Trachurus trachurus*), Mackerel (*Scomber scombrus*), and Cod (*Gadus morhua*).

Over 50 species of fish have been recorded in the Medway estuary including sea trout (*Salmo trutta*) and representatives of mullet (*Mugilidae*), dragonets (*Callionymidae*), gobies (*Gobiidae*), flatfish (*Pleuronectifromes*), sprat and herrings (*Clupeidae*), and the cod family (*Gadidae*). The herring present in the Medway are from the Thames Estuary stock, which are thought to be a unique strain. The creeks, saltmarsh, mudflats and eel grass beds provide nursery/foraging grounds for juvenile fish, with the Kingsnorth Power station (Damhead Creek) and Isle of Grain power station outfalls designated as bass (*Dicentrarchus labrax*) nursery areas[31].

The nutrient rich waters and sediments of the Thames and Medway estuaries provide ideal conditions for a number of invertebrates and shellfish species such as cockles, oysters and mussels. As mentioned previously, the tentacled lagoon worm (*Alkmaria romijni*) is present in the sediments of the Medway estuary and is protected by national legislation. Several species of marine mammals (subject to various international and national conservation designations) have been recorded in the Thames Estuary off the Hoo Peninsula, and Blyth Sands is a known haul out site for common seal (*Phoca vitulina*) and grey seal (*Haliochoerus grypus*)[32].

4.4.4 Ecosystem Value of the Area

The Hoo Peninsula supports a complex mosaic of intertidal, wetland and terrestrial habitats that interact with each other. The complex of a wide range of habitat types

[29] Wharfe, J. R., Wilson, S. R. and Dines, R. A. (1996). Observations on the Fish Populations of an East Coast Estuary. Southern Water Authority Report. 14 pp
Williams, J., and Brown, N. (eds.), (1999), An Archaeological Research Framework for the Greater Thames Estuary, Essex County Council, Kent County Council and English Heritage.

[30] Maitland, P. S. (2003). The status of smelt *Osmerus eperlanus* in England. English Nature Research Reports. 82 pp.

[31] Rogers, S. I. (2007). A Review of closed areas in the United Kingdom Exclusive Economic Zone. Sci. Ser., Tech. Rep., CEFAS, Lowestoft, (106), 20pp.

[32] (Marine mammals likely to regularly occur around the Hoo Peninsula. Information gathered from (IUCN 2013; JNCC 2010; Council of Europe, 2009; Eur-Lex 2008; Evans et al., 2011, Kowalik et al., 2007

within the ecosystem results in high biodiversity. The Thames estuary has relatively high productivity that supports internationally important habitat areas and species, and this productivity in turn supports internationally important bird assemblages and numbers. This is recognised by the designation of large parts of the estuary as Ramsar, SPA and/or SAC.

The Thames estuary is one of a group of estuaries from north Kent to Suffolk that provide extensive mosaics of intertidal and wetland habitats. Areas of mud and sand flats, saltmarsh, lagoons, grassland, wetlands, creeks, ditches and dykes support aquatic invertebrates and fish which in turn support bird populations. Eel grass beds are important feeding grounds for wildfowl.

Such clusters of estuaries are important to migrating birds seasonally and during severe weather and as they move between them. Each acts as a staging post for some species at different times of the year and also may be important in some years more than others. In this way, the group of estuaries that the Thames is within forms a fundamental part of the structure and function of the European network of sites that support the migratory waterfowl. Figure 4.7 shows the Thames estuary in the context of the group of estuaries within Essex and north Kent.

As described above, the intertidal and subtidal habitats found within the Thames and Medway estuaries support diverse and rich communities of benthic invertebrates. These in turn provide abundant foraging opportunities for fish. Hence, the area is important for a variety of fish, including migratory species such as European eel, lamprey and smelt. The estuary supports a commercial eel fishery which targets descending silver eels on their spawning migration to the Sargasso Sea. Smelt are also known to migrate from the outer estuary in the spring to spawn on gravels located around the Chiswick area[33]. The lower estuary also supports a Dover sole and herring fishery. Dover sole are known to spawn in the area adjacent to the Hoo Peninsula, the wider estuary providing key nursery habitat for the species. The Thames estuary is considered to be one the largest Dover sole nursery areas in the southern North Sea, and thus is a critical component of the wider commercial stock network[34].

As a consequence of the richness of the waters and sediments, the waters off the Isle of Grain and seaward (named Southend) are one of several in the outer Thames estuary designated under the Shellfish Waters Directive (79/923/EEC) which aims to protect the habitats of bivalve and gastropod molluscs. The lower Thames estuary supports a thriving cockle fishery which is targeted by commercial cockle dredges working out of Kent and Essex ports. There is also a protected native mussel and oyster fishery in the Swale estuary.

The ecosystem within the Hoo Peninsula therefore sits in a hierarchy of networks of local, estuary, regional and international scale importance providing conditions for habitats and species of national and international conservation concern.

4.4.5 Evolution of the Baseline

The Greater Thames Estuary is under pressure from development and anthropogenic disturbance as well as the longer term effects of climate change.

[33] Colclough, pers comm
[34] Colclough, pers comm

Climate change is leading to sea level rise, which results in increased coastal/shoreline erosion, changes to the geomorphology of the estuary and sediment composition, reduction in natural wave attenuation for example, expanses of saltmarsh which protect flood defences; increased and more unpredictable flood risk; and saline intrusion. Climate change may also lead to significant summer droughts.

All of these predicted changes will lead to the degradation, and/or loss of coastal habitat, as well as loss of species and changes in species composition including changes in the relative abundance of invertebrates in different sediment conditions leading to subsequent changes in bird assemblages specialising in different invertebrate prey assemblages.

The TE2100 plan provides a long term adaptive management approach, with the capacity to accommodate the predicted range of change if necessary. Mitigation for the predicted effects proposed include managed realignment and habitat creation of threatened habitats such as coastal grazing marsh, saltmarsh, and mudflats,

As the TE2100 plan has identified a number of potential sites for managed realignment and habitat creation, it is not anticipated that the predicted plan and climate change impacts on the estuary's habitats will lead to significant long term reductions habitat area or populations of species they support[35]. However, this is dependent on the continued availability (and eventual delivery) of habitat creation opportunities within the estuary. A number of these opportunities lie on the Hoo Peninsula, for example, St Mary's Marsh, and most are within the wider Thames estuary area. (See Figure 4-7)

Without the availability of habitat creation opportunities, it is less likely that the existing threats to the habitats of the Thames Estuary could be managed effectively to maintain all the internationally important interests at favourable conservation status.

4.5 Impacts from an Airport Hub Development

4.5.1 Impact / Effect Pathways

Impacts on ecological features as a result of a hub airport development and operation in the Inner Thames Estuary have been categorised broadly as:

- Habitat loss;
- Habitat fragmentation;
- Habitat degradation;
- Species loss / mortality;
- Introduction of non-native species;
- Visual disturbance (species only);
- Geomorphological changes (leading to habitat degradation / loss);

[35] Environment Agency (2009a). TE2100 Flood Risk Management Plan Statement of Case (Appendix 20) in respect of the effects on the Thames Estuary EC designated sites. 64pp.

- Noise / vibration disturbance;
- Air Pollution;
- Changes to the water environment including pollution; and
- Lighting.

The potential effects of the construction and operation on the species and habitat groupings within the internationally and nationally designated sites are summarised in Table 4.7. The proposed works would impact directly and indirectly upon marine, freshwater and terrestrial habitats and species. A summary of the main source / pathways to effects from the construction and operation of the airport are provided in Appendix A4

4.5.2 . Likely Significant Effects

A hub airport development in the Thames Estuary would result in direct and indirect impacts on the Natura 2000 sites. This section sets out the areas of international sites which could be affected and provides an estimate of the loss of habitat for each of the options. The pathways of impacts on habitats and species and the sensitivity of these receptors to these impacts are discussed.

The internationally designated sites that would be potentially impacted directly are:

- The Medway Estuary and Marshes SPA and Ramsar sites; and
- The Thames Estuary and Marshes SPA and Ramsar sites.

These sites could be the most severely affected by a proposed airport because they would experience a physical loss of habitat area, along with associated species. The location of Natura 2000 sites are shown in Figure 4-1.

The differences in the losses of internationally designated ecological sites between the options are shown in Table 4.8.

The minimum area of the Thames Estuary and Marshes SPA that could be lost is approximately 1140ha (24%); the maximum area that could be lost is approximately 2175ha (46%). Some options also directly impact the Medway Estuary and Marshes SPA.

The minimum area of the Thames Estuary and Marshes Ramsar site which could be lost is approximately 1490 ha (27%); the maximum area that could be lost is approximately 2175ha (39%). Some options also directly impact the Medway Estuary and Marshes Ramsar site.

It may be possible that an airport located more centrally and within the existing flood defences could reduce direct footprint losses to the SPAs and Ramsar sites although conversely this is likely to leave more habitat exposed to disturbance and to require birdstrike risk management and will have other potential effects.

The consequential impact of habitat loss in one area would be fragmentation of the wider habitat i.e. smaller separate areas of habitat would remain. Degradation could also occur within other areas as a result of this.

Table 4.7: Potential Effects of Proposals on Species / Habitat Receptor Groupings

Effects of proposals	Potential effects	Receptors
Habitat loss/ fragmentation/ degradation	Land reclamation would cause the loss of saltmarsh, mudflat and erosion of surrounding habitats and associated species. Terrestrial habitats and associated species would also be lost, including woodland and grazing marsh and associated breeding grounds. This could impact on habitats further afield where species (including birds) are displaced. Loss of continuity along the shoreline may impede migrations of marine species, and expansion of populations. Fish nursery areas may be destroyed. Haul out site removal would reduce the value of the Thames estuary habitat to grey and common seals. Foraging routes of terrestrial species could also be disrupted and could leave individuals vulnerable to predation or road traffic kill. Changes in habitatand vegetation type would decrease the suitability for certain bird species which require a certain height/type.	**Birds** **Invertebrates** **Mammals** **Plants** **Fish** **Freshwater habitats** **Terrestrial habitats (such as Woodland)** **Intertidal habitats**
Species loss/ mortality	Loss of species as a result of the development would have an impact on wider populations particularly if species were scarce or had specific habitat requirements. Predator species would also be affected, for example, wading birds if benthic invertebrate species were removed or changes in diversity occurred. This could cause associated changes within the overall food chain.	**Birds** **Invertebrates** **Mammals** **Plants**
Introduction of non-native species	Non-native species may be introduced/spread, for example, via vessels bringing reclamation or other building material to the site. These species could out-compete existing species.	**Invertebrates** **Plants**
Geomorphological changes	Changes in sedimentation would primarily impact on the intertidal and subtidal habitats such as saltmarsh, mudflats and sandflats. Erosion or accretion of sediments could occur and change the current distribution and status of these habitats. Release of contaminants from sediments could impact particularly on benthic invertebrates and possible bio-magnification up the food chain.	**Benthic invertebrates** **Intertidal habitats** **Subtidal habitats**
Noise/ vibration/ disturbance	General disturbance could impact on bird and mammal species (both terrestrial and marine), causing displacement of individuals further afield. Displacement of birds reduces their feeding time as they have a specific window between tidal inundations.	**Marine mammals** **Terrestrial Mammals** **Birds** **Fish**
Air pollution	Air pollution and dust settlement may impact on plant species in the vicinity, as well as any freshwater habitats possibly causing water pollution.	**Plants** **Freshwater habitats**
Changes to water environment	Any changes to the water environment could impact on marine species if occurring in the estuary or freshwater habitats if on land. Changes could relate to pollution and alteration in hydrodynamics, which could make habitat less suitable for fish and invertebrates.	**Fish** **Invertebrates**
Lighting/ shading	Artificial lighting could alter the diurnal activities of bird species and may attract other species including fish. Insects may be attracted to the light which could have an impact on bat species targeting them as prey Shading from buildings and walls and bridges may have a negative impact on plants growing adjacent to the development (such as saltmarsh).	**Fish** **Birds** **Mammals** **Plants** **Intertidal habitats**

Table 4.8: Percentage Area of International Designated Sites Directly Impacted by Footprint of Options

		Total area (ha)	Area lost in ha Percentage of site lost (%)				
			Foster + Partners	IAAG	IoG	Metrotidal Mid-Range Option	TFL
SPA	Thames Estuary & Marshes	4838.94	1694.ha 35.0%	1140ha 24%	1607ha 33%	1656ha 34%	2175ha 45%
	Medway Estuary & Marshes	4684.36	21ha 0.4%	0.0%	0.0%	0.0%	188ha 4%
Ramsar	Thames Estuary & Marshes	5588.59	1694ha 30%	1490ha 27%	1607ha 29%	1656ha 30%	2175ha 39%
	Medway Estuary & Marshes	4696.74	20ha 0.4%	0.0%	4ha 0.1%	0.0%	199ha 4%

(i) Impacts on Designated Bird Species

The loss or degradation of habitats within and outside the designated sites would have a significant effect on the birds for which many of the sites are designated.

Direct habitat loss would lead to the loss of foraging and roosting opportunities, reducing the carrying capacity of the estuary for the birds.

Habitat degradation would occur through changes in environmental conditions such as pollution as well as changes in sedimentation patterns. Degraded habitats would provide less valuable foraging habitat and could change the range of prey items for different bird species as different groups of species rely on different foraging strategies; for example, some species specialise in small intertidal invertebrates; some on intertidal bivalves; some on fish; and some are wetland generalists.

Disturbance through bird strike mitigation, human activity, noise and light would also make otherwise valuable habitats for supporting birds unavailable or at least highly degraded or devalued. This would also reduce the carrying capacity of the estuary.

Habitat fragmentation would occur through reducing the number of sites supporting foraging and roosting birds in the network within the estuary. This would lead to reduced ability to move between foraging and roosting sites and therefore increase the energetic requirements to survive the winter. At a wider scale, fragmentation of habitats would also disrupt migration routes and reduce the effectiveness of the estuary as a staging post for migrating birds.

Birds would also suffer increased mortality through airstrike and any lethal bird strike mitigation undertaken.

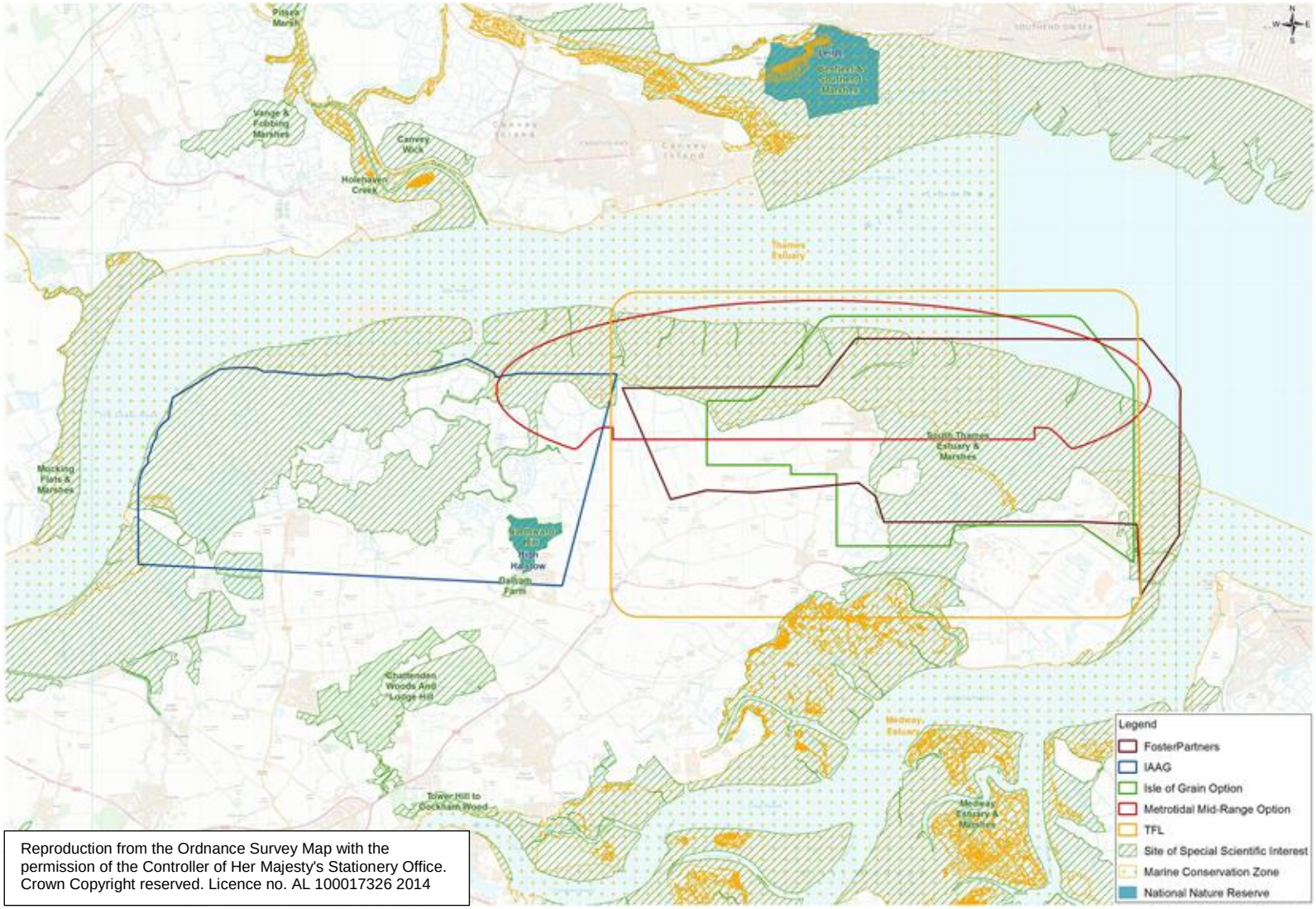


Figure 4-2: Nationally Designated Sites

(ii) Aquatic Habitats and Species

Aquatic habitats are not only sensitive to the direct impacts from the footprint of a development, but are also sensitive to impacts from changes to other parameters on a wider spatial extent, for example through changes to the geomorphology of the estuary (such as through erosion and accretion) and by changes to water quality. This is because the quality and function of aquatic habitats such as mudflats and saltmarsh are strongly influenced by daily tidal inundation and estuarine processes.

Within the Thames and Medway Estuaries marine mammals may be affected by habitat loss (loss of food resource); from changes to hydrodynamics (for example, haul out areas may be altered or navigational cues may be modified); from construction and operational noise and artificial lighting; and from changes to water quality.

Fish may be impacted through the direct loss of foraging and spawning areas, habitat degradation and reduced carrying capacity, and a reduction in water quality. Changes to or loss of spawning and nursery areas may have much wider impacts, especially where juveniles are known to feed into more distant stocks, for example Dover sole. Migratory fish species may also be impacted if there are changes to migration cues as a result of alterations to the tidal prism and hydrodynamics of the estuary. The overriding impacts on freshwater fish will be the direct impacts associated with habitat loss or modification, for example, channel diversion and culverting.

The Thames River Basin District Eel Management Plan aims to assess the compliance with the target set out in the Eel Recovery Plan (Council Regulation No 110/2007) concerning silver eel escapement and the recovery of European eel stocks. It is considered that the main issues affecting eel populations in the Thames are barriers to migration, river channelisation and habitat removal. The latter two are applicable to the Thames hub airport development, which would involve the removal of eel habitat comprising grazing marsh and associated drainage ditches, along with the likely culverting and channelisation of other watercourses.

Proposals where the development footprint extends into the estuary will result in the direct loss of benthic invertebrate species and indirect impacts associated with habitat degradation, changes to sedimentation patterns and reduction in water quality. For example, shellfish beds are particularly vulnerable to poor water quality episodes that can result where sediment plumes are created during works. Impacts to benthic invertebrate communities also have wider implications to the fish and bird populations that target them as food resources.

4.5.3 Sensitivity of Future Baseline

The impacts of construction and operation of a hub airport require consideration over the timescale of the development and within the context of climate change which will influence the distribution of habitats and species within the Thames Estuary). Many of these habitats are already under threat from sea level rise and additional pressures could mean that the magnitude of impact is wider than that of the extent of the development. Saltmarsh habitat is eroding along the north coast of the peninsula. It is likely that this trend will continue as flood management projects are carried out in response to sea level rise, resulting in changes to the morphology and hydrodynamics of the estuary.

Bird populations are sensitive to changes in availability of food (prey) resource and suitability of breeding grounds and it is possible that bird numbers may change over the timescale of the development from factors outside those attributable to the development.

4.6 Secondary and Cumulative effects

4.6.1 Indirect Changes to Estuary Ecological Processes from Airport Development

There is the potential for indirect impacts as a result of a hub airport development and operation in the Inner Thames Estuary.

Options which encroach on the estuary would have potentially large scale impacts on the hydrodynamics and morphology of the estuary. These impacts are discussed further in Section 5. Changes to tidal current velocities and wave patterns could alter patterns of erosion and deposition within the estuary with consequential impacts on intertidal habitats. It is likely that the maximum and minimum water levels within the estuary will change and this will put large areas of intertidal habitat at risk of loss as the viability of these habitats depends on the schedule of exposure and inundation.

HR Wallingford Ltd has modelled the predicted change in maximum spring tide water level and has provided an outline showing the increase throughout the estuary[36]. This prediction has been used to determine the Natura 2000 sites that would potentially be impacted as a result of changes to hydrodynamic and morphological regimes:

- Benfleet and Southend Marshes SPA and Ramsar site;
- The Swale SPA and Ramsar;
- Foulness SPA and Ramsar;
- Tankerton slopes and Swalecliffe SAC; and
- Essex Estuaries SAC.

The Crouch, Blackwater and Dengie SPA/Ramsar sites are also potentially affected as they lie within the 25km zone of influence (see Figure 4-3).

The impacts on the sites further from the source are uncertain at this stage and further modelling would be required to determine the implications for these sites.

The designated ecological areas also form part of the OSPAR Marine Protected area (MPA) network including the northern extent of the peninsula and therefore this area would also be impacted.

[36] HR Wallingford (2014). Inner Estuary Airport Call for Evidence. Technical submission by HR Wallingford to Airports Commission. Report No RT01.

Figure 4-3: Natura 2000 Sites within 25km

Habitats such as mudflats and saltmarsh outside the immediate vicinity of the development such as Annex I habitats in the Essex Estuaries SAC to the north may indirectly be affected by changes in the tidal prism, (through the nature and duration of tidal incursion on inter-tidal areas), altered water levels, bed scour, erosion and accretion processes. Similarly changes may take place in the Swale Estuary SPA habitats to the south. Upstream of the development, changes in sediment transport processes may have an impact on habitats and replenishment. Modelling would be needed to fully understand these indirect effects further.

Noise and air pollution could have significant indirect effects in relation to disturbance and pollution making areas of habitat unsuitable for use by qualifying species and / or changing the species distribution and abundance within the estuarine ecosystem.

Other indirect impacts observed in areas relatively distant from the development, could include changes in populations of migratory species in areas up or downstream either temporarily or permanently (for example, deterred during construction phase or from altered hydrological regimes during operation).

Section 41 habitats both within and outside the footprint of the scheme would be impacted, some of which lie outside the suite of designated sites (see

Figure 4-4).

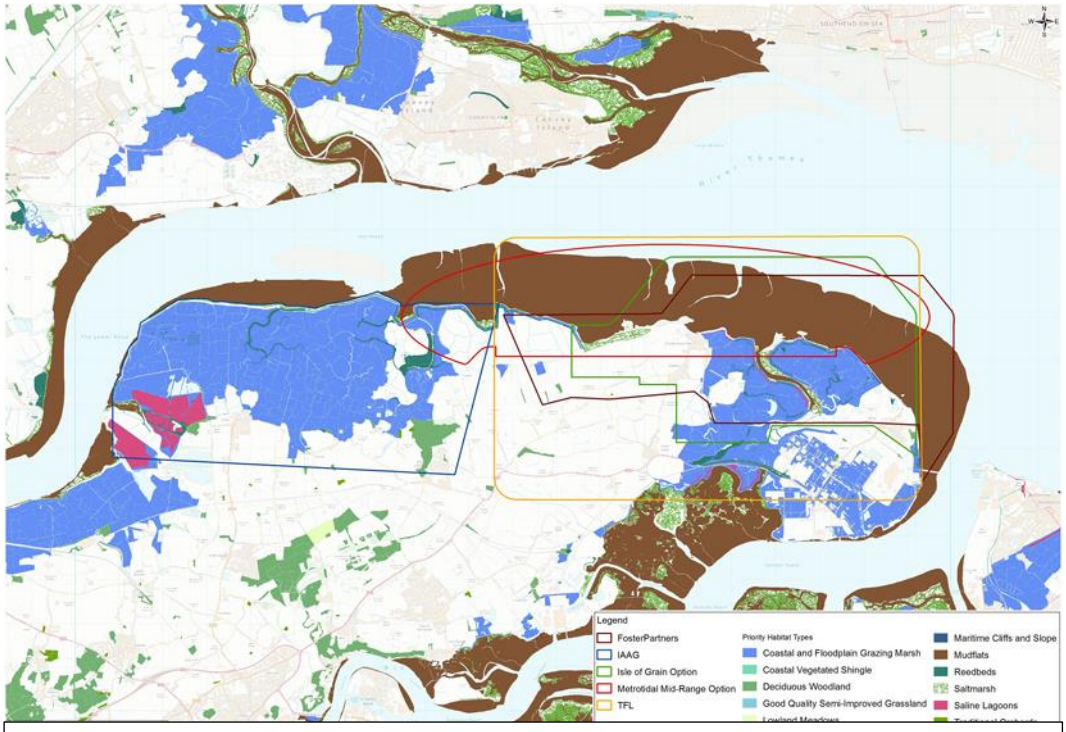


Figure 4-4: Section 41 Habitat Types

4.6.2 Cumulative Impacts from Airport-Related Development

Cumulative impacts from airport hub related development together with the airport itself could result in additional implications for ecological receptors. Connecting infrastructure and related building development outside the main airport footprint

and employment opportunities are likely to bring pressure for development and increased pressure on services and resources. Key areas are described below:

(i) Surface Access

The Thames Estuary and Marshes and Medway Estuary and Marshes SPA and Ramsar sites would be directly affected by land loss for the rail or road surface access routes outside the airport footprint area. These are described in the **Surface Access Impacts Study (Study 4)**. They are also likely to be affected by disturbance impacts from construction and operation where the new rail and road infrastructure lie close to the designated areas. The extent of loss and disturbance will depend on the option location. The additional losses will need to be included in the overall Compensatory Measures for the airport development.

(ii) Bird Strike Risk Management

A report on bird strike risk for an inner Estuary airport by the Centre for Wildlife Management is provided in the **Operational Feasibility and Attitudes to Moving to a New Airport (Study 2)**. This reviews the potential bird strike risk and scope for managing the risk. It concludes that there is a high bird strike risk but that the risk may not be insurmountable. Controlling the bird strike risk from sites off the airfield will require the management or removal of additional habitat or the imposition of additional off-airfield bird control, which will significantly increase the ecological impact of the development.

It recommends that habitat compensatory measures that might attract birds should be provided well outside the 13km safeguard zone; possibly beyond 20km from the airport.

All of the options, including any other possible location within and around the Hoo Peninsula, are likely to suffer from the same broad set of problems. Individual proposals have greater or lesser levels of risk and requirements for off-airfield bird control depending on the relationship between bird-attracting habitat and the airport footprint and active airspace. For example, an option aimed at limiting direct footprint losses to airport construction is likely to leave greater areas of habitat that would need to be managed to reduce bird strike risk.

Without more detailed information relating to bird movements as well as numbers on the ground, covering the full range of hazardous birds found in the area at different times of day, year and in different weather and tidal conditions, more detailed comparisons are not possible.

Active airspace that is subject to bird strike risk is identified in Figure 4-5, which shows an example flight path departure zone for easterly and westerly operations indicating approximate aircraft heights. Active control of birds is likely to be required to targeted areas within the 0-2000ft (610m) zones. Designated habitat or habitat that supports designated birds within these zones could be affected by disturbance and bird strike management so that the habitat is degraded in its function resulting in fragmentation of remaining habitat used by birds. This area has been considered as an area for potential loss to birds in this study in addition to the direct footprint losses (Table 4.11).

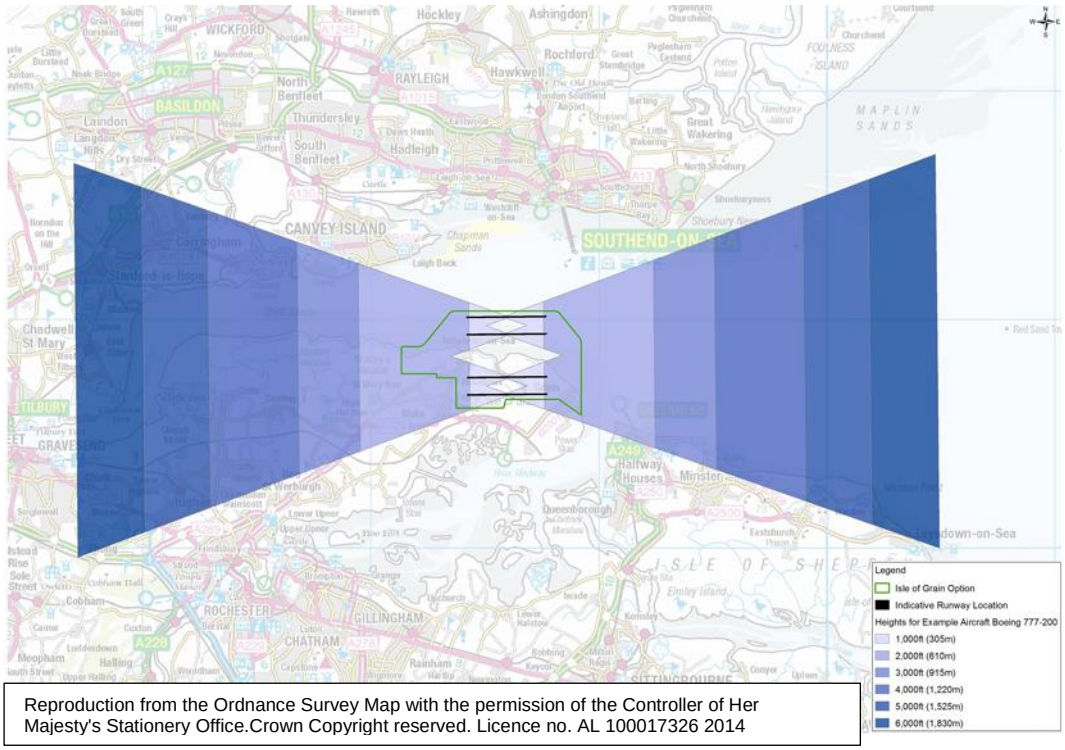


Figure 4-5: Flight Path Aircraft Height (example)

Figure 4-6: Birdstrike Safeguarding Zones

Figure 4-6 illustrates the 13k zone within which planned activities which might cause birdstrike hazard can be restricted.

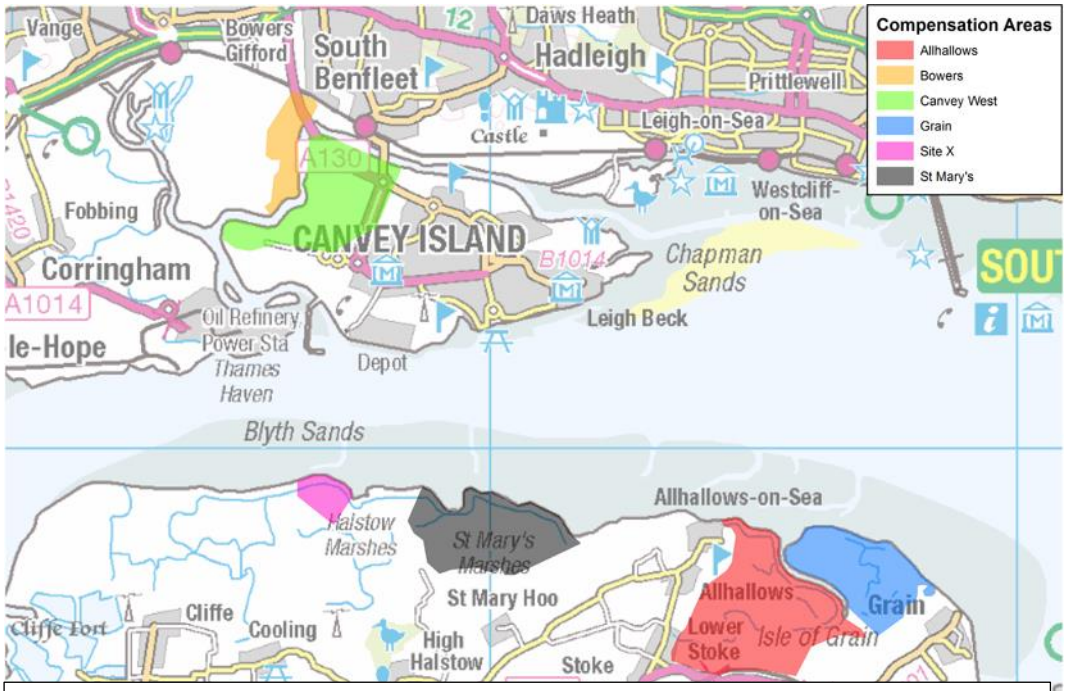


Figure 4-7: TE2100 and London Gateway Identified Compensation Areas

However, areas of habitat that would support birds within the 13km safeguard zones would also pose a bird strike risk as birds from these areas could fly into the active airspace whilst aircraft were within it. The airport may well need to control birds across a much wider area, but it is impossible to calculate this at this stage as this needs further study on bird movements to identify specific risk areas. Where these areas are on private land they would be subject to agreement with landowners and the implications for protected sites and species would need to be addressed.

4.6.3 Cumulative Impacts from Key Developments

Development within the Thames Estuary will continue throughout the construction and operation of a hub airport. Developments along the London Gateway coastal zone and inland which involve sea defences, habitat removal, dredging and land reclamation such as flood defence works, industry / port developments and offshore windfarm construction could add to the magnitude of impacts cumulative with the airport development. The assessment of potential impacts on the Natura 2000 sites has to consider in-combination effects with other schemes that are within the consenting process but have not yet been built referred to as committed development.

At this stage it is not possible to identify the schemes that may be relevant for the assessment because the HRA will be undertaken in the future when additional projects may have been brought forward that are not currently foreseeable.

However, the developments that are currently proposed give an indication of the type of project that could be in progress and relevant for an in-combination or cumulative impact assessment with a hub airport.

(ii) Recently-Consented Development

In their response to the call for evidence, Natural England highlighted a number of developments that have been consented recently. These are considered in Table 4.9 below.

Table 4.9 Consented Projects

Project	Details	Impact on feasibility of hub airport
London Gateway Port and associated developments of the Harbour Empowerment Order	The London Gateway port will provide 2,700 m of quay, six deep-water berths with depth alongside of 17m, 24 giant quay cranes and an annual capacity of 3.5 million shipping units. This has been constructed and is operational.	Operation of the port and effects on the estuary would combine with construction and operation of the airport. Competition for compensation areas as site X is potentially affected by the airport Hub footprint.
The Gateway Energy Centre (GEC), Underground Gas Pipeline and power transmission lines connecting GEC to the National Grid	A 900-megawatt (MW) gas-fired power station within the London Gateway Logistics Park, next to the London Gateway Port on the north bank of the River Thames.	Construction of the power station could have cumulative disturbance impacts although the location of the development on the opposite side of the estuary reduces the potential impact. Cumulative operational effects could arise from deposition of air emissions.
The London Gateway Access Road and the London Gateway Administration Building	Access and buildings for the port	The nature and scale of development makes it unlikely this would be considered in cumulative assessment.
The London Array offshore wind farm Phase 1	Offshore construction of the 177 wind turbines in Phase 1 was completed in 2012.	Potential implications from bird displacement. Monitoring studies are ongoing.
Warehousing at the former BP Oil Refinery, Isle of Grain	-	The scale and nature of the development makes it unlikely this would be considered in a cumulative assessment.
5 wind turbines at the BP site south of the former BP Oil Refinery	-	The scale and nature of development makes it unlikely this would be considered in a cumulative assessment for the airport.
A second power station at Damhead Creek	Consent was obtained in 2011 to construct and operate a Combined Cycle Gas Turbine generating station (CCGT) at Damhead Creek, Isle of Grain, Kent. An application is currently in progress for increasing the output to 1200MW.	Cumulative construction effects could arise if both projects were constructed at the same time. Cumulative operational effects could arise from deposition of emissions.

(iii) Forthcoming Projects

Examples of projects currently within the planning process include:-

Table 4.10 Planned Future Projects

Project	Details	Examples of Potential Incombination issues
Kentish Flats Offshore Wind Farm	Kentish flats offshore windfarm (north of Herne Bay) has been granted approval for an extension[37].	• Potential for additional disturbance to species and fragment the existing continuity of habitats if construction is concurrent. • Potential to displace bird species. • Cumulative effects on geomorphological processes.
Perry's Farm Hazardous Waste Management Facility	Construction of a waste management facility near the industrial land on the Isle of Grain[38].	• Potential for footprint conflict for options on Isle of Grain side. • Potential for conflict with birdstrike risk from activities.

Other schemes that could come forward in the future could include:-

- Kingsnorth Paramount's plans for a theme park at Swanscombe Peninsula,
- the North Thames Link Road from Canvey Island across Holehaven Creek;
- Proposals for a new power station at Tilbury, (although it was noted that these are currently on hold); and
- Lower Thames Crossing.

(iv) Long-Term Planning Initiatives

Thames Estuary 2100

In addition to the specific development proposals identified above the Thames Estuary 2100 (TE2100) project was established in 2002 by the Environment Agency with the aim of developing a strategic flood risk management plan for London and the Thames Estuary. Three implementation periods are identified for the plan, the first epoch 2006- 2026, the second epoch 2026 – 2056 and the third epoch 2056 - 2106.

[37] Vattenfall, (2014). Kentish Flats Extension Available at http://www.vattenfall.co.uk/en/kentish-flats-extension.htm. Accessed 04/06/2014.

[38] Peel Environmental Ltd (2013). Perry's Farm, Isle of Grain Proposed Hazardous Waste Management Facility Application for Development Consent Order The Planning Act 2008 as amended. Request for Scoping Opinion. SLR Ref : 402-02536-00005. 28 pp

The Hoo Peninsula is split into two action zones, the North Kent Marshes and the Isle of Grain. Table 4.11 provides the key details for each of the action zones.

Table 4.11: TE2100 Flood Risk Management Plans

Name	Associated Policy	Policy Context	Vision
North Kent Marshes	Policy 3 - to continue with the existing or alternative actions to manage flood risk	Shrone Marshes and Cliffe Pools are designated and include the restoration of the marshes.	Conserve and enhance this important marine and freshwater environment
		Shrone Marshes have been identified as potential areas for flood risk management or replacement intertidal habitat – ideally this land should be safeguarded for future management options	Create replacement intertidal habitat as sea level rises
			Enhance freshwater grazing marsh habitats as potential compensation for loss of designated habitat
Isle of Grain	Policy 4 to take further action to keep up with climate and land use change so that flood risk does not increase	Intertidal areas to the north and south west are designated. No new development should therefore be permitted in these areas	Western and northern part of the policy unit would be suitable for the creation of replacement intertidal habitat.
		The marshes themselves do not justify the current level of tidal protection along the Thames and Yanlet Creek, so must be examined	Vision for the area is intertidal habitat with surrounding community parkland areas including public access and facilities.
			Eastern area to continue to be developed for industry and commerce.

The aim of TE 2100 is, where appropriate, to maintain, enhance, improve or replace river and estuary defences along the Hoo Peninsula. The policy to create intertidal habitat along this stretch of coastline could potentially be impacted as a result of hub airport construction, with two conflicting regimes in place.

The TE2100 flood risk management plan has identified that it has the potential to have an adverse effect on the integrity of the Thames Estuary Natura 2000 complex, either alone or cumulative with the likely impacts of other plans or projects. Consequently the Environment Agency is seeking compensatory intertidal habitat within the Thames Estuary and Medway Estuary for approximately 900ha.

4.6.4 Compensatory Habitat Allocation Conflicts

Cumulative effects could involve conflicts with existing or planned compensatory habitats for other projects. The compensation site for the London Gateway Port has already been identified as site X (shown on Figure 4-7) and is discussed in more detail in Section 4.7.2 below.

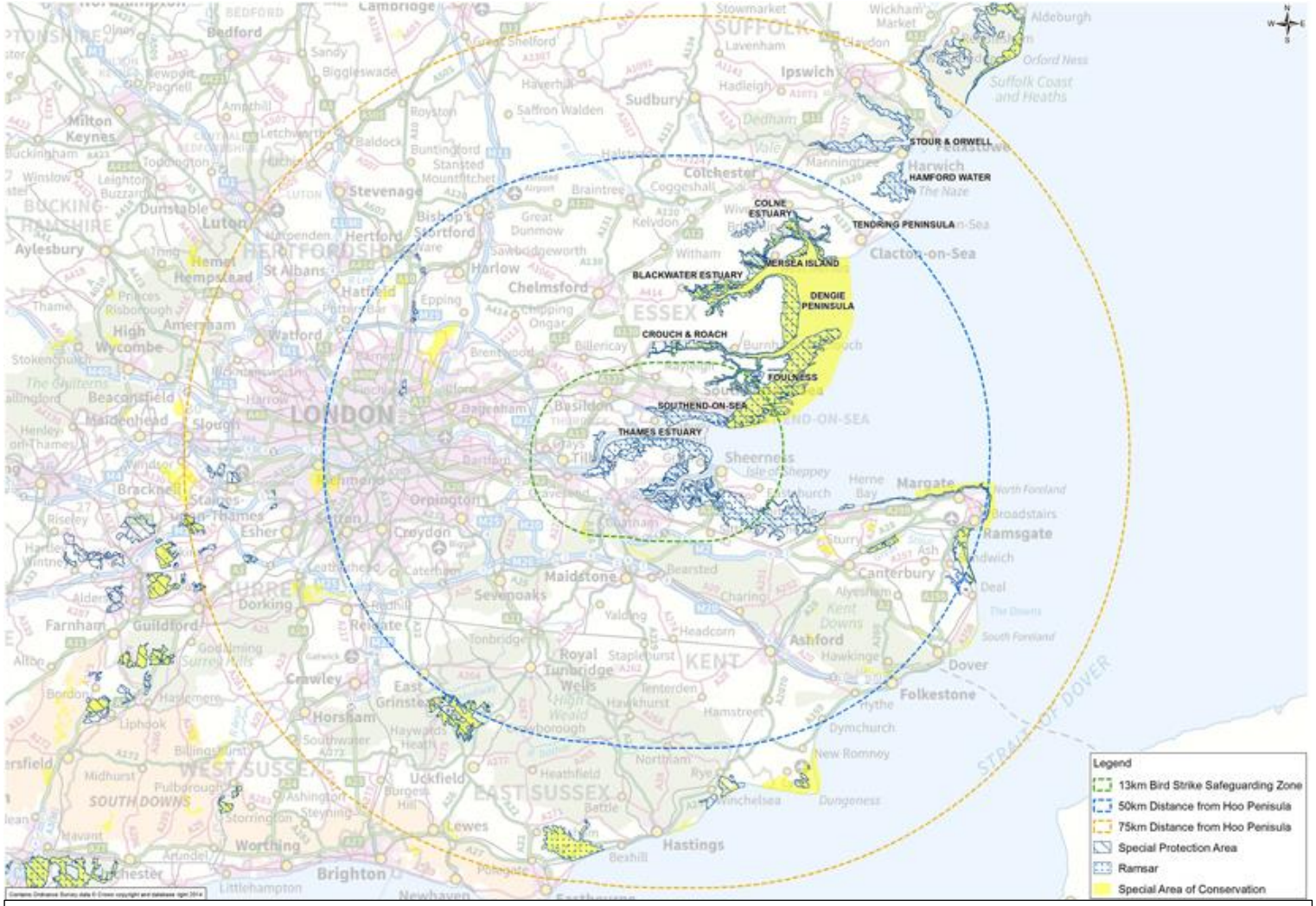


Figure 4-8: Estuaries in Essex and Suffolk and Natura 2000 Sites

The main cumulative impact of the TE2100 plan with the airport development would be as a result of the plan's potential compensatory sites. The TE2100 plan will result in the loss of hundreds of ha of intertidal habitat throughout the Thames Estuary as a consequence of holding the line of existing defences in some locations. Intertidal habitat will be lost as a result of coastal squeeze and therefore compensation is required to replace this lost habitat. Overall around 1600 ha of habitat compensation are sought including around 900ha of intertidal habitat within the lifetime of the plan and also 780ha of grazing marsh. These areas are identified in the TE2100 Statement of Case for the Habitat Regulations Assessment[39] approved by Defra.

The areas identified in the SoC for compensation include several sites on the Hoo Peninsula at St Mary's Marshes (236 ha net gain), Grain Marsh (264 ha net gain) and Allhallows Marsh (398 ha net gain)[40].

The hub airport options on the east of the peninsula therefore would conflict with these options and even options that do not have a direct conflict with the airport may conflict indirectly as these newly realigned areas would be created with the aim of attracting birds.

There is also a wider conflict between TE2100 and the airport development with regards to the number and size of areas which are suitable for creation of intertidal habitat. The majority of sites identified in the TE2100 plan are only identified at a very high level and the land is not necessarily owned by the Environment Agency or their partners. The EA are currently seeking alternative sites to St Mary's Marsh as landowners are not willing to sell the land.

Compensation for both the TE2100 plan and an Estuary airport will require large areas for managed realignment and these requirements could conflict if there is limited land available. There would also be a conflict with bird strike management for the airport. This could limit the potential for creating compensatory habitat within at least 13km of the airport potentially displacing compensation habitat away from the estuary.

Policies arising from the relevant SMPs[41,42] include 'hold the line' options which will allow the process of coastal squeeze to continue and over time will result in losses of intertidal habitat. To compensate for these losses the Environment Agency has set up Regional Habitat Creation Programmes which have a remit to locate and progress options for potential managed realignment sites. These sites will be used replace intertidal habitat such as mudflats and saltmarsh habitat that is being lost through coastal squeeze.

Within East Anglia, the Regional Habitat Creation Programme already has a number of realignment projects underway including Wallasea, Devereux Farms and Hill House Farm. These projects ensure the targets for habitat creation are met within the region and account for both historic losses and losses resulting from implementation of SMP policies. A total of around 1200ha have been identified to

[39] TE2100 Statement of Case for the Habitat Regulations Assessment
[40] Environment Agency (2009a). TE2100 Flood Risk Management Plan Statement of Case (Appendix 20) in respect of the effects on the Thames Estuary EC designated sites. 64pp.
[41] Halcrow (2010a). Isle of Grain to South Foreland Shoreline Management Plan Review. 148 pp.
[42] Essex and South Suffolk Shoreline Management Plan 2 Final Version 2.4 2010

compensate for around 935ha of first epoch losses to 2025. A further 512 ha of losses are expected from 2026 to 2055 which will also require compensation.

The Southern Regional Habitat Creation Programme is at an earlier stage of development; some potential areas for managed realignment have been set out at a high level, but there is still uncertainty about the viability of these areas. It is important to note that there are some extensive areas on the Hoo Peninsula which are favoured for managed realignment, for example at Allhallows-on-Sea which was identified in the SMP for managed realignment in the medium term. The realignment areas identified on the peninsula would conflict with the footprint of some hub airport options but any managed realignment in the area could be considered as being in conflict with an airport development where its aim would be to attract birds which might be a bird strike risk.

4.6.5 Summary of Habitat and Functionality Loss

Potential adverse effects on Natura 2000 sites include:

- Direct habitat loss from airport and related development and transport infrastructure footprints;
- Direct loss of identified for compensation habitat creation for TE2100 and other plans or schemes;
- Displacement of identified compensation areas, for the airport and plans and schemes, outside 13Km from the airport (and possibly to beyond 20km);
- Additional loss of habitat supporting designated bird species due to active bird strike risk management;
- Disturbance to designated species, disturbed habitats degraded for the species; and
- Indirect habitat loss or degradation due to changes in the geomorphology of the estuary including changes from water level, erosion and accretion patterns and sedimentation changes.

For SPA and Ramsar sites, habitats are not designated for their intrinsic value (as is the case for SACs) but for their function in supporting the SPA and Ramsar qualifying features – that is the bird, plant and invertebrate species.. In terms of offsetting such adverse effects, the package of measures would need to focus on offsetting habitat loss for its function of supporting the designated birds.

A number of designated bird species will also be affected by loss of habitat that they rely on outside the footprint of the scheme. Disturbance caused to birds from, for example, noise, human presence and lighting would degrade the functionality of habitats as they would make them unavailable and effectively lost to the species. Bird strike mitigation would also prevent birds from using habitat in the areas subject to such measures.

The zone assumed to be actively managed for bird strike mitigation is taken as a minimum footprint under the main approach flight paths under 2000ft (610m). Additional losses / degradation of habitats used by birds are estimated from the 1km zone of influence of disturbance from the footprints. There is however considerable uncertainty over the extent of disturbance or management within this area. The SPA areas potentially affected through bird strike mitigation or disturbance outside the

airport footprints has been calculated approximately to range from 570 ha for the Isle of Grain option to around 1100ha for the IAAG option (the latter is high as much of of the intertidal habitat is outside the airport footprint).

Table 4.12: Indicative Estimates of Habitat Loss from Different Elements of an Airport Hub

	Foster + Partners	IAAG	IoG	Metrotidal Mid-Range Option	TFL	Certainty
a) Direct loss of habitats within SPA designated sites from footprint	1710ha	1140ha	1607ha	1650ha	2360ha	**High**
b) Additional loss of functional habitat for birds through disturbance - SPA within 1km area outside footprint and outside approach departure route	240ha	210ha	200ha	20ha	370ha	**Moderate** – area likely to be subject to targeted bird strike control and to disturbance
c) Additional functional habitat loss (as SPAs within 1,000 ft (305m) approach / departure routes(*)(***)	30ha	90ha	0ha	40ha	0ha	**High** – most likely area to be subject to additional control for bird strike
d) Additional functional habitat loss (as SPAs within 2,000 ft (610m) approach / departure routes*	580ha	1100ha	780ha	940ha	570ha	**Moderate** – most likely area to be subject to additional targeted control for bird strike
e) TE2100 Identified SPA Compensatory Habitat displaced from Inner Thames Estuary	900ha	900ha	900ha	900ha	900ha	**High** this area needs to be relocated
f) Indirect habitat loss from water level change **	100ha	0 If within flood defence	100ha	100ha	100ha	**High**
g) Additional change (maximum indirect change with potential to cause loss) from morphology / hydrology changes within the estuary**	2500ha	0 If within flood defence	2500ha	2500ha	2500ha	**High** certainty for change but M**oderate** over extent of loss of habitat
Range of loss of habitat or functionality & displacement of compensation areas: **Low estimate** - a+c+e+f (certainty -High only) **High estimate** – a +b +d +e +f+g (certainty - Moderate and High)	2740ha 6030ha	2130ha 3350ha	2607ha 6087ha	2690ha 6110ha	3360ha 6800ha	

*Flight paths based noise modelling for on 4 runways as configured for Isle of Grain for an example aircraft.
** based on - HR Wallingford evidence report (May 2014) based on modelling the IoG example.
*** Aircraft would be over 1000ft within the land included in the footprint of the proposed scheme.

Table 4.12 summarises the losses of habitat and ecological functionality from the proposals. The minimum loss of habitat or functionality from the proposals has been calculated as around 2,130ha. The high estimate for loss of habitat and ecological functionality has been calculated as 6,800ha.

There are a number of uncertainties over these estimates:

- Functional habitat loss through bird strike mitigation or disturbance is based on the areas of highest risk within the approach and departure zones and

SPA designations within 1km. Detailed study would be required to determine how bird strike management would need to be targeted more accurately and how remaining fragmented habitat would function to support bird interest in close proximity to the airport.

- Effects due to estuary morphological change have the potential to result in habitat gains or losses. For these calculations either no loss or net change for the minimum estimate or area of change resulting only in habitat loss for the high estimate. The extent of change will vary depending on extent of intrusion into the estuary and the shape of the development area.

- Surface transport losses, and cumulative effects from other development, along with a better understanding of functional habitat and species requirements may increase compensatory area requirements.

The high level estimates of direct habitat loss from different elements of an airport hub are appropriately calculated in the submissions by TfL, Foster +Partners and Metrotidal / Thames Reach. The areas of direct loss correspond approximately with the measurements for this study. Figures differ slightly depending on whether it is the habitats or the designations that are measured. Also the footprint templates used for this study are approximations from the material submitted.

Foster + Partners note that the ratio for compensation habitat creation to loss is expected to be greater than 1:1 and up to 4:1. They estimate a direct loss of 1,800ha of Natura 2000 sites and apply these ratios to get a range of 2,000ha to 7,000ha as areas required for compensation.[43]

TfL identify a direct loss of 2,100ha of intertidal and subtidal habitats (including transitional grassland and brackish standing water). They also allow 70 ha for indirect losses from hydrodynamic (water level) changes based on the hydrodynamic modelling undertaken[44]. They assume that the likely replacement ratios for compensation will be between 2:1 and 3:1 amounting to an area of between 4,000ha and 6,500 ha.

The approaches submitted for the TfL and Foster + Partners options compare worst and best case scenario ratios for direct replacements and use ratios that are broadly appropriate compared to a number of case study examples. It should be noted, however, that the scale of compensation required in the case studies is generally much smaller and replacement sites are usually located close to the original loss. There is potential for higher ratios to be required to address the higher levels of uncertainty and risk.

The main difference with the submitted proposal information, is that indirect loss is not fullyincorporated into the calculated areas for option submissions. Although the TfL option includes indirect loss from water level changes of 70ha, their proposal does not include potential impacts from morphological changes (see Section 5 on modelling and estuary impacts).

It could be argued that TfL's and Foster+Patrtners' worst case scenario for the gain to loss replacement ratio could potentially include the habitat necessary to

[43] Fosters + Partners Thames Hub Airport July 2013
[44] New Hub Airport: Isle of Grain - Mayor of London Submission July 2013

compensate for the indirect effects. However, as a precautionary approach the figures presented in the option submissions probably underestimate the indirect habitat loss and therefore the compensation required.

4.7 Mitigation and Compensation

In relation to the loss of habitats within European sites, Regulation 61 of the Habitats Regulations requires Appropriate Assessment of plans or projects before authorising them. Proposals can be authorised if the assessment demonstrates that proposed mitigation would offset any Likely Significant Effects identified so that site integrity would not be adversely affected.

Regulation 66 of the Habitats Regulations states that the Competent Authority must secure any necessary compensatory measures are taken to ensure that the overall coherence of Natura 2000 is protected, if they are to authorise a plan or project on the basis of IROPI. The Compensatory Measures constitute measures specific to a project or plan, additional to the normal practices of implementation of the "Nature" Directives. They aim to offset the negative impact of a project and to provide compensation corresponding precisely to the negative effects on the species or habitat concerned.

Offsetting adverse effects could only be achieved through mitigation if the measures enabled the integrity of the European Site affected to be maintained. This would require the measures to be either within or adjacent to the Site affected. If the integrity of a European Site were to be adversely affected, then offsetting would need to be achieved through Compensatory Measures.

4.7.1 Offsetting Through Mitigation

The minimum direct footprint loss to the Thames Estuary and Marshes SPA / Ramsar is estimated to be 1140/1490Ha (24%/27%) of the site without taking account of other likely losses.

The geomorphology of the estuary, flood risk management constraints and bird strike mitigation requirements would make it impossible to create even a minimum area of this scale of new habitats in the immediate vicinity of the site. It is unlikely therefore that the adverse effects could be mitigated on or near the site itself.

It is highly unlikely therefore that the scale of offsetting measures required could be delivered through mitigation therefore. Compensatory Measures would be required.

4.7.2 Likely Compensatory Measures required

At a minimum, Compensatory Measures will be required to provide a like-for-like replacement of the functionality of habitats in supporting designated species lost. This has been assumed to equate to a 1:1 ratio of gain to loss of habitats.

However, a number of issues relating to the adequacy of measures in maintaining the coherence of the Natura 2000 Network need to be addressed before a 1:1 ratio would be considered to be acceptable including:

- Uncertainty as to the scale of the adverse effects caused;
- Uncertainty as to the success of proposed Compensatory Measures;

- Timing of the delivery of measures in relation to the timing of loss of functionality;
- Complexity of the proposals and the ecosystems involved;
- Proximity of the measures in relation to the current use of the designated species on the European Site affected; and
- Ability of the designated species affected to adapt and/or colonise the new habitat provision.

Although it is acknowledged that each development is assessed on its own merits, it is useful to consider how Compensation Measures have been addressed in previous projects. Because of the uncertainties relating to the issues above, the ratio of compensation habitat to loss of designated habitat which has been regarded as acceptable by Competent Authorities has varied from project to project. From the case studies examined in relation to coastal habitats, the ratios typically vary from 1:1 to around 4:1, gain : loss. There are examples of much higher ratios in other cases relating to other habitat types, for example, a ratio of 14.5:1 was used in the French TGV high speed rail link, but this was not coastal and affected habitats that were later successional habitats and so would take longer to establish full functionality. Coastal habitats are generally early successional habitats and so there can be less uncertainty in relation to the complexity of the ecosystems involved and the timing of delivery of full functionality (however, see section below on Likely Success of Compensatory Measures).

The ratios of gain to loss of habitats in examined case studies (see Appendix A1), and the rationale if greater than 1:1, is summarised in Table 4.13.

Table 4.13: Gain to Loss Ratios in Case Studies

Case	Ratio	Rationale
Harwich approach channel deepening	4:1	To compensate for accelerated intertidal erosion over the five years taken to provide the compensation
Able Marine Park	3.2:1	Replacement ratio for loss is 2:1 but additional wetland habitat was required to provide habitat for birds during the time delay until the managed realignment area becomes functional for birds
Bremerhaven Port	3:1	
Immingham Outer Harbour Port, Humber Estuary	2:1	To compensate for direct loss of mudflat and saltmarsh
Bristol Deep Sea Container Terminal	1.7:1	Compensation for impacts on habitats both inside and outside boundaries of internationally designated sites
Bathside Bay	1.6:1	Compensation habitat expected to provide value in 1-2 years
London Gateway	1.2:1	
Green Port, Hull	1:1 - 2:1	For majority ratio is 1:1 as compensation site is already functional, for additional area not yet established ratio required is 2:1

The scale of the Compensatory Measures created for the recent consented projects ranged from 4ha to 120ha, which should be seen in the context of the minimum requirement of 2,130ha habitat creation for the airport proposals (see Table 4.12). The increase in scale (and subsequent increase in complexity and uncertainty) could result in even higher ratios being required than for past projects. However, this

can only be ascertained in consultation with stakeholders and so the range of past cases has been used for the minimum likely measures required in this report (Table 4.14).

Table 4.14: Case Study Habitat Losses

Case studies: Plans and Projects	Designated Habitat lost (ha)	Compensation required (ha)	Consented?
TE2100 Plan	876	876 ha intertidal	SoC approved by Defra
Cardiff Barrage	-	436	Yes
Harwich approach	4	16.5	Yes
Able Marine Park	56.6	181	Yes
Bremerhaven Port	105	348	Yes
Immingham Outer Harbour Port	22.4	50	Yes
Bristol Container Terminal	114	189.5	Yes
Bathside Bay	69	110	Yes
London Gateway	69	80	Yes
Green Port Hull	7.5	10.2	Yes
Severn Tidal Power	1600-16300	-	No

Development of an acceptable specification for a Compensatory Measures package would be a complex matter and would require a great deal of additional study and consultation. It is therefore not possible to define the specification at this stage and so this study, as an indicative measure only, uses estimates of the total habitat creation requirement as well as splitting the requirement by habitat. This gives the range of what may be required as a minimum.

It should also be noted that at least one of the indicative proposals would directly affect Compensatory Measures already carried out for the London Gateway project at a location known as ‘site X’. Additionally, the safeguarding zone of 13km is likely to reduce the potential for Compensatory Measures to be delivered for other plans and projects such as TE2100 in this part of the estuary, which may affect the coherence of the network of sites in the wider estuary and cluster of estuaries between Essex and Kent, which may require further Compensatory Measures. As such complex and detailed considerations are beyond the scope of this study; this has not been taken into account in the estimated requirement for habitat creation given in this report.

The range of habitat type losses across the different options indicated in Table 4.15. As a minimum therefore (notwithstanding the need to also offset losses due to indirect effects such as geomorphological changes) the Compensatory Measures of coastal habitats required in total (a mosaic of all the habitats in some proportion) would range between 1,569 ha and 2,564.8 ha.

Table 4.15: Range of Individual Habitat Types required for Compensatory Habitat

Habitat Type	Range of Compensatory Habitat required (ha)

Coastal and floodplain grazing marsh	145.8 to 1,515.2
Deciduous woodland	0 to 73.2
Good quality semi-improved grassland	0 to 3.2
Maritime cliff and slope	0 to 2.3
Saltmarsh	14 to 114
Mudflats	50.9 to 1,569.8
Reedbeds	30.2 to 87.3
Saline lagoon	1.7 to 139.1
Traditional orchards	0 to 1.9

The provision of different compensation habitat types is an added complexity for delivery. Some habitats such as deciduous woodland require tens of years to mature. Functional species within ecosystems can also have a profound influence on their structure and wider biological community structure they support. The habitat can also vary with fluctuations in abiotic factors within the environment. The compensation habitat structure will also be closely linked with resource gradients, which in dynamic estuarine systems are unpredictable. Therefore, having the land area available for each habitat type is only part of the answer to delivering effective compensation habitat. It maybe that the required area of mudflat can be created but the invertebrate assemblage that establishes may vary from that of the mudflat habitat that is lost. Therefore, the bird species that would be supported by the mudflat compensation habitat would be different from that of the mudflat lost. It follows that this would not be functional compensation habitat of the Natura 2000 network.

The Compensation Measures to protect the overall coherence of the network of European sites would therefore be very difficult to establish and their success monitored.

This habitat creation requirement can be put in the context of the habitat creation requirements for TE2100, which is designed to compensate for the predicted effects of climate change and the subsequent flood risk management proposals to protect London, TE2100 requires around 900ha of intertidal and also proposes around 780ha of grazing marsh habitats to be created. The Compensatory Measures required for the airport proposals are likely to increase the need to compensate for losses in the Thames Estuary by between approximately 3 to 6 times.

Using the minimum and maximum loss of habitat or functionality from the proposals (2,130ha to 6,800ha), and range of gain to loss ratio of 1:1 to 3:1, the potential range of required area of compensatory habitat creation has been calculated as 2,310ha to 20,400ha (Table 4.16).

The call for evidence submissions for the Inner Thames Estuary airport options generally agree on range for direct habitat loss and the range of habitat creation but have not included indirect effects on the habitat such as compensation area displacement, disturbance effects, bird strike management and indirect geomorphology related losses although TfL and Foster + Partners submissions recognise the potential for these effects.

Table 4.16: Compensation Ratios and Area Summary

Compensation area ratio	Low – High
Total 1.1 ratio range	2,130 – 6,800 ha
Total 2:1	4,260 – 13,600 ha
Total 3:1	6,390 – 20,400 ha

4.7.3 Requirements for Compensatory Measures of Individual Habitats

The habitat creation requirements for like-for-like replacement of individual habitats may not be either desirable or deliverable. Deliverability is considered within the next section on likely success of Compensatory Measures.

The desirability of like-for-like replacement of individual habitats would be dependent on a complex assessment of the relative importance or contribution of functions of the different habitats in supporting the designated species and whether a package of measures with different proportions of those habitats could provide a better functionality for supporting the species. A complicating factor in creating habitat for estuarine bird species is the inter-species competition avoidance strategies which have evolved as resource partitioning tactics for invertebrate food resources. This means that individual bird species have specific prey items they exploit as a food resource. Without the specific invertebrate community establishing in the compensatory habitat, the habitat would not support the desired bird assemblage.

Appendix A5 presents bird distribution maps taken from BTO WeBS Reports[45] for just two of the species potentially affected: dark bellied Brent geese and black tailed godwit. These maps demonstrate the complexity of the distribution and use of the estuarine ecosystem and the differences in use between species. The potential difficulties in identifying impacts for these species with their different distributions are also highlighted by these maps. The black tailed godwit is particularly sensitive to disturbance and so could be affected over a wider area of the estuary than the Brent geese. However, because of the flight collision risk caused by Brent geese any collision risk management would have different impacts on this species. This provides a further added challenge of factoring the distribution of all the species using the estuary as well as their abundance affected by an Estuary airport development. However, the distribution of each species is crucial to understanding the functional compensation habitat required to maintain the integrity of the Natura 2000 network.

The habitats affected form part of a complex ecosystem within which there is much interaction between the habitats and movement of the species they support – especially in the case of the bird features. Table 4.17 shows a summary of the key functions of coastal habitats in supporting the SPA / Ramsar species features.

Table 4.17: Functions of Coastal Habitats in Supporting SPA / Ramsar Species Features

[45] BTO WeBS Reports (http://blx1.bto.org/webs-reporting/?tab=lowtide)

	Mud flats	Saltmarsh	Grazing marsh	Coastal lagoon
Supporting habitat of plants		X	X	
Supporting habitat of invertebrates	X	X	X	X
Foraging habitat of birds	X	X	X	X
Roosting habitat for birds		X	X	

This is further complicated by the fact that the scale and proportions of habitats lost would be different within each indicative proposal. Before further study into the relative contribution of different habitats to the functionality of supporting the species is undertaken, it is not possible to identify which option is the least damaging and therefore requires compensating. It may also be the case that damaging more of the most important habitat may be the best option in the long term if that habitat is more easily created elsewhere. The specification for Compensatory Measures would therefore require an iterative consideration of the existing provision; study into the relative importance of each habitat in supporting species; and assessment of the likely success of delivering any target habitat creation.

Development of an acceptable specification for a Compensatory Measures package would be a complex matter and would require a great deal of additional study and consultation. It is therefore not possible to define the specification at this stage and so this study, as an indicative measure only, uses estimates of the total habitat creation requirement as well as splitting the requirement by habitat. This gives the range of what may be required as a minimum.

(i) Likely Success of Compensatory Measures

Assessing the likelihood of successful implementation of coastal habitat creation would depend on evidence of previous creation projects' success in delivering the functionality required to support the designated species and / or experimentation to demonstrate the approach would succeed. The timescale for those habitats and functions to develop would also be a key consideration.

Models can predict the development of mud flats or saltmarsh based on topography and so it should be possible to design a package of measures that can predict the relative development of these intertidal habitats. However, in the managed realignment project at Paull Holme Strays, unexpected high accretion rates within the site led to saltmarsh development on the new mudflat areas, so modelling is not a completely reliable predictive tool[46].

Predicting the area of grazing marsh and saline lagoons is likely to be much more accurate as they will be delineated by flood defences and banks.

[46] Environment Agency (2009) Paull Holme Strays Environmental Monitoring Report. Part of the Humber Estuary Flood Defence Strategy. March 2009

From the case studies examined, it appears that compensatory habitats can be classified into the broad categories of mud / sand flats, saltmarsh, grazing marsh and coastal lagoons. Early-colonising communities of plants and invertebrates appear to develop quickly and bird species that rely on these colonising species find and exploit the new resources relatively quickly. However, the development of high saltmarsh or a complex invertebrate fauna within new grazing marsh may take many years to develop and may never develop fully. This may have a knock on effect on bird species that rely on more mature communities. Different bird species are adapted to feed on different plants and animals and whilst a newly created habitat may provide foraging for a wide range of designated feature species, there may be one or two specialist species that require the presence of prey items that are only present in mature communities.

Recent work on saltmarsh development within managed realignment sites has demonstrated that the vegetation shows persistent differences to that of natural saltmarshes[47]. After five years the plant communities remained different from mature marshes with persistence of pioneer species, which may be attributed to the low sediment redox potentials at newly restored sites[48] .There are a number of examples where restored sites have not achieved the required function in terms of supporting bird species. A study assessing the success of a newly restored saltmarsh site for the Clapper Rail found that on the restored marshes the Spartina was insufficiently high and dense to allow birds to weave their nests in the canopy, as result of the lower nutrient levels within the material used to create the new habitat[49].

Other studies have shown that although the waterbird assemblage changed during the first year or two after creation, changes over the years became smaller compared to the original assemblage and slowly evolved towards an established assemblage[50]. At Orplands managed realignment site, the wildfowl species assemblage was found to be similar to that in the surrounding mud flats after only two years, although there was less inter-annual variation indicating that a component of the 'natural' assemblage was absent. At Seal Sands realignment site after seven years the waterfowl assemblage was found to be different to the surrounding estuary. It is however important to note that there can be natural variation in site usage by waterfowl and that there is a lack of post-realignment monitoring data and there are still many uncertainties regarding the success of managed realignment as a compensation measure.

It appears therefore that creation of a range of the coastal habitats required is technically possible, but the relative proportions of each habitat may be difficult to predict accurately. The development of some vegetation types and invertebrate

47 Mossman, H. L., Brown, M. J. H., Davy, A. J. and Grant, A. (2012a), Constraints on Salt Marsh Development Following Managed Coastal Realignment: Dispersal Limitation or Environmental Tolerance?. Restoration Ecology, 20: 65–75.

48 Mossman, H. L., Davy, A. J., Grant, A. (2012b), Does managed coastal realignment create saltmarshes with 'equivalent biological characteristics' to natural reference sites? Journal of Applied Ecology, 49: 1446–1456.

49 Zedler, J.B. (1993). Canopy Architecture of Natural and Planted Cordgrass Marshes - Selecting Habitat Evaluation Criteria. *Ecological Applications*, **3**(1), pp. 123-138.

50 Atkinson, P.W., Crooks, S., Grant, A. & Rehfisch, M.M. (2001). *The success of creation and restoration schemes in producing intertidal habitat suitable for waterbirds.* English Nature Research Reports. No. 425.

communities may take many years to develop or may never develop fully. In terms of providing functionality for supporting target species, there is again uncertainty as to whether equivalent function would be delivered on new habitats as on existing, naturally formed, habitats. These uncertainties are likely to require a higher ratio of gain to loss to be incorporated into any package of Compensatory Measures, but are unlikely to make the development of a package of measures totally infeasible.

The Competent Authority would need to be certain that the Compensatory Measures would be sufficient, including the effectiveness of measures to overcome uncertainties (such as higher than 1:1 ratios). The Dibden Bay proposals were refused by the Secretary of State partly on the basis that the proposed offsetting measures would not be adequate Compensatory Measures under the Regulations.

(ii) Potential for Compensatory Habitat Provision

Compensation Studies[51,52] undertaken for the Severn Tidal Power feasibility study indicated that technically, large areas of intertidal habitat could be created through managed realignment. However given the large scale required and the likely distance from the Severn and the range of specific compensatory requirements and lack of evidence, it was concluded that although compensation might not be impossible, it would require unprecedented measures including some measures which rely on an interpretation of the requirements of the directive that varies from the Commission's interpretation of its guidance.

The requirement for Compensatory Measures is to maintain the coherence of the Natura 2000 network. This suggests that measures can be provided anywhere (including in other member states) as long as the network of European Sites still fulfils its function in conserving the designated habitats and species in Favourable Conservation Status (FCS). In relation to Compensatory Measures for adverse effects on the SPA / Ramsar sites in question, this would require providing additional functionality to support the designated species within (or near to and capable of being designated as) other European Sites where it could be reasonably expected that the feature species would find and adapt to in order to maintain the same overall populations as existing.

The designated bird features are known to migrate through staging posts and on to wintering sites to survive the winter season. The exploitation of staging posts and wintering sites can vary in different years dependent on breeding success in that year and weather conditions, but the availability of such sites is critical to long term maintenance of the populations. They are also known to move between estuaries in different seasons, weather and states of the tide and so are able to exploit new resources relatively easily at some distance. However, the further from the original resource provision new resources are provided, the more uncertainty there is in success of the Compensatory Measures.

The distribution of estuaries within the UK needs to be considered and groups of estuaries could be considered together with individual estuaries likely to serve a separate function as a wintering site or staging post for migrating birds, albeit with birds moving within the group at different times.

[51] DECC (2010a).Severn Tidal Power – SEA Environmental Report. 345 pp.
[52] DECC (2010b).Severn Tidal Power - SEA Topic Paper Feasibility of Large Scale Managed Realignment. ABPmer report. 107 pp.

As Natural England identifies in their submitted evidence[53], the compensation habitat should be within the same bio-geographical region in the territory of the same Member State (the Thames Estuary is within the Atlantic bio-geographical region[54]).

In order to maintain the functionality of the network of estuarine sites across Europe for the migration and wintering of bird features, it is likely therefore the further away from the original estuary and estuary group that compensation is provided, the more uncertainty there would be in the measures maintaining the functionality of the network. In such circumstances, it is likely that a higher gain:loss ratio would be required.

The Thames Estuary can be considered as part of a group of estuaries lying between the Suffolk coast and the eastern tip of the north Kent coast. Whilst it may be conceptually possible to provide Compensatory Measures anywhere in Europe therefore, it is unlikely that measures outside the UK would be acceptable for all the species involved and any outside the group of estuaries within which the Thames estuary lies would need to be at a higher gain to loss ratio.

The search area for potential Compensatory Measures within this study has focussed first on the coast and estuaries between Harwich and Ramsgate. Whilst other substantial areas of potential for habitat creation have been identified in the north east of England, it is considered that the distance from the original loss would be likely to make these areas less suitable for compensation and much higher risk in terms of meeting diverse requirements of the different bird species. The BTO evidence submission[55] gives further detail on the range of bird species and their sensitivities in terms of site fidelity and feeding requirements and experience in creating habitat for them.

The potential area for creation of coastal habitats within this cluster of estuaries has been identified through analysis of the coastal flood zone. It has been assumed that any area liable to coastal flooding would be topographically suitable for coastal habitat creation. This area therefore can provide the technical maximum area that could host Compensatory Measures.

The Environment Agency (EA)'s Regional Habitat Creation Programme in the Essex, Norfolk and Suffolk Area have identified a number of possible sites along the Essex and Suffolk coast associated with managed realignment policies in the Essex and South Suffolk Shoreline Management Plan (SMP) but outside the areas they have already allocated for compensation. These include a number of sites over 1000ha and a total area of around 13,000ha of land located within flood plain but outside existing freshwater SPA designations.

While it is possible to identify relatively large areas of land which have potential for habitat creation, there are a number of additional constraints that can make it extremely difficult to deliver the habitats required. These are constraints can that would mean that areas might not be suitable or available. There will also be

[53] Natural England (2014) Inner Thames Estuary Airport Feasibility Studies – call for evidence

[54] European Environment Agency Europe's biodiversity – biogeographical regions and seas Biogeographical regions in Europe The Atlantic region

[55] BTO Research Report No. 657 (2014) Review of knowledge regarding the effect of major estuarine developments on bird populations with reference to proposals for an airport in the Thames Estuary

requirements to demonstrate that proposed sites do not cause additional impacts on properties, cultural heritage interest, or flood risk. There are often also additional knock-on requirements to offsetting adverse effects on the existing network of designated sites, species features and their associated habitats at proposed locations.

Specific areas that would not be feasible include:

- The new airport footprint and the 13km safeguarding zone and possibly beyond 20km might be advisable;
- Existing designated sites (these would create further compensatory measure requirements);
- Significant existing infrastructure;
- Proposed plans and projects that could act in combination; and
- Compensatory habitat creation areas (or plans for) relating to other plans and projects.

Additional constraints (challenging on political or policy grounds) on delivery of the necessary Compensatory Measures within the potentially feasible area include:

- Cost (for example, if new flood defences were required);
- Political will and landowner cooperation;
- Loss of residential property;
- Loss of agricultural production;
- Flood risk management;
- Contaminated land;
- Existing biodiversity (non-designated); and
- Cultural heritage and other planning constraints

(iii) Compensation costs

In order to put a cost to compensatory habitat creation, past case studies have been examined. The Department for Energy and Climate Change (DECC) commissioned a study into the estimated costs per ha of sustainable, managed realignment habitats. Three case studies were explored, ranging from <600ha to >32,000ha of habitat created. It was found that costs such as for the occurrence of protected species (£1,000 per ha), presence of SSSIs (£20,000 per ha), compulsory purchase (5% of total land value), Public Enquiries (£5million) and on site monitoring (£455 per ha) contribute significantly to the overall design, engineering and consenting costs.

The range in cost per ha varied considerably across the case studies from between £21,000 and £110,500 for habitat created. Site characteristics were cited as the primary driver in costs, accounting for the high variability in costs per ha. When taking an average of all the case study areas and all the sensitivity tests (such as property purchase prices) along with cost reductions, for example, by excluding of rock armour components or reduction in construction costs, the baseline average

cost per ha of habitat created was approximately £53,000 (£45,000-£55,000 with low-high cost scenarios). With a 60% optimism bias this increased to approximately £85,000 per ha. As this was considered to be high, a low scenario cost with 60% optimism bias of £71,500 per ha was the likely figure to be applicable[56] (DECC, 2010).

A managed realignment project completed within the last year at Medmerry in West Sussex cost £28 million (approximately £155,500 per ha) and involved the creation of 180 ha of new intertidal habitats on former agricultural land, along with flood defences[57]. This cost included surveys, consultants fees, construction costs Local Authority fees, compensation and environmental enhancement.

Taking the above examples into account the cost of recreating saltmarsh and mudflat habitat in the Thames Estuary by methods such as managed realignment is likely to fall in the region of £70,000 - £100,000 per ha.

Using the potential range of area required for compensation habitat creation and the range of costs per ha, the cost of Compensatory Measures has been calculated to lie between £149million and £476million assuming 1:1 ratio with the lower cost rate per ha, and up to £2.04billlion assuming a 3:1 ratio for the higher loss estimate and the higher cost rate per ha.

4.8 Case Studies for Habitat Regulations Process

(i) Scale and Adverse Effect on Integrity

Natural England research report 704[58] provides a number of case studies where the Secretary of State concluded an adverse effect on integrity because of small scale effects of approximately 1.0% or less of land take or habitat loss:

- London Gateway Port, Essex (0.1%);
- Quay 2005 Hull (0.01% - in fact 0.03%);
- Dibden Bay Terminal Southampton (0.76%);
- The Outer Harbour Immingham (0.145%);
- Barksore Marshes (1.79%); and
- Bathside Bay (1.87%).

The minimum permanent loss of habitat in the Thames Estuary and Marshes SPA / Ramsar is estimated to be around 24%-27% of the designation. It is also unlikely to be possible to reduce the direct impact on the SPA / Ramsar site significantly with alternative site location within the Hoo Peninsula. Reducing impacts from the airport

[56] DECC (2010a).Severn Tidal Power – SEA Environmental Report. 345 pp.; DECC (2010b).Severn Tidal Power - SEA Topic Paper Feasibility of Large Scale Managed Realignment. ABPmer report. 107 pp.

[57] Solent Protection (2013). Medmerry Managed Realignment officially opened. Available at http://www.solentprotection.org/2013/11/medmerry-managed-setback-officially-opened/. Accessed 04/06/2014.

[58] English Nature (Hoskin & Tyldesley 2006) research report 704: “How the scale of effects on internationally designated nature conservation sites in Britain has been considered in decision making: A review of authoritative decisions”

footprint are likely to need to be balanced by more birdstrike management activity on remaining habitat designated for bird interest close to the airport.

Furthermore, the geomorphology of the estuary and bird strike mitigation requirements would make it impossible to create this scale of new habitats in the immediate vicinity of the site. It is unlikely therefore that the adverse effects could be mitigated on or near the site itself.

It is highly likely therefore that it could be concluded that the proposals would have an impact on the integrity of the Thames Estuary and Marshes SPA / Ramsar. The proposals would therefore be required to progress to stages 3 to 5 of the process in order to comply with the provisions of Article 6(4) of the Habitats Directive.

(ii) Alternative Solutions & IROPI

In the decision letter relating to the Dibden Bay Container Terminal, proposed Harbour Revision Order, following a Public Inquiry, the Secretary of State (SoS) decided not to make the Orders and not to give the requested planning direction. Whilst the SoS agreed there were IROPI for the expansion of this type of port provision, Alternative Solutions existed elsewhere in the region that could feasibly provide such with less damage to European Sites.

In the case of the Bathside Bay container terminal, the Secretary of State considered the argument that, for reasons of overriding public interest to be imperative they also need to be immediate. He believed, in line with the Inspector, that the timescales required to plan and implement new container capacity, including dealing with surface access implications, which were not far advanced in the case of Bathside Bay, meant that it was appropriate to take decisions approving such capacity sufficiently in advance of such need arising to allow for sensible planning and implementation of those proposals. The potential damage from the Bathside Bay container terminal project was the loss of 69ha intertidal habitat the compensation measures were to provide 138ha intertidal habitat.

(iii) Compensatory Measures

The Sustainable Development Commission identified three options for the Severn Tidal Power proposals for the overall compensatory measures necessary to secure the overall coherence of the Natura 2000 network[59]:

- *Compensation using the same features as those affected ("like for like" or "within type") and located within the same functional ecological unit as the affected site ;*
- *Compensation using the same features as those affected but located within a different functional ecological unit;*
- *Compensation by substituting different features to those affected ("out of type"), whether within the same or a different functional ecological unit.*

[59] Equal Value Can a major Severn Tidal Power scheme be compatible with enhancing the Natura 2000 Biodiversity Network? Recommendations to the Severn Tidal Power Project Board as part of the Severn Tidal Power Feasibility Study, Sustainable Development Commission (December 2010)

The first point would be particularly challenging for the Thames Estuary airport proposal. As Natural England[60] identifies, compensation habitat outside the Thames Estuary would be required to demonstrate its ability to support the bird populations affected. The ability to do so may be compromised unless the SPA bird assemblages affected are capable of moving to sites distant from the Estuary itself without adverse impact occurring. The further the birds would have to travel could potentially lessen the effectiveness of the compensation habitat.

Wallasea Wetlands Creation Project at Allfleet's Marsh is an example of the potential timeframes for the implementation for compensation habitat. As compensation habitat has to be functional before an impact on the Natura 2000 network occurs this example gives further implication for the Thames Estuary airport.

In 1997, the House of Lords, after receiving an opinion from the EU Court of Justice, decreed that an area of marine wetlands, mudflats and saltmarsh of international importance for birds that had been left out of a Special Protection Area (SPA) – a designation under the EU Birds and Habitats Directives – to allow for port developments at Sheerness and Felixstowe, should be replaced. In 2004, Wallasea was chosen, by a team of experts, as the most suitable site because it was big enough to attract the large numbers of birds that had been using the destroyed wetlands, and would not cause damage to the functioning of the surrounding estuary, or adversely affect those that use it. In 2006, a process known as 'managed realignment' allowed the tide back onto its old floodplain. The primary objective of the project is that by 2016 the site should be of sufficient quality to qualify for designation as an extension to the Crouch and Roach Estuaries SPA and Ramsar site.

The Wallasea project will have taken 12 years to create the target habitat, from 2004 to the projected completion date in 2016, and gives an indication of the length of time for delivering large scale compensation habitat.

4.9 Summary

The Hoo Peninsula supports a complex mosaic of intertidal, wetland and terrestrial habitats that interact with each other. The complex of a wide range of habitat types within the ecosystem results in high biodiversity. The Thames estuary has relatively high productivity that supports internationally important habitat areas and species; and this productivity in turn supports internationally important bird assemblages and numbers. This is recognised by the designation of large parts of the estuary as Ramsar, SPA and / or SAC.

The assessment of potential impacts from the location of an airport hub within the Inner Thames Estuary identified a range of potential sources of impact including:

- Direct habitat loss from airport and related development and transport infrastructure footprints;
- Displacement of identified compensation areas, for the airport and plans and schemes, outside the 13 km of airport (possibly to beyond 20km);

[60] Inner Thames Estuary Airport Feasibility Studies – call for evidence Written submission of Natural England 23 May 2014

- Additional loss of functional habitat supporting designated bird species due to active bird strike risk management;
- Disturbance to designated species, disturbed habitats degraded for the species; and
- Indirect habitat loss or degradation due to changes in the geomorphology of the estuary including changes from water level, erosion and accretion patterns and sedimentation changes.

The Thames Estuary and Marshes SPA / Ramsar and the Medway Estuary and Marshes SPA / Ramsar are the sites that would be the most severely affected by a proposed airport because they would experience a large physical loss of habitat area, along with the associated species they support. The minimum permanent loss of habitat in the Thames Estuary and Marshes SPA / Ramsar as a result of the airport proposal is estimated to be around 24%/27%.

The geomorphology of the Thames estuary, flood risk management and bird strike risk management requirements would make it impossible to create this scale of new habitats in the immediate vicinity of the site. It is highly likely that the proposals would have an impact on the integrity of the Thames Estuary and Marshes SPA / Ramsar site and also potentially on the Medway Estuary and Marshes SPA / Ramsar site. In terms of the HRA test steps, the proposals would, therefore, be required to progress to the Alternatives Solutions test.

The Competent Authority (Secretary of State for Transport) would need to be certain that no alternative solutions existed, had considered the best scientific knowledge and taken into account the representations of Natural England and Environment Agency.

If the proposals were to pass through the Alternative Solutions and IROPI HRA tests, there would be a requirement also to develop an acceptable package of Compensatory Measures. This would need to identify the precise negative effects on each feature of each European Site adversely affected. The proposed measures would need to provide sufficient functionality to support the designated species of the sites within the wider network of Natura 2000 sites to ensure each species affected was maintained in Favourable Conservation Status. This would involve significant in-depth field studies and monitoring over a period of time (several years), including, for example, studying bird movements between estuaries and understanding aquatic ecology and other aspects influencing functional habitat.

A minimum of around 2,130ha is likely to be needed for habitat compensation for the airport proposals and displacement of other compensatory habitat, but given the uncertainty with providing compensation habitat further afield it is likely that a ratio of gain for loss of greater than 1:1 would be required. Ranges from other studies indicate 2:1 and 3:1 might be applied. Higher ratios might be considered appropriate where the success of proposed compensation measures is considered uncertain.

Indirect losses to the function of habitats through bird strike management, disturbance, and morphological changes to the estuary could affect other Natura 2000 sites also and add greatly to total amount of compensatory habitat required but these areas are difficult to measure at this stage without detailed study. An upper estimate of 6,800ha attempts to capture some of these indirect losses. The airport transport schemes are also likely to result in additional direct losses to Natura 2000 sites. These are therefore likely to add further to the total area required for compensation.

It is likely that to maintain the functionality of the network of estuarine sites across Europe for the migration and wintering of bird features, that each species group should maintain its own functionality. The Thames Estuary is part of a group of estuaries lying between the Suffolk coast and the eastern tip of the north Kent coast. The EA's Regional Habitat Creation Programmes in these areas have good experience of coastal habitat creation work as compensation for flood risk management plans. In addition, there are number of sites associated with managed realignment policies that could provide potential for large areas of intertidal habitat creation. Although these potential land areas are likely to reduce as constraints in terms of availability, suitability and additional impacts are considered.

Whilst it may be conceptually and technically possible to provide compensatory measures anywhere in Europe, measures outside the group of estuaries within which the Thames estuary lies will be more difficult to demonstrate as acceptable compensation for the full range of bird species and all their different requirements.

There is potential for providing adequate compensation i.e. it is technically possible but the scale of the required compensation is unprecedented to date and there is a high level of uncertainty given that the full requirement is yet to be understood. There is also uncertainty over the ability to deliver the functional quality of habitat to meet all the species needs that might be affected. There is an added complexity in the potential ability to provide adequately the like-for-like combination of habitats; i.e. not just the habitat types in isolation but a mosaic of habitats for the requirements of some species. The compensation habitat also needs to be provided in a geographic region which would support the species affected and to demonstrate this is deliverable a need for extensive studies over a large area of the Inner Thames Estuary and compensation sites over many years. The uncertainty over successful compensation would remain until displacement occurs and sufficient long term monitoring data collected to demonstrate that compensation habitat had been provided.

5 Estuarine Processes & Geomorphology

This section covers:

- Introduction to estuarine processes and fluvial/ coastal geomorphology.
- Legislation and Policy Context.
- Baseline.
- Impacts from an Airport Development.
- Secondary and Cumulative Effects.
- Compensation and Mitigation.
- Risks.
- Summary.

The Study ToR included a requirement to consider aspects that affected the overall stability of the ecosystem and wider environmental conditions. In addition, a number of consultees, such as the Environment Agency, asked specifically that the implications of changes to the morphology of the Thames Estuary were considered. The Environment Agency also requested that the context for the proposals in terms of the Water Framework Directive[61] and specifically impacts on water body status were considered.

This section therefore focuses on the potential for changes to hydrodynamic conditions; patterns of sediment erosion, transport and deposition; and the resultant changes in the shape and form of the inner estuary channel and tributary watercourses across the Hoo Peninsula. An understanding of possible changes of physical processes is key to understanding of the effects on ecological receptors, not least internationally designated Natura 2000 sites (SPA, SAC, Ramsar). The potential for water and sediment quality impacts arising from the re-suspension and subsequent deposition of contaminative sediments is noted but not considered in detail for this report. Processes affecting flood risk are addressed separately in Section 6.

5.1 Legislative and Policy Context

5.1.1 European Union (EU) and National Legislation

European Union (EU) and national legislation drives the protection and enhancement of the key receptors defined for the geomorphological assessment, including the Thames Estuary and watercourses on the Hoo Peninsula. The key relevant legislation is the Water Framework Directive.

This is a significant piece of EU legislation that has been transposed into UK law through The Water Environment (Water Framework Directive) (England and Wales) Regulations 2003 (Statutory Instrument 2003 No. 3242, with the Environment Agency as regulator in England. The Thames Estuary and a number of the tributary watercourses on the Hoo Peninsula are classified under the WFD. The WFD has the aim that all water bodies achieve Good Ecological Status / Potential by defined dates. This is contributed to by three elements: biological, physico-chemical and

[61] Water Framework Directive (Directive 2000/60/EC)

geomorphological. River Basin Management Plans (RBMPs) have been created and these set out measures to ensure that water bodies achieve the goals. The Thames RBMP provides details of the anticipated ecological status for the water bodies within the study area for years 2021 and subsequently 2027. If suitable mitigation is put in place along each water body, then it is anticipated that water body status will improve.

5.1.2 Local Policy

There are also a number of policies and plans covering the study area that are implemented by local authorities and statutory bodies. These include:

- The Isle of Grain to South Foreland Shoreline Management Plan; and
- Thames Estuary 2100 (TE2100) Plan.

A Shoreline Management Plan provides an assessment of the risks associated with coastal evolution and presents a policy framework to address these risks to people and the developed, historic and natural environment in a sustainable manner. According to the Isle of Grain and South Foreland Shoreline Management Plan (SMP) there is not considered to be a risk of deterioration of ecological status / prevention of achieving good ecological status under WFD for the majority of units defined in the study area. An exception are those areas where a 'hold the line' approach to management may be used (maintaining existing sea defences but not introducing any new defences), such as at the Isle of Grain. 'Holding the line' may cause a narrowing of the inter-tidal area in the future, altering its overall ecological status.

The Thames Estuary 2100 project (TE2100) was formed in 2002 and is led by the Environment Agency. The concept of the project was to develop a comprehensive action plan for managing flood risk for the Tidal Thames from Teddington (West London) through to Sheerness and Shoeburyness in Kent and Essex (respectively). This was the UK government's first action plan to specifically address climate change.

5.2 Baseline

5.2.1 Estuarine Physical Processes

(i) Previous Research

There has been considerable research on the Estuary in terms of its geomorphology, hydrodynamics and sediment, providing a significant baseline. In particular HR Wallingford Ltd and their predecessors have undertaken numerous studies in relation to encroachment and associated dredging over a period of more than 60 years. A physical model of the Estuary was first constructed in the 1950's and more recent studies by HR Wallingford include the nearby London Gateway Port Development on the northern bank, from which some data / information (specifically on the morphological changes associated with encroachment) could be drawn.

(ii) Background to Natural Tidal Processes

The Thames has one of the UK's major east coast estuaries and extends from the tidal limit of the Thames at Teddington Lock, through London and then out to the

North Sea. In the upper reaches the dominant processes are related to fluvial inflow, whilst at the downstream limit there are storm surges and waves. It is defined as a generally well-mixed estuary, meaning that the river flow is small compared with the tidal volume. Although difficult to define, the eastern boundary of the estuary was defined by the Hydrological Survey of 1882-9 as a line drawn from North Foreland in Kent to Harwich in Essex. The estuarine sandbanks typically extend to this line. The name Greater Thames Estuary refers to the coast and the low-lying land abutting the estuary itself. These lands comprise mudflats, low lying open beaches and salt marshes, namely the North Kent and Essex Marshes. These provide important habitat.

Factual information for the Thames estuary[62] :

- Tidal limit - Teddington
- Tidal range – macro-tidal with a mean spring tide range of 5.2m at Sheerness and 6.6m at London Bridge[63]. The increased tidal range is due to the funnelling effect of the estuary. Historically the estuary has seen an increase in tidal range due in part to the effects of encroachment by embankments[64]
- Tidal velocities – up to 1.55m/s on a flood tide and up to 1.60m/s on the ebb tide[65]
- Size of tidal prism – flood tide of 3-5 hours and ebb tide of up to 9 hours due to the large inflow of freshwater from the non-tidal Thames

(iii) Natural Sedimentary Processes

There are a large number of published papers and reports for the Thames Estuary providing an insight into the baseline for sedimentary processes and morphological change. The Inner Estuary is naturally a dynamic environment, with seabed erosion and sediment deposition during each flood and ebb tide.

Several factors also influence estuarine sediment transport in the short term including the semi-diurnal tide distribution, wave effects (Outer Thames) and spring/neap tide cycles[66].

On a large spring tide, a particle of water moves up the estuary for about 12km if it starts at Southend, with the equivalent distance at Greenwich being up to 17km. The vast majority of the sediment transported in suspension in the estuary occurs on spring tides, because the neap tide forces are insufficient to raise more than a minimal quantity of sediment into suspension. The mobilising force in the Thames Estuary appears to be the salt concentration, which is a function of the freshwater flow. In normal years, freshwater flow is lower in the period April to September than in the winter months (October to March).

[62] http://www.pla.co.uk/Environment/Physical-Processes
[63] United Kingdom Hydrographic Office, (2003). Admiralty Tide Tables. Volume 1, 2004. United Kingdom and Ireland including European Channel Ports. UKHO
[64] Royal Haskoning, (2004). Thames Estuary 2100 - Geomorphological Review and Conceptual Model, October 2004 Project Number: STCG/2003/81. Report to Environment Agency.
[65] Institute of Estuarine and Coastal Studies (1993). The Thames Estuary Coastal Processes and Conservation. Report to English Nature.
[66] Environment Agency. (2003). Planning for Flood Risk Management in the Thames Estuary - Technical Scoping Report.

The coarser sands and gravels that exist in the sub-tidal areas of the Estuary and in the Outer Thames reaches are transported under the strong tidal currents. In the Outer Estuary, wave effects enhance sediment transport by increasing entrainment from the seabed, and on the exposed coast, wave breaking tends to be the dominant mechanism for littoral drift.

Estuaries are well known to be ecologically important. Fine sediments in particular have an important role in suspension on the ebb and flow tides and can be deposited as material on mudflats and saltmarshes[67]. Using new data and information the authors confirmed a previous study in 1969. In the Lower estuary (seaward of Barking) the sub-tidal channel has deepened and narrowed in the 20th Century with a corresponding gain in inter-tidal areas. The estuary was found to be not dependent on a large sediment input from marine sources.

Human Influences

Along particular reaches man-made embankments encroach on the Estuary and are backed by reclaimed grazing areas. Through London itself sedimentary processes are restricted by urban encroachment and the presence of embankments. The cumulative effect of historic developments has led to an increase in the tide range from Tower Pier upstream to Richmond[68].

It is difficult to discern between natural and anthropogenic change in the Estuary. Observations by Baugh et al.[69] confirmed that longitudinal variability of suspended sediment concentrations within the Inner Thames Estuary had not changed significantly from 1969 to 2004. However, the assessment also confirmed that during the 20th century the Upper estuary (landward of London Bridge) had deepened and widened resulting in a loss of inter-tidal area, whereas the Lower estuary (seaward of Barking) had widened and narrowed over time resulting in a gain in inter-tidal area[70]. The recent regime of morphological change in the Estuary is characterised by inter-tidal accretion with some sub-tidal erosion[71].

The Estuary has been subject to considerable local capital dredging in recent years and also ongoing maintenance dredging to create new channels for shipping or to maintain previously dredged areas. The capital dredging of shipping channels to the London Gateway Port Development, which started in 2010, is one of the largest dredging operations ever to be undertaken in the world. There are currently some 20 locations where operators undertake maintenance dredging on a regular basis, from several times a year to once every 18 months or so. The quantity of sediment removed is dependent on the sedimentation characteristics at each location and can vary from less than 2,000 cubic metres to 45,000 cubic metres per commission. This dredging activity tends to be at or close to berth facilities and dock entrances.

[67] Baugh, J. V., Feates, N., Littlewood, M. A. and Spearman, J. (2012). The fine sediment regime of the Thames Estuary – A clear understanding. Journal of Ocean and Coastal Management – Special issue on coastal and estuarine sediment and their management.
[68] Siggers, G., Spearman, J., Littlewood, M. and Donovan, B. (2006) One hundred years of morphological change in the Thames Estuary. Impacts on tide levels and implications for flood risk management to 2100, 41st Defra Flood and Coastal Management Conference, 4-6.
[69] Baugh, J. V., Feates, N., Littlewood, M. A. and Spearman, J. (2012). The fine sediment regime of the Thames Estuary – A clear understanding. Journal of Ocean and Coastal Management – Special issue on coastal and estuarine sediment and their management.
[70] ibid
[71] ibid

Through more recent Water Injection Dredging the sediment is agitated and remains in the estuary rather than being deposited on land. HR Wallingford[72] (1992) believe that such dredging does not cause significant damaging changes in the Estuary. In fact the Estuary is considered to be in dynamic equilibrium even with the WID and it has been asserted there has been no detrimental effect on the inter-tidal morphology[73].

5.2.2 Fluvial Environment

The key designated fluvial receptors within the study area are those protected by the Water Framework Directive and explained below.

(i) Water Framework Directive (WFD)

The objective of WFD is to prevent deterioration in the status of water bodies and achieving Good Ecological Status / Potential (for Heavily Modified Water Bodies) by 2015, 2021 or 2027. Each water body is assessed based on ecological, physico-chemical and geomorphological elements, which are then used to determine the status of the water body.

Table 5.1 describes the status of the biological, physico-chemical and hydromorphological elements for the WFD designated rivers, estuaries, lakes and groundwater within the study area.

[72] HR Wallingford (1992) Water Injection Dredging at Tilbury Bellmouth. A Study of the probable effects on the silt regime of the Thames Estuary. Report EX 2648.
[73] Institute of Estuarine and Coastal Studies (1993). The Thames Estuary Coastal Processes and Conservation. Report to English Nature.

Table 5.1: Water Framework Directive Information for Water Bodies within the Study Area

Water Body Name	Water Body ID	Hydromorphological Status	Current Ecological Status	Biological Quality	Chemical Status	Hydromorphological Quality	
						Quantity and Dynamics of Flow	Morphology
Rivers							
Dry Valley south of Gravesend	GB106040024230	Not designated A/HMWB	Moderate Status	-	Does Not Require Assessment	Supports Good	Supports Good
Tributary of Medway Estuary at High Halstow	GB106040024120	Not designated A/HMWB	Moderate Status	-	Does Not Require Assessment	Does not Support Good	Supports Good
Tributary of Medway Estuary at Kingsnorth	GB106040024030	Not designated A/HMWB	Moderate Status	-	Does Not Require Assessment	Does not Support Good	Supports Good
Damhead Creek	GB106040024160	Not designated A/HMWB	Moderate Status	-	Does Not Require Assessment	Does not Support Good	Supports Good
Estuarine							
Lower Thames	GB530603911401	Heavily Modified	Moderate Potential	Moderate	Fail	-	
Medway	GB530604002300	Heavily Modified	Moderate Potential	Moderate	Fail	-	
Lakes							
Unnamed (Buckland lake)	GB30642407	Artificial	Good Potential	-	Does Not Require Assessment	Supports Good	No Data
Groundwater							
North Kent Medway Chalk	GB40601G500300	Poor	Good	Poor	Poor	-	

5.2.3 Other Baseline Receptors

There are a number of national policies within the UK covering fluvial watercourses, estuaries and coastal areas. The important receptors are detailed in Table 5.2. These include: Main Rivers, other watercourses, lakes and water dependant habitats. Potentially these would be directly and indirectly impacted.

Estuarine and riverine impacts relate directly to one another and are not stand alone impacts.

Table 5.2: Other Baseline Receptors

Type	Description	Receptor Name
Main Rivers	Rivers (in England) defined by Defra to enable the Environment Agency to carry out flood defence work.	Decoy Fleet Yanlet Creek Cliffe Fleet Hope Fleet Salt Fleet Buckland Fleet River Medway
Ordinary Watercourses	Defined here as all rivers and drains not classified as Main Rivers (see above).	Pound Fleet Hamshill Fleet Hooks Fleet Stoke Creek Colemouth Creek
Lakes	A large body of water surrounded by land and fed and drained by a river or other outfall.	Cliffe Pools
Saltmarshes	Inter-tidal areas occupied by salt-tolerant vegetation and periodically inundated by tides.	Stoke Saltings Hingham Saltings
Mudflats	An inter-tidal coastal wetland that forms when mud is deposited by tides or rivers.	The Flats Blyth Sands

The inter-tidal area, defined as land exposed at low tide and inundated at high tide, is also one of the receptors specifically considered in this assessment. Inter-tidal areas provide crucial habitat, and could be impacted by changes in the hydrodynamic and sediment transport regimes.

Outside the study area, the following Geological Conservation Review (GCR) sites are also considered as they could be indirectly impacted by a development:

- Dengie Marsh, Essex (this is a SSSI designated for tidal mudflats and saltmarsh but also of interest from a geomorphological point of view for its unique spits and beaches)
- Joss Bay (GCR Name: Foreness Point), Kent (this is part of the Thanet Coast SSSI and noted for coastal geomorphology)

GCR sites are currently in the process of being considered for long-term conservation under British law and have the potential to be impacted by changes within the Thames Estuary[74].

5.2.4 Evolution of the Baseline

(i) Estuarine Physical Processes

The area is under continued pressure from development, coastal squeeze, erosion and associated habitat loss and anthropogenic disturbance.

As discussed in the section on the baseline environment above, there have been numerous consultant reports and research papers for the Thames Estuary giving important background to baseline evolution. Specific recent studies include work by HR Wallingford Ltd who have ownership of the Thames Estuary 2D base model which was used for the key TE2100 (2012) study for the Environment Agency. This work has shown that changes to the physical processes associated with climate change within the Estuary over the next century are highly uncertain. TE2100 states that as a result of climate change-related predicted sea level rise water levels within the Estuary are likely to rise between 200mm and 900mm within the next 100 years (due primarily to the melting of glaciers and polar ice, and thermal expansion of the oceans) (see discussion in Section 6 re uncertainty over sea level rise included in the approach for TE 2100).

According to the Isle of Grain and South Foreland SMP[75] there is not considered to be a risk of deterioration of ecological status / prevention of achieving Good Ecological Status under WFD for the majority of shoreline units defined in the study area. The exception is for those areas where a 'hold the line' approach may be used, such as the Isle of Grain. 'Holding the line' may cause a narrowing of the inter-tidal area in the future, altering its ecological status.

(ii) Fluvial Environment

The Thames River Basin Management Plan (RBMP)[76] provides details of the anticipated ecological status for the water bodies within the study area for years 2021 and subsequently 2027. As suitable mitigation is put in place then it is anticipated that the water body status will improve, potentially from 'Moderate status' to 'Good status'. Table 5.1 provides information on the current Ecological Status of the WFD Water Bodies within the Study Area.

[74] May, V. J. and Hansom, J. D. (2003). Chapter 1: An introduction to the coastal geomorphology of Great Britain. In: Coastal Geomorphology of Great Britain, Geological Conservation Review Series, No. 28, Joint Nature Conservation Committee, Peterborough.
[75] Halcrow (2010a). Isle of Grain to South Foreland Shoreline Management Plan Review. 148 pp.
[76] Environment Agency (2009c) River Basin Management Plan: Thames River Basin District

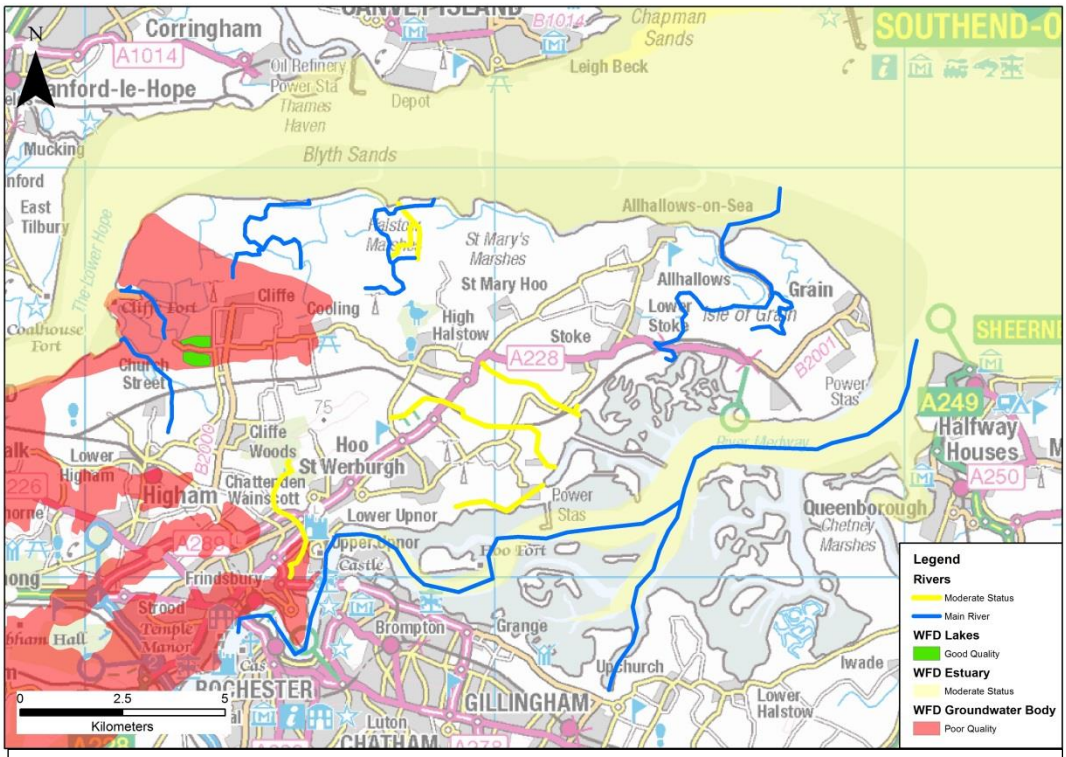


Figure 5-1: WFD Ecological Status and Main Rivers

5.3 Impacts from an Airport Development

5.3.1 Construction Phase

Sources of Impact
The main potential sources of impact include:

- Soil or sediment excavation, removal and storage;
- Soil compaction;
- Drainage;
- In channel works/ diversions;
- Culverts;
- Channel realignment/diversion;
- In-channel works such as piling, piers, bridges and vehicle movements;
- Channel realignment/ diversions;
- Laying of impervious surfaces; and
- Other temporary structures/ causeways.

Potential Impacts
The main potential impacts associated with airport construction include direct modifications to watercourses, surface water bodies, groundwater and the estuary and include:

- Changes to surface water runoff, velocities, tidal prism, flow regimes, duration of tidal inundation, bed and bank stability, sediment loadings, sediment and erosion patterns and infiltration; and
- Disturbance to natural bed forms.

The HR Wallingford Report[77] suggests the following uncertainties: construction sequencing; sourcing of fill material and the release of plumes of fine material during construction. They assumed a raised platform construction and estimated that about 140 million cubic metres of fill would be required, although this could be higher (which should be compared with an annual yearly dredging requirement of the navigational channel of about 30 million cubic metres). However it should be noted that different construction approaches have been put forward by the airport hub proponents including raised platform construction but also the creation of flood bunds reducing the need for land raising. These approaches are described in Section 6 in relation to flood risk and in more detail in the **Operational Feasibility and Attitudes to Moving to a New Airport (Study 2)**. None of the proponents have identified dredging in the Thames estuary as a source of material, although they have not specifically ruled this out either. Foster + Partners have indicated sourcing large quantities of material from dredging in the North Sea.

There would also most likely be dispersion of suspended sediment from the construction site due to sourcing and placement of this material. This could have both short-term and / or longer term impacts. A substantial experience and body of work is available specifically in relation to seabed dredging impacts (sediment release) and reclamation losses from the DP World Gateway Port development at the Shellhaven site on the north shore of the estuary.

All of these impacts if not managed or mitigated have the potential to alter habitats, lose habitat, change species diversity, change plant and animal biomass and cause the loose of sensitive species.

However it is assumed in this review that best practices and standard mitigation measures would be implemented during the construction phase to minimise these potential impacts on the Estuary and riverine environments. This should include a Construction Environmental Management Plan for the site and appropriate Method Statements for the works. Appropriate good practice guidance would be drawn upon, including the Pollution Prevention Guidelines from the Environment Agency.

5.3.2 Operational Phase

(i) Estuarine Coastal and Estuarine Processes: Geomorphology, Hydrodynamics and Sediments

The Thames Estuary is a relatively natural dynamic system that may potentially be significantly affected by an airport development. Potential sources of impact and impacts in the operation phase are listed below:

Sources of Impact
The key sources of likely impact are:

[77] HR Wallingford (2014). Inner Estuary Airport Call for Evidence. Technical submission by HR Wallingford to Airports Commission. Report No RT01.

- Encroachment into the Thames Estuary; and
- Potentially large areas of compensatory habitat in the Thames Estuary itself or other estuaries.

Potential Impacts
Changes to estuarine processes as a consequence of an airport development include the following potential changes:

- Tidal prism;
- Wave reflection;
- Sediment deposition;
- Sediment entrainment;
- Bank erosion; and
- Morphology.

Each of these changes would be likely to impact on adjacent areas / receptors.

Related potential consequences
Increased entrainment of sediment could lead to the migration and erosion of inter-tidal areas. This could subsequently alter the processes and habitats (such as saltmarshes) and composition of these areas. Equally, sediment deposition may also lead to changes in inter-tidal habitats through accretion.

Changes in the tidal prism could also alter the duration and extent of tidal inundation. The tidal prism is the volume of water in an estuary held between mean high tide and mean low tide, or the volume of water leaving at ebb tide. If it is known how much water is exported compared to how much of the estuarine water remains, the duration of inundation can be determined. There could be lateral encroachment of water / sediment on inter-tidal areas. This could lead to indirect changes to the extent of inter-tidal and sub-tidal habitats arising from changes of water levels.

HR Wallingford Analysis for an example Airport Hub Development
The HR Wallingford Report[78] provides a preliminary analysis of the likely magnitude of selected potential impacts based on their considerable 60 years of experience and some early modelling of flows and waves.

The Airport Commission's Isle of Grain option was used as an example for the analysis. The estimated footprint of this airport option was taken to be 1,100 ha over inter-tidal and sub-tidal areas (i.e. below high water). It was measured as extending 2,100 metres into the estuary and to reduce the estuary cross-section by 20% at low water and by up to 27% at high water. These figures would be different for the other proposed options.

Using the existing 2D Thames Estuary base model, for an airport platform located at the Inner Estuary at the Isle of Grain, they have been able to make the following preliminary conclusions:

[78] HR Wallingford (2014). Inner Estuary Airport Call for Evidence. Technical submission by HR Wallingford to Airports Commission. Report No RT01.

- There is a likelihood of minor changes in maximum and minimum water levels associated with the development (the rise in minimum tide levels from a development could be about 40mm. To set this in context as a result of climate change water levels are likely to rise between 200mm and 900mm over the next 100 years. This approximates to around 250mm over an assumed 30 year life of an airport scheme).
- The Airport Platform will alter current speeds and directions (leading to morphological change).
- Wave reflection may increase wave heights on the northern bank of the estuary (opposite the platform), increasing erosional forces in this area.
- Some morphological change of the nearby inter- and sub-tidal areas will occur due to the footprint of the scheme, raised low water levels, and the likelihood of areas of increased erosion and deposition.
- Up to 2,500 ha of morphological change may occur (assuming a 10% change in peak shear stress informed by experience).
- Inter-tidal habitat loss due to increases of minimum tide levels have been provisionally estimated to be 100ha.
- There is a risk of loss of estuary habitats as a result of the footprint of the development (these are discussed in section 4).
- If the footprint of the airport platform was to be reduced (or the shape of the platform), or less of footprint extended beyond the existing flood defences, the impacts would be proportionately less.

It is important to stress that this is provisional work only and that no sediment sampling has been undertaken, nor sediment modelling. Sediment plume studies have not been undertaken either. HR Wallingford have also referred to the potential impacts from construction sequence and in particular from associated dredging to facilitate reclamation.

The report concludes that the changes cannot be mitigated in their entirety and that an airport option is likely to lead to a magnitude of change not seen in the Inner Thames Estuary for more than 100 years.

Call evidence submission from TfL (May 2014)[79]
The TfL Report by ABP Marine Environmental Research Ltd (ABPmer) provides an overview of the likely compensation requirements associated with the Inner Thames Estuary Option for an airport hub. This includes reference to indirect impacts on ecological receptors arising from potential changes to physical processes. The Report is based on a 'numeric hydrodynamic (water level) modelling exercise' and does not appear to be based on the widely used HR Wallingford Thames Estuary 2D base model. The ABP Report comprises a strategic approach and in addition does not account for any additional changes to the morphological or hydrodynamic regime of the estuary (such as waves and sediment erosion / deposition). In this sense it appears to have a less comprehensive scope than the HR Wallingford Report. The ABPmer work on indirect losses does not take account of additional changes to the morphological or hydrodynamic regime of the estuary (such as waves, sediment erosion and deposition). With the proviso that improved resolution of modelling is required to reduce uncertainty in their findings, the Report concluded:-

[79] New Hub Airport: Isle of Grain - Mayor of London Submission July 2013

- 20mm reduction in high water and a 10mm increase in low water (this is less than suggested in the HR Wallingford Report).
- That the predicted indirect losses associated with change in water levels are estimated to be less than 5% of the direct losses of inter-tidal, transitional and sub-tidal habitat under the direct footprint.
- That the potential changes to inter-tidal extent as a result of changes in water levels with the airport in place (under a worst case scenario using the assumption in their study) is about 70 ha (this compares with a figure of 100ha given in the HR Wallingford Report)

As the scope of the ABPmer study would appear to be limited, they do not provide an observation on an estimated additional habitat loss due to morphological change (which HR Wallingford estimate to be 2,500 ha). The ABPmer study also alludes to the fact that compensatory habitats (such as those created through managed realignment) can significantly impact on the hydrodynamics / sediment regime and that an impact assessment is likely to be required. The Study does not take account of cumulative and in-combination impacts with other relevant plans or projects.

Differences in the approach and assumptions between the HR Wallingford and ABPmer studies may explain the differences in results. The ABPmer study is less comprehensive than the HR Wallingford work in terms of the parameters examined. Both studies conclude the need for further work in order to reduce uncertainty.

Recommendations on further work

Further work would be required to determine the precise impacts of an airport development. At the stage of environmental impacts assessment then a combination of tools and techniques are likely to be required, including:

- Geomorphological Expert Assessment;
- Hydrodynamic modelling;
- Sediment analysis;
- Sediment modelling;
- Historic bathymetric analysis;
- Historical trend analysis; and
- Sediment plume analysis.

(ii) Fluvial Processes: Geomorphology, Hydraulics and Sediments

Sources of Impact

The watercourses on the Hoo Peninsula are likely to be significantly affected by the airport development. Potential sources of impact and impacts in the operation phase include impervious surfaces (runways, terminals, car parks), drainage network changes and culverting and changes to:

- Surface water runoff;
- Flow velocities;
- Frequency and duration of flooding;
- Bed/ bank stability;
- Erosion/ sedimentation patterns;

- Bed load; and
- Riparian drainage.

Potential impacts
Any alteration to Estuary processes, including the tidal prism, could have an impact on the transitional sections of the fluvial systems associated with the Estuary. As a result, possible changed levels of saline intrusion into the fluvial system could vary, locally altering the mixing zone of saline and fresh water. As a consequence the existing receptors could be impacted. Smaller watercourses could be most impacted, particularly if they currently freely flow into the Estuary rather than through a sluice mechanism. Changed estuarine processes could also change sedimentation patterns in the lower sections of watercourses impacted by the tide.

The use of artificial structures in developments and replacement of earth channels with man-made materials (such as concrete) also impacts natural processes, reducing the likely groundwater connectivity relevant under the WFD (impacting the baseflow[80] of the channel) and causing discontinuance in the bed profile and bank stability.

Consequential Impacts
Such changes lead to potential impacts on the ecology, including:

- Altered habitats;
- Loss of habitat;
- Changed species diversity;
- Loss of sensitive species;
- Changed animal and plant biomass; and
- Effects on fish spawning.

(iii) Other Related Impacts

Erosion processes leading to alterations to the composition of surrounding saltmarshes may also alter the estuarine water quality, as these inter-tidal zones are thought to be significant sources of pollutants[81]. This is primarily as a result of following reasons:

- Tidal velocities are reduced which can cause pollutant-bound sediments to fall out of suspension; and
- Saltmarsh vegetation has the ability to intercept pollutants from the water column.

[80] Baseflow is the portion of stream flow that comes from groundwater.
[81] Jones, L., Angus, S., Cooper, A., Doody, P., Everard, M., Garbutt, A., Gilchrist, P., Hansom, J., Nicholls, R. J.,Pye, K., Ravenscroft, N., Rees, S. Rhind, P. and Whitehouse, A. (2011). Coastal margins: UK National Ecosystem Assessment Technical Report. United Nations Environment Programme World Conservation Monitoring Centre (UNEP-WCMC), Cambridge.

The presence of a new airport development could lead to the disruption of the source-sink pathways of pollutant-bound sediment directly, through placing the development on the saltmarsh, or indirectly by altering estuarine hydrodynamics and applying additional pressure on the inter-tidal zone (causing sediment entrainment / disturbance). A major concern of the London Gateway Port Development was the potential for suspended sediment impacts on cockle beds along the Essex shoreline.

Similarly, any changes to the hydrodynamics of the Estuary could have the potential to entrain polluted sediments or heavy metals.

5.3.3 Specific Potential Implications under the Water Framework Directive

The following watercourses are classified under the legislation transposing the Water Framework Directive and Floods Directive into UK Law:

WFD Water Bodies

- Dry Valley south of Gravesend (River).
- Tributary of Medway Estuary at High Halstow (River).
- Tributary of Medway Estuary at Kingsnorth (River).
- Damhead Creek (River).
- Thames Estuary (Estuary).
- Medway (Estuary).
- Unnamed - Buckland Lake (Lake).
- North Kent Medway Chalk (Groundwater).

Main Rivers

- Hingham Creek.
- Cliffe Fleet.
- Decoy Fleet.
- Buckland Fleet.
- Hope Fleet.
- Salt Fleet.

Potential direct operational impacts to specific European designated water bodies have been detailed previously in Section 5.2.2, including both estuarine and riverine environments. Connection of fluvial and estuarine water bodies means that a hub airport would have an impact on the Estuary even with a footprint entirely on the Hoo Peninsula (or vice versa with a footprint mainly within the estuary). For example alteration of sediment processes in a fluvial system, would potentially extend downstream into the Estuary. Deterioration in water body status (i.e. the biological, physico-chemical and morphological elements) is defined under the Water Framework Directive. Deterioration could be as a result of a number of the direct impacts described in Section 5.3.1 occurring.

Table 5.3 provides an approximate indication of the differences in the losses of water bodies between the potential airport hub location options. The minimum area

of the Thames Estuary that could potentially be lost is 0.24 km^2 with the maximum area being approximately 23.39km^2. The minimum length of the riverine environment within the study area that could potentially be lost is approximately 11.45km and the maximum approximately 35.77km.

Table 5.3: Approximate Area and Length of Designated Sites Directly Impacted by Footprint of Options

	IAAG	Foster + Partners	Isle of Grain Option	TFL	Metrotidal Mid-Range Option
Fluvial (Riverine) Environment (km)					
WFD Rivers	2.88	0	0	0.73	1.54
Main Rivers	19.83	7.0	9.01	13.31	3.64
Other Water Courses	13.06	11.51	10.29	12.49	6.27
Total	35.77	18.51	19.3	26.53	11.45
Estuarine Environment (km^2)					
Thames Lower WFD Water Body	0.24	13.31	13.13	23.23	19.82
Medway WFD Water Body	0	0.77	0.03	0.16	0
Total	0.24	14.08	13.16	23.39	19.82

In general it can be seen that the airport options affecting fewer rivers intrude more into the Thames (and in one case the Medway estuary). It is unlikely that any other location would be significantly outside the range of impacts represented by the proposed options.

5.3.4 Sensitivity of Siting

The following sections provide a high level description of potential geomorphological impacts arising from an airport proposal affecting the Hoo Peninsula. The precise nature of such impacts would be dependent on the exact location of the airport, its footprint and possible design of mitigation.

As a general 'rule of thumb' it is most likely that the greater the encroachment into the estuary then the greater the sum of potential impacts on hydrodynamics and geomorphology of the estuary. Subject to quantification, a reduced estuary width would be likely to result in higher velocity flows and changes to sediment dynamics (accretion and erosion) and channel position (this statement is supported by the HR Wallingford Report[82], which assumes a reduction in cross-sectional area of 20% at low water and 27% at high water). For a large encroachment possible morphological changes to the Estuary could include changed patterns of tidal erosion and sedimentation altering the bathymetry and location of the channel which could also lead (in concept) to further secondary impacts on navigation (the HR Wallingford Report gives a scenario of a development 370m from the navigation channel at the closest point). The degree of encroachment would therefore impact on an assemblage of receptors detailed in Section **Policy and Legislative Context**4.4.

[82] HR Wallingford (2014). Inner Estuary Airport Call for Evidence. Technical submission by HR Wallingford to Airports Commission. Report No RT01.

Also the greater the encroachment of a footprint into the estuary then the greater the area of the WFD Thames Estuary water body likely to be impacted.

Locating the airport closer to the mouth of the Estuary (on the north-west or north-east of the peninsula) could potentially alter the tidal hydrodynamics by constraining the width of the channel. It is possible that this could lead to increased velocities and changes to tidal flow patterns putting additional pressure on the surrounding coastline, existing sea defences and fluvial systems inland (possibly requiring further investigation).

5.3.5 Sensitivity of Future Baseline

Likely changes related to climate change, flood risk management and development pressure all have potential to increase the sensitivity of the study area affected by an airport development. In the future there could be changes in the geographical extent of the Thames Estuary Natura 2000 Sites, and changes of physical processes affecting specific ecological receptors. The TE2100 plan details the anticipated effects of climate change on the Estuary, with the tidal impacts expected to include rises in mean sea level, peak surge tide level and wave heights. Whilst current rates of sea level rise are anticipated to be low, there is a particular concern over the uncertainty of this rate. In addition, due to expected higher winter rainfall, there is anticipated to be additional pressure on Natura 2000 Sites from freshwater flood flows from the Thames tributaries.

5.4 Secondary & Cumulative Effects

In association with the direct operational impacts detailed in Section 5.3.1 and 5.3.2, the following provides details of some of the key potential secondary (indirect or induced) impacts. Potentially a secondary impact can have a greater impact than the primary impact that induces it.

(i) Secondary Impacts on Morphological Features

A hub airport with a footprint on the Hoo Peninsula and encroachment into the Thames Estuary has the potential to cause direct changes to the flows and sediment dynamics of both the fluvial and estuarine environments, with the systems attempting to gain new equilibria. Any changes could lead to associated secondary impacts such as mobilisation of sediments, which could be potentially deposited on more distant Natura 2000 sites (namely inter-tidal areas). The volume and quality of the sediment would determine the precise impact on important habitats, potentially in both the ebb and flow direction of the tides. For example there could be a risk of exposure of contaminated bed sediments in the estuary, potentially re-mobilising contaminants attached to the sediment. Also, there could potentially be the release of sediments from impacts on fluvial water bodies, extending beyond downstream reaches to the estuary itself.

Changes to the sediment dynamics (through patterns of erosion or accretion) could also potentially have other secondary effects, including:

- Navigational routes through the estuary;
- Pressures on existing flood defences; and
- Suspended sediment concentrations.

(ii) Changes to Water Levels

A hub airport involving a degree of encroachment into the Estuary could also have a potential impact on the tidal prism dynamic (for example, on the nature and duration of tidal incursion on inter-tidal areas). Altered water levels within the Estuary could also impact on the fluvial flows (for example, a higher water level at a high tide could cause some degree of tide lock to water bodies on the Hoo Peninsula and elsewhere). This could potentially have a secondary impact on flood risk (see Section 6) but also might cause ecological changes through changed geomorphological processes, including on adjacent Natura 2000 (inter-tidal) sites.

(iii) Potential Compensatory Requirements

For compensation under Natura 2000 there could be a requirement for compensatory habitat, required over a several thousand hectares (see Section 4.7). These features (possibly new inter-tidal and sub-tidal areas) would be likely to have a potential impact on the hydrodynamics and geomorphology of the estuary or coast they are located in depending on their location. This would require further assessment.

5.5 Compensation and Mitigation

(i) Construction Phase

During the construction phase it is also assumed that Best Practice(s) would be adhered to. A particular issue typical of most developments during construction is the release of fine silt to water bodies (the HR Wallingford Report[83] identifies the need for further work on sediments, including sediment plume modelling). Effective mitigation of sediment deposition includes implementation of Method Statements, following the Environment Agency Pollution Prevention Guidelines. For the London Gateway Port Development a detailed Monitoring and Mitigation Plan was devised in conjunction with statutory, non-statutory and other groups, facilitating a consensus approach to this issue.

(ii) Operational Phase

It is assumed that during the planning and design phases of a hub airport scheme that good practice would be followed to ensure adequate mitigation measures were in place. For example it is assumed that an airport design would meet current standards and incorporate suitable sustainability measures, such as Sustainable Drainage Systems (SuDS), attenuation ponds and methods of filtering the drainage from the site. This would attenuate the flow and filter out sediments that would otherwise enter fluvial water bodies and / or the estuary itself. Future monitoring would most likely be required by Regulators to determine the effectiveness of mitigation measures.

Any impact to a WFD water body requires the provision of at least like-for-like mitigation / enhancement on the same water body. If this is not feasible the work must take place within a river catchment and / or coastal water body (as applicable) to ensure that no deterioration in water body status is experienced. Such mitigation

[83] HR Wallingford (2014). Inner Estuary Airport Call for Evidence. Technical submission by HR Wallingford to Airports Commission. Report No RT01.

measures and enhancement methods would need to be taken into account for all impacts (within the Estuarine or fluvial water bodies).

A number of exemptions apply if the provision of suitable mitigation is not achievable on a WFD water body. These are set out in Article 4 of the Water Framework Directive. Article 4.7 specifically details an exemption when/if a deterioration is caused in the status of a water body as a result of physical modifications. Such modifications could include culverting, loss of a watercourse or creation of a concrete channel. To establish if a development is acceptable under an Article 4.7 exemption, the scheme has to consider the following steps and a comprehensive justification for each needs to be provided:

- All practicable mitigation measures have been considered and taken on-board;
- There are reasons of overriding public interest or the benefits to human, health, safety or sustainable development that outweigh the benefits in achieving the WFD objective;
- There are no better alternatives for the development; and
- The reasons for the physical modification are explained in the relevant river basin management plan and suitable means for improving the water body are considered in the next phase of the WFD[84].

In some instances it may be applicable for more than like-for-like mitigation to be implemented as a result of a modification to the estuarine or riverine environment, requiring assessment once a development is established.

5.6 Risks

There are some risks associated with the development of a hub airport affecting the Hoo Peninsula, including:

- Construction: temporary works in estuaries can often have the most impact, with rapid change occurring as a result of works such as causeways and coffer dams. The HR Wallingford Report[85] stresses the importance of carefully planned construction sequencing in estuarine environments to reduce potential impact;
- Dredging: reclamation of land to build a hub airport out into the Estuary could require a substantial amount of sediment. The source of the dredging of this sediment is largely unknown to date and as a result this is a risk. If the dredgings are to be taken from within the Thames Estuary in the proximity of the scheme, this could have impacts on the sediment and flow dynamics as well as the stability of the surrounding sub-tidal area;
- Changes to physical processes: this report has taken a generic approach to detailing the potential impacts on the changes to the physical processes within the Estuary and associated watercourses, due to uncertainty at this stage of the exact location of a development. Consequently exact changes

[84] MMO, (2012) http://www.marinemanagement.org.uk/licensing/supporting/water.htm
[85] HR Wallingford (2014). Inner Estuary Airport Call for Evidence. Technical submission by HR Wallingford to Airports Commission. Report No RT01.

to physical processes and the resulting impacts could vary from those detailed in this review. Specific information would be needed to make a more robust assessment; and

- Compensatory habitat requirements: potentially significant hydrodynamic, morphological and sediment impacts arising from a requirement for large areas within the Estuary (although it is noted that compensatory measures could be implemented elsewhere in UK under Natura 2000)

5.7 Summary

It is important to understand the potential effects of development on physical processes of both estuarine and fluvial systems. Changes to physical processes during construction and in the operational phases could lead to consequential ecological changes, including direct and indirect impacts on Natura 2000 Sites. Compensation and mitigation measures would need to be in place for the Thames Estuary. Some of the potential impacts on the estuary could be mitigated to a degree but there is a likelihood of long-term permanent changes, potentially including significant adverse effects..

During the construction phase it is assumed that best practices would be adhered to for all activities to minimise the release of sediment into the environment. However it is known from published experiences that estuarine environments are particularly sensitive to construction and therefore careful construction sequencing would be required to mitigate impact as far as possible.

Changes to the estuary geomorphology and hydrodynamics caused by an airport development are likely to arise from encroachment into the estuary. The following potential changes could relate to :

- Tidal prism;
- Wave reflection;
- Sediment deposition;
- Sediment entrainment; and
- Bank erosion.

Potential consequential ecological impacts in inter-tidal and sub-tidal areas include changed habitats and species composition. Changes to the tidal prism could also alter the duration and extent of inundation.

HR Wallingford[86] reported that there is only a likelihood of minor changes in maximum and minimum water levels due to an airport development in their scenario of airport development, with an inter-tidal loss of about 100 ha. However the study also indicates current speeds and directions would be altered, potentially leading to an indirect loss of 2,500 ha of inter-tidal habitats. Wave reflection could increase wave heights on the northern bank, potentially causing erosion.

[86] HR Wallingford (2014). Inner Estuary Airport Call for Evidence. Technical submission by HR Wallingford to Airports Commission. Report No RT01.

Any alteration to estuarine processes could have an impact on the transitional sections of the fluvial systems associated with the Estuary, including the extent of saline intrusion and changed sedimentation patterns. Such changes in processes are also likely to have ecological implications. However there would be several sources of impact on fluvial systems arising from a development partially located on the Hoo Peninsula, including impervious surfaces (runways, terminals, car parks), drainage network changes and culverting and changes impacting:

- Surface water runoff;
- Flow velocities;
- Frequency and duration of flooding;
- Bed/ bank stability;
- Erosion/ sedimentation patterns;
- Bed load;
- Groundwater connectivity; and
- Riparian drainage.

If a particular airport footprint affects a number of WFD water bodies, including rivers, estuaries, groundwaters and lakes, there would be the potential for deterioration of the hydromorphological quality of those water bodies. Cumulatively (that is, considering ecological, physico-chemical and hydromorphological elements) this could impact the ecological status of the water bodies. It would then be necessary to determine whether the status of all the quality elements deteriorated from one status class to another, and whether any changes prevented the water body from achieving good ecological status / potential. If there were to be the prospect of a scheme not being in line with the WFD principles, it is possible that an Article 4.7 exemption route could be required. This would invoke a series of tests to determine whether the development would be applicable for an Article 4.7 exemption, bypassing the normal WFD requirements.

The precise magnitude of impact of an airport development depends on where the airport is located, its footprint and detailed design. The greater the encroachment into the estuary, for example, the greater the potential impacts on the estuary.

Further studies would be needed to determine the precise nature and extent of potential impacts on the estuary and fluvial watercourses and the requirement for mitigation and compensation.

6 Flood Risk

This section covers:

- Policy and legislative context
- Baseline: current and future flood risk management
- Climate change and flood risk
- Potential impacts from an airport hub development
- Mitigation and compensation
- Summary

Consultation comments on the study ToR requested that flood risk implications were considered along with the impacts on the Estuary processes and morphology. Flood risk and mitigation measures that might need to be taken to manage flood risk for an airport development are recognised to be closely linked to the changes to the geomorphology of the estuary and impacts on habitats and designated sites and requirements for compensatory habitat creation.

This section considers the relevant policy and legislative context; the management of flood risk within the estuary and the area of development; key regional and local flood risk management plans; the potential impact of airport development on flood risk management; the need for flood risk assessment; and potential scope for mitigation.

In general, potential sources of flooding are:

- Fluvial flooding from designated Main Rivers – high flows in rivers overspilling river channels into floodplain;
- Coastal and Estuarine Tidal flooding including high tides, storm surges and, in estuaries, combinations of high tides and high fluvial flows;
- Surface water flooding: from overland flow, ordinary watercourses and surface water drainage systems;
- Groundwater flooding; and
- Sewer flooding.

A development on an estuary that intrudes into the natural floodplain may impact on the levels of fluvial and tidal flooding elsewhere in the estuary. The development area itself would clearly require a drainage system sized appropriately to ensure continued operation in extreme rainfall events with due consideration to the need to prevent an increase in flooding in adjacent areas.

The **Operations Viability Report (Study 2)** considers how flood risk would need to be addressed in the design and operation of a new hub airport, whereas this report focuses on the implications of an airport on the wider flood risk for the estuary. In this context, it is primarily the effect of tidal flooding which needs to be considered, the implications of other sources of flooding being essentially limited to the area of the airport itself and associated areas of development.

For this report, the key issue for the airport development options is whether they would increase flood risk elsewhere on the Thames or Medway estuaries, what mitigation would be required and what the implications would be for the designated sites in the estuaries.

6.1 Policy and legislative context

The Flood Risk Regulations (2009) transposed the EU Floods Directive (2007/60/EC) into England and Wales law. These regulations require designated Lead Local Flood Authorities (LLFAs) to prepare:

- Preliminary Flood Risk Assessments, which identify Flood Risk Areas
- Flood Hazard Maps and Flood Risk Maps for main river, tidal, reservoir and other sources of flooding
- Flood Risk Management Plans

The responsibilities for the management of floods in England are set out in the Floods and Water Management Act 2010, which consolidates the provisions of the Flood Risk Regulations, and establishes the Environment Agency in a Strategic overview role to coordinate the planning and management of all sources of flood risk across the country. The Environment Agency is responsible for producing a National Flood and Coastal Erosion Risk Management Strategy covering flooding from main rivers and the sea. Lead Local Flood Authorities (LLFAs) are responsible for producing local flood risk management strategies, including flooding from ordinary watercourses, surface water and groundwater. In the case of the Hoo Peninsula, Medway Council is the LLFA.

The National Planning Policy Framework (NPPF - 2012), as published on the Government planning portal[87], sets out the Government's planning policies for England and how they should be applied. This includes specific planning practice guidance on flood risk and coastal change[88], which replaces Planning Policy Statement 25, and defines the requirements for flood risk assessments for Local Plans and development planning applications. This presents a sequential, risk-based approach to guide development away from medium and high flood risk areas (Flood Zones 2 and 3) and other areas affected by other sources of flooding where possible. Where avoiding development within these flood risk zones is not possible, an Exception Test needs to be passed which requires demonstrable wider sustainability benefits to the community with a scheme that is safe over its lifetime with due regard to the vulnerability of its users, without increasing flood risk elsewhere, and where possible reducing overall flood risk.

A section of the Environment Agency's Flood Zone map covering the Hoo Peninsula and part of the Thames and Medway estuaries is shown in Figure 6-1. As can be seen, large areas of the peninsula lie within Flood Zone 3, indicating that these areas are at risk of flooding in events with an annual probability of 1 in 200 or greater.

87 http://planningguidance.planningportal.gov.uk/blog/policy/

88 Flood risk and coastal change guidance: update 06/03/2014 http://planningguidance.planningportal.gov.uk/blog/guidance/flood-risk-and-coastal-change/

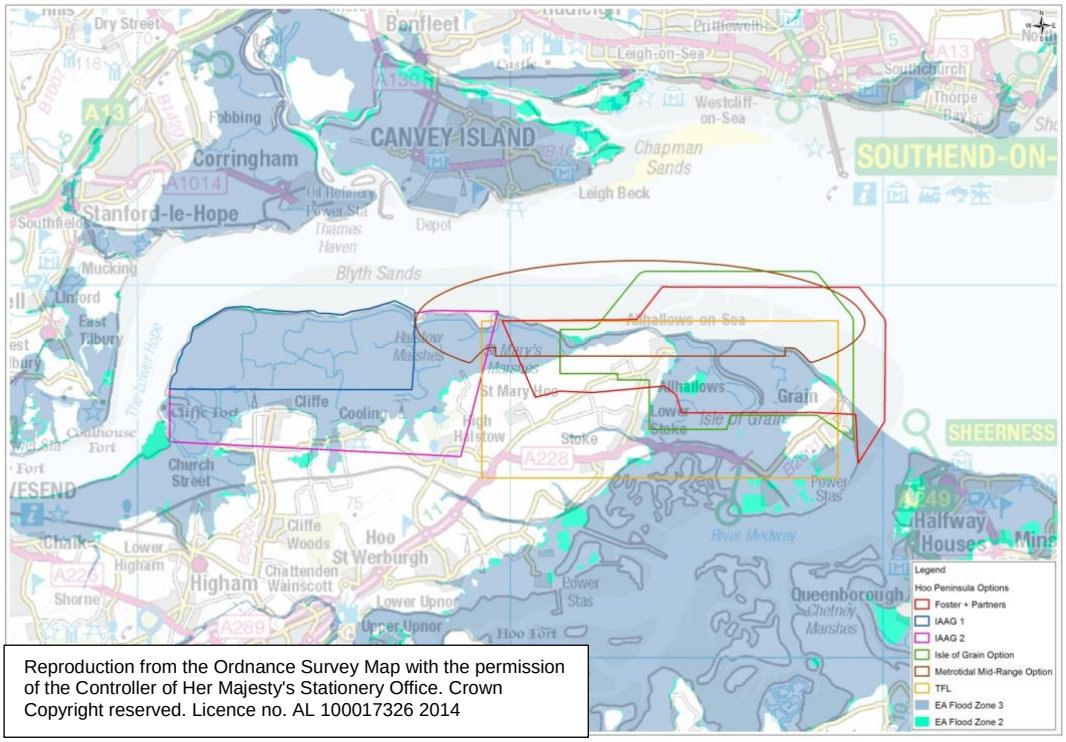


Figure 6-1: Flood Zones and the Airport Footprints

6.2 Baseline: Current and Future Flood Risk Management

There are a number of regional and local strategies and plans relevant to current and proposed management of flooding risk around the Hoo peninsula in the Thames and Medway estuaries:

- Thames Estuary 2100 Plan (2012)
- North Kent Rivers Catchment Flood Management Plan (CFMP) (2009)
- Medway Estuary and Swale Shoreline Management Plan (SMP) (2010)
- Isle of Grain to South Foreland SMP Review (2010)
- Medway Flood Defence Strategy, Strategic Flood Risk Assessment (2006) and Addendum (2011)
- High Level Appraisal of Potential Solutions to Management Flood Risk in the Urban Medway (Feb 2011)
- Medway Council Local Flood Risk Management Strategy (LFRMS) (2014)

These strategies and plans are discussed in terms of how they propose to address current and predicted flood risk as part of the current baseline and future baseline environment.

The management of the tidal defences on the Hoo Peninsula together with the main rivers that drain the North Kent marshes and the isle of Grain are the responsibility of the Environment Agency.

The responsibility for surface water flooding is distributed between the Medway Council, the Highways Agency, Southern Water and the riparian (riverside) owners. In the northern part of the Hoo Peninsula, there is an extensive network of small channels and watercourses which are not designated as main river. In accordance with the provisions of the Medway Local Flood Risk Management Strategy, these are considered to be the responsibility of the Medway Council, the Lower Medway Internal Drainage Board and the riparian owners.

(i) Thames Estuary 2100 Plan

Tidal flooding on the Thames estuary, from Teddington at the tidal limit through to its outer limits, has been extensively investigated in model studies carried out by HR Wallingford for the Environment Agency, the Port of London Authority and other clients. These models have been used in the development of the Thames Estuary 2100 (TE2100) Plan which provides a basis for flood risk management within the estuary to the end of the century, taking into account rising sea levels due to climate change.

Design flood defences levels are set in relation to the results of modelling studies in this integrated process which are linked to and take account of the Shoreline Management Plans.

TE2100 is aimed at protecting London and the people living in the Thames Estuary from flooding now and into the next century. The primary source of flooding in the Thames estuary is tidal. The main focus of the plan is the management of tidal flood risk, which forms the main source of flood risk to the communities involved, adopting an integrated approach with climate change adaptation at its core.

In London and the Thames estuary, climate change is considered likely to affect:

- average sea and tide levels;
- the frequency and severity of North Sea storm surges; and
- fluvial flows coming down the Thames and its tributaries.

In the work for TE2100, the range of uncertainty in the predictions on sea level rise was recognised to be very wide and to potentially lead to a large variation in the level of future flood risk management planning and therefore large associated differences in costs. This is issue addressed further in Section 6.3.

In terms of extent, TE 2100 covers the tidal Thames from Teddington to Sheerness, to the east of the Hoo Peninsula, including the potential sites for airport development under consideration in this report. The plan is linked to the CFMPs for adjacent catchments and to SMPs in Kent and Essex.

Information presented in the TE2100 Plan confirms that substantial areas of the Hoo Peninsula, on which the airport development schemes would be sited, are within Flood Zone 3, in areas currently benefiting from existing tidal defences. The plan underlines the significance of surges in the North Sea as a major risk to the TE2100 area and along with the uncertainties over the predictions for storm surges. The plan anticipates rising flood levels caused by climate change and recognises the uncertainty in the predictions for sea level rise including worst case scenarios. In response the Plan, adopts a managed adaptive approach, involving maintaining and

improving the existing system, which defers the need for investment in a new tidal barrier to 2070.

The plan envisages the development of 876ha of new habitat to compensate for the intertidal habitat that will be lost due to sea level rise over the same period of time. Several of the identified sites for habitat creation are on the Hoo Peninsula and conflict with the proposed airport development schemes (this is discussed in section 4.7).

The TE2100 Plan identifies a number of Action Zones, two of which involve the Hoo Peninsula and are relevant for the proposed airport development proposals:[89].

Action Zone 6 includes the North Kent Marshes policy unit, which includes the extensive areas north of the village of Cliffe forming the Cliffe and Halstow freshwater marshes. This area is at risk of flooding in a 1 in 100 (or 1%) annual probability tidal flood event or greater. The policy adopted for this area is P3, which envisages maintenance and repair of defences but no defence raising. Floodplain management is envisaged, with improved flood forecasting and warning and a flood emergency plan for evacuation. The policy unit includes an area identified for habitat creation.

Action Zone 7 includes the Isle of Grain policy unit, which consists of the Allhallows and Grain freshwater marshes to the west and an industrial area to the east. This area is at risk of flooding in a 1 in 200 (or 0.5%) annual probability tidal flood event or greater. The policy adopted for this unit is P4, involving the raising of defences for the eastern half and realignment for western half by breaching the defences to create replacement intertidal habitat.

(ii) North Kent Rivers Catchment Flood Management Plan

The North Kent Rivers CFMP covers the south bank of the Thames estuary, from Dartford to Faversham, encompassing the Hoo Peninsula and the Isle of Sheppey. It includes the tidal reach and estuary of the River Medway, from the tidal limit at Allington. The southern limit of the CFMP area is the ridge along the top of the North Downs. The CFMP establishes a number of sub-areas to each of which are assigned specific flood risk management policies.

Sub-area 5, referred to as the North Kent Downs, extends into the Hoo Peninsula as a ridge of high ground which contains the main settlements. This is assigned Policy 1, representing an area of little or no fluvial or tidal flood risk with a commitment to monitor and advise.

Sub-area 4 is referred to as the North Kent Marshes and includes the majority of the area on both banks of the Medway estuary, including the Isle of Grain which forms the eastern end of the Hoo Peninsula and the marsh area on the western side of the peninsula. This area is assigned Policy 3, which presents an area of low to moderate risk of flooding where the current level of risk will be maintained but impacts of flooding may be expected to increase in the future due to climate change.

[89] Environment Agency: TE2100 Plan November 2012: https://www.gov.uk/government/publications/thames-estuary-2100-te2100

The footprint of the various airport options lies predominantly in sub-area 4, with two extending into sub-area 5.

(iii) Shoreline Management Plans

Shoreline Management Plans (SMPs) are tasked with identifying policies to manage coastal flood and erosion and provide the basis for developing Strategy Plans to put these policies into practice on the basis of economic analysis and environmental assessment, leading ultimately to the development of schemes for specific locations.

The Isle of Grain to South Foreland SMP[90] and the Medway and Swale Estuary SMP[91] were prepared in parallel, both of which include policy units on the Hoo Peninsula. The Isle of Grain to South Foreland SMP includes one policy unit on the Isle of Grain (4a01). The Medway Estuary and Swale SMP includes policy units covering the whole of the Medway Estuary extending out to link with policy unit 4a01. The policies for those units from these two SMPs that lie within the footprint of the airport development schemes summarised below.

Unit Number	**Frontage**	**Preferred Policies**		
		Short term	Medium term	Long term
4a01	Allhallows-on-Sea to Grain (south)	Hold the Line	Managed Realignment	Managed Realignment
E4 01	Grain Tower to Colemouth Creek	Managed Realignment with localised Hold the Line		
E4 02	Colemouth Creek to Bee Ness Jetty	Hold the Line.		

The western coastline of the peninsula, from Allhallows to Cliffe and on towards Gravesend, which includes the North Kent Marshes, is not covered in any published SMP. However, this area is covered by Action Zone 6 of the TE2100 Plan.

(iv) Medway Strategic Flood Risk Assessment

The Medway SFRA was first produced in 2006. An SFRA model of flood risk was developed to evaluate the consequences of a wide range of flood events taking into account the presence of local flood defences. Maps of inundation for 1 in 200 and 1 in 1000 events were produced to assist in planning purposes. These are distinguished from the Environment Agency's Flood Zone maps which do not account for the presence of local flood defences.

The study focused on the flood risk to 15 areas targeted for development under the Medway Waterfront Renaissance Strategy plus the new settlement of Chattenden. All locations are upstream of Lower Upnor and Gillingham waterfront, 8km or more to the south of the proposed new airport developments.

[90] Halcrow (2010a) Isle of Grain to South Foreland Shoreline Management Plan Review.
[91] Halcrow (2010b) Medway Estuary and Swale Shoreline Management Plan.

An Addendum to the SFRA was produced in 2011 to take advantage of updated modelling information and in the light of revised policy provided in Planning Policy Statement 25 (now replaced by the NPPF Planning practice guidance on Flood Risk and Coastal Change). The Addendum provided updated information for the 16 sites considered previously and on the development of site-specific Flood Risk Assessments. This was accompanied by a High Level Appraisal of Potential Solutions to Management Flood Risk in the Urban Medway[92], which considered the status of present flood defences, modelled the damages from overtopping by flooding, undertook cost-benefit analysis of mitigating works and provided a strategy for implementation. It is worthy of note that all of the defences would be overtopped in the 1 in 200 year event.

(v) Medway Council Local Flood Risk Management Strategy

The recent Medway Council Local Flood Risk Management Strategy (LFRMS)[93] has considered the risks and management of flooding from surface water, groundwater and ordinary watercourses within the Hoo Peninsula and throughout the remainder of the Medway unitary authority area.

The Medway LFRMS provides an overview of local flooding problems within the Medway area as a whole, including the Hoo Peninsula; considers the roles and responsibilities for management of flood risk, including the role of developers; identifies the objectives of flood risk management; develops a set of measures for flood risk management consistent with the established objectives for implementation in the short, medium and long term; reviews sources of funding for these measures; and considers how the measures to be taken will contribute to wider environmental objectives. The document refers to the forthcoming development of a Medway Council Surface Water Management Plan (as of January 2014). This has not been published to date.

The assessment of groundwater flooding risk[94] for the Medway LFRMS identifies the Hoo peninsula as highly susceptible to groundwater flooding although does not record specific events.

6.3 Climate Change and Flood Risk

NPPF Policy 10, Meeting the challenge of climate change, flooding and coastal change, requires that new developments should be planned to avoid increased vulnerability to the range of impacts arising from climate change. When new development is brought forward in areas which are vulnerable, care should be taken to ensure that risks can be managed through suitable adaptation measures, including through the planning of green infrastructure. Specific guidance on climate change for planners is provided in Guidance to support the National Planning Policy Framework. This provides recommended contingency allowances for net sea level rises specifically for London and the east of England. National precautionary sensitivity ranges for peak rainfall, peak river flow, offshore wind speed and extreme wave height are also provided as indicated in Table 6.1.

[92] Scott Wilson (2011b) High Level Appraisal of Potential Solutions to Management Flood Risk in the Urban Medway.
[93] Capita Symonds / URS (2014). Medway Council Local Flood Risk Management Strategy (LFRMS) (2014)
[94] The High Level Assessment of Groundwater Flooding Susceptibility Final Report October 2013 Medway Council Local Flood Risk Management Strategy Technical Appendix 2

Table 6.1: Recommended National Precautionary Sensitivity Ranges for Peak Rainfall, Peak River Flow, Offshore Wind Speed and Extreme Wave Height

Parameter	1990 – 2025	2025 – 2055	2055 – 2085	2085 – 2115
Peak rainfall intensity	+5%	+10%	+20%	+30%
Peak river flow	+10%	+20%		
Offshore wind speed	+5%		+10%	
Extreme wave height	+5%		+10%	

Note: percentages relate to 1990 values

For major infrastructure plans and projects, climate change should be considered in much more detail than simply applying the recommended allowances. In particular, development of an airport on the Hoo Peninsula must address the uncertainty over the rates of sea level rise through considering different scenarios.

The UKCP09 climate change projections suggest that by 2050 we may see an increase of winter mean temperature of 2.2º C, an increase in summer mean temperature of 2.8º C and a change in precipitation distribution, with a decrease of 19% in summer and increase of 16% in the winter throughout the Southeast (central estimate under a medium emissions scenario, UKCP09).[95]

Following scientific research on ice cap melt presented at the Avoiding Dangerous Climate Change Conference[96] in 2005, a worst case scenario identified as the H++ scenario was devised. This was further developed for TE2100. The range of adaptive flood risk management options in the final plan aim to protect London and the Thames Estuary against all plausible sea level rise scenarios over the next century. These scenarios include the top of the new H++ range for increases in extreme sea levels in the Thames Estuary. A key driver for TE2100 was adaptation to the uncertain effects of climate change, with the prospect of changes in sea level, storm surge height and frequency and river flows. A component of the work was undertaken by the Met Office Hadley centre, the Proudman Oceanographic Laboratory and the Centre for Ecology and Hydrology[97] to look into the uncertainties. Based on this work the following conclusions were made in TE2100:-

- Sea level rise in the Thames over the next century due to thermal expansion of the oceans melting glaciers and polar ice is likely to be between 20 cm and 90 cm.
- There remains a lot of uncertainty over the contribution of polar ice melt to increasing sea level rise. At the extreme, it may cause sea level to rise by a total of up to 2 m (including thermal expansion) – although this is thought be highly unlikely.
- Climate change is less likely to increase storm surge height and frequency in the North Sea than previously thought.

95 Murphy, J.M., et al UK Climate Projections Science Report: Climate change projections. (2009), Met Office Hadley Centre, Exeter

96 http://www.stabilisation2005.com/index.html

97 Lowe, J, et al UK Climate Projections Science Report: Marine and Coastal Projections (2009) Met Office Hadley Centre, Exeter

- 21st century increases in storm surge height and frequency in the southern North Sea are less likely than previously thought.

The implications on flood risk for this study is the potential for:-

- Increased risk of flooding within the Hoo Peninsula and Thames estuary;
- Although a rise by up to 2 metres by 2100 as a result of enhanced melting of the ice sheets is considered very unlikely to occur during the 21st century, it cannot yet be ruled out completely based on current models or observations.
- Sea level rise is likely to result in significant losses of salt marsh and other habitats (including sand dunes, coastal vegetated shingle and mudflats) through coastal squeeze, with increased pressure on coastal defence structures due to reduced wave attenuation by the salt marsh and pressure on active dynamic coastal processes[98];

6.4 Impacts from an Airport Hub Development

6.4.1 Sources of Impact

Key sources of impact for flood risk from an airport development located within the Inner Thames estuary are:

Tidal flood risk

- Airport development intruding into the Thames (or Medway Estuary) which may change the morphology of the estuary and restrict the conveyance capacity of the Thames (or Medway).
- Airport development on the seaward side of existing defences may reduce the volumetric capacity of the estuaries and thus increase tidal levels along the Thames Estuary thereby increasing flood risk elsewhere
- Some aspects of airport development within the currently defended tidal floodplain area (such as an increased level of raised defences) may reduce the capacity of the existing low lying areas to receive flood water from overtopping of defences during extreme events and this may act to increase tidal levels elsewhere.

Fluvial flood risk

- The construction of large paved areas leading to an increase in storm runoff that may increase flood risk in neighbouring areas.
- The construction of the airport may affect drainage routes through the footprint of the development, potentially increasing flood risk in upstream areas.

A further consideration is the potential for both tidal and fluvial flood risks to be affected by assumptions on climate change. Uncertainty over the level of change

[98] Wade, S.D.,et al. The UK Climate Change Risk Assessment Evidence Report. Defra (January 2012). http://www.defra.gov.uk/environment/climate/government/risk-assessment/# evidence

and how these factors combine for example also needs to be considered in planning major infrastructure development[99].

The standards of flood protection for the airport and airport design to address tidal and fluvial flood risk are important aspects which will influence potential for wider impacts.

(i) Standards of Protection

The impact of airport development on flooding will depend upon the option selected and the details of the particular design. At present, the options are preliminary outline and no detailed flood risk assessment has been provided by the proposers at this stage.

No design criterion for the level of protection of the new airport from tidal flooding has been defined. However, given the importance of the facility, the likely scale of the impact of tidal flooding and the consequence for repair and recovery of operation, a defence level of 1 in 1000 annual exceedance probability (AEP) would be reasonable. This corresponds to the level of protection adopted for the Thames Gateway port recently constructed on the opposite bank of the estuary. It also corresponds to the level of protection provided to London by the Thames Barrier.

Once constructed, the airport would be classed as Critical National Infrastructure (CNI) within the transport sector, in accordance with Cabinet Office (2011)[100]. This report, which considers risk and the four components of resilience: resistance, reliability, redundancy and response/recovery, states that, as a minimum, essential services provided by CNI should not be disrupted by a flood event with an annual likelihood of 1 in 200. No service standard within the transport sector is cited, but it is worthy of note that the energy sector has adopted a target of 1 in 1000 for high priority assets within their CNI. This standard would need to be confirmed during the planning process and will need to take due account of the influence of climate change on the physical works required and future plans for flood defence under the TE2100 Plan. This includes the plan for construction of a new tidal barrier at Long Reach after 2070.

Climate change will lead to an increase in the maximum flood level associated with a 1 in 1000 AEP event largely through sea level rise. The actual defences would need to be designed to accommodate the change but also be designed to accommodate the uncertainty over sea level rise, such as by considering the more extreme scenarios and providing a higher level of protection at the time of construction or allowing for future works to raise the level of defence.

It may be the case that a lower standard of protection could be considered acceptable for surface water flooding of the airport from rainfall over the airport itself and adjacent catchment areas, such as 1 in 200, provided that the design incorporates adequate provision for resilience to flooding together with organisational resilience to respond and recover rapidly from a flood event.

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[99] Wade, S.D.,et al. The UK Climate Change Risk Assessment Evidence Report. Defra (January 2012). http://www.defra.gov.uk/environment/climate/government/risk-assessment/#evidence

[100] Cabinet Office (2011) Keeping the country running: natural hazards and infrastructure. Civil Contingencies Secretariat, Cabinet Office, Whitehall.

6.4.2 Potential Receptors and Pathways

The potential receptors for flood risk in the Thames estuary are:

- Properties, settlements, business and recreational interests and transport and other infrastructure alongside the Thames and Medway estuaries
- Properties and settlements within the Hoo Peninsula and the local river catchments

Potential receptors potentially affected by flood risk changes and mitigation responses to maintain flood protection include:

- Designated sites and habitats and the associated species that may be susceptible to coastal squeeze (see section 2).or saline water intrusion
- Cultural heritage interest

Pathways for impacts include:

- overtopping of defences – due to high tides, storm surges, high flows exceeding channel capacities and wave action
- breaching or failure of defences
- fluvial flows backing up of water on the landward side of defences due to lack of storage or conveyance capacity,
- increased pressure on habitats on seaward side of defences from increased submersion and coastal squeeze effects.

6.4.3 Flood Risk Assessment

The planning process for developments within the Medway Council unitary area are subject to a Flood Risk Assessment as laid out in the Medway Council Strategic Flood Risk Assessment[101]. For developments that lie within Flood Zones 2 and 3, this would involve the Sequential Test, as described previously. The airport options would all occupy large areas of Flood Zone 3. If implemented, they imply the need for substantial changes to the Local Flood Risk Management Strategy.

The scale of the developments is such that, at a minimum, one or more main rivers (Section 5 lists the main rivers and other watercourses affected by the different options) will be affected and tidal defences would need to be modified to provide the level of protection required by an airport, with four of the six options intruding into the Thames estuary. Any such works would require the approval of the Environment Agency, as there is the potential for changes to tidal flood levels, with implications for the shoreline management plans and the wider TE2100 Plan.

6.4.4 Potential Impacts

(i) Tidal Flood Risk Impacts

In principle, the construction of any works that intrude into the Thames estuary will change the hydrodynamics of flow in the estuary and lead to changes in the

[101] Scott Wilson (2011a). Medway Flood Defence Strategy, Strategic Flood Risk Assessment (2006) and Addendum (2011)

maximum water levels over the tidal cycle and during extreme events, such as a storm surge in the North Sea.

The locations affected and the magnitude of the impact today and in the future with predicted climate change cannot be determined without recourse to detailed hydrodynamic modelling using a model such as that used for the TE2100 Plan. However, a general expectation would be that tidal levels would be increased in some locations in the estuary with the possibility of reductions elsewhere.

The obstruction caused by the options built into the estuary would lead to changes in the direction of flow and the velocities within the estuary, with consequences for the pattern of sedimentation and erosion. This is considered in more detail in Section 5 on estuarine processes and geomorphology. The works would therefore lead eventually to changes in the geometry of the estuary. This effect would also lead to changes in the maximum tidal levels within the estuary. The assessment of the impact of these changes on tidal levels would require a detailed understanding of the properties of the material forming the bed of the estuary and in the processes of erosion and sedimentation. Hydrodynamic modelling with a mobile bed may present a suitable method to assess this impact. It may be necessary to obtain samples of the bed material at different locations to undertake this analysis, depending upon what data is presently available.

It is assumed that the airport will be defended from tidal floods with an AEP of up to 1 in 1000 (0.1%). Under these circumstances, all options may be expected to impact on tidal levels elsewhere in the Thames and Medway estuaries in the occurrence of an event with an AEP of greater than 1 in 200 (0.5%).

Preliminary modelling work has been carried out by HR Wallingford (May 2014)[102] to investigate the impact of a hypothetical airport option, on a pro bono basis. The study used a 2D vertically integrated hydrodynamic model, as applied to the TE2100 work, to look at the impact of an example of airport construction on maximum and minimum spring tide water levels along the estuary, and on the speed and direction of flow in the estuary. It also used an open source wave propagation model called SWAN characterised for the Thames estuary with and without the airport option, to assess the impact on waves from two selected directions. The option used for modelling was the Isle of Grain option.

The HR Wallingford report comments that the airport option assessed reduces estuary cross-section by 20% at low water and 27% at high water, with the airport boundary extending 2.1km from the existing line of tidal defence, approaching the deep water navigation channel to within 370m at its closest point. These would constitute significant changes to the hydraulic capacity of the estuary.

The 2D model identified changes in water level at maximum and minimum high water springs, and changes in the maximum spring tide current speed in the vicinity of the airport development suggestive of future morphological changes to the bed. These are conditions that would occur every year. The modelling of extreme tidal events or North Sea storm surges was not carried out. The modelling established a decrease in maximum water level at high water springs of up to 20mm in the vicinity of the airport development in the estuary between the development site and the

[102] HR Wallingford (2014). Inner Estuary Airport Call for Evidence. Technical submission by HR Wallingford to Airports Commission. Report No RT01.

opposite bank, and on the on the seaward side of the development, and in the Medway estuary, with an increase of up to 10mm in the area of north Kent from Herne Bay to Thanet.

These results are indicative and relate only to the Isle of Grain option for events of annual occurrence. Preliminary analysis on wave propagation for the Isle of Grain option suggests an increase in the wave exposure on the north bank by waves reflected from sloping revetment walls surrounding the airport with implications for morphology and flood risk.

All options lie substantially in Flood Zone 3 in areas currently defended with a standard of protection in the range 1 in 100 to 1 in 200 (1%- 0.5%) AEP. Development of these areas with a higher standard of protection may raise flood levels in the estuary for events with an annual exceedance probability in excess of around 1 in 200 (0.5%) as a result of the reduced capacity of the existing low lying areas to receive flood water from overtopping of defences during extreme events.

At this stage no analysis has been carried out on the impact of airport construction on maximum tide levels during North Sea storm surges and extreme events as used for the TE2100 planning such as the 1 in 200 and 1 in 1000 AEP events. This would need to be undertaken with due regard to climate change and sea level rise and may be expected to vary between the airport options depending upon the extent of the intrusion into the Thames estuary and the level of tidal defence adopted. It has been suggested that, based upon analysis carried out for the Thames Gateway port, a relatively low impact on extreme tidal levels is likely, but this remains to be confirmed. No suitable model study to assess the impact of airport development on extreme tidal levels has been undertaken to date.

The morphological changes indicated by the HR Wallingford modelling will act to increase estuary capacity within the channel between the Hoo Peninsula and the opposite bank through increased water velocity increasing habitat erosion. However, in the case of the Isle of Grain airport option, this is unlikely to be sufficient to counter the loss of channel section caused by the construction of the works.

(ii) Fluvial Flood Risk Impacts

Impacts of an airport on fluvial flood risk are limited to the development area itself and potentially on small areas upstream of the development where drainage paths are affected. Compared with the tidal flood risk, the impacts outside of the footprint of the airport are likely to be relatively minor and can be addressed during design development as described in Section 6.4.1 (ii).

Combinations of high tides and high fluvial flows within the Thames and Medway Estuaries are unlikely to be significant issues. The Hoo Peninsula lies near the seaward limit where the fluvial component contributing to water levels in the estuaries will be insignificant compared with the tidal component, particularly for the extreme high water levels which are critical for flood risk aspect.

(iii) Impact of Changes to Planned Compensatory Habitat

As noted above, the TE2100 Plan envisages the development of 876ha of new habitat to compensate for the intertidal habitat that will be lost due to sea level rise. Several of the identified sites for habitat creation are on the Hoo Peninsula and conflict with the proposed airport development schemes. If these sites, which as

managed realignment provide additional volume under flood conditions, are no longer available then there may be an impact on extreme water levels in the estuary unless alternative sites can be made available. These would need to be nearby to have a similar benefit in flood risk terms. This appears unlikely both because of potential 13km birdstrike safeguarding zone (see Chapter 4) and since the TE2100 work found limited realistic potential nearby for such compensatory habitat.

6.5 Mitigation and Compensation

With regard to flooding, mitigation requirements will be related to the specific airport option selected and will be dependent upon the details of the design, including: extent of intrusion into the Thames estuary; the shape in plan of the development; the areas of Flood Zones 2 and 3 covered by the airport; and the design of the flood defences surrounding the airport.

HR Wallingford, in their report, comment that it should be possible to reduce the scale of changes to the estuary regime by refinement of the design, but that it would not be possible to eliminate the changes altogether.

At this stage, the impact of airport options on tidal levels under extreme events remains to be established, so that need for mitigation also remains to be determined.

It is likely that there would need to be changes to tidal defences elsewhere within the Thames estuary, such as the north shore opposite the development due to changes in tidal and wave regimes. These remain to be established and could be accommodated within the scope of the overall airport project. As part of the managed adaptive approach the TE2100 Plan recognises that many of the existing walls, embankments and smaller barriers will need raising and major refurbishment or replacement in the period 2035 -2049. This would provide the opportunity for any marginal increases in defence levels required as a direct result of airport development, although in some localities it may be necessary for such works to be advanced depending on the timing of the airport development.

Flood risk within the airport will be managed at design stage to criteria that remain to be established. This will encompass runoff within the airport development and, where necessary, external runoff from adjacent areas.

6.6 Summary

This report focuses on the implications of an airport on the wider flood risk for the estuary. In this context, it is primarily the effect of tidal flooding which needs to be considered, the implications of other sources of flooding being essentially limited to the area of the airport itself and associated areas of development.

The primary policy document relating to flood risk in the Thames Estuary is the TE2100 Plan. Before an airport development in the Inner Thames Estuary could proceed it would be necessary to undertake extensive modelling studies in order to demonstrate that the airport could be implemented without increasing flood risk elsewhere, and where possible reducing overall flood risk. These studies would need to be similar in complexity to those carried out for TE2100 and would include such aspects as:

- Reduction in both conveyance and storage capacity in the Thames Estuary (and possibly the Medway) as a consequence of intrusion beyond the existing defence lines.

- The hydraulic consequences of long term geomorphological changes as a result of intrusion into the estuary.

- Loss of the managed realignment benefit for extreme flood events of the compensatory habitat areas on the Hoo Peninsula included in the TE2100 plan.

- Loss of the ability of other low-lying defended areas to receive flood water from overtopping in events exceeding the current design standard of the existing defences, which is lower than the likely design standard for the airport.

- A range of potential climate change scenarios, including the extreme H++ scenario to ensure that the design could be adapted in the future.

No analysis has been carried out on the impact of airport construction on maximum tide levels during North Sea storm surges and extreme events as used for the TE2100 planning. However, it has been suggested that, based upon analysis carried out for the Thames Gateway port, a relatively low impact on extreme tidal levels is likely, but this remains to be confirmed.

It is likely that there would need to be changes to tidal defences elsewhere within the Thames estuary. As part of the managed adaptive approach the TE2100 Plan recognises that many of the existing walls, embankments and smaller barriers will need raising and major refurbishment or replacement in the period 2035 -2049. This would provide the opportunity for any marginal increases in defence levels required as a direct result of airport development, although in some localities it may be necessary for such works to be advanced depending on the timing of the airport development.

7 Landscape

This section covers landscape character and visual amenity:

- **Policy & legislative context**
- **Baseline environment –how it is currently and how it might develop in the future.**
- **Potential Impacts from an airport hub development**
- **Mitigation and Compensation**
- **Summary**

Landscape was identified as an additional area to consider through the stakeholder consultation comments on the Environmental Study ToR. This section responds by considering impacts on landscape character and visual amenity in relation to the potential impacts from airport development on the Hoo Peninsula. Landscape character is closely linked to the wider environment particularly ecological value and biodiversity discussed in Section 4 and historic landscape and the setting for heritage assets addressed as part of the Cultural Heritage in Section 8.

Landscape impacts are defined as the changes to physical landscape features and to the overall character of the landscape. These changes can occur over large areas. This section considers potential regional landscape character changes. Visual assessment is the extent of the views of the proposed development from particular locations considered important because of their importance and sensitivity such as nationally designated landscapes or due to the number of people affected. The study area considers the wider Thames estuary context including north Kent and south Essex.

7.1 Policy and Legislative Context

The European Landscape Convention (ELC) was signed by the UK Government in February 2006, becoming binding from March 2007. Created by the Council of Europe, the convention promotes landscape protection, management and planning, and European co-operation on landscape issues. The Convention was reaffirmed as being part of the Defra delivery framework through the Natural Environment White Paper in June 2011.

Nationally important landscapes are protected through the National Parks and Access to the Countryside Act 1949. This act sets out to conserve and enhance certain areas for their natural beauty, including areas designated as Areas of Outstanding Natural Beauty (AONBs).

The National Planning Policy Framework also sets out the policy to protect and enhance valued landscapes. One of the core principles in the NPPF is that planning should recognise the intrinsic character and beauty of the countryside. Local plans should include strategic policies for the conservation and enhancement of the natural environment, including landscape. This includes designated landscapes but also the wider countryside.

All landscapes, regardless of quality or designation, form part of Natural England's Countryside Character initiative. Landscape Character Assessment is a tool to help understand the character and local distinctiveness of the landscape and identify the features that give it a sense of place. It can help to inform, plan and manage change and may be undertaken at a scale appropriate to local and neighbourhood plan-making. Landscape Character Assessments at the national, regional and local levels are typically adopted as Supplementary Planning Documents (SPDs) to support landscape policies in statutory planning documents such as local plans.

7.2 Baseline

7.2.1 Designated sites within the study area

(i) National Landscape Designations

The Kent Downs Area of Outstanding Natural Beauty (AONB) lies to the south of the study area. It is described by the Kent Downs AONB unit as follows:

'The Kent Downs AONB covers 878 sq. km from the White Cliffs at Dover and Folkestone to the Surrey Border. The geology of the area defines the topography and landscape features that form the basis of the natural beauty for which it is nationally recognised. A large arch of chalk, shaped like an eyelid, sweeps across Kent. This creates a central ridge through the county, and forms the most important geological feature of the AONB.'

The primary purpose of AONB designation is to conserve and enhance natural beauty. It is this ridge that provides the vantage point for long reaching views over the Hoo Peninsula and wider Thames Estuary, particularly from open high points on the dip slope where there is limited intervening settlement and vegetation.

There are no national landscape designations north of the River Thames within the study area.

(ii) Local Landscape Designations

Many of the districts/boroughs throughout the study area contain local landscape designations within their adopted Development Plans.

Medway Local Plan (Adopted 2003) contains a number of local landscape designations including Special Landscape Areas (SLA) covered by Policy BNE33 and Areas of Local Landscape Importance covered by Policy BNE34. These policies aim to protect the landscape character and resist development that would harm the landscape. An area of Undeveloped Coast is also defined and covered by Policy BNE45. This aims to protect the scenic value of the coast and resist development in general.

7.2.2 Landscape Character

(i) National Landscape Character

At a national scale, Natural England (NE) have divided England into 159 National Character Areas (NCAs), based on a combination of landscape, biodiversity, geodiversity and cultural and economic activity. The NCA's likely to be affected by the airport proposal are:

- 81 Greater Thames Estuary
- 111 Northern Thames Basin
- 113 North Kent Plain
- 119 North Downs

The Greater Thames Estuary and North Kent Plain would be directly affected by the footprints of the airport proposals and NE summary descriptions are provided below. Their full descriptions and the descriptions of the NCA's in the wider study area can be viewed online[103].

81 Greater Thames Estuary

The Greater Thames Estuary National Character Area (NCA) is predominantly a remote and tranquil landscape of shallow creeks, drowned estuaries, low lying islands, mudflats and broad tracts of tidal salt marsh and reclaimed grazing marsh that lies between the North Sea and the rising ground inland. It forms the eastern edge of the London Basin and encompasses the coastlines of South Essex and North Kent, along with a narrow strip of land following the path of the Thames into East London.

Despite its close proximity to London, the NCA contains some of the least settled areas of the English coast, with few major settlements and medieval patterns of small villages and hamlets on higher ground and the marsh edges. This provides a stark contrast to the busy urban and industrial areas towards London where population density is high and development pressures are increasing. Sea defences protect large areas of reclaimed grazing marsh and its associated ancient fleet and ditch systems, and productive arable farmland. Historic military landmarks are characteristic features of the coastal landscape.

113 North Kent Plain

The North Kent Plain National Character Area (NCA) is the strip of land between the Thames Estuary to the north and the chalk of the Kent Downs to the south. The area is open, low and gently undulating. It is a very productive agricultural area with predominantly high-quality, fertile loam soils characterised by arable use.

It is generally an open landscape: characteristic shelterbelts occur within the fruit-growing areas and the agricultural land is mostly devoid of hedgerows. The area has a strong urban influence, with several built-up areas, including coastal towns and these occupy a substantial part of the area with significant development around London and the Medway towns, which has a strong influence in the west of the NCA. International and European designated habitats are a feature of the coast line the coast, falling either wholly or partially within the NCA.

(ii) Regional & Local LCAs

The Hoo Peninsula is covered at the regional level by the Landscape Assessment of Kent[104] and further sub-divided at the local level by the Medway Landscape Character Assessment[105].

[103] http://www.naturalengland.org.uk/publications/nca/default.aspx
[104] Jacobs Babtie (2004) The Landscape Assessment of Kent - report for Kent County Council.
[105] Medway Council (2011) Medway Landscape Character Assessment, March 2011

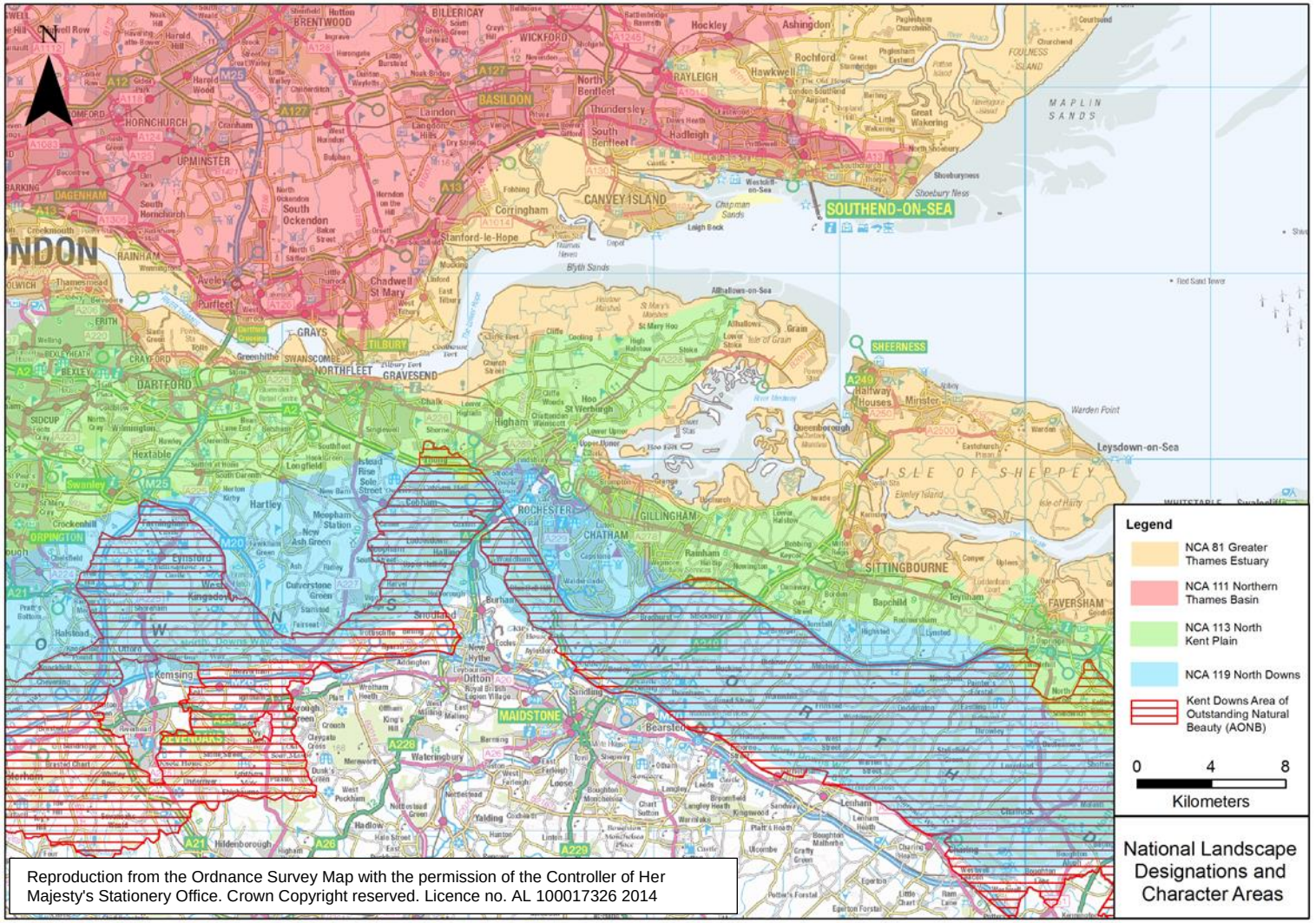

Figure 7-1: National Landscape Designations and Character Areas

Table 7.1: Hierarchy of Landscape Character Areas

NATIONAL	REGIONAL	LOCAL
National Character Areas	**Landscape Assessment of Kent**	**Medway Landscape Character Assessment**
81. Greater Thames Estuary	Eastern Thames Marshes	1. Cliffe Pits and Pools 2. Cliffe to St Mary's Marshes
	Medway Marshes	3. Allhallows to Stoke Marshes 4. Hoo Flats 5. Riverside Marshes 6. Motney Hill
113. North Kent Plain	Hoo Peninsula	7. Cliffe Farmland 8. Cooling Farmland 9. Northward Hill 10. St Mary's Farmland 11. Hoo Peninsula Farmland 12. Lower Stoke Farmland 13. Cliffe Woods Farmland 14. Chattenden Ridge 15. Deangate Ridge 16. Hoo Farmland 17. Cockham Farm Ridge 18. Hogmarsh Valley 19. Bald Top Hill 20. Tower Hill
	North Kent Fruit Belt	21. Lower Rainham Farmland 22. Moor Street Farmland 23. Meresborough Farmland

Condition and sensitivity assessments were undertaken for the Landscape Assessment of Kent and Medway Landscape Character Assessments.

Landscape Assessment of Kent (October 2004)

At the regional scale the Eastern Thames Marshes are identified as the most sensitive landscape on the Hoo Peninsula and in moderate condition compared to the central Hoo Peninsula character area which is assessed as low. However it should be noted that the Swale Marshes are assessed as of being both in good condition and of very high sensitivity and given the close proximity of this area to the proposal impacts on this area should not be overlooked. It is particularly noted for its sense of tranquillity and remoteness.

It should also be noted that both the Eastern Thames Marshes and Medway Marshes are extensive areas and locally condition and sensitivity could vary from the overall average assessment.

The Medway Landscape Character Assessment followed the same methodology as the Kent assessment to analyse condition and sensitivity to provide guidance on appropriate actions for the landscape but at a more local level.

Medway Landscape Character Assessment (March 2011)

Whilst the condition of the landscape on and around the Hoo Peninsula varies, the sensitivity is assessed as moderate to high for both farmland and marshland landscapes, largely due to their openness. The Cliffe to St. Mary's Marshes are assessed as in both good condition and of high sensitivity, supporting the county level assessment.

In conclusion, the marshland areas of the Hoo Peninsula are assessed as being more sensitive than the farmland areas with the marshes to the west being most sensitive overall.

Other published landscape character assessments for areas within the study area, but not directly affected by the proposers' footprints comprise:

- Landscape Character Assessment of the Essex Coast (2005)
- Essex Landscape Character Assessment (2003)
- Thurrock Landscape Capacity Study (March 2005)
- Gravesham Landscape Appraisal (May 2009)
- Swale Landscape and Biodiversity Appraisal (November 2011)
- Maidstone Landscape Character Assessment (March 2012)

7.2.3 Zone of Theoretical Visibility (ZTV)

The ZTV is defined as those areas that have potential views of the airport sites, comprising associated buildings and others structures, along with runways, car parking areas, fencing, lighting and drainage features. Receptors within these areas are also likely to experience changes in their view from the operation of the airport including low flying planes taking off and landing, and an increase in traffic.

The ZTV includes the wider Thames Estuary including the North Kent and South Essex Marshes, and the key urban areas of:

- Southend and Canvey Island
- The Medway Towns
- Gravesend
- Sheerness and Queenborough
- Tilbury
- Stanford le Hope

More local to the proposed airport locations are the communities on the Hoo Peninsula most notably Cliffe, Cooling, High Halstow, St Mary Hoo and All Hallows.

Occasional long views may also be possible from vantage points on the North Downs.

7.2.4 Visual Receptors and Existing Views

Visual receptors that would experience views of the airport include residents within the key urban areas and the numerous small settlements and scattered farmsteads within the study area. Residents are considered as having the highest sensitivity to changes in view.

Within the wider area those receptors assessed as having a landscape focus for their enjoyment of the countryside and the estuary are also considered highly sensitive. Users of the River Thames, River Medway and The Swale, along with those enjoying the coastline for pleasure or recreational use (including pleasure craft, beach users and fisherman) are also considered highly sensitive to changes in their view.

7.2.5 Tranquillity and Remoteness

In 2006 The Campaign to Protection of Rural England (CPRE) carried out a major study into the importance of tranquillity in the English Landscape which included the production of national and regional Tranquillity Maps[106]. The Tranquillity Maps for Essex and Kent are shown in Figure 7-3 and Figure 7-3.

Parts of the Hoo Peninsula and Isle of Sheppey are identified as the 'most tranquil' areas in England which is notable given their close proximity to London which is amongst the 'least tranquil' areas. The 'most tranquil' areas are coincident with the marshlands.

Remoteness is assessed by measurements of accessibility and absence of settlement. Whilst there are no known assessments that define the sense of remoteness within the study area, it is considered that much of the marshland throughout the study area is very remote given the lack of roads and development.

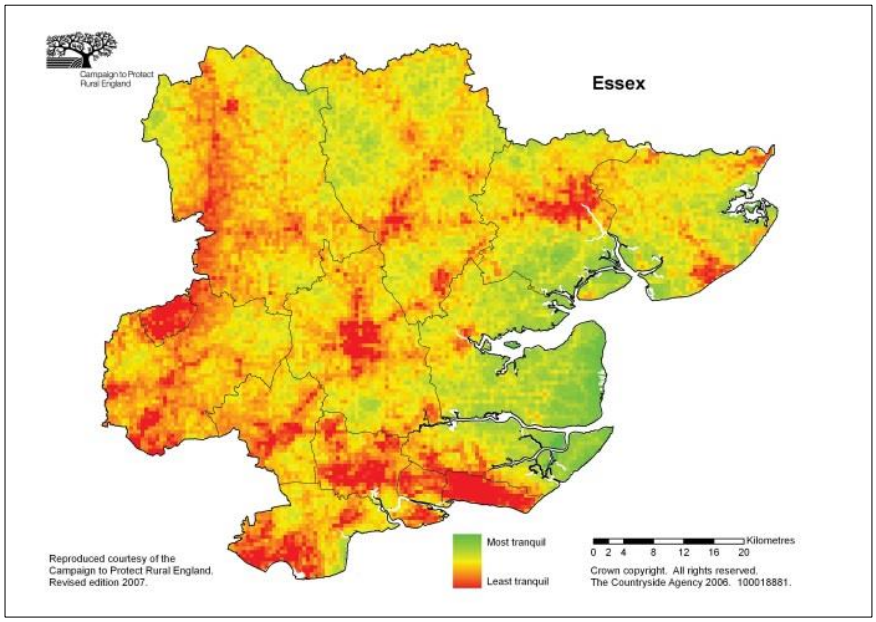

Figure 7-2: Tranquility Map for Essex

[106] http://www.cpre.org.uk/what-we-do/countryside/tranquil-places

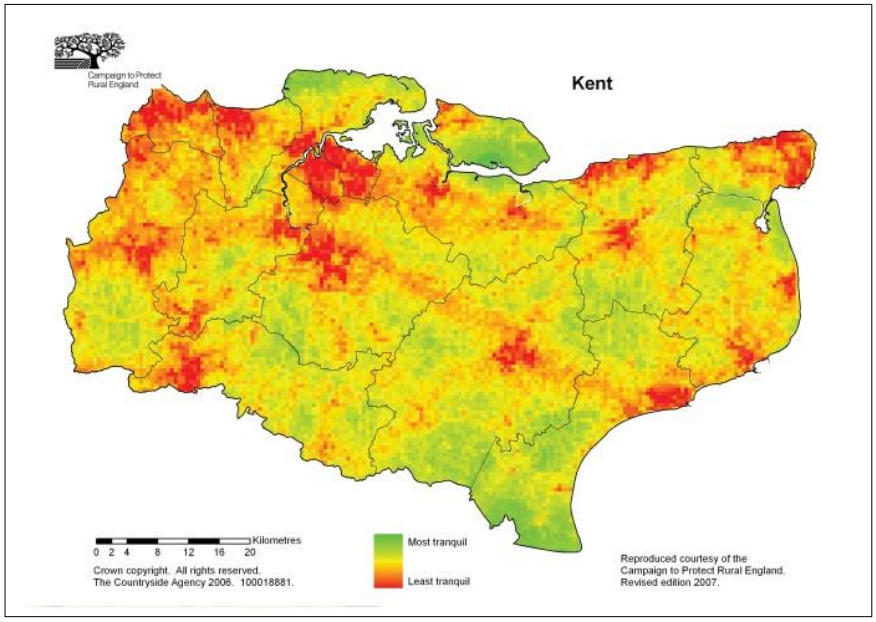

Figure 7-3: Tranquility Map for Kent

7.2.6 Landscape and Visual: Evolution of the baseline

Predicted future landscape change is recorded by NE in their NCA descriptions. The key drivers for change for the Greater Thames Estuary and North Kent Plain are identified as follows:

(i) Greater Thames Estuary:

- Climate change impacts on land use and landscapes
- New industrial complexes and their ancillary structures including roads, the Thames Gateway and associated developments all form growing pressures on the landscape. Such developments are particularly visible within the flat landscape of the Estuary.
- There is intense pressure to increase housing provision and for linear expansion of settlement along major communication routes and towards London. This is likely to increase further within the Thames Gateway Growth Area.
- Major port developments and other nationally important infrastructure projects may further impact upon character, especially in the London area.
- The restoration of mineral and waste sites, including areas of disused industrial land, offers opportunities to enhance the character of the landscape.
- New planting to re-establish tree and shrub cover around farmsteads and other sites on areas of higher ground may help to conserve the open character of the Estuary.
- Tourism and formal recreation-related uses of the Estuary, such as boating, water and jet skiing, new marinas and increasing visitor pressure, may reduce the feeling of remoteness and wilderness in some areas.

(ii) North Kent Plain

- Climate change impacts on traditional orchards and existing habitats.

7.3 Impacts from an Airport Hub Development

7.3.1 Likely impacts

Landscape and visual impacts have been categorised broadly as:

- Visibility of new infrastructure;
- Intrusion from flights to and from the new airport;
- Light pollution
- Change in character of the area.
- Loss of openness and long views; and
- Loss of tranquillity and remoteness.

7.3.2 Nationally important landscape and visual impacts

(i) Impacts on landscape character and landscape features

There would be no direct impact on nationally designated landscapes.

There would be a direct impact on the Greater Thames Estuary NCA resulting in the loss of the traditional field and ditch patterns associated with areas of salt marsh and reclaimed grazing land. In particular the proposals would cause the permanent loss of one of the least settled areas of English coast and intrude into an area recognised for its sense of tranquillity and remoteness.

The proposals would also have a direct impact on the central spine of the Hoo Peninsula which forms part of the North Kent Plain NCA. This would result in the loss of high quality, open productive agricultural land, and the traditional features associated with it, such as shelterbelts.

(ii) Visual impact

Whilst there is no land loss from the Kent Downs AONB, there are potential views from vantage points on the dipslope of the Downs which currently enjoy wide views over the Thames Estuary. However these views would be within the context of a background Thames Estuary industrial landscape.

7.3.3 Regionally important landscape and visual impacts

(i) Impacts on landscape character and landscape features

All proposals would result in the permanent loss of:

- Field and enclosure pattern
- Land use
- Vegetation cover

- Heritage features and cultural associations – including traditional marshland features

Overall there would be a significant change in the landscape character of the Hoo Peninsula with the loss of landscape features over a substantial area. There would be a permanent loss of openness, which is a particular feature of the marshland areas.

The Landscape of Kent and Medway Landscape Assessment both assess the western marshlands of the Hoo Peninsula as being highly sensitive, with the central spine and western marshes assessed as moderately to highly sensitive.

(ii) Tranquillity & remoteness

The degree of tranquillity and remoteness would be affected by all proposals as a result of views of the proposals and aircraft, as well as noise and lighting effects. Impacts would extend beyond the immediate footprint of the proposals to include other areas potentially affected by flight path changes and supporting infrastructure.

(iii) Visual impact

All proposals would result in visual impacts on the following types of visual receptor:

- Residents within properties
- Users of public open spaces, Public Rights of Way, country parks, coastline, and beaches
- Users of the River Thames, River Medway and The Swale

The open character of the area means that views of the proposed airport would potentially extend throughout the Thames Marshes and to vantage points on higher ground to the north and south of the river. There would also be views of the proposals from the Thames, Medway and Swale.

(iv) Potential views from Thurrock and South Essex

There would be views of all potential sites from the Thurrock and South Essex area. However the most populated areas generally lie to the east, most notably at Southend and the Canvey Island. These areas are also the focus of most recreational activity, popular with holiday makers and day trippers.

To the west there is a more industrial character along the Thames itself, whilst inland there are a number of villages and small settlements on higher ground at the edge of the marshes with potential views of the airport sites.

(v) Potential views from Medway and North Kent

There are potential views from the Medway Towns, particularly from the northern edge of Gillingham and Rainham which experience views across the Medway towards the Isle of Grain. Views from Rochester and Strood are less extensive due to the density of the urban form and due to the higher ground that forms the central spine of the Hoo Peninsula and intervening woodlands.

There would be views of the western airport sites from the eastern edge of Gravesend across the open North Kent Marshes. Similarly there would be direct views of Sheerness and Queenborough across the Medway to the eastern sites, including views from residents and users of the Medway and Swale Marshes.

More local to the proposed airport locations are the communities on the Hoo Peninsula most notably Cliffe, Cooling, High Halstow, St Mary Hoo and All Hallows which would all experience views from the airport developments at close proximity.

In addition to the views of the airport development, the introduction of new built elements would also obstruct the existing extensive views across the Estuary landscape.

All visual impacts would be relevant both during daylight and during darkness as a result of lighting impacts.

(vi) Potential effects of flight paths

Planes taking off and landing from the potential airport sites would have both a visual impact and an impact on the sense of tranquillity. All impacts will diminish with distance.

Westbound flight paths from the potential sites on the west of the Hoo Peninsula would have an impact on the most populated areas of Gravesham, Dartford, Grays, South Ockendon, Aveley and Purfleet. Eastbound flights would impact the remaining area of the Hoo Peninsula, Sheerness and west Sheppey and the southern side of Southend. In addition to impacting on residents there would also be a visual impact for users and visitors to the countryside and coast in these areas, and to users of the River Thames.

Westbound flights from the potential sites on the east of the Hoo Peninsula would have an impact on the south of Canvey Island, the eastern edge of Gravesend and the Stanford-le-Hope. Eastbound flights would primarily fly over the estuary itself, although there would be an impact on the north Sheppey Coast and possibly the southernmost part of Southend.

7.3.4 Landscape and visual: Sensitivity of siting

At this strategic level of study it is only possible to draw broad conclusions on the sensitivity of siting. All potential impacts identified would need to undergo a full landscape and visual impact assessment to be able to draw firmer conclusions. However some general assumptions can be made:

(i) Landscape Character

All locations are sited to a greater or lesser extent on land that is identified as being highly sensitive in published landscape assessments. Therefore, overall the siting of an airport in the Thames Estuary is likely to have a significant adverse impact on landscape character. At the local and regional level the western Hoo Peninsula (Eastern Thames Marshes) are assessed as being highly sensitive, thus making the potential eastern sites slightly less damaging in landscape character terms.

(ii) Visual Impact

There are a number of highly sensitive receptors throughout the study area so the overall potential visual impact is likely to significant throughout. Broadly speaking there are more receptors in the east as this is the most populated area. Based upon this, and without the benefit of a detailed assessment, the eastern sites are most likely to experience the most direct views due to the proximity of Sheerness and Southend to these sites and the size of the settlements. Therefore the western sites would be marginally less damaging in visual impact terms.

(iii) Flight paths

All flight paths will have an adverse visual impact and impacts on tranquillity throughout the area. Flights from the western sites fly over areas of greater population, as flights to the east fly over the estuary itself. Therefore, overall, the visual impact on receptors would be greater for the western sites. However, according to CPRE's mapping the most tranquil area is the Hoo Peninsula itself. All flight paths fly over this area so it would be a direct loss of tranquillity from all potential options.

7.3.5 Landscape and visual: Sensitivity of future baseline

It is possible that the potential future evolution of the baseline, such as increased development and reduced saltmarsh, could reduce the sensitivity of the landscape. Whilst some degree of change is inevitable, this is a heavily designated landscape that is valued as an ecological and recreational resource as well as for its undeveloped character, its tranquillity, remoteness and dark night skies. It is not therefore considered likely that the future baseline and the sensitivity of the landscape would change significantly, or that the overall impacts would be markedly less significant as a result.

7.4 Mitigation and Compensation

Opportunities for landscape/visual impact mitigation that would be in keeping with the existing open rural landscape, is limited. For example, it is unlikely that extensive planting to screen views or soften large scale buildings would be appropriate because this would not be in keeping with the landscape character. However, sensitive building design and material/colour specification could potentially help to reduce visual intrusion.

If an airport was to be developed in this area there would be a complete change of character, in particular the loss of openness, sense of remoteness and tranquillity. These features could not be substituted in the new proposals, so it would be appropriate to create a new landscape framework to mitigate adverse impacts and provide an attractive setting for the new development. Where practicable the creation of a new landscape should consider replacement of existing landscape functions, for example facilities for pedestrians and cyclists such as maintaining a coastal path and proving opportunities to view the Thames and Medway.

7.5 Summary

The sensitivity of the Thames Estuary landscape is recognised at national, regional and local scales. It is noted for its open character, sense of remoteness and relative tranquillity.

The development of an airport hub in this location would radically and irreversibly change this landscape. The hub, along with associated infrastructure, would be visible over an extensive area with potential views from the nationally designated Kent Downs AONB. Visual impacts would be relevant both during daylight and during darkness as a result of lighting impacts.

Planes taking off and landing from the potential airport sites would also have both a visual impact and an impact on the sense of tranquillity.

Overall, all potential airport locations on the Hoo peninsula are likely to cause significant adverse landscape character and visual effects and loss of tranquillity.

8 Cultural Heritage

This section covers:

- **Policy & legislative context**
- **Baseline environment –how it is currently and how it might develop in the future.**
- **Potential Impacts from an airport hub development**
- **Mitigation and Compensation**
- **Summary**

Consultation comments on the Study ToR requested that further consideration was given to cultural heritage and historic landscapes particularly in relation to potential for future designation of existing heritage features.

For the purpose of this report, cultural heritage is divided into three sub-topics: 'Archaeological Remains', 'Historic Buildings' and 'Historic Landscape'. Individual archaeological sites, historic buildings and historic landscape character types are known as cultural heritage assets. This section considers the designated cultural heritage assets within the Hoo Peninsula and the value of the area in historic environment terms. The scope of the assessment is the statutory designated sites and regional or national scale impacts.

8.1 Policy and Legislative Context

(i) Legislative Context

Scheduled Monuments are by definition of National importance and are protected by law under the Ancient Monuments and Archaeological Areas Act 1979. Consent must be obtained from the Secretary of State before undertaking any works affecting a Scheduled Monument. It is an offence to undertaken works to Scheduled Monument without this consent being in place.

Listed Buildings are protected under the Planning (Listed Buildings and Conservation Areas) Act 1990 and are recognised to be of special architectural and/or historic interest. Under the Act, planning authorities are required to have special regard to the desirability of preserving a Listed Building, its setting, or any features of special architectural or historic interest which it possesses (Planning (Listed Buildings and Conservation Areas, Act Section 66(1)). Designation as a Listed Building confers additional controls over demolition, alteration and extension through the requirement for Listed Building Consent to be obtained before undertaking such works.

Under Section 69 of the Planning (Listed Buildings and Conservation Areas) Act 1990, local authorities have the duty to designate 'areas of special architectural or historic interest the appearance of character of which it is desirable to preserve or enhance' as Conservation Areas. Conservation Area designation provides controls over the demolition of unlisted buildings, limits permitted development rights and provides the basis for planning policies to further preserve and enhance the area.

Historic wreck sites in UK territorial waters can be protected by designation under the Protection of Wrecks Act 1973, the Protection of Military Remains Act 1986 and the Ancient Monuments and Archaeological Areas Act 1979.

Wreck sites designated under Section 1 of the Protection of Wrecks Act 1973 are deemed to be important by virtue of their historical, archaeological or artistic value. Each wreck has an exclusion zone around it and any activities within this exclusion zone can only be carried out under a licence granted by the Secretary of State, who receives advice from the Historic Wreck Panel (HWP) including English Heritage.

The remains of any aircraft which crashed while in military service or any vessel designated (by name, not location) which sank or was stranded in military service after 4th August 1914 can be designated as a Protected Place under the Protection of Military Remains Act 1986, which is administered by the Ministry of Defence. Under the same Act, any area containing the remains of or substantial remains of an aircraft or vessel which sank or was stranded in military service after 4th August 1914 can be designated as a Controlled Site. For both Protected Places and Controlled Sites, any operations which disturb the sites are illegal unless undertaken under licence from the Ministry of Defence. In addition the Ancient Monuments and Archaeological Areas Act 1979 has also been used to provide some level of protection for underwater sites.

(ii) National Planning Policy Framework

National planning policies for the conservation of the historic environment are set out in Section 12 of the National Planning Policy Framework (NPPF)[107].

The National Planning Policy Framework (NPPF) recognises that cultural heritage assets are an irreplaceable resource which should be conserved in a manner appropriate to their significance. This significance may be related to archaeological, architectural and artistic or historic elements, and may also derive from the setting of the site[108].

Setting is defined in the NPPF as:

> *'The surroundings in which a heritage asset is experienced. Its extent is not fixed and may change as the asset and its surroundings evolve. Elements of a setting may make a positive or negative contribution to the significance of an asset, may affect the ability to appreciate that significance or may be neutral.'.*

Key considerations for development affecting cultural heritage assets are identified at paragraph 131 as:

- the desirability of sustaining and enhancing the significance of heritage assets and putting them to viable uses consistent with their conservation;
- the positive contribution that conservation of heritage assets can make to sustainable communities including their economic vitality; and

[107] Department for Communities and Local Government (2012) National Planning Policy Framework (NPPF)
[108] Department for Communities and Local Government (2012) National Planning Policy Framework (NPPF), para 56

- and the desirability of new development making a positive contribution to local character and distinctiveness (NPPF paragraph 131).

In making planning decisions, the NPPF states that great weight is to be given to the conservation of designated cultural heritage assets (NPPF paragraph 132), whilst proposals that preserve elements of setting of Conservation Areas, or which enhance or better reveal their significance are encouraged under NPPF paragraph 137.

Where development would lead to substantial harm or total loss of significance, local planning authorities are instructed that they should refuse consent, unless it can be demonstrated that it is necessary to achieve substantial public benefits that outweigh that harm or loss, or all of the following apply: the nature of the cultural heritage asset prevents all reasonable uses of the site; no viable use of the site can be found in the medium term which will enable its conservation; conservation by grant-funding or charitable/public ownership is not possible; and the harm/loss is outweighed by the benefit of bringing the site back into use (NPPF paragraph 133). Where development will lead to less than substantial harm to the significance of a designated asset, this harm should be weighed against the public benefits of the proposal (NPPF para 134).

Under paragraph 139 of the NPPF, non-designated assets of archaeological interest that are demonstrably of equivalent significance to Scheduled Monuments should be considered as subject to the same to the policies for designated assets.

NPPF paragraph 141 sets out the requirement for developers to record and advance the understanding of the significance of any cultural heritage assets lost as a result of development and make the results publicly available.

8.2 Scope and Study Area

The study area for cultural heritage was agreed with the client as an area comprising the Hoo Peninsula with a buffer area around it which extends, at its widest to approximately 27kms from east to west, and approximately 12kms from north to south. The study area extends from the middle of the Thames estuary to the north, across to Sheerness in the east, and down to the Medway estuary in the south, but excludes Gravesend in the west.

The cultural heritage baseline was based principally on the information contained in the previous reports comprising:

- The Hoo Peninsula Historic Landscape Project (English Heritage, 2013);
- The Greater Thames Estuary: Historic Research Framework (Essex County Council et al, 2010);
- The North Kent Coast Rapid Coastal Zone Assessment Survey Phase II (Wessex Archaeology, 2005); and
- The Thames Gateway: Historic Characterisation Project (Chris Blandford Associates, 2004).

Data was also gathered from the following sources of information:

- National Heritage List maintained by English Heritage for information on nationally designated cultural heritage assets including World Heritage Sites, Scheduled Monuments, Listed Buildings, Protected Wrecks, Registered Parks and Gardens, and Registered Battlefields ;
- Kent County Council Historic Environment Record (KHER) for information on Areas of Archaeological Potential (AAPs) , Scheduled Monuments, Protected Wreck Sites, Protected Military Remains, Conservation Areas and Listed Buildings;
- Consultation with English Heritage for undesignated sites recorded within the KHER which may potentially be designated as Scheduled Monuments, Listed Buildings or Protected Wreck Sites;
- Gravesham Borough Council's (GBC) website for Conservation Areas;
- Medway Council's (MC) website for Conservation Areas; and
- Swale Borough Council's (SBC) website for Conservation Areas.

The preliminary assessment of the importance of designated cultural heritage assets has been measured on a scale of Low, Moderate and High based on professional judgement informed by the guidance provided in Conservation Principles[109], the National Planning Policy Framework[110] and The Setting of Heritage Assets[111] and the level of statutory protection attributed to each cultural heritage asset.

8.3 Baseline

8.3.1 Designated and potential designated cultural heritage assets within the study area

A total of 407 cultural heritage assets which are designated, or have potential to be designated, have been identified within the study area. A summary of the baseline information including a preliminary assessment of their significance is provided below with a full list of baseline cultural heritage assets impacted within the study area is provided in Appendix C. The location of the baseline cultural heritage assets are shown on cultural heritage Figure 8.1 and Figure 8. 2. These comprise:

- 11 Scheduled Monuments which are assessed to be of National significance;
- 11 Grade I Listed Buildings which are assessed to be of National significance;
- 11 Grade II* Listed Buildings which are assessed to be of National significance;
- 109 Grade II Listed Buildings which are assessed to be of National significance;

[109] English Heritage (2008). Conservation Principles, Policies and Guidance for the Sustainable Management of the Historic Environment.
[110] Department for Communities and Local Government (2012) National Planning Policy Framework (NPPF)
[111] English Heritage (2011). The Setting of Heritage Assets: English Heritage Guidance

10 Potential Designated Sites which are undesignated sites identified by English Heritage as having the potential to be designated as Scheduled Monuments, Listed Buildings or Protected Wreck Sites and are assessed to be of National significance;

- 23 Protected Military Remains which are assessed to be of National significance;
- 1 Protected Wreck Site which is assessed to be of National significance;
- 6 Conservation Areas designated by Gravesham Borough Council, Medway Council and Swale Borough Council which are assessed to be of Regional significance; and
- 225 Areas of Archaeological Potential identified by Kent County Council which are assessed to be of Regional significance.

In summary, these assets comprise:

- 176 cultural heritage assets of National significance; and
- 231 cultural heritage assets of Regional significance

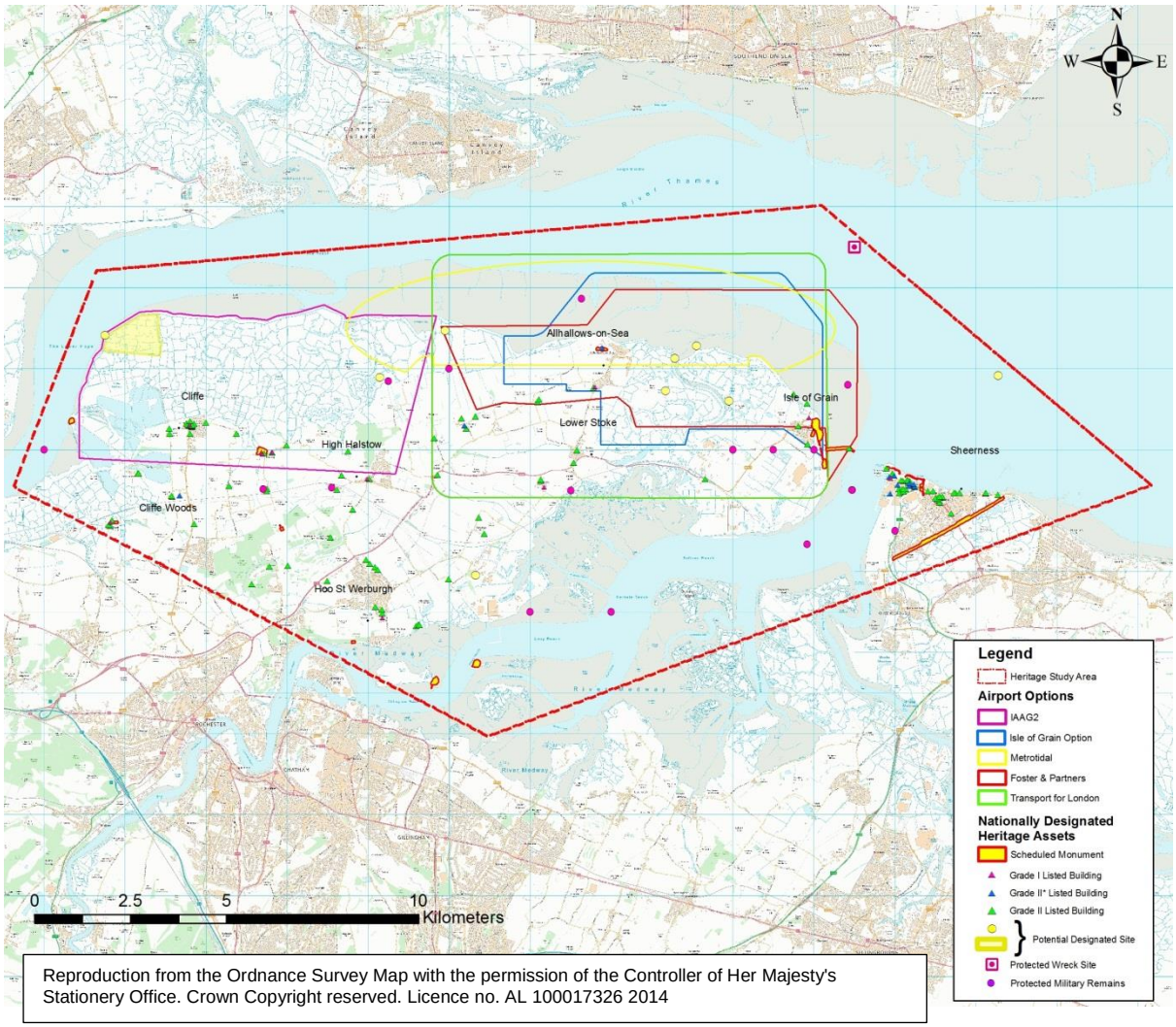

Figure 8-1: Nationally Designated and Potentially Designated Cultural Heritage Assets

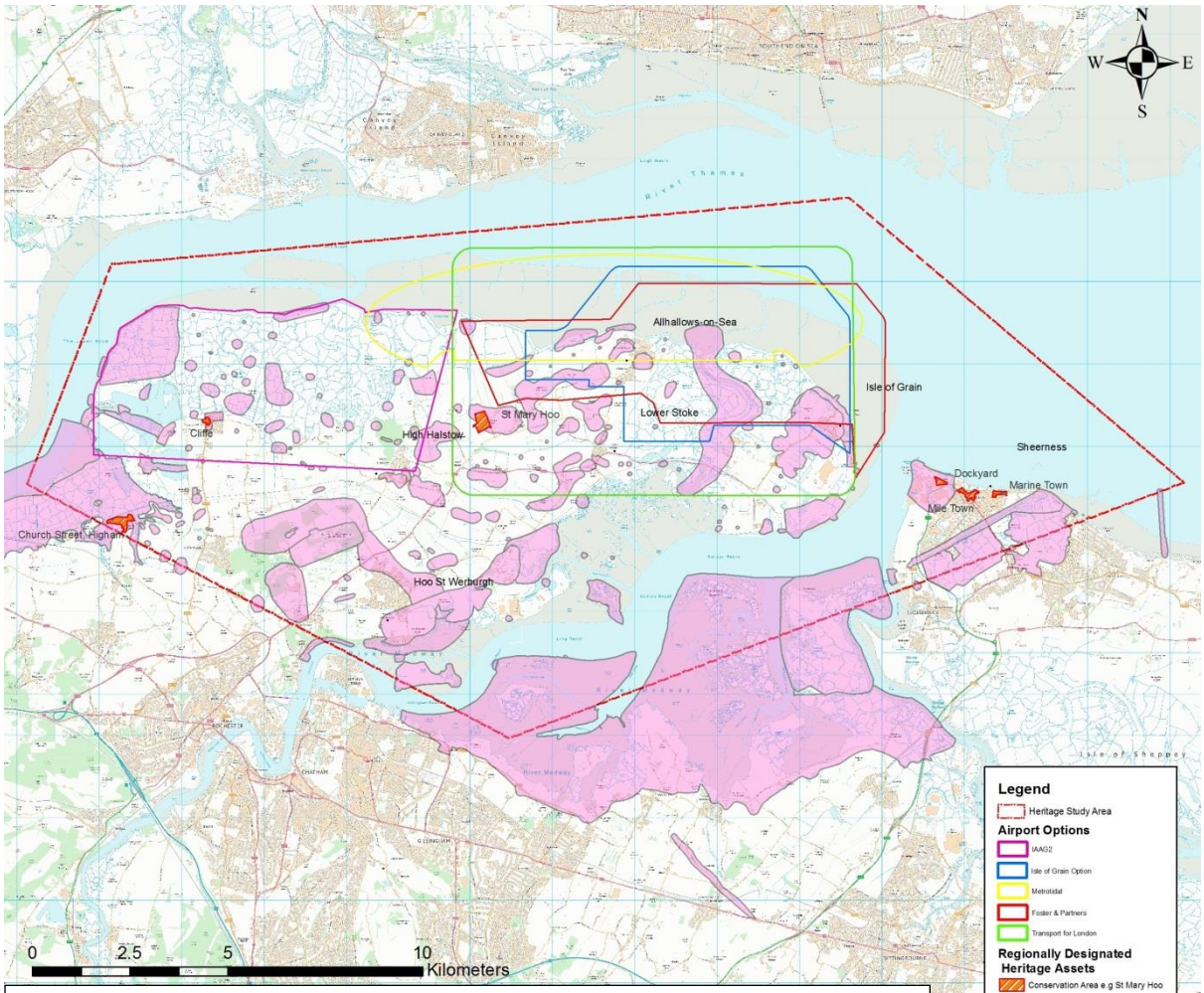

Figure 8-2: Regionally Designated Cultural Heritage Assets

The study area is primarily characterised by cultural heritage assets which date from the post-medieval and modern periods. These assets are related to the use of the Hoo Peninsula for military and industrial purposes such as defence, salt production, brick-making, cement and gravel extraction and, more recently, the production of explosives, oil refining and electricity generation.

Across the Hoo Peninsula the historic landscape is particularly distinctive for its nationally significant military heritage, reflecting the historic importance of the area in protecting London and the southeast of England from invasion by sea. The coastal defences are among the most prominent cultural heritage features of the study area. Many of these sites, including post-medieval and modern forts, gun batteries, defensive lines and explosive factories, are protected as Scheduled Monuments and are located within AAPs. These prominent military sites include the historic naval dockyard at Sheerness, with later forts and fortified lines dating from the late 19th century at Cliffe, Darnet, Slough, Cookham Wood, Sheerness and the Isle of Grain; all of which are protected as Scheduled Monuments.

At the Isle of Grain, in the east of the Hoo, the historic character of the area is dominated by several significant military landmarks. These include five separate coastal and artillery defences which extend over 1.3kms but which are protected as a single Scheduled Monument. These defences are made up of the sites of the

Grain Fort, Grain Tower, the Dummy Battery, the Wing Battery and the Grain Battery on the Isle of Grain. The defences were built from the mid to late-19th century and were re-armed in the twentieth century, forming part of the front line of defences for the Thames and Medway estuaries and serving as heavy-gun emplacements throughout the Second World War. Other than these assets, there are six Listed Buildings located within the Isle of Grain which include four Grade II* and one Grade I Listed Buildings associated with a 19th century boat building yard. The northern coastal area of the Hoo Peninsula is also less densely populated and has fewer cultural heritage designations apart from the 19th century Slough Fort at Allhallows-on-Sea, a Grade II* Listed and Scheduled Monument.

A large number of anti-invasion structures dating from WWI and WWII such as artillery emplacements, pill-boxes and anti-tank obstacles can be found dispersed across the landscape and along the coastline. Many of these sites are protected as Listed Buildings.

Three of the six Conservation Areas within the study area, are also centred on military sites: Sheerness Dockyard, Sheerness Mile Town and Sheerness Marine Town. The largest concentration of Listed Buildings within the study area is found around the naval dockyard at Sheerness which contains 50 Listed Buildings. The Dockyard Conservation Area encompasses 13 Listed Buildings, including four Grade II* Listed Buildings, consisting of a church, offices, terrace housing, cottages and stable buildings. The Mile Town Conservation Area contains 10 Grade II Listed Buildings including a church, a Sunday school, clock tower and terrace housing.

Cultural heritage assets dating from the medieval period include the historic cores of the remaining three Conservation Areas which are primarily based around their medieval village churches. The St Mary Hoo Conservation Area, situated towards the centre of the study area, contains three Listed Buildings including the Grade II* Church of St Mary which is a 14th century foundation with Victorian remodelling. In the southwest of the study area, the Higham Conservation Area encompasses four Grade II Listed Buildings centred on the Grade I Church of St Mary, a Saxon foundation, remodelled in 1357, and the Benedictine Priory of St Mary's, a Scheduled Monument, which was founded in 1148 and survives as upstanding masonry fragments. The Cliffe Conservation Area, to the northwest of the study area, includes 11 Listed Buildings as well as the Grade I church of St Helen which dates from c.1200 and was remodelled in the early 14th century and the Victorian period.

Beyond the Conservation Areas, the other main concentrations of Listed Buildings are also found around medieval settlements in the western and southern and extents of the Hoo Peninsula. Cooling medieval castle, located to the east of the study area, is a Scheduled Monument which also encompasses a Grade I Listed gatehouse, a Grade I Listed inner ward structure and a Grade II Listed barn. Around the village of Hoo St Werburgh, in the south of the peninsula, there are four Listed Buildings including the Grade I Listed 12th century church of St Werburgh.

The remaining Listed Buildings are primarily isolated farmsteads or churches scattered throughout the Hoo Peninsula, or defensive structures dating from World War II located along the south coast on the Medway River.

The earliest archaeological features within the study area are largely protected as Areas of Archaeological Potential (AAP). These include AAPs around Bronze Age

hoard sites, burials and trackways, Iron Age ring ditches and hoard sites, Roman settlements and industrial sites, and medieval settlements.

The study area includes a number of areas identified as potential Pleistocene deposits which are designated as AAPs. These areas could contain archaeological evidence from the Palaeolithic period including early hominids comparable to those found at Swanscombe, 10km to the west of the study area. These potential Pleistocene deposits are primarily concentrated in the centre and east of the Hoo Peninsula within gravels belonging to the Hoo Gravel Formation. The Hoo Peninsula has few known sites dating from the Palaeolithic era and the majority of these sites have yielded only a few artefacts which are often of insecure provenance. However, this apparent dearth of Palaeolithic evidence could result from lack of archaeological investigation, rather than a real absence of such sites[112].

8.3.2 Cultural heritage character of the Hoo Peninsula landscape

The character of the Hoo Peninsula's historic landscape is based on its relative geographical isolation between the Thames and Medway estuaries and the influence of the coast and the sea. This distinctive character is embodied in its atmosphere of 'otherness' which is recorded in 'Great Expectations' by Charles Dickens who set its opening scenes at the Church of St James in Cooling and had a home at Gadshill on the peninsula[113]. During the 19th century the river Medway was also the subject of J M W Turner's vivid paintings and engravings which included Upnor Castle on the Hoo Peninsula.

To the west end of the peninsula the farmed landscape has a traditional pattern of orchards, shelterbelts, hedgerows and mixed cropping. The central area of the peninsula, which overlies an outcrop of London Clay, forms an elevated complex of hills and valleys with broadleaved woodland mixed with areas of pasture. At the eastern end of the peninsula, the agricultural landscape is dominated by large-scale open arable cultivation[114].

The Hoo Peninsula is a predominantly agricultural area, fringed by extensive flat, low-lying alluvial marshes to north and south. These areas are formed of patterns of reed-filled drainage ditches criss-crossing the landscape which emerged when it was reclaimed as farmland in medieval period[115].

The peninsula's coastal fringe has a long history of use and trade as evidenced by the patterns of oyster beds, duck decoys, sea defences and drainage works, small settlements with minor wharfs and harbours, and remains relating to local salt industries with notable later medieval salt mounds[116].

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112 English Heritage (2013), (Carpenter, E., Newsome, S., Small, F., & Hazell, Z.) Hoo Peninsula, Kent: Hoo Peninsula Historic Landscape Project (Research Report Series N0. 21-2013)

113 (Medway Council, Undated, 12).

114 Jacobs Babtie (2004) The Landscape Assessment of Kent - report for Kent County Council, paragraph 73.

115 ibid

116 English Heritage (2013), (Carpenter, E., Newsome, S., Small, F., & Hazell, Z.) Hoo Peninsula, Kent: Hoo Peninsula Historic Landscape Project (Research Report Series N0. 21-2013), paragraph 151.

Across the Hoo the medieval pattern of settlement is reflected in the isolated farms and nucleated villages and manorial complexes and churches set on higher land around the marshes. The main historic settlements are found at Hoo St. Werburgh, where the town grew around the foundation of an early medieval minster church, and Cliffe, which was a medieval port and a site to take ferries to the Essex coast[117].

The modern, industrial landscape of the Isle of Grain is characterised by the remains of the BP oil refinery, the site of the Thamesport container port, the new gas-fired Grain Power Station and a Liquefied Natural Gas (LNG) Terminal[118].

8.3.3 Future evolution of the baseline

Within the lifetime of the project (2030- 2080/2100), it is anticipated that there will be additional assets identified within the Hoo Peninsula which will be subject to cultural heritage designation. This is likely to take place as a result of systematic re-surveys of the area by English Heritage or following recommendations from the local authorities. Consultation with English Heritage has identified a total of 10 currently undesignated cultural heritage assets within the study area which have been identified by English Heritage as potential designated sites.

It is also likely that additional cultural heritage assets will be designated as a result of the discovery of previously unknown archaeological sites identified in advance of, or during, new developments on the Hoo Peninsula.

It is anticipated that, due to climate change, there will be increasing pressure on cultural heritage assets within the Thames estuary, the intertidal areas and on-shore areas within the coastal fringe. Climate change would be likely to give rise to hotter and drier summers, wetter winters and rising sea-levels, putting heritage sites at risk of erosion, drying-out, flooding, increased vegetation overgrowth and indirect impacts from cropping changes and agricultural intensification[119]). Climate change could affect cultural heritage assets both below-ground and above-ground. It is possible that, without additional flood defences in the future, designated cultural heritage assets within coastal areas will be eroded by sea-level rises and some inter-tidal and marshland areas will become permanently submerged. Coastal sites such as Darnet Fort on the Medway Estuary and areas of relict saltmarsh could be lost. Inland sites, such as Cooling Castle and St James Church in Cooling on the edge of Cooling Marshes, could also be affected by flooding[120] .

The inter-tidal zone and the sea-bed of the Thames Estuary have a high potential for preserving unknown archaeological features dating from the prehistoric period onwards. It is likely that, as the river Thames has been a natural routeway for millennia, there will be greater finds of preserved boats and ships on the sea-bed dating from the prehistoric to modern periods. It is also likely that, as the inter-tidal zone around the Hoo Peninsula and the sea-bed of the estuary are subject to greater archaeological investigation, increasing numbers of archaeological assets will be designated within these areas[121]. Greater technological innovations in the field of underwater archaeology are also likely to increase this process of discovery and designation of estuarine cultural heritage assets in the future.

117 ibid, paragraph 118
118 ibid, paragraph 25
119 ibid, paragraph 70
120 ibid, paragraph 70
121 ibid, paragraph 185.

8.4 Impact / effect pathways

The following impacts from an airport development are likely to be experienced by cultural heritage assets of national and regional significance:

- Permanent physical loss, in whole or part, of cultural heritage assets due to construction activities;
- Permanent severance of individual or related cultural heritage assets due to construction activities;
- Permanent alterations to hydrology affecting preservation of cultural heritage assets due to construction activities;
- Permanent loss of cultural heritage assets in coastal areas, intertidal areas and on the sea-bed due to tidal scour and the migration and erosion of intertidal areas due to changes to estuarine geomorphology, hydrodynamics and sedimentation;
- Temporary intrusion on the settings of cultural heritage assets as a result of construction activities such as piling, vehicle movements, noise and lighting;
- Permanent intrusion on settings of cultural heritage assets resulting from the presence of airport runways, new buildings and related infrastructure; and
- Intermittent operational effects on the settings of cultural heritage assets from flights and transport movements associated with an airport.

8.4.1 Receptors

8.4.2 Internationally significant cultural heritage assets

Internationally significant cultural heritage assets consist of World Heritage Sites or those assets which are undergoing designation as World Heritage Sites. The closest World Heritage Sites to the study area are Canterbury cathedral, located approximately 25km to the southeast, and the Greenwich Maritime site, located approximately 28km to the west.

There are not predicted to be any physical or setting impacts on designated cultural heritage assets of international significance from the proposed airport options on the Hoo Peninsula.

8.4.4 Nationally significant cultural heritage assets

(i) Physical impacts

Nationally significant cultural heritage assets within the study area consist of Scheduled Monuments, Listed Buildings, Protected Wreck Sites, Protected Military Remains and sites indicated by English Heritage as potential designated sites.

Table 8.1 below summarises the nationally significant cultural heritage assets which would potentially be physically affected by the five proposed airport options.

Table 8.1: Potential Physical Impacts on Nationally Significant Cultural Heritage Assets

Cultural Heritage Designation	Cultural Heritage Assets Physically Impacted				
	IAAG	Isle of Grain	Metro-tidal	Foster + Partners	Transport for London
Scheduled Monuments	1	2(5)	1	2(4)	2(6)
Grade I Listed Buildings	4	2	0	2	3
Grade II* Listed Buildings	0	1	1	1	2
Grade II Listed Buildings	21	4(5)	0	5(6)	16(17)
Protected Wreck Sites	0	0	0	0	0
Protected Military Remains	1	2	1	1	6
Potential Designated Sites	3	4	3	5	5
Sub-total	30	15	6	16	34

Note: The figures relate to the numbers of separate designations but in some cases these are split across a number of separate site locations (numbers in brackets).

(ii) Impacts on setting

Where cultural heritage assets located in the east of the study area are not physically impacted by one of the eastern airport options (Isle of Grain, Metrotidal, Foster + Partners and Transport for London), they would potentially be subject to significant visual and noise operational impacts on their setting. These cultural heritage assets would include the setting of five Listed Buildings in the village of St Mary Hoo and also six Listed Buildings and the coastal and artillery defences Scheduled Monument located on the Isle of Grain. During operation, these airport options would also potentially give rise to visual and noise operational effects on the setting of the 50 Grade I, Grade II* and Grade II Listed Buildings located in the town of Sheerness and on the Sheerness Defences and Queensborough Lines Scheduled Monuments.

Similarly, where cultural heritage assets located within the IAAG airport option are not physically impacted by development, they would potentially be subject to significant visual and noise operational impacts on their setting. The IAAG airport option also has the potential to result in visual and noise impacts during operation on the setting of adjacent cultural heritage assets, including four Listed Buildings in the village of Higham, and 16 Listed Buildings immediately around the airport option and a further five Listed Buildings within the village of St Mary Hoo.

8.4.5 Regionally significant cultural heritage assets

(i) Physical impacts

The regionally significant cultural heritage assets within the study area consist of Conservation Areas and Areas of Archaeological Potential.

The table below summarises the regionally significant cultural heritage assets which would potentially be physically affected by the proposed airport options.

Table 8.2: Potential Physical Impacts on Regionally Significant Cultural Heritage Assets

Cultural Heritage Designation	Cultural Heritage Assets Physically Impacted				
	IAAG	Isle of Grain	Metro-tidal	Foster + Partners	Transport for London
Areas of Archaeological Potential	60	34	18	42	75
Conservation Areas	1	0	0	0	1
Sub-total	61	34	18	42	76

8.4.6 Impacts on setting

Where regionally significant cultural heritage assets located within the airport options are not physically impacted by construction, they would potentially be subject to significant visual and noise operational impacts on setting.

During operation, the airport options to the east of the Hoo Peninsula (Isle of Grain, Metrotidal, Foster + Partners and Transport for London) would potentially cause visual and noise operational effects on the Marine Town Conservation Area, the Dockyard Conservation Area and the Mile Town Conservation Area in Sheerness.

During operation, the airport options to the west of the Hoo Peninsula would potentially give rise to significant visual and noise operational effects on the Cliffe Conservation Area and Church Street Higham Conservation Area.

8.4.7 Cultural Heritage: Sensitivity of siting

The main factor determining the physical impacts on nationally and regionally significant cultural heritage assets would be the size of the footprint of each airport option, whether it is located onshore or offshore, and whether it is located to the northeast or the northwest of the study area.

(i) Estuarine locations

Within the study area there are fewer designated cultural heritage assets located in estuarine locations in comparison to those on land. The encroachment of an airport into the Thames estuary would therefore potentially result in fewer physical impacts on known cultural heritage assets of national and regional significance than an entirely land-based airport of similar size.

This scarcity of designated sites may however reflect the limitations of the current knowledge of marine archaeology and the limited number of intertidal and underwater archaeological surveys which have been undertaken, rather than the absence of assets of sufficient quality to merit designation.

(ii) Inland locations

Within the study area there are a greater number of designated cultural heritage assets located on land in comparison to those in estuarine locations. There is therefore likely to be a greater number of physical impacts on known cultural heritage assets of national and regional significance from an entirely land-based airport option in comparison to similarly-sized estuarine-based airport.

There is also a variation in the numbers of designated cultural heritage assets distributed across the north-eastern and north-western extents of the study area. Fewer Scheduled Monuments, Listed Buildings, Conservation Areas, Protected Wreck Sites, Protected Military Remains and Areas of Archaeological Potential are found to the northwest of the study area. Therefore, given a similar airport footprint, an airport option located towards the northwest of the study area would potentially have fewer physical impacts on designated cultural heritage assets than those to the northeast of the study area.

Of the five airport options under consideration the Isle of Grain and Metrotidal options, which are located towards the northeast of the study area and are both based partly on land and partly within the estuary, would have the fewest impacts on designated cultural heritage assets. This is primarily due to the proportion of the airport footprints located within the estuary and the relative scarcity of designated cultural heritage remains along the north-eastern coast of the Hoo Peninsula.

The airport options located in the northeast of the study area would give rise to potential operational effects on the settings of designated cultural heritage assets located within Sheerness. These designations include the Marine Town Conservation Area, Dockyard Conservation Area, Mile Town Conservation Area, the Sheerness Defences and Queensborough Lines Scheduled Monuments and the associated Grade I, Grade II* and Grade II Listed Buildings.

8.4.8 Potential secondary effects

Potential secondary effects from the airport could include:

- Ecological habitat compensation measures could require the loss of areas, particularly of estuarine land, which could remove designated cultural heritage assets or undesignated assets of potential national significance or affect the settings of designated cultural heritage assets;
- Flood risk mitigation for an airport development could cause changes to estuary processes causing sedimentation, erosion or changes to hydrology which affects designated cultural heritage assets as well as undesignated assets of potential national significance; and

8.4.9 Potential cumulative effects

The development of further large-scale infrastructure projects within the Thames estuary would be likely to give rise to cumulative effects in conjunction with a Thames estuary airport location. Such developments include the Environment

Agency's on-going TE 2100 flood risk management project, and the proposed Perrys Farm waste management site and other potential proposed development on the Isle of Grain. These cumulative effects could include:

- Combined effects of the airport scheme on a designated cultural heritage asset from, for instance, effects on the setting of a designated cultural heritage asset due to the physical presence of the scheme and from the noise of aircraft;
- Combined impacts on the settings of designated cultural heritage assets from other schemes, for instance proposed developments on the Isle of Grain affecting the coastal defences Scheduled Monument;
- Combined effects from the airport scheme and other schemes on the same asset or incremental effects arising from a number of actions over time. For instance changes to estuarine processes leading to erosion, sedimentation or hydrology changes affecting designated cultural heritage assets in the study area;
- Additional population growth associated with an airport could cause changes to the character and appearance of Listed Buildings, Conservation Areas and Areas of Archaeological Potential from increased pressure for residential, commercial and infrastructure developments; and
- Additional development, due to the growth associated with an airport, could cause the loss of visitor numbers to designated cultural heritage assets due to decreased attractiveness of the area as an unspoilt historic landscape.

8.5 Mitigation and Compensation

In terms of archaeological mitigation a staged programme of archaeological evaluation may be required across areas of proposed development in order to establish the presence or absence of archaeological remains, the potential effects of the scheme and allow appropriate mitigation measures to be identified. The evaluations may consist of a programme of geophysical survey (including marine geophysical survey, where appropriate), followed by targeted trial trenching to provide additional information on known archaeological remains and identify unknown archaeological remains. Due to the depth of many Pleistocene and Holocene deposits on the Hoo Peninsula this may include the modelling of geological deposits to identify areas of potential.

Archaeological mitigation strategies which could be applied to an airport located within the study area (including marine locations, where appropriate) may consist of:

- Preservation of archaeological remains *in situ* through design solutions to avoid or minimise any effects of development;
- Preservation of archaeological remains by record in advance of development (including where necessary detailed archaeological excavation); and/or
- Preservation of archaeological remains by record during the course of construction (archaeological watching brief).

Mitigation strategies which could be applied to historic buildings impacted by airport development may consist of:

- Investigation and recording of standing buildings in advance of construction;

- Recording works prior to construction to document the setting of historic buildings;
- Preservation of historic buildings *in situ* through design solutions to avoid or minimise the effects of development;
- Investigation, recording and re-location of standing buildings, especially Listed Buildings, beyond the footprint of the scheme; and
- Screening and enhancement of settings where possible through landscaping.

Historic landscape mitigation strategies which could be applied to an airport located within the study area may consist of:

- Historic landscape recording works prior to construction; and
- Retention, re-establishment or protection, where possible, of existing hedgerows, field boundaries or historic saltmarshes.

Mitigation measures specific to the construction and operation of an airport which may also mitigate the effects on cultural heritage assets includes:

- Creation of noise mitigation bunds to reduce airport noise on landing and take-off;
- Use of low noise aircraft;
- Reducing flight paths, or limiting the times of flights, over designated cultural heritage assets;
- Flood risk management measures such as hard engineered defences, managed retreat or realignment of watercourses, to protect cultural heritage assets which are at risk from coastal erosion or sedimentation; and
- Use of suitable materials and designed finishes to reduce visual impacts.

Government advice in the National Planning Policy Framework promotes the preservation of significant cultural heritage assets, wherever practicable. It should be noted that the historic environment is a finite resource and once lost or damaged it cannot be recreated. Recording the evidence for the historic past is not the same as the continued existence of a specific place with all its heritage values[122].

8.6 Risks

The main risk is the risk of discovering previously unknown archaeological remains of international or national importance on land or in the marine environment within construction work areas.

KCC Heritage Conservation have noted that the deep alluvial and estuarine deposits within and adjacent to the Hoo Peninsula are not usually responsive to standard archaeological evaluation techniques such as field-walking, near surface

[122] English Heritage (2013), (Carpenter, E., Newsome, S., Small, F., & Hazell, Z.) Hoo Peninsula, Kent: Hoo Peninsula Historic Landscape Project (Research Report Series N0. 21-2013), paragraph 181.

geophysical survey and trial trenching. If an Inner Thames Estuary option is taken further there will be a need to assess the potentially deep sediment sequences using geophysical survey methods such as electrical sectioning and combine this with borehole analysis to produce deposit models which can be used to help predict where significant archaeological remains are likely to be found.

8.7 Summary

The Metrotidal option would have the fewest overall physical impacts on cultural heritage assets with 6 physical impacts on nationally significant cultural heritage assets and 18 impacts on regionally significant assets. The Isle of Grain option is predicted to result in 15 physical impacts on cultural heritage assets of national significance, and 34 cultural heritage assets of regional significance.

The airport options which are predicted to have the greatest overall physical impact on cultural heritage assets would be the Transport for London option followed by the IAAG option with impacts 39 and 30 on nationally significant assets respectively and 76 and 61 regionally significant assets respectively. The Foster + Partners option is predicted to have direct impacts on 16 nationally significant assets and 42 regionally significant assets.

All options have the potential to impact the setting of cultural heritage assets outside the airport option footprint and this would be particularly marked for eastern airport options.

There is a high likelihood of future cultural heritage designations within the study area as a result of further surveys and on-going archaeological investigation.

9 Conclusions

This study sets out to consider the scale and significance of the potential impacts of a new airport development on the Hoo Peninsula, Inner Thames Estuary location, focusing particularly on the implications for internationally designated sites and the relevant legal process. The study scope responds to the recognition that the impacts and risks associated with a completely new airport location on the Inner Thames Estuary need to be better understood. In addition, the study has taken account of stakeholder comments to consider the wider environmental effects on the estuary processes and morphology, as well as on flood risk, landscape and cultural heritage.

The Hoo peninsula supports a complex mosaic of intertidal, wetland and terrestrial habitats that interact with each other. This complex of a wide range of habitat types within the ecosystem results in high biodiversity. The Thames estuary has relatively high productivity that supports internationally important habitat areas and species; and this in turn supports internationally important bird assemblages and numbers. This is recognised by the designation of large parts of the estuary as Ramsar, SPA and/or SAC sites.

The study was based on a review of desk based information, available data on the designated sites and species and referred to some of the information submitted as part of the call for evidence. The key findings are listed below:

- All the airport options proposed on the Hoo Peninsula would result in large scale direct habitat loss to Thames Estuary and Marshes SPA and Ramsar sites. Some locations would also involve direct loss to the Medway Marshes SPA and Ramsar sites.

- The minimum permanent loss of habitat on the Thames Estuary and Marshes SPA/Ramsar sites alone is estimated to amount to 24%/27 of their total area and it would not be possible to mitigate these losses in close proximity to the airport due to bird strike risk and geomorphology and flood risk management limitations.

- In terms of the Habitats Regulations Assessment process, it is expected that any future appropriate assessment would conclude that there are likely significant effects on the Natura 2000 network.

- Under the steps of the HRA process, the proposals would, therefore, be required to progress to the Alternatives Solutions test. The Competent Authority (Secretary of State for Transport) would need to be certain that no alternative solutions existed, had considered the best scientific knowledge and taken into account the representations of Natural England and Environment Agency. If this test is passed it would need to be demonstrated that the proposals were needed for Imperative Reasons of Overriding Public interest (IROPI).

- In the event that the proposals were to be taken through HRA alternative solution and IROPI steps, an acceptable package of compensatory measures would need to be developed. The compensatory measures would need to be created in advance and would need to demonstrate that they would be adequate before losses occur.

- A minimum of around 2130ha is likely to be needed for habitat compensation for the airport proposals and displacement of other compensatory habitat. An upper estimate of 6800ha attempts to capture some of the potential indirect losses. The road and rail transport infrastructure schemes required for airport access are also likely to result in additional direct losses to Natura 2000 sites and are therefore likely to add to the total area required for compensation.

- Compensatory habitat the purpose of attracting birds would need to be provided at least outside the 13km birdstrike safeguarding zone and it is recommended that habitat for birds is created beyond 20km from the airport

- Given the uncertainty with providing compensation habitat further afield it is likely that a ration of gain for loss of greater than 1:1 would be required. Gain for loss ratios from other studies indicate that 2:1 and 3:1 ratios might be applied. It is possible that higher ratios might be considered appropriate to reflect higher uncertainty over the success of proposed compensation measures is considered uncertain.

- There is good experience on provision of compensatory habitat from the Environment Agency's Regional Habitat Creation Programmes. There are also a number of potential intertidal habitat creation sites associated with managed realignment policies along the Essex and Suffolk coast. Potential compensation areas would need to be investigated in detail to identify potential constraints in terms of availability, suitability and additional impacts and these would require significant study to determine realistic deliverability.

- Although it may be technically possible to create large scale intertidal and freshwater habitats for compensation, there is considerable uncertainty over the ability to deliver the functional quality of habitat to meet the requirements of all the species that might be affected. There is an added complexity in the potential ability to adequately provide the like for like combination of habitats –not just the habitat types in isolation but a mosaic of habitats for the requirements of some species. Estuaries and coastal areas along the Essex and Suffolk coast should be the first area to consider for compensation areas, locations further afield might be possible but are likely to increase the uncertainty that all different species needs could be met.

- In terms of the wider environment, there are additional areas of impact or risk particularly associated with the construction of an airport into the estuary channel, seaward of the existing defences, including:

    - Construction impacts and the release of sediment which could potentially result in long term effects on the estuary;
    - Change to estuary geomorphology and hydrodynamics through changes to tidal prism, wave reflection, sediment deposition, sediment entrainment and bank or habitat erosion.
    - Changes to current speeds and directions will change erosion and accretion patterns and could lead to significant changes to intertidal habitats (affecting up to 2500ha of estuarine intertidal and subtidal habitat).
    - Changes to water levels, although these are expected to be minor
    - Potential for impacts on the ecological status of Water Framework Directive (WFD) water bodies through combination of impacts on a number of water courses on the Hoo peninsula. These are likely to result in addition

ecological effects on aquatic species and may need to be subject to WFD article 4.7 tests to determine if exemptions from normal WFD requirements would apply;

- Uncertainty in relation to flood risk and the extent of impacts from airport construction beyond existing defences, including reduced conveyance and storage capacity in the Thames Estuary and possibly the Medway Estuary and potential for increased flood risk in extreme event especially given the high design standard for flood protection likely to be required for a new hub airport; also high level of uncertainty over climate change and particularly sea level rise, storm surges and extreme events;

- Extensive detailed studies including hydrodynamic modelling would be required, along the lines undertaken for TE2100, in order to understand the geomorphological and flood risk changes and requirements for mitigation and related additional impacts on designated sites.

- Impacts on landscape and cultural heritage include large scale changes altering the tranquil and remote character of the area, and resulting in direct loss of a number of statutory designated or potential designated heritage features as well as resulting in changes to the settings of remaining heritage interest.

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Inner Thames Estuary Feasibility Study 1:
ENVIRONMENTAL IMPACTS - APPENDICES

July 2014

Appendix Contents

Appendix A: Ecology

A1: Case Study examples for Habitat Regulations Assessment and Compensatory Measures

Table A1.1 Case studies used within this study

Ref	Project	Developer	Date	Status
CS1	Green Port Hull Development	ABP	October 2012	Approved
CS2	Able Marine Energy Park	Able	December 2013	Approved
CS3	Bathside Bay Container Terminal	Hutchinson Ports UK	2006	Approved
CS4	Stornoway Wind Farm, Outer Hebrides	Lewis Wind Power Ltd.	Initial application 2008, reapplication Sept 2012	Approved on reapplication
CS5	Galway Bypass	Galway County Council	2013	Rejected by EU Court of Justice
CS6	Baden-Baden Airport, Germany	Giss Group GmbH & Co. KG,	2005	Approved
CS7	The Second Maasvlakte	Netherlands Government and Rotterdam Port Authority	2005	Approved
CS8	Bristol Deep Sea Container Terminal (BDSCT)	The Bristol Port Company	2010	Approved
CS9	Dibden Bay, Southampton	ABP	2000	Rejected by SoS
CS10	Hinkley Point C Nuclear Power Station	EDF	2013	Approved
CS11	London Gateway Port	DP World	2007	Approved
CS12	London Ashford Airport, Lydd	London Ashford Airport Ltd.	April 2013	Approved
CS13	Immingham Outer Harbour port development, Humber	ABP	August 2013	Approved
CS14	Severn Tidal Power	Feasibility Study of range of options from call for proposals in 2008. Feasibility Study on 5 potentially viable schemes	May 2010	Strategic Level Feasibility study - decision to not take forward by DECC. Could be revisited in future but significant (many years) additional information required on Natura 2000 site/ network impacts
CS15	TE2100 Flood Risk Management Plan	Environment Agency	October 2009	Plan adopted. SoC for Natura 2000 approved by Defra
CS16	Harwich Approach Channel deepening, Trimley Marshes	Harwich Haven Authority	February 2006	Approved
CS17	Cardiff Bay Barrage	Government Act	1993	Approved
CS18	Container Terminal III, Bremerhaven, Germany	Bremen Ports	2003	Approved
CS19	Wallasea Island	RSPB/EA	Initiated in 2000	Approved
CS20	London Array Offshore Wind Phase II	DONG Energy, E. ON, Masdar and La Caisse de dépôt et placement du Québec consortium	Phase I initiated in 2001	Approved in outline as part of Phase I but under 'Grampian conditions' . Phase II cancelled.

CS1: Green Port Hull Development

Project, proponent and date	**Green Port Hull Development** **ABP, Hull** **Date approved: October 2012**
Description	Wind turbine manufacturing facility including infilling a third of the dock, the creation of two ro-ro structures, repair of jetty , capital dredge and disposal of dredge material.
Compensation measures proposed & ratio (gain : loss)	Direct loss of 7.5ha designated habitat (4.5 ha of mudflat and 3 ha subtidal estuary). Ratio is 1:1 to compensate for direct and indirect loss of mudflat and subtidal. This ratio is acceptable to NE as main compensation site is already established. For compensation outside the main site a ratio of 2:1 is required as site is not established.
Authority /decision process	Secretary of State, MMO (Marine Works (EIA) Regs 2007)
HRA stage	IROPI
Challenged by	No major objectors
Argument for	MMO concluded that a rigorous case has been made to show that there is no current alternative solution or site and that there is IROPI. Furthermore the MMO is satisfied that adequate compensatory habitat is in place and will ensure the overall coherence of the network of SPAs and SACs.
Argument against	-
Conclusion and rationale	AA concluded that the development would have an adverse effect upon the integrity of the interest features of the Humber Estuary Special Area of Conservation (SAC), Special Protection Area (SPA) and Ramsar site (Wetland of International Importance). Following this conclusion, ABP Hull prepared a case for alternatives, imperative reasons of overriding public interest (IROPI) and compensation. The Secretary of State (SoS) notified the MMO on the 17 July that the case for Green Port Hull had been considered and that a strong case had been made to demonstrate no alternative solution and that there is IROPI. The SoS also considered that in the event satisfactory compensatory measures will be in place and delivered the SoS had no objection to the Green Port Hull proposal.

CS2: Able Marine Energy Park

Project, proponent and date	Able Marine Energy Park, Humber (AMEP) Able Humber Ports Ltd. Consent granted December 2013
Description	Construction of a platform 'energy park' for assembling wind turbines taking up subtidal, intertidal mudflat habitat.
Compensation measures proposed & ratio (gain : loss)	Direct loss of designated habitat (mudflat and estuarine) was a total of 45 ha and indirect loss 11.6 ha. Direct replacement ratio (gain of compensation habitat : loss of designated habitat) was 2.3 : 1. If loss from indirect effects is included then ratio was 1.8 : 1. However condition of consent includes creation of wet grassland habitat to allow for time delay until the managed realignment area becomes functional. This takes ratios to 4 : 1 for direct loss or 3.2 : 1 if indirect loss is included.
Authority /decision process	Secretary of State
HRA stage	IROPI
Challenged by	Natural England and also RSPB
Argument for	Location was vital (in respect of distance to wind farm sites re CO2 emissions for vessels). Demonstrated that more than one marine energy park would be required in the UK. Ruled out other sites on size of land required. The only feasible alternative was in Southampton and they showed that this would result in the loss of more Natura 2000 network that then AMEP (and it is further from windfarm sites). Showed comparable damage to N2000 sites of other sites.
Argument against	Natural England identified 'substantial risk' that the ecological compensation measures would not work. Later this was down-graded to 'residual risk'.
Conclusion and rationale	Granted. SoS was satisfied that there was an absence of alternative solutions and that 'do nothing' was also not acceptable given the commitment to renewable energy. Developer set out that only sites that can provide significant socio-economic benefit to the UK are considered feasible alternatives as only these sites would meet the long term economic and social needs of the UK and stated Government policy. The SoS concluded that there are no realistic alternatives to the project with lesser impacts on the sites protected under the Habitats Directive SoS noted that the applicant's reference to comparable port projects and the compensatory measures that had been approved in the past was not relevant as every development must be assessed on its own merits.

CS3: Bathside Bay Container Terminal

Project, proponent and date	Bathside Bay Container Terminal Hutchinson Ports UK Granted 2006
Description	Development of a container terminal, construction of a small boat harbour and the partial demolition of a listed gantry at Bathside Bay, Harwich.
Compensation measures proposed & ratio (gain : loss)	Direct loss of 69 ha of intertidal area. Ratio of 1.6:1. Compensation habitat is located within 3km of development and is expected to 'provide value' within 1 to 2 years.
Authority /decision process	Initial decision made by SoS.
HRA stage	IROPI
Challenged by	Local Campaigner (D. Saunders)
Argument for	Economics
Argument against	Direct loss of protected habitats within the proposed expansion to the Stour and Orwell Special Protection (69 ha).
Conclusion and rationale	Appeals were heard by way of a public inquiry (2004). In 2005 the Secretary of State accepted a majority of the Inspector's conclusions. In particular he accepted that Bathside Bay would be required to be in place well before 2020 and that "there is an overriding need for a container port at Bathside Bay to meet the national need for container capacity in the UK". The application has been granted a ten year extension by SoS so must now start by 2023.

CS4: Stornoway Wind Farm

Project, proponent and date	Stornoway Wind Farm, Outer Hebrides Lewis Wind Power Ltd. 2004-2008. Reapplication saw consent granted in September 2012
Description	36 turbine development with a generating capacity of up to 129.6MW. Direct effect on Lewis Peatlands SPA and associated species and habitats.
Compensation measures proposed & ratio (gain : loss)	No compensation habitat required.
Authority /decision process	Scottish Government
HRA stage	Assessment of alternatives
Challenged by	Scottish Natural Heritage. Since then they have withdrawn their objection as long as six particular turbines are not constructed.
Argument for	Electricity generation for 90,000 homes and socio-economic investment.
Argument against	Potential displacement and collision risk for golden eagle and red-throated diver
Conclusion and rationale	This was originally refused due to the significant adverse effect on many of the qualifying bird species of the Lewis Peatlands SPA and that the mitigation proposed was unlikely to avoid this. There were alternative solutions to meet national wind farm and electricity generation objectives and so no need to consider the tests of IROPI. Subsequently the application was modified and consent was granted – main driver was requirement for renewable energy (Scotland has a target to generate 100% of electricity from renewable sources by 2020).

CS5: Galway Bypass

Project, proponent and date	Galway Bypass Galway County Council 2013
Description	Construction of a bypass road around Galway, Ireland. Direct loss of priority habitat limestone pavement.
Compensation measures proposed & ratio (gain : loss)	Not possible to compensate for the loss.
Authority /decision process	EU Court of Justice. The Supreme Court of Ireland referred it to the EU court.
HRA stage	IROPI
Challenged by	
Argument for	Stimulate economic growth and create employment
Argument against	ECJ ruled that national authorities could not “authorise interventions where there is a risk of lasting harm to the ecological characteristics of sites which host priority natural habitat types”. The bypass would have destroyed a limestone pavement. The habitat had not been formally included in the EU’s list of protected areas at the time, but by the time for planning permission the government had submitted them for inclusion on the list.
Conclusion and rationale	Ongoing. EU court has ruled against development and the matter has now been returned to the Irish Supreme Court, which could still opt to approve the plans on the “imperative reason of overriding public interest” [but not on socio-economic grounds].

CS6: Baden, Baden Airport

Project, proponent and date	Baden-Baden Airport, Germany Giss Group GMBH &Co, KG 2005
Description	Expansion of airport. Direct effect on four designated sites, species and habitats. A further five habitats adjacent or within close proximity
Compensation measures proposed & ratio (gain : loss)	Total direct loss was around 9 ha, with some additional temporary effects on around 14 ha of designated habitats. Compensation area was 45 ha for 'coastal sand dunes and continental dunes' habitat. Compensation area of 2 ha is created for 'European dry heaths' habitat. Compensation area of 3.5 ha is created for 'species-rich Nardus grassland, on siliceous substrates in mountain areas (and submountain areas in continental Europe)' habitat. Compensation area of 10 ha is created for 'Lowland hay meadows' habitat. Compensation ratio was different for different habitats with ratios ranging from approximately 2:1 to 23:1.
Authority /decision process	EC opinion
HRA stage	IROPI
Challenged by	
Argument for	Environmental protection and increasing demand
Argument against	Impacts on Natura 2000 sites, construction and operational impacts e.g. increase in take offs and landings, light, noise and air pollution
Conclusion and rationale	Favorable; case for airport expansion was considered to outweigh nature conservation aspects and that the development should go ahead subject to compensatory measures.

CS7: The Second Maasvlakte

Project, proponent and date	The Second Maasvlakte Dutch government and the Port Authority of Rotterdam 2005
Description	Large scale land reclamation (2000ha) for port / industrial use. Direct effect on Voordelta Natura 2000 sites, species and habitats.Unknown indirect effect on Waddenzee SPA through changes to geomorphological processes.
Compensation measures proposed & ratio (gain : loss)	Direct loss of 2,000 ha of designated habitat. Compensation was in the form of a new sea reserve (25,000 ha) and 35 ha dune areas and beach habitats Ratio of gain : loss was 12.5:1.
Authority /decision process	ECJ opinion sought Dutch Gov. Dutch Council of State
HRA stage	IROPI
Challenged by	
Argument for	Rotterdam Port vital to Dutch economy to remain competitive an essential multimodal junction in the Trans European transport network. While scientific data suggested little effect on the Waddenzee, the margin of error of these findings was deemed considerable. Amended proposal.
Argument against	Potential impact on the Waddenzee relating to the transport of Fish larvae therefore would affect a SPA. Therefore the impacts had not adequately been assessed.
Conclusion and rationale	Favourable; authorised 2010. IROPI (economic). This annulled the decision of the Dutch Government.

CS8: Bristol Deep Sea Container Terminal

Project, proponent and date	Bristol Deep Sea Container Terminal (BDSCT), Avonmouth The Bristol Port Company 2008
Description	Construct and operate a new container terminal Compensation on the Steart peninsula delivering 132.5ha of intertidal habitat; 10 ha of transitional marsh; and 47 ha of terrestrial and freshwater habitat. Habitat to be created in advance of the loss of habitats from construction of the BDSCT. This will support >3,000 birds. It should be of sufficient quality to qualify for designation as an extension to the Natura 2000 site within 10 years.
Compensation measures proposed & ratio (gain : loss)	Losses are 13.5 ha of SAC designated intertidal mudflat. Plus 20 ha of intertidal habitat including 0.5 ha of saltmarsh designated as SSSI, beyond the European sites. Indirect effects as a result of changes to hydrodynamics on 75 ha of mudflat and 5 ha of saltmarsh. Total loss = 114 ha. Total gain =189.5ha. Ratio of 1.7 : 1.
Authority /decision process	SoS: Harbour Revision Order
HRA stage	IROPI
Challenged by	Public inquiry cancelled (2009)
Argument for	Economic need for container port expansion at Bristol to help meet national need. Providing capacity outside SE England and closer to main inland freight destinations. Reduce land miles
Argument against	Accretion of sediment on intertidal feeding areas for birds upstream within SPA and SAC.
Conclusion and rationale	Consented (2010) as the SoS concluded that there were IROPI of an economic and social nature. There was deemed no alternative and adequate compensatory measures were agreed.

CS9: Dibden Bay

Project, proponent and date	Dibden Bay, Southampton, UK (Associated British Ports (ABP)) 2000
Description	Deep-water container port Direct effect on Solent and Southampton Water Ramsar/SPA. Direct effect on 76 ha plus a further 250 ha of grassland.
Compensation measures proposed & ratio (gain : loss)	Direct loss of 76 ha SPA. Creation of 137 ha of wetlands, grassland and woodland within a nature conservation area including a tidal creek, totalling approximately 170 ha. Ratio of 2.2 : 1.
Authority /decision process	Secretary of State
HRA stage	Test of alternative solutions
Challenged by	Public inquiry
Argument for	No alternatives currently existed in the locality of Southampton
Argument against	Test of alternative solution. Credible and feasible alternatives existed and national need could be met without the Dibden Terminal.
Conclusion and rationale	Permission was refused by the Secretary of State for Transport as: Without the proposed terminal, there was a reasonable prospect of sufficient capacity being provided at UK ports to handle the expected growth in the UK's container trade. A temporary lack of handling capacity was not regarded as an IROPI that should override the protection of European sites.

CS10: EDF Hinkley Point

Project, proponent and date	Hinkley Point C Proposed Nuclear Development EDF 2013
Description	Concluded that no compensatory habitat creation would be required for identified adverse effects on designated features.
Compensation measures proposed & ratio (gain : loss)	N/A
Authority /decision process	MMO, SoS
HRA stage	IROPI
Challenged by	
Argument for	Energy generation
Argument against	Public opinion on nuclear generation, storage on site and damage to sites of nature conservation
Conclusion and rationale	Consented

CS11: London Gateway Port

Project, proponent and date	London Gateway Port DP World 2002-2007
Description	Deepening of Thames Estuary by dredging and land reclamation for port construction. Indirect effects upon c.69ha of habitats within Thames Estuary and Marshes SPA through high levels of accretion on intertidal mudflats
Compensation measures proposed & ratio (gain : loss)	30 hectares near to the development and approximately 50 ha on the opposite southern bank of the River Thames (on the Isle of Grain). Ratio of 1.2 : 1. .
Authority /decision process	UK Government
HRA stage	n/a
Challenged by	
Argument for	Part of network of economic hubs. Increase handling capability of Port of London and Britain's container handling capability.
Argument against	Will result in significant adverse effects on habitats and species at local, national and international levels. Not in accordance with national and international nature conservation policy. Inadequate environmental statements Community opposition, employment created is likely to be taken by commuters; access issues
Conclusion and rationale	Consented.

CS12: Lydd Airport

Project, proponent and date	Lydd Airport London Ashford Airport Ltd Consented April 2013
Description	Runway extension to modernise the airport top allow it to handle larger aircraft.
Compensation measures proposed & ratio (gain : loss)	SoS "there is little evidence that there would be any, never mind a significant, decline in size, distribution, structure or function of the population such as to require an appropriate assessment (AA)."
Authority /decision process	SoS
HRA stage	Appropriate Assessment
Challenged by	RSPB
Argument for	Economic –use of airport for fare-paying passengers
Argument against	Conservation concern for bird populations
Conclusion and rationale	Consent granted

CS13: Immingham Outer Harbour Port development

Project, proponent and date	Immingham Outer Harbour port development, Humber Estuary, UK ABP 2001-2006
Description	A 4 berth deep water ro-ro terminal at the Port of Immingham
Compensation measures proposed & ratio (gain : loss)	Direct loss of 22 ha mudflat and 0.4 ha of saltmarsh. Two managed realignment schemes in compensation total 50 ha (plus 6 ha for another scheme), this constitutes a ratio of approximately 2:1 for this scheme.
Authority /decision process	SoS
HRA stage	IROPI
Argument for	Economic: SoS agreed that there were no alternative solutions and IROPI
Argument against	Direct intertidal habitat loss within SPA.
Conclusion and rationale	Consented.

CS14: Severn Tidal Power

Project, proponent and date	Severn Tidal Power 2010 - Feasibility Study.
Description	Tidal power scheme to provide up to 5% of UK's electricity needs (various scheme designs have been put forward).
Compensation measures proposed & ratio (gain : loss)	Estimated area loss of designated intertidal habitat (with mitigation) lower boundary 1,600 – 16,300 ha upper boundary. An investigation considered if it would be plausible to use offsetting (compensation) for intertidal habitat loss. The review concluded that opportunities for mudflat creation under the baseline situation are very limited, although 5,500ha of saltmarsh and coastal grassland can be created. Within the Severn Estuary the opportunity for habitat creation was between 300 and 5,000 ha. It is noted that the scale and nature of many of these potential compensation measures are unprecedented and their implementation would present significant challenges. Nationally it was estimated that there exists opportunity for 112,000 ha for compensatory habitats with 50% of this in eastern England.
Authority /decision process	DECC :Feasibility Study of 5 potentially viable options
HRA stage	SEA and plan level HRA
Argument for	Benefit of Renewable energy from tidal power and local economic benefits with potential for large scale habitat creation for compensation nationally
Argument against	Loss of very large areas of internationally designated habitats and lack of adequate compensatory habitat potential locally within the Estuary.
Conclusion and rationale	Not taken forward with reasons including unprecedented scale and impact on designated areas, uncertainty as to how the regulatory framework would apply and recognition of challenge provision of compensatory habitat and land use change within and possibly outside the estuary. After 2 years of study only able to cover feasibility and strategic level impacts. Many years of additional work including detailed impacts before a case could be put forward for consent. Long lead in time with new habitat would need to be in place and effective in advance

CS15: TE2100 Flood risk management plan

Project, proponent and date	TE2100 Flood Risk Management Plan Environment Agency 2009
Description	Management of flood risk in the Thames Estuary, planned over the next 100 years. Flexible approach, depending on development of risk.
Compensation measures proposed & ratio (gain : loss)	Managed realignment would need to be within the area of the plan to ensure continuity of Natura 2000 sites, therefore sites outside TE2100 area not considered. M Enhancement of existing non designated grazing marsh (to be functional before impact occurs) also proposed to mitigate loss of designated areas of this habitat during managed realignment. Strategic implementation of compensatory habitats over the life of the plan (100 years). Loss of 876 ha of designated intertidal habitat. Compensation habitat creation at a ratio of around 1:1.
Authority /decision process	Environment Agency is the competent authority.
HRA stage	IROPI agreed with SoS, no alternative solutions.
Argument for	Protection of 1.25 million people and property worth £200 billion from tidal flood risk in London and along the River Thames.
Argument against	
Conclusion and rationale	Provided the evidence that no feasible alternatives exist and that the chosen policies are necessary. The Statement of Case for IROPI was public safety and human health.

CS16: Harwich Approach Channel deepening

Project, proponent and date	Harwich Approach Channel deepening, Trimley Marshes Harwich Haven Authority 2006
Description	Deepening of Port of Felixstowe approach channel to allow accept larger vessels.
Compensation measures proposed & ratio (gain : loss)	16.5ha intertidal habitat created; this includes a 1:1 replacement of 4ha of intertidal habitat lost due to the scheme plus 12.5ha to mitigate losses that could occur before sediment replacement measures were expected to be fully effective. Overall ratio: 1:1
HRA stage	Originally part of the compensation was presented as mitigation but this was not accepted by SoS as adverse effect still remained.
Argument for	Increase size of vessels able to enter the port
Argument against	Loss of habitat, erosion
Conclusion and rationale	Consented, operational

CS17: Cardiff Bay Barrage

Project, proponent and date	Cardiff Bay Government Act — Completed 1999
Description	1km long tidal exclusion barrage that impounds freshwater from the Rivers Taff and Ely in the Cardiff Bay area, creating a constant high water level designed to encourage redevelopment of the surrounding land, which includes former dock areas. Total loss of SSSI.
Compensation measures proposed & ratio (gain : loss)	Ratio of 2.6:1 due to non-equivalence in habitat provision (i.e. freshwater wetland habitat compensating for lost mudflat).
Authority /decision process	Act of Parliament / Government
HRA stage	
Challenged by	CCW, EA Wales
Argument for	Economic
Argument against	Conservation
Conclusion and rationale	Economic regeneration of south Cardiff was considered by the UK government to be a consideration of overriding public interest to that of conserving the SPA in Cardiff Bay. Note this is an early example prior to emergence of current HRA guidance

CS18: Container Terminal III, Bremerhaven

Project, proponent and date	Container Terminal III, Bremerhaven, Germany Bremerhaven ports — 2001-2003
Description	Extension to container terminal to include additional berths.
Compensation measures proposed & ratio (gain : loss)	Loss of 105ha estuary habitat, 348ha offered in compensation Container Terminal IV also consented with similar works. Overall ratio: 3:1
HRA stage	No alternative solutions, IROPI
Argument for	Increase capacity of port.
Argument against	Loss of estuary habitat.
Conclusion and rationale	Consented, operational.

A2: Designated sites

Table A2.1: Special Protection Areas

SPA	Size	Summary of designated species/habitats
Hoo Peninsula and immediate coastal waters to within 1 km of the footprint		
Thames Estuary and Marshes	4,838.94ha	**Birds:** • Over winter the area regularly supports: *Circus cyaneus*; *Recurvirostra avosetta* (Western Europe/Western Mediterranean -breeding). • Over winter the area regularly supports: *Calidris alpina alpina* (Northern Siberia/Europe/Western Africa); *Calidris canutus* (North-eastern Canada/Greenland/Iceland/North- western Europe); *Limosa limosa islandica* (Iceland - breeding); *Pluvialis squatarola* (Eastern Atlantic - wintering); Tringa totanus (Eastern Atlantic - wintering). • On passage the area regularly supports: *Charadrius hiaticula* (Europe/Northern Africa - wintering). • Over winter the area regularly supports: 75019 waterfowl (5 year peak mean 21/03/2000) Including: *Recurvirostra avosetta , Pluvialis squatarola , Calidris canutus , Calidris alpina alpina , Limosa limosa islandica , Tringa totanus.*
Medway Estuary and Marshes	4,684.36ha	**Birds:** • During the breeding season the area regularly supports: *Recurvirostra avosetta* (Western Europe/Western Mediterranean - breeding); *Sterna albifrons* (Eastern Atlantic - breeding); *Sterna hirundo* (Northern/Eastern Europe - breeding). • Over winter the area regularly supports: *Cygnus columbianus bewickii* (Western Siberia/North-eastern & North-western Europe); *Recurvirostra avosetta* (Western Europe/Western Mediterranean - breeding). • Over winter the area regularly supports: *Anas acuta* (North-western Europe); *Anas clypeata* (North-western/Central Europe); *Anas crecca* (North-western Europe*); Anas penelope* (Western Siberia/North-western/North-eastern Europe); *Arenaria interpres* (Western Palearctic - wintering); *Branta bernicla bernicla* (Western Siberia/Western Europe); *Calidris alpina alpina* (Northern Siberia/Europe/Western Africa); *Calidris canutus* (North-eastern Canada/Greenland/Iceland/North- western Europe); *Charadrius hiaticula* (Europe/Northern Africa - wintering); *Haematopus ostralegus* (Europe & Northern/Western Africa); *Limosa limosa islandica* (Iceland - breeding); *Numenius arquata* (Europe - breeding); *Pluvialis squatarola* (Eastern Atlantic - wintering); *Tadorna tadorna* (North-western Europe); *Tringa nebularia* (Europe/Western Africa); *Tringa totanus* (Eastern Atlantic - wintering). • During the breeding season the area regularly supports: *Alcedo atthis, Anas platyrhynchos , Asio flammeus, Aythya ferina , Circus cyaneus, Falco columbarius, Gavia stellata , Phalacrocorax carbo , Vanellus vanellus.* • Over winter the area regularly supports: 65496 waterfowl (5 year peak mean 01/04/1998) Including*: Gavia stellata , Podiceps cristatus , Phalacrocorax carbo , Cygnus columbianus bewickii , Branta bernicla bernicla , Tadorna tadorna , Anas penelope , Anas crecca, Anas platyrhynchos , Anas acuta , Anas clypeata , Aythya ferina , Haematopus ostralegus , Recurvirostra avosetta , Charadrius hiaticula , Pluvialis squatarola , Vanellus vanellus , Calidris canutus , Calidris alpina alpina , Limosa limosa islandica , Numenius arquata, Tringa totanus , Tringa nebularia , Arenaria interpres.*

1-25 km zone		
Benfleet and Southend Marshes	2,251.31ha	**Birds:** • Over winter the area regularly supports: *Branta bernicla bernicla* (Western Siberia/Western Europe); *Calidris alpina alpina* (Northern Siberia/Europe/Western Africa); *Calidris canutus* (North-eastern Canada/Greenland/Iceland/North-western Europe); Charadrius hiaticula (Europe/Northern Africa - wintering); *Pluvialis squatarola* (Eastern Atlantic - wintering). • Over winter the area regularly supports: 34789 waterfowl (5 year peak mean 30/06/1999) Including: *Branta bernicla bernicla , Charadrius hiaticula , Pluvialis squatarola , Calidris canutus , Calidris alpina alpina.*
The Swale	6,514.71ha	**Birds:** • Over winter the area regularly supports: *Branta bernicla bernicla* (Western Siberia/Western Europe); *Calidris alpina alpina* (Northern Siberia/Europe/Western Africa); *Tringa totanus* (Eastern Atlantic - wintering). • During the breeding season the area regularly supports: *Acrocephalus scirpaceus, Anas crecca , Anas platyrhynchos , Anas strepera , Charadrius hiaticula , Emberiza schoeniclus, Fulica atra , Gallinula chloropus , Haematopus ostralegus , Numenius arquata , Pluvialis squatarola , Tadorna tadorna , Tringa totanus , Vanellus vanellus*. • Over winter the area regularly supports: 65588 waterfowl (5 year peak mean 01/04/1998) Including*: Branta bernicla bernicla , Anas strepera , Anas crecca , Haematopus ostralegus , Charadrius hiaticula , Pluvialis squatarola , Calidris alpina alpina , Numenius arquata , Tringa totanus.*
Foulness	10,968.9ha	**Birds:** • During the breeding season the area regularly supports: *Recurvirostra avosetta* (Western Europe/Western Mediterranean - breeding); *Sterna albifrons* (Eastern Atlantic - breeding); *Sterna hirundo* (Northern/Eastern Europe - breeding); *Sterna sandvicensis* (Western Europe/Western Africa). • Over winter the area regularly supports: *Circus cyaneus; Limosa lapponica* (Western Palearctic - wintering); *Recurvirostra avosetta* (Western Europe/Western Mediterranean -breeding). • During the breeding season the area regularly supports: *Charadrius hiaticula* (Europe/Northern Africa - wintering). • Over winter the area regularly supports: *Branta bernicla bernicla* (Western Siberia/Western Europe); *Calidris canutus* (North-eastern Canada/Greenland/Iceland/North- western Europe); *Haematopus ostralegus* (Europe & Northern/Western Africa); *Pluvialis squatarola* (Eastern Atlantic - wintering); *Tringa totanus* (Eastern Atlantic - wintering). • Over winter the area regularly supports: 107999 waterfowl (5 year peak mean 01/04/1998) Including: *Branta bernicla bernicla , Haematopus ostralegus , Recurvirostra avosetta , Pluvialis squatarola , Calidris canutus , Limosa lapponica, Tringa tetanus.*

Crouch and Roach Estuaries	1,735.58ha	**Birds:** • Wintering birds, hen harrier. • Over winter the area regularly supports: *Circus cyaneus*. • Over winter the area regularly supports: *Branta bernicla bernicla* (Western Siberia/Western Europe). • Over winter the area regularly supports: 18607 waterfowl (5 year peak mean 30/06/1999) Including: *Branta bernicla bernicla.*
Blackwater Estuary (Mid Essex Coast Phase 4) SPA	4395.15ha	**Birds** • During the breeding season the area regularly supports: *Sterna albifrons* (Eastern Atlantic - breeding). • Over winter the area regularly supports: *Circus cyaneus.* • During the breeding season the area regularly supports: *Aythya farina* (North-western/North-eastern Europe); *Charadrius hiaticula* (Europe/Northern Africa – wintering). • Over winter the area regularly supports: *Branta bernicla bernicla* (Western Siberia/Western Europe); *Calidris alpina alpina* (Northern Siberia/Europe/Western Africa); *Charadrius hiaticula* (Europe/Northern Africa - wintering); *Limosa limosa islandica* (Iceland - breeding); *Pluvialis squatarola* (Eastern Atlantic - wintering). • Over winter the area regularly supports: 109964 waterfowl (5 year peak mean 01/04/1998) Including: *Branta bernicla bernicla , Charadrius hiaticula , Pluvialis squatarola , Calidris alpina alpina , Limosa limosa islandica.*
Dengie (Mid Essex Coast Phase 1) SPA	3127.23ha	**Birds** • Over winter the area regularly supports: *Circus cyaneus.* • Over winter the area regularly supports: *Branta bernicla bernicla* (Western Siberia/Western Europe); *Calidris canutus* (North-eastern Canada/Greenland/Iceland/North-western Europe); *Pluvialis squatarola* (Eastern Atlantic - wintering). • Over winter the area regularly supports: 31454 waterfowl (5 year peak mean 01/04/1998) Including: *Branta bernicla bernicla , Pluvialis squatarola , Calidris canutus.*
Outer Thames Estuary	379,268.14ha	**Birds:** • Over winter the area regularly supports: *Gavia stellata* (North - western Europe - wintering)

Table A2.2: Ramsar sites

Ramsar	Size Ha	Summary of designated species/habitats
Hoo Peninsula and immediate coastal waters to within 1 km of the footprint		
Thames Estuary and Marshes	5588.59ha	**Ramsar criterion 2:** • The site supports more than 20 British Red Data Boo k invertebrates and populations of the GB Red Book endangered least lettuce (Lactuca saligna), as well as the vulnerable slender hare's-ear (*Bupleurum tenuissimum*), divided sedge (*Carex divisa*), sea barley (*Hordeum marinum*), Borrer's saltmarsh-grass (*Puccinellia fasciculata*), and dwarf eelgrass (*Zostera noltii*). **Ramsar criterion 5:** • Assemblages of international importance: Species with peak counts in winter: 45,118 waterfowl (5 year peak mean 1998/99-2002/2003). **Ramsar criterion 6 Species/populations occurring at levels of international importance:** • Qualifying Species/populations (as identified at designation): Species with peak counts in spring/autumn: Black-tailed godwit, *Limosa limosa islandica.* • Species with peak counts in winter: Dunlin ,*Calidris alpina alpina*, Red knot , *Calidris canutus islandica.* **Coastal lagoons:** • Section 41 Priority habitat at Cliffe Pools.
Medway Estuary and Marshes	4,696.74ha	**Ramsar criterion 2a:** • The site supports a number of rare plants and animals including several nationally scarce plants and Britsh RDB invertebrates. **Ramsar criterion 3a:** • Internationally important waterfowl assemblage (greater than 20,000 birds). **Ramsar criterion 3c:** • Over winter the site regularly supports internationally important populations of: *Branta bernicla bernicla; Calidris alpina alpina; Pluvialis squatarola; Calidris canutus; Anas acuta; Tringa totanus; Charadrius hiaticula; Tadorna tadorna*.

1-25 km zone		
Benfleet and Southend Marshes	2251.31ha	**Ramsar criterion 3a and 3c:** • The site is regularly host to over 20,000 waterfowl in winter. 7,200+ *Branta bernicla bernicla* (4% of theworld population); 2,500 *Pluvialis squatarola* (1% of the east Atlantic flyway pop.); and 8,400 *Calidris canutus* (2% of E. Atlantic flyway pop.). Notable also are nationally important wintering populations of *Charadrius hiaticula* and *Calidris alpina.*
Crouch and Roach Estuaries	1735.58	**Ramsar Criteria 1a,2a,2b,3c:** • The Mid-Essex Coast comprises an extensive complex of estuaries and intertidal sand and silt flats including several islands, shingle and shell beaches and extensive areas of saltmarsh. The River Crouch Marshes support a number of rare plants and animals. Among the nationally scarce plants present are: *Ceratophyllum submersum , Hordeum marinum, Limonium humile, Myosurus minimus, Parapholis incurve, Suaeda vera and Trifolium squamosum*. The area also contains the following Red Data Book invertebrates: a damselfly *Lestes dryas*, which is classified as vulnerable, and the following invertebrates which are classified as rare: a *beetle Graptodytes bilineatus* and the moths *Malacosoma castrensis* and *Eucosma catoptrana*. The area is also important for wintering water birds. During the period 1987/88 to 1991/92 an average peak count of 2,820 *Branta bernicla bernicla* was recorded.
Foulness	10,932.95ha	**Ramsar criterion 1a:** • Extent and diversity of saltmarsh habitat. **Ramsar criterion 2a:** • Supports a number of nationally rare and nationally scrace plant species and Britsh RDB invertebrates. **Ramsar criterion 2b:** • Extensive saltmarsh habitat. **Ramsar criterion 3a:** • Internationally important waterfowl assemblage (greater than 20,000 birds). **Ramsar criterion 3c:** • Overwinter the site regularly supports: *Limosa lapponica, Branta bernicla bernicla, Pluvialis squatarola, , Calidris canutus, Haematopus ostralegus, Tringa totanus.*
The Swale	6,514.71ha	**Ramsar Criterion 2:** • The site supports nationally scarce plants and at least seven red data book invertebrates. The site supports the GB Red Book vulnerable plants *Bupleurum tenuissimum, Carex divisa and Hordeum marinum,* as well as the endangered *Spartina maritima*. The Mediterranean gull *Larus melanocephalus* is also included in CITES Appendix I. **Ramsar criterion 5:** • Assemblages of international importance: Species with peak counts in winter: 77,501 waterfowl (5 year peak mean 1998/99-2002/2003).

		Ramsar criterion 6: • Species with peak counts in spring/autumn: Ringed plover *Charadrius hiaticula*. • Species with peak counts in winter:,*Limosa limosa islandica, Anas penelope, Northern pintail ,Anas acuta, Anas clypeata.*
Blackwater Estuary (Mid Essex Coast Phase 4) RAMSAR	4395.15ha	**Ramsar Criteria 1a,2a,2b:** • The Mid-Essex Coast comprises an extensive complex of estuaries and intertidal sand and silt flats including several islands, shingle and shell beaches and extensive areas of saltmarsh. The Mid-Essex Coast includes a total of 3,237ha of saltmarsh, which represents 7% of the British total. The Blackwater Estuary is one of three areas within the whole complex which are of international importance through supporting full and representative sequences of saltmarsh plant communities. Twenty-two nationally scarce plant species are present: *Bupleurum tenuissimum, Carex divisa, Ceratophyllum submersum, Chenopodium botryodes, Euphorbia paralias, Limonium humile, Inula crithmoides, Myosurus minimus, Hordeum marinum, Puccinellia fasciculate, P. rupestris, Ranunculus baudotii, Ruppia cirrhosa, Salicornia perennis, S. pusilla, Spartina maritima, Suaeda vera, Trifolium ornithopodioides, T. squamosum, Zostera angustifolia, Z. marina and Z. noltii*. The invertebrate fauna is well represented and includes at least 16 Red Data Book species. Among these are the endangered water beetle *Paracymus aeneus* and the vulnerable damselfly *Lestes dryas*, and vulnerable flies *Aedes flavescens, Erioptera bivittata, and Hybomirra expollicata.* Notable also are nationally important numbers of breeding waterbirds: *Aythya farina*, *Sterna albifrons* and *Charadrius hiaticula*; and nationally important wintering numbers of *Phalacrocorax carbo, Tadorna tadorna, Anas strepera, Anas crecca, Bucephala clangula, Charadrius hiaticula, Numenius arquata* and *Tringa totanus.*
Dengie (Mid Essex Coast Phase 1) RAMSAR	3127.23ha	• The Mid-Essex Coast comprises an extensive complex of estuaries and intertidal sand and silt flats, including several islands, shingle and shell beaches and extensive areas of saltmarsh. The Dengie component of the Mid-Essex Coast supports a number of rare plant and animal species. Dengie has 11 species of nationally scarce plants: *Crambe maritima, Hordeum marinum, Inula crithmoides, Limonium humile*, the glassworts *Salicornia perennis* and *S. pusilla, Spartina maritime, Suaeda vera* , and the eelgrasses *Zostera angustifolia, Z. marina and Z. noltii*. The invertebrate fauna includes Red Data Book Species including a weevil Baris scolopacea, a horsefly *Atylotus latistriatus* and a jumping spider Euophrys browningi. The Dengie regularly supports over 20,000 waterfowl in winter. The Dengie had, in the five year period 1987/88 to 1991/92, an average peak count of 27,947 birds, comprising 3,146 wildfowl and 24,901 waders. In addition, the Dengie has over the same period regularly supported, in winter, internationally important populations of species of waterfowl: 2,250 *Branta bernicla bernicla* (1.3% of the total world population), 7,763 *Calidris canutus* (2.2% of east Atlantic flyway pop.) and 1,752 *Pluvialis squatarola* (1% of the east Atlantic flyway pop.).

Table A2.3: Special Areas of Conservation

SAC	Size Ha	Summary of designated species/habitats
1-25 km zone		
Blean Complex SAC	520.62ha	**Terrestrial Habitats:** • 9160 Sub Atlantic and medio European oak or oak hornbeam forests of the *Carpinion betuli.*
North Downs Woodlands SAC	287.58ha	**Terrestrial Habitats:** • 9130 Asperulo-Fagetum beech forests, 91J0 Taxus baccata woods of the British Isles * Priority feature, 6210 Semi-natural dry grasslands and scrubland facies on calcareous substrates (Festuco-Brometalia) (* important orchid sites).
Essex Estuaries SAC	46140.82ha	**Intertidal habitats:** • 1130 Estuaries, 1140 Mudflats and sandflats not covered by seawater at low tide, 1310 *Salicornia* and other annuals colonizing mud and sand, 1320 *Spartina* swards (*Spartinion maritimae*), 1330 Atlantic salt meadows (Glauco-*Puccinellietalia maritimae*), 1420 Mediterranean and thermo-Atlantic halophilous scrubs (*Sarcocornetea fruticosi*), 1110 Sandbanks which are slightly covered by sea water all the time.
Peters Pit SAC	28.3ha	**Terrestrial Species:** • 1166 Great crested newt *Triturus cristatus.*
Queendown Warren SAC	14.28ha	**Terrestrial Habitats:** • 6210 Semi-natural dry grasslands and scrubland facies on calcareous substrates (Festuco-Brometalia) (* important orchid sites).
Tankerton Slopes and Swalecliffe SAC (Candidate)	13.01ha	**Invertebrates:** • 4035 Fisher's estuarine moth *Gortyna borelii lunata.*
Margate and Long Sands SAC	64914ha	**Intertidal Habitats:** • 1110 Sandbanks which are slightly covered by sea water all the time.

Note: OSPAR Marine Protected Areas form all or part of an existing UK protected areas (SAC, SPA, Ramsar, MCZ and SSSIs) up to the mean high water mark.

Table A2.4: Sites of Special Scientific Interest

SSSI	Summary of species/habitats in citation
Hoo Peninsula and immediate coastal waters to within 1 km of the footprint (Land and intertidal components). Sites shaded grey are located within existing internationally designated sites (either wholly or to a greater proportion of their extent).	
South Thames Estuary and Marshes (individual areas approximating to 20 ha outside of internationally designated site)	• **Intertidal and coastal habitats**: Grazing marsh, saltmarsh, mudflats and shingle. Vegetation • **Freshwater habitats**: pools • **Woodland** • **Invertebrates:** including *Lestes dryas, Lejops vittata, Saldula opacula, Macrochilo cribrumalis*, four • species of *Bagous*, three species of *Berosus* and *Hydrophilus piceus.* • **Birds:** Wintering birds and breeding birds including: *Tringa totanus Calidris canutus Calidris alpina Recurvirostra avosetta Charadrius hiaticula Anser albifrons* spp *albifrons*, *Tadorna tadorna*, *Anas strepera*, *Anas crecca*, *Anas acuta*, *Anasclypeata*, *Pluvialis squatarola*, *Numenius arquata Limosa limosa*, *Tringa nebularia, Anas querquedula*, *Panurus biarmicus*.*Circus cyaneus*, *Asio flammeus*, *Philomachus pugnax*, *Sterna hirundo*, *Pluvialis apricaria*. • **Plants**: *Puccinellia spp incl. P. fasciculata, Salicornia, Aster tripolium, Limonium vulgare, Atriplex portulacoides, Inula crithmoides, Chenopodium botryodes,Rumex maritimus, Bupleurum tenuissimum, Trifolium squamosum, Alopecurus spp. incl. A. bulbosus, Agrostis, Lolium perenne , Festuca spp., Trifolium , Ranunculus spp. incl. R. baudotii , Lactuca saligna Scirpus maritimus, Phragmites australis, Potamogeton pectinatus, Sparganium erectum , Typha spp. ,Ceratophyllum submersum, Stratiotes aloides* *Zostera angustifolia, Z. noltii, Crambe maritima.*
Medway Estuary and Marshes (Individual areas approximating to 46 ha outside of internationally designated sites)	• **Intertidal /coastal habitats:** Including shell beaches scrub, reedbeds, sand dune, mudflats and saltmarsh . • **Plants:** Include: *Aster tripolium*, *Limonium vulgare*, *Spartina anglica*, *Puccinellia maritima*, *Inula crithmoides, Salicornia pusilla, Vanellus vanellus*, *Anas platyrhynchos*,*Hordeum marinum, Bupleurum tenuissimum*, *Chenopodium glaucum*, *Trifolium squamosum, Scirpus maritimus Polypogon monspeliensis, Chenopodium botryodes, Rumexmaritimus, Ranunculus baudotii,, Elymus farctus*, *Eryngium maritimum*, *Honkenya peploides*, *Cakile maritima Salsola kali.* • **Birds:** Wintering and breeding birds including *Tadorna tadorna*, *Branta bernicla*, *Pluvialis squatarola*, *Charadrius hiaticula*, *Anas acuta*, *Calidris alpina*, *Tringa totanus Arenaria interpres*, *Limosa limosa*, curlew *Numenius arquata*, *Podiceps cristatus*, *Anas clypeata*, *Anas crecca*, *Anas penelope Anser albifrons. Philomachus pugnax*, *Numenius phaeopus Recurvirostra avosetta. Athyia ferina*,*Cygnus olor*, *Athyia fuligula*, *Anas crecca Anas strepera, Larus ridibundus Sterna hirundo*.
Northward Hill	• **Woodland**: over 200 plant species • **Breeding birds** Largest heronry Britain, This site also supports breeding little egrets and most recent estimates are 250 pairs of herons and little egrets are nesting here. Other species recorded include the long-eared owl.

	• **Invertebrates** *Aleucis distincta, Idaea vulpinaria, Strymonidia w-album, Sympetrum sanguineum.*
Chattenden Woods and Lodge Hill	• **Woodland:** ancient and other long-established semi-natural woodland, National Vegetation Classification (NVC) type W10 • **Scrub, and neutral grassland** nationally scarce NVC type MG5 incl *Genista tinctoria***.** • **Breeding birds:** *Luscinia megarhynchos*, *Accipiter nisus*, *Scolopax rusticola*, *Columba oenas*, *Streptopelia turtur*, *Cuculus canorus*, tawny owl *Strix aluco*, *Picus viridis*, *Dendrocopos major*, *Sylvia communis*, *S. curruca*, *Carduelis cannabina Pyrrhula pyrrhula*. • **Reptiles:** *Vipera berus*, *Natrix natrix*, *Zootoca vivipara* and *Anguis fragilis*. • **Invertebrates**: *Lucanus cervus Elegia similella*, *Sitochroa palealis* and *Dichomeris alacella*.
Tower Hill to Cockham Wood	• **Woodland.** • **Plants:** include *Fraxinus, excelsior*, *Quercus robur, Ulmus* spp *Acer campestre Crataegus monogyna*,*Cornus sanguinea*, *Lonicera periclymenum*, *Rubus fruticosus*, *Mercurialis perennis*, *Urtica dioicaBlackstonia perfoliata*, *Inula conyza*.*Elymus pycnanthus*, *Vicia bithynica*. • **Invertebrates:** Incl.aculeate hymenoptera, approx. 1/3 of all UK spp; 7 nationally rare. • **Geology.**
Dalham Farm	• **Geology**
1-25 km zone (with intertidal component only, i.e. excluding fully landlocked sites). Sites shaded grey are located within existing internationally designated sites (either wholly or to a greater proportion of their extent).	
Mucking Flats and Marshes. (approx. 22.6 ha of SSSI is outside of internationally designated sites)	• **Intertidal habitats:** Mudflats, saltmarsh, seawall grassland. • **Invertebrates :***Baryphyma duffeyi*, as well as many notable and local species. • **Plants** *Elymus pycnanthus Atriplex portulacoides*, *Aster tripolium*, *Limonium vulgare Puccinellia maritima*.*Salicornia spp.*, *Spartina anglica Spergularia marina*, *Inula crithmoides*. • **Birds:** Wintering and breeding birds; Charadruis hiaticula; *Tadorna tadorna, Pluvialis squatarola, Calidris alpina, Limosa limosa and Tringa totanus, Recurvirostra avosetta, Calidris ferruginea, Larus michahellis.*
Benfleet and Southend Marshes (Individual areas approximating to 91 ha outside of internationally designated sites)	• **Intertidal habitats:** Extensive salt marshes and mudflats. • **Birds:** Wintering wildfowl and waders; *Branta bernicla bernicla, Pluvialis squatarola, Calidris alpina, Tringa totanus, Charadruis hiaticula, Limosa lapponica, Calidris canutus Haematopus ostralegus, also Motacilla flava* • **Plants**: Include nationally uncommon species. *Festuca rubra*, *Dactylis glomerata*, *Arrhenarherum elatius Agrostis spp. Crataegus monogyna*, *Prunus spinosa*, *Rosa sp[p]*, *Rubus sp[p]. Vicia bithynica*,

	Tordylium maximum, *Lathyrus hirsutus Vicia tenuissima*. *Dianthus armeria* *Alopecurus pratensis Lolium perenne*, *Trifolium squamosum*, *T. fragiferum, Ranunculus sardous Scirpus maritimus*, *Glyceria spp.*, *Lemna spp.*, *Hippuris vulgaris, Ceratophyllum demersum* and *C.submersum*. tasselweed *Ruppia maritime, Ranunculus baudotii*, *Elymus pungens*,*Hordeum marinum*, *Bupleurumtenuissimum Chenopodium botryoides*. *Atriplex portulacoides, Limonium vulgare*, *Triglochin maritima*,*Puccinellia maritima*, *Aster tripolium*, *Limonium humileSalicornia spp.*, *S. perennis*. *Inula crithmoides Spartina maritime, Zostera marina* and *Z. noltii.* • **Invertebrates:** Including scarce species. *Strymonidia w-album Melanargia galathea* *Myopites bloti, Tettigonia Cnaemidophorus rhododactyla, Lestes dryas.* • **Reptiles:** *Triturus cristatus.*
The Swale	• **Intertidal and coastal habitats, saltmarsh, grazing marsh, mudflats** • **Invertebrates:** Thought to be the only site in Britain for the polychaete worm *Clymenella torquata*. *Malacostoma castrensis*, beetles, dragon and damsel-flies. • **Plants:** *Carex divisa,Chenopodium botryodes*,*Peucedanum officinale, Lactuca saligna*, *Bupleurum tenuissimum,Trifolium squamosum*,barley *Hordeum marinum,Alopecuris*, *Agrostis*, *Lolium Festuca, Trifolium*, *Ranunculus Scirpus maritimus*, *Phragmites australis Potamogeton pectinatus* *Sparganium erectum Typha latifolia Ruppia, Ceratophyllum submersum, Crambe maritime, Glaucium flavum*, *Ammophila arenaria Cakile maritima Spartina maritime,* Inula *crithmoides Puccinellia Salicornia*, *Aster tripolium*, *Limonium vulgare*, *Atriplex portulacoides, Spartina anglica.* • **Birds:** Wintering and breeding birds including *Charidrius hiaticula Sterna albifrons*, *Anas penelope*, *Anas crecca Pluvialis squatarola, Anas clypeata*, *Caladris canutus*, *Caladris alpina Tringa erythropus Alauda arvensis*, *Anthus pratensis , Arenaria interpres, Motacilla flava*, *Anas platyrhynchos*, *Tadorna tadorna*, coot *Fulica atra*, *Gallinula chloropus*, *Vanellus vanellus Tringa totanus*. *Anas strepera*, *Athyia farina*, *Anas quercedula*, *Anas acuta*, *Philomachus pugnax.*
Holehaven Creek,	• **Intertidal habitats** including saltmarsh containg species such as *Puccinellia maritima Aster tripolium Atriplex portulacoides.* • **Birds:** Wintering waterfowl - especially *Limosa limosa islandica*. Also *Numenius arquata* and *Calidris alpina.*
Vange and Fobbing Marshes	• **Terrestrial/coastal habitats:** Unimproved coastal grassland. • **Intertidal habitats:** Saltmarsh. • **Plants:** *Agrostis stolonifera, Anthoxanthum odoratum, Bromus hordeaceus, Cynosurus cristatus, Dactylis glomerata, Elymus repens, Festuca rubra, Phleum spp., Poa spp., Ranunculus sardous Lathyrus nissolia,* *Hordeum marinum, Bupleurum tenuissimum,Trifolium squamosum ,Pucinellia rupestris,Cynoglossum officinale, Petroselinumsegetum Lotus tenuis, Lactuca saligna, Ranunculus baudotii Scirpus maritimus, Phragmites australis Glyceria fluitans aquatica.*

	• **Birds:** Tringa totanus, *Asio flammeus.* • **Invertebrates:** *Lestes dryas,Metrioptera roeselii*, *Tettigonia viridissima, Mutilla europaea*, *Lasius flavus.*
Canvey Wick	• **Terrestrial/coastal habitats:**Grassland, including herb-rich grassland, early successional habitat and scrub edge. Coastal wetland. • **Invertebrates**: (*Bombus sylvarum*, *Sitona cinerascens*) *Scybalicus oblongiusculus*) *Hecatera dysodea*).
Pitsea Marsh	• **Freshwater Habitats**: Mosaic of reedbed (*Phragmites australis)* and fen, open water. • **Intertidal habitats**: Saltmarsh. • **Invertebrates**: *Metrioptera roeselii*, *Leiobunum rotundum, Dyschirius impunctipennis.*

Table A2.5: National Nature Reserves within 25km of the Hoo Peninsula.

NNR	Summary of designated species/habitats
Hoo Peninsula and immediate coastal waters to within 1 km of the footprint	
High Halstow	**Woodland habitat:** • Complex mosaic of scrub and woodland habitat. • Dominated by hawthorn scrub and ancient oak woodlands. • Regenerating elm woodland.
1-25 km zone	
Leigh	**Intertidal habitats:** • Encompasses Leigh Sands intertidal flats. **Birds:** • The flats support a wide variety of birds, particularly migratory wading species.
Elmley NNR	**Birds:** • Supports large numbers wintering wildfowl and breeding waders, including golden plover, curlew, pintail and teal, as well as hen harriers, marsh harriers, merlins and short-eared owls. **Coastal grazing marsh habitat:** • Diverse patchwork of grazing marsh, including grasses and wildflowers.

Table A2.6: MCZ sites within 25km of the Hoo Peninsula

MCZ	Size (Ha)	Summary of designated species/habitats
Hoo Peninsula and immediate coastal waters to within 1 km of the footprint		
Thames Estuary (*Recommended)	13,214	**Fish:** • European eel *(Anguilla anguilla*). • Smelt (*Osmerus eperlanus*). **Intertidal and subtidal habitats**: • Mudflats. • Saltmarsh. • Sedimentary gravels. **Invertebrates:** • Tentacled lagoon worm (*Alkmaria romijni*) . • Ross worms (*Sabellaria spinulosa).*
Medway Estuary(Designated)	6,483	**Marine Invertebrates:** • Tentacled lagoon worm (*Alkmaria romijni*) . **Intertidal and subtidal habitats**: • Mosaic of habitats including subtidal and intertidal sands, gravels, mud and mixed sediment. **Terrestrial habitats:** • Saltmarsh islands. • Peat and clay exposures.
1-25 km zone		
The Blackwater, Crouch, Roach and Colne Estuaries (Designated)	28,400	**Invertebrates:** • Native oyster *(Ostrea edulis***).** • Ross worms (*Sabellaria spinulosa).* • Blue mussel *(Mytilus edulis).* • Lagoon slug *(Tenellia adspersa).* **Intertidal habitats:** • Mosaic of subtidal and intertidal sands, gravels, mud and mixed sediment. • Saltmarsh.

A3(a): Natura 2000 within 25km sites of the Hoo Peninsula (grouped by site): Conservation Objectives

Site Name	Citation Number	Size (ha)	Conservation Objectives
Thames Estuary and Marshes SPA	UK9012021	4,802.5	With regard to the individual species and/or assemblage of species for which the site has been classified ("the Qualifying Features" listed below); Avoid the deterioration of the habitats of the qualifying features, and the significant disturbance of the qualifying features, ensuring the integrity of the site is maintained and the site makes a full contribution to achieving the aims of the Birds Directive. Subject to natural change, to maintain or restore: • The extent and distribution of the habitats of the qualifying features; • The structure and function of the habitats of the qualifying features; • The supporting processes on which the habitats of the qualifying features rely; • The populations of the qualifying features; • The distribution of the qualifying features within the site. Qualifying Features: A082 *Circus cyaneus*; Hen harrier (Non-breeding) A132 *Recurvirostra avosetta*; Pied avocet (Non-breeding) A137 *Charadrius hiaticula*; Ringed plover (Non-breeding) A141 *Pluvialis squatarola*; Grey plover (Non-breeding) A143 *Calidris canutus*; Red knot (Non-breeding) A149 *Calidris alpina alpina*; Dunlin (Non-breeding) A156 *Limosa limosa islandica*; Black-tailed godwit (Non-breeding) A162 *Tringa totanus*; Common redshank (Non-breeding) Waterbird assemblage
Thames Estuary and Marshes RAMSAR	1025	5553.6	
Medway Estuary and Marshes SPA	UK9012031	4,684.4	With regard to the individual species and/or assemblage of species for which the site has been classified ("the Qualifying Features" listed below); Avoid the deterioration of the habitats of the qualifying features, and the significant disturbance of the qualifying features, ensuring the integrity of the site is maintained and the site makes a full contribution to achieving the aims of the Birds

Site Name	Citation Number	Size (ha)	Conservation Objectives
			Directive. Subject to natural change, to maintain or restore: • The extent and distribution of the habitats of the qualifying features; • The structure and function of the habitats of the qualifying features; • The supporting processes on which the habitats of the qualifying features rely; • The populations of the qualifying features; • The distribution of the qualifying features within the site. Qualifying Features: A046a *Branta bernicla bernicla*; Dark-bellied brent goose (Non-breeding) A048 *Tadorna tadorna*; Common shelduck (Non-breeding) A054 *Anas acuta*; Northern pintail (Non-breeding) A132 *Recurvirostra avosetta*; Pied avocet (Breeding) A132 *Recurvirostra avosetta*; Pied avocet (Non-breeding) A137 *Charadrius hiaticula*; Ringed plover (Non-breeding) A141 *Pluvialis squatarola*; Grey plover (Non-breeding) A143 *Calidris canutus*; Red knot (Non-breeding) A149 *Calidris alpina alpina*; Dunlin (Non-breeding) A162 *Tringa totanus*; Common redshank (Non-breeding) A195 *Sterna albifrons*; Little tern (Breeding) Waterbird assemblage Breeding bird assemblage Additional Qualifying Features Identified by the 2001 UK SPA Review: A156 *Limosa limosa islandica*; Black-tailed godwit (Non-breeding)
Medway Estuary and Marshes RAMSAR	645	4697.9	
Benfleet and Southend Marshes SPA	UK9009171	2,284	With regard to the individual species and/or assemblage of species for which the site has been classified ("the Qualifying Features" listed below);

Site Name	Citation Number	Size (ha)	Conservation Objectives
			Avoid the deterioration of the habitats of the qualifying features, and the significant disturbance of the qualifying features, ensuring the integrity of the site is maintained and the site makes a full contribution to achieving the aims of the Birds Directive. Subject to natural change, to maintain or restore: • The extent and distribution of the habitats of the qualifying features; • The structure and function of the habitats of the qualifying features; • The supporting processes on which the habitats of the qualifying features rely; • The populations of the qualifying features; • The distribution of the qualifying features within the site. Qualifying Features: A046a *Branta bernicla bernicla*; Dark-bellied brent goose (Non-breeding) A137 *Charadrius hiaticula*; Ringed plover (Non-breeding) A141 *Pluvialis squatarola*; Grey plover (Non-breeding) A143 *Calidris canutus*; Red knot (Non-breeding) A149 *Calidris alpina alpina*; Dunlin (Non-breeding) Waterbird assemblage
Benfleet and Southend Marshes RAMSAR	648	2284	
The Swale SPA	UK9012011	6,509.9	With regard to the individual species and/or assemblage of species for which the site has been classified ("the Qualifying Features" listed below); Avoid the deterioration of the habitats of the qualifying features, and the significant disturbance of the qualifying features, ensuring the integrity of the site is maintained and the site makes a full contribution to achieving the aims of the Birds Directive. Subject to natural change, to maintain or restore: • The extent and distribution of the habitats of the qualifying features; • The structure and function of the habitats of the qualifying features; • The supporting processes on which the habitats of the qualifying features rely; • The populations of the qualifying features;

Site Name	Citation Number	Size (ha)	Conservation Objectives
			• The distribution of the qualifying features within the site. Qualifying Features: A046a *Branta bernicla bernicla*; Dark-bellied brent goose (Non-breeding) A149 *Calidris alpina alpina*; Dunlin (Non-breeding) Breeding bird assemblage Waterbird assemblage Additional Qualifying Features Identified by the 2001 UK SPA Review: A054 *Anas acuta*; Northern pintail (Non-breeding) A056 *Anas clypeata*; Northern shoveler (Non-breeding) A081 *Circus aeruginosus*; Eurasian marsh harrier (Breeding) A082 *Circus cyaneus*; Hen harrier (Non-breeding) A132 *Recurvirostra avosetta*; Pied avocet (Breeding) A132 *Recurvirostra avosetta*; Pied avocet (Non-breeding) A137 *Charadrius hiaticula*; Ringed plover (Non-breeding) A140 *Pluvialis apricaria*; European golden plover (Non-breeding) A141 *Pluvialis squatarola*; Grey plover (Non-breeding) A143 *Calidris canutus*; Red knot (Non-breeding) A156 *Limosa limosa islandica*; Black-tailed godwit (Non-breeding) A157 *Limosa lapponica*; Bar-tailed godwit (Non-breeding) A162 *Tringa totanus*; Common redshank (Non-breeding) A176 *Larus melanocephalus*; Mediterranean gull (Breeding)
The Swale RAMSAR	299	6,509.9	
Foulness (Mid Essex Coast Phase 5) SPA	UK9009246	10,942.1	With regard to the individual species and/or assemblage of species for which the site has been classified ("the Qualifying Features" listed below); Avoid the deterioration of the habitats of the qualifying features, and the significant disturbance of the qualifying features, ensuring the integrity of the site is aintained and the site makes a full contribution to achieving the aims of the Birds Directive.

Site Name	Citation Number	Size (ha)	Conservation Objectives
			Subject to natural change, to maintain or restore: • The extent and distribution of the habitats of the qualifying features; • The structure and function of the habitats of the qualifying features; • The supporting processes on which the habitats of the qualifying features rely; • The populations of the qualifying features; • The distribution of the qualifying features within the site. Qualifying Features: A046a *Branta bernicla bernicla*; Dark-bellied brent goose (Non-breeding) A082 *Circus cyaneus*; Hen harrier (Non-breeding) A130 *Haematopus ostralegus*; Eurasian oystercatcher (Non-breeding) A132 *Recurvirostra avosetta*; Pied avocet (Breeding) A137 *Charadrius hiaticula*; Ringed plover (Breeding) A141 *Pluvialis squatarola*; Grey plover (Non-breeding) A143 *Calidris canutus*; Red knot (Non-breeding) A157 *Limosa lapponica*; Bar-tailed godwit (Non-breeding) A162 *Tringa totanus*; Common redshank (Non-breeding) A191 *Sterna sandvicensis*; Sandwich tern (Breeding) A193 *Sterna hirundo*; Common tern (Breeding) A195 *Sterna albifrons*; Little tern (Breeding) Waterbird assemblage Additional Qualifying Features Identified by the 2001 UK SPA Review: A132 *Recurvirostra avosetta*; Pied avocet (Non-breeding) A140 *Pluvialis apricaria*; European golden plover (Non-breeding)
Foulness (Mid Essex Coast Phase 5) RAMSAR	861	10,942.1	
Crouch and Roach Estuaries (Mid Essex	UK9009244	1,735.6	With regard to the individual species and/or assemblage of species for which the site has been classified ("the Qualifying Features" listed below); Avoid the deterioration of the habitats of the qualifying features, and the significant disturbance of the qualifying features,

Site Name	Citation Number	Size (ha)	Conservation Objectives
Coast Phase 3) SPA			ensuring the integrity of the site is maintained and the site makes a full contribution to achieving the aims of the Birds Directive. Subject to natural change, to maintain or restore: • The extent and distribution of the habitats of the qualifying features; • The structure and function of the habitats of the qualifying features; • The supporting processes on which the habitats of the qualifying features rely; • The populations of the qualifying features; • The distribution of the qualifying features within the site. Qualifying Features: A046a *Branta bernicla bernicla*; Dark-bellied brent goose (Non-breeding) Waterbird assemblage
Crouch and Roach Estuaries (Mid Essex Coast Phase 3) RAMSAR	721	1735.6	
Blackwater Estuary (Mid Essex Coast Phase 4) SPA	UK9009245	4403.41	With regard to the individual species and/or assemblage of species for which the site has been classified ("the Qualifying Features" listed below); Avoid the deterioration of the habitats of the qualifying features, and the significant disturbance of the qualifying features, ensuring the integrity of the site is maintained and the site makes a full contribution to achieving the aims of the Birds Directive. Subject to natural change, to maintain or restore: • The extent and distribution of the habitats of the qualifying features; • The structure and function of the habitats of the qualifying features; • The supporting processes on which the habitats of the qualifying features rely; • The populations of the qualifying features; • The distribution of the qualifying features within the site.

Site Name	Citation Number	Size (ha)	Conservation Objectives
			Qualifying Features: A046a *Branta bernicla bernicla*; Dark-bellied brent goose (Non-breeding) A059 *Aythya ferina*; Common pochard (Breeding) A082 *Circus cyaneus*; Hen harrier (Non-breeding) A137 *Charadrius hiaticula*; Ringed plover (Breeding) A141 *Pluvialis squatarola*; Grey plover (Non-breeding) A149 *Calidris alpina alpina*; Dunlin (Non-breeding) A156 *Limosa limosa islandica*; Black-tailed godwit (Non-breeding) A195 *Sterna albifrons*; Little tern (Breeding) Waterbird assemblage Additional Qualifying Features Identified by the 2001 UK SPA Review: A048 *Tadorna tadorna*; Common shelduck (Non-breeding) A132 *Recurvirostra avosetta*; Pied avocet (Non-breeding) A137 *Charadrius hiaticula*; Ringed plover (Non-breeding) A140 *Pluvialis apricaria*; European golden plover (Non-breeding) A151 *Philomachus pugnax*; Ruff (Non-breeding) A162 *Tringa totanus*; Common redshank (Non-breeding)
Blackwater Estuary (Mid Essex Coast Phase 4) RAMSAR	543	4403.41	
Dengie (Mid Essex Coast Phase 1) SPA	UK9009242	3134.01	With regard to the individual species and/or assemblage of species for which the site has been classified ("the Qualifying Features" listed below); Avoid the deterioration of the habitats of the qualifying features, and the significant disturbance of the qualifying features, ensuring the integrity of the site is maintained and the site makes a full contribution to achieving the aims of the Birds Directive. Subject to natural change, to maintain or restore: • The extent and distribution of the habitats of the qualifying features; • The structure and function of the habitats of the qualifying features; • The supporting processes on which the habitats of the qualifying features rely;

Site Name	Citation Number	Size (ha)	Conservation Objectives
			• The populations of the qualifying features; • The distribution of the qualifying features within the site. Qualifying Features: A046a *Branta bernicla bernicla*; Dark-bellied brent goose (Non-breeding) A082 *Circus cyaneus*; Hen harrier (Non-breeding) A141 *Pluvialis squatarola*; Grey plover (Non-breeding) A143 *Calidris canutus*; Red knot (Non-breeding) Waterbird assemblage Additional Qualifying Features Identified by the 2001 UK SPA Review: A157 *Limosa lapponica*; Bar-tailed godwit (Non-breeding)
Dengie (Mid Essex Coast Phase 1) RAMSAR	651	3134.01	
Outer Thames Estuary SPA	UK9020309	379,268.14	The conservation objective for the Outer Thames Estuary Special Protection Area is, subject to natural change, maintain or enhance the red-throated diver population (*Gavia stellata*) and its supporting habitats in favourable condition The interest feature red-throated diver will be considered to be in favourable condition only when both of the following two conditions are met: (i) The size of the red-throated diver population is at, or shows only non-significant fluctuation around the mean population at the time of designation of the SPA to account for natural change; (ii) The extent of the supporting habitat within the site is maintained.
Blean Complex SAC	UK0013697	522.89	With regard to the natural habitats and/or species for which the site has been designated (“the qualifying Features" listed below); Avoid the deterioration of the qualifying natural habitats and the habitats of qualifying species, and the significant disturbance of those qualifying species, ensuring the integrity of the site is maintained and the site makes a full contribution to achieving Favourable conservation Status of each of the qualifying features.

Site Name	Citation Number	Size (ha)	Conservation Objectives
			Subject to natural change, to maintain or restore: • The extent and distribution of qualifying natural habitats and habitats of qualifying species; • The structure and function (including typical species) of qualifying natural habitats and habitats of qualifying species; • The supporting processes on which qualifying natural habitats and habitats of qualifying species rely; • The populations of qualifying species; • The distribution of qualifying species within the site. Qualifying Features: H9160. Sub-AAtlantic and medio-European oak or oak-hornbeam forests of the *Carpinion betuli*; Oak-hornbeam forests
North Downs Woodlands SAC	UK0030225	288.58	With regard to the natural habitats and/or species for which the site has been designated ("the Qualifying Features" listed below); Avoid the deterioration of the qualifying natural habitats and the habitats of qualifying species, and the significant disturbance of those qualifying species, ensuring the integrity of the site is maintained and the site makes a full contribution to achieving Favourable Conservation Status of each of the qualifying features. Subject to natural change, to maintain or restore: • The extent and distribution of qualifying natural habitats and habitats of qualifying species; • The structure and function (including typical species) of qualifying natural habitats and habitats of qualifying species; • The supporting processes on which qualifying natural habitats and habitats of qualifying species rely; • The populations of qualifying species; • The distribution of qualifying species within the site. Qualifying Features: H6210. Semi-natural dry grasslands and scrubland facies: on calcerous substrates (*Festuco-Brometalia*); Dry grasslands and scrublands on chalk or limestone H9130. *Asperulo-Fagetum* beech forests; Beech forests on neutral to rich soils H91J0. Taxus baccata woods of the British Isles; Yew-dominated woodland
Essex Estuaries SAC	UK0013690	46109.96	Wiith regard to the natural habitats and/or species for which the site has been designated ("the Qualifying Features" listed below);

Site Name	Citation Number	Size (ha)	Conservation Objectives
			Avoid the deterioration of the qualifying natural habitats and the habitats of qualifying species, and the significant disturbance of those qualifying species, ensuring the integrity of the site is maintained and the site makes a full contribution to achieving Favourable Conservation Status of each of the qualifying features. Subject to natural change, to maintain or restore: • The extent and distribution of qualifying natural habitats and habitats of qualifying species; • The structure and function (including typical species) of qualifying natural habitats and habitats of qualifying species; • The supporting processes on which qualifying natural habitats and habitats of qualifying species rely; • The populations of qualifying species; • The distribution of qualifying species within the site. Qualifying Features: H1110. Sandbanks which are slightly covered by sea water all the time; Subtidal sandbanks H1130. Estuaries H1140. Mudflats and sandflats not covered by seawater at low tide; Intertidal mudflats and sandflats H1310. Salicornia and other annuals colonising mud and sand; Glasswort and other annuals colonising mud and sand H1320. Spartina swards (*Spartinion maritimae*); Cord-grass swards H1330. Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*) H1420. Mediterranean and thermo-Atlantic halophilous scrubs (*Sarcocornetea fruticosi*); Mediterranean saltmarsh scrub
Peters Pit SAC	UK0030237	28.91	With regard to the natural habitats and/or species for which the site has been designated (the “Qualifying Features‟ listed below), and subject to natural change; Ensure that the integrity of the site is maintained or restored as appropriate, and ensure that the site contributes to achieving the Favourable Conservation Status of its Qualifying Features, by maintaining or restoring; • The extent and distribution of the habitats of qualifying species • The structure and function of the habitats of qualifying species • The supporting processes on which the habitats of qualifying species rely • The populations of qualifying species, and, • The distribution of qualifying species within the site.

Site Name	Citation Number	Size (ha)	Conservation Objectives
			Qualifying Features: S1166. *Triturus cristatus*; Great crested newt
Queensdown Warren SAC	UK0012833	14.42	With regard to the natural habitats and/or species for which the site has been designated ("the Qualifying Features" listed below); Avoid the deterioration of the qualifying natural habitats and the habitats of qualifying species, and the significant disturbance of those qualifying species, ensuring the integrity of the site is maintained and the site makes a full contribution to achieving Favourable Conservation Status of each of the qualifying features. Subject to natural change, to maintain or restore: • The extent and distribution of qualifying natural habitats and habitats of qualifying species; • The structure and function (including typical species) of qualifying natural habitats and habitats of qualifying species; • The supporting processes on which qualifying natural habitats and habitats of qualifying species rely; • The populations of qualifying species; • The distribution of qualifying species within the site. Qualifying Features: H6210. Semi-natural dry grasslands and scrubland facies: on calcerous substrates (*Festuco-Brometalia*) (important orchid sites); Dry grasslands and scrublands on chalk or limestone (important orchid sites)
Tankerton Slopes and Swalecliffe cSAC	UK0030378	13.01	• **This is a candidate SAC so no formal conservation objectives are published**
Margate and Long Sands cSAC	UK0030371	64876.84	• **This is a candidate SAC so no formal conservation objectives are published**

Note: OSPAR Marine Protected Areas form all or part of an existing UK protected areas (SAC, SPA, Ramsar, MCZ and SSSIs) up to the mean high water mark.

A3(b): Species of conservation importance

Table A3(b): Additional information on species or groups of species of conservation importance likely to be within or near the airport footprint

Group	Details
Breeding birds	See citations above for species present. The Hoo peninsular and wider Thames estuary supports important breeding bird populations of a number of internationally and nationally designated bird species. In 2002, the Thames Estuary and Marshes SPA/Ramsar site supported 60 breeding pairs of avocet, as well as 45 pairs outside the site boundary at the Northward Hill RSPB Reserve. Common tern *Sterna hirundo*, regularly breeds at the Cliffe Pools RSPB reserve, with 7 pairs recorded in 2002 (RSPB). Inland habitats on the peninsula support a range of woodland and farmland birds, as well as the largest heronry in the UK at Coastal sites adjacent to the wider Thames estuary support similar breeding waterfowl assemblages with waders, wildfowl, gulls, and terns, as well as marsh harriers and hen harriers. Examples are habitats such as grazing marsh and flooded mineral workings are important for species such as hen harrier and avocet, both within and beyond the SPA boundaries.
Over-wintering birds	See citations above for species present. The Thames estuary complex forms a vital staging post and wintering site for a large number of migratory waterfowl, especially in harsh weather conditions where the relatively sheltered nature of the estuary provides accessible foraging (e.g. mudflats) and high tide roosting sites (e.g. saltmarsh). The Swale and Medway estuaries adjacent to the Hoo Peninsula are also important for waterfowl, with average waterbird counts in the magnitude of 75,000 and 33,000, respectively. The Thames estuary is internationally important for wintering and migrating waterfowl. Within the UK it is one of the most important estuaries for waterfowl, ranking fifth in terms of numbers of waterbirds recoded in WeBS (Wetland Bird Survey) core counts (2007-2012, mean of 159,528). Dunlin, knot and oystercatcher have been recorded as the most abundant species in the Thames Estuary WeBS low tide counts between the Medway and Crouch Estuaries, with densities of 9.35, 2.53 and 3.39 per ha, respectively (2008/09 figures). This assemblage of birds is also present throughout the coastal areas adjacent to the wider Thames Estuary. The total numbers of waterbirds in the Thames Estuary have been relatively stable over the last four years (from 2008/09 to 2011/12) with 153,801 birds recorded in 2011/12 (Austin *et al*., 2014). The adjacent Swale Estuary showed some variation in numbers between years from a peak of 91,390 n 2007/08 to a low of 51,837 in 2011/12. Total bird numbers in the Medway Estuary also show fluctuations between years but no overall trend.
Fish	European eel (*Anguilla anguilla*) (Section 41 species, IUCN Red List Critically endangered) is present in the Thames and this species also utilise the drainage channels and ponds on the Hoo Peninsula and Isle of Grain. Sea lamprey (*Petromyzon marinus*) and twaite shad (*Alosa fallax*) (both Section 41 species) have been caught at Kingsnorth Power station (Wharfe et al., 1996), therefore are expected to be using the waters around the area. The Thames, Medway and Swale are described as rivers where smelt *(Osmerus eperlanus*) (a Section 41 species) populations are thriving (Maitland, 2003).

Group	Details
	Other Section 41 species recorded in the waters around Thames/Medway estuary include: • Herring • Short-snouted Seahorse • Lesser sandeel • Whiting • Dover sole • Scad • Mackerel • Cod Over 50 species of fish have been recorded in the Medway estuary including mullet, dragonets, gobies, flatfish, sprat and herrings, sea trout and members of the cod family. The herring present in the Medway are the from the Thames Estuary stock, which are a unique strain that are smaller than usual and have fewer vertebrae. The creeks and areas in the vicinity of the saltmarsh and mudflats provide nursery grounds for small fish, with the Kingsnorth Power station (Damhead Creek) and Isle of Grain power station outfalls designated as bass nursery areas (Rogers, 2007).
Aquatic Invertebrates	The tentacled lagoon worm is present in the sediments of the Medway estuary. This species is a nationally scarce marine animal, protected under Schedule 5 of the Wildlife and Countryside Act 1981. The other invertebrate of interest is the introduced polychaete *Clymenella torquata*, as the Swale is one of the few places it is found in the UK. In addition to the rich benthic invertebrate community that is present all around the coastline of the Hoo Peninsula and Isle of Grain, there is a protected mussel and oyster fishery in Swale estuary. Waters off the Isle of Grain and seaward (named Southend) are one of several in the outer designated under the Shellfish Waters Directive (79/923/EEC) which aims to protect the habitats of bivalve and gastropod molluscs. There is a thriving cockle fishery in the Thames Estuary within this designated area.
Marine mammals	Four species of internationally designated marine mammal regularly occur in the Thames Estuary off the Hoo Peninsula and further upstream: • Grey seal • Common seal • Harbour porpoise • Common dolphin Blyth Sands provide a haul out site for seals (Kowalik et al., 2008, 2005).
Terrestrial and freshwater mammals, reptiles and amphibians.	A range of mammals, reptiles and amphibians are likely to be present on the Hoo Peninsula. These are mobile species and/or live in metapopulations in the area. There are no mammals, reptiles or amphibians which are qualifying features for internationally or nationally designated sites within 1 km of the potential footprint, but a number of these species are protected. Great crested newt is afforded considerable protection under various conservation designations and is present on the Hoo Peninsula, along with slow worm and grass snake. There is also an expanding water vole population recorded in the area of Damhead Creek. The Hoo Peninsular has also been reported as being an important area for serotine bats.

A4: Summary of Potential Impacts

Table A4.1: Summary of construction impacts relating to the footprint of the airport hub (generic for all options).

Ref no.	Source (activity)	Feature or activity leading to impact	Impact (pathway)	Receptors	Direct / Indirect	Location of impact	Duration	Magnitude of impact: upper range	Magnitude of impact: lower range
1	Aquatic ecology								
1.1	Land reclamation	Placement of dredged material on existing habitats to create new land for airport	Habitat loss	SPA, Ramsar, SSSI, MCZ. Subtidal, intertidal, freshwater habitats	Direct	Footprint	Permanent	High. Large area of international nature conservation area lost.	High. Large area of international nature conservation area lost.
			Habitat fragmentation (reduction in coherency of Natura 2000 network)	SPA, Ramsar, SSSI, MCZ. Subtidal, intertidal, freshwater habitats Annex II designated species Non-designated species including phytoplankton, zooplankton, fish	Indirect	Footprint and immediate surrounding area.	Permanent	High. Loss of coherence of Natura 2000 network.	Medium. Smaller options may reduce magnitude of impact on Natura 2000 network.
			Habitat degradation (e.g. change in sediment particle size).						
			Species loss / mortality.	Annex II designated benthic species Non-designated benthic species	Direct	Footprint	Permanent	Dependent on densities; potentially high for some.	Dependent on densities; potentially low for some.
			Loss of food (prey) resource	Annex II designated mobile species including fish and marine mammals	Indirect	Outside footprint	Permanent	Medium. Dependent on species' foraging range.	Low. Dependent on species' foraging range.
			Change to biodiversity/food chain Loss of species	Annex II designated, SPA and Ramsar qualifying mobile	Indirect	Outside footprint	Permanent	High. If food chain is disrupted.	Very low if no key species are impacted.

Ref no.	Source (activity)	Feature or activity leading to impact	Impact (pathway)	Receptors	Direct / Indirect	Location of impact	Duration	Magnitude of impact: upper range	Magnitude of impact: lower range
			which provide a food resource for other species and loss of species which cannot adapt to habitat alteration may alter the dominance or dependence of species within the food chain, e.g. an alternative food source may have to be utilised by some species.	species including fish and birds					
		Geomorphological changes from encroachment into estuary	Changes in patterns of sedimentation (accretion / erosion) could impact habitats leading to habitat loss or degradation	SAC, SPA Ramsar, SSSI, MCZ. Subtidal, intertidal habitats	Indirect	Immediate surrounding area and beyond (modelling needed)	Permanent	Large if scale of encroachment is large.	Medium, depending on scale of encroachment.
1.2	Site clearance	Building over existing ponds and diverting watercourses	Habitat loss	SPA, Ramsar Freshwater habitats	Direct	Footprint	Permanent	High. Large area of international nature conservation area lost.	Low. Depends on scale of designated habitat loss.
			Habitat fragmentation. Disruption of migration routes between ponds / rivers	Fish	Direct	Immediate surrounding area	Permanent	High. Large areas of freshwater habitat lost.	Low. If freshwater habitat is avoided.

Ref no.	Source (activity)	Feature or activity leading to impact	Impact (pathway)	Receptors	Direct / Indirect	Location of impact	Duration	Magnitude of impact: upper range	Magnitude of impact: lower range
			Habitat degradation or modification. Loss or redirection of freshwater flows may modify habitats which are dependent on freshwater flows.	SPA, Ramsar	Direct	Immediate surrounding area	Permanent	High. Large areas of freshwater habitat lost.	Low. If freshwater habitat is avoided.
			Species loss / mortality. Freshwater species lost either through loss of habitat in footprint or if species cannot adapt to change in conditions.	Fish Great crested newt Water vole	Direct	Immediate surrounding area	Permanent	High. Large areas of freshwater habitat lost.	Low. If freshwater habitat is avoided.
			Loss of food (prey) resource for freshwater species	Fish	Direct	Footprint	Permanent	High. Large areas of freshwater habitat lost.	Low. If freshwater habitat is avoided.
1.3	Piling	Piling around edge of land reclamation area	Species loss / mortality	Annex II designated benthic species Non-designated benthic species	Direct	Footprint	Permanent	Low. Small area lost.	Low. Small area lost.
2	**Terrestrial ecology**								
2.1	Site clearance	Building over existing terrestrial habitats.	Habitat loss	Section 41 priority habitats including coastal and floodplain grazing marsh, reedbed;	Direct	Footprint	Permanent	High. Large area of international nature conservation area	Low. Depends on scale of designated habitat loss.

Ref no.	Source (activity)	Feature or activity leading to impact	Impact (pathway)	Receptors	Direct / Indirect	Location of impact	Duration	Magnitude of impact: upper range	Magnitude of impact: lower range
				and deciduous woodland. In addition tree lines, hedgerows and scrub habitat could be lost.				lost.	
			Habitat fragmentation.	Loss of migration routes or wildlife corridors.	Direct	Immediate surrounding area	Permanent	High. Large area of international nature conservation area lost.	Low. Depends on scale of designated habitat loss.
			Habitat degradation or modification.	Changes to habitat, e.g. loss of scrub areas, trees, plant communities	Direct	Immediate surrounding area	Permanent	High: Large areas of terrestrial habitat degraded.	Low: Depends on scale of degradation.
			Species loss / mortality. Loss of protected and non-protected species. Some protected can be relocated.	Direct loss of non-mobile species (e.g. plants, invertebrates) which provide food for Annex II bird species. Indirect loss of species as a result of habitat loss / degradation / fragmentation, e.g. birds (Annex II), bats, badgers, dormice.	Direct / indirect	Footprint and immediate surrounding area.	Permanent	High: Large number of species impacted including Annex II designated birds.	Medium: Any option would impact Annex II designated birds.
			Loss of food (prey) resource for terrestrial species	Section 41 species including bats and badgers	Indirect	Footprint	Permanent	High: Large areas of terrestrial habitat lost.	Medium: Any option would result in loss of terrestrial habitat.

Table A4.2: Summary of construction impacts relating to the construction activities of the airport hub (generic for all options)

Ref no.	Source (activity)	Feature or activity creating impact	Impact (pathway)	Receptors	Direct / Indirect	Location of impact	Duration	Magnitude of impact: upper range	Magnitude of impact: lower range
1	Aquatic ecology								
1.1	Land reclamation	Changes to water environment.	Settlement of dredged material within bunded area will result in discharge of very high turbidly water into adjacent estuarine waters leading to smothering of benthic fauna, reduction in light availability and decrease in water quality (dissolved oxygen).	Annex II designated benthic species Non-designated benthic species Fish	Indirect	Immediate surrounding area and beyond (modelling needed)	Temporary	Medium if scale of encroachment is large.	Medium, depending on scale of encroachment.
		Numerous vessels bringing material by sea for land reclamation and construction of runway, roads, buildings etc.	Introduction of non-native (invasive) species. These could out-compete native species and / or cause habitat degradation.	Designated habitats e.g. SAC, SPA, Ramsar Fish Benthic species Non-designated habitats and species	Indirect	Immediate surrounding area to km	Permanent	High. Potential for invasive species to cause degradation of habitats and loss of native species.	Low. If materials are brought by land rather than sea.
1.3	Piling	Piling around edge of land reclamation area	Noise / vibration Underwater noise can cause disturbance to species leading to avoidance or attraction to the	Marine mammals Fish (salmon and trout in particular)	Indirect	Immediate surrounding area	Temporary	Low. Assumes best practice methodology but modelling needed.	Very low. Assumes best practice methodology but modelling needed.

Ref no.	Source (activity)	Feature or activity creating impact	Impact (pathway)	Receptors	Direct / Indirect	Location of impact	Duration	Magnitude of impact: upper range	Magnitude of impact: lower range
			works and / or modification of natural behaviour.						
			Disturbance (visual)	Marine mammals	Indirect	Immediate surrounding area	Temporary	Low. Assumes best practice methodology.	Low. Assumes best practice methodology.
1.4	Earthworks and drainage	Movement of earth around site, diversion of water courses	Increased run-off with high turbidity	Annex II designated benthic species Non-designated benthic species Fish	Indirect	Immediate surrounding area and beyond (modelling needed)	Temporary	Medium if scale of encroachment is large.	Medium, depending on scale of encroachment.
			Habitat degradation. Smothering of habitats and fauna from turbid water and deposition of dust on intertidal habitats. Impact on water quality in ponds, rivers and estuarine waters from reduction in dissolved oxygen levels and contaminants with associated impacts on species.	SPA, Ramsar Benthic estuarine and freshwater species Fish	Indirect	Immediate surrounding area to ~2km	Temporary	Low. Assumes best practice methodology.	Low. Assumes best practice methodology.
1.5	Construction activities	Noise from vessel	Intermittent noise / vibration over a	Marine mammals Fish (salmon and	Indirect	Immediate surrounding	Temporary	Low. Assumes best practice	Very low. Assumes best

Ref no.	Source (activity)	Feature or activity creating impact	Impact (pathway)	Receptors	Direct / Indirect	Location of impact	Duration	Magnitude of impact: upper range	Magnitude of impact: lower range
		movements, construction machinery etc. (piling covered separately)	prolonged period of time	trout in particular)		area		methodology but modelling needed.	practice methodology but modelling needed.
		Artificial light	Disturbance to species which could have their behaviour modified as a result of artificial lighting	Marine mammals Fish	Indirect	Immediate surrounding area	Temporary	Medium. Depends on species' response and extent of lighting.	Low. Depends on species' response and extent of lighting.
2	**Terrestrial ecology**								
2.1	Construction activities	Air pollution	Mobilisation of dust which can settle on terrestrial habitats and vegetation.	Plants Coastal grazing marsh	Indirect	Immediate surrounding area	Permanent	Low: Unlikely to cause degradation if best practice is followed.	Very low: Unlikely to cause degradation if best practice is followed.
		Noise and vibration from construction vehicles and building work	Disruption of normal behaviour of terrestrial mammals and birds.	Annex II designated birds (particularly important for breeding birds) Protected species including bats, badgers, dormice	Indirect	Immediate surrounding area	Temporary	Medium: If best practice is followed then disturbance can be mitigated for. Timing is crucial to avoid impacts on breeding and feeding birds.	Low: If best practice is followed then disturbance can be mitigated and will have a relatively low impact.
		Disturbance	Visual disturbance from presence of machinery and construction	Annex II designated birds (particularly important for	Indirect	Immediate surrounding area	Temporary	Medium: If best practice is followed then disturbance can be mitigated for.	Low: If best practice is followed then disturbance can be mitigated and

Ref no.	Source (activity)	Feature or activity creating impact	Impact (pathway)	Receptors	Direct / Indirect	Location of impact	Duration	Magnitude of impact: upper range	Magnitude of impact: lower range
			personnel.	breeding birds) Protected species including bats, badgers, dormice				Timing is crucial to avoid impacts on breeding and feeding birds.	will have a relatively low impact.
		Artificial light	Visual disturbance from lighting used at night.	Annex II designated birds (particularly important for breeding birds) Protected species, especially for species which forage at night, e.g. bats.	Indirect	Immediate surrounding area	Temporary	Medium: If best practice is followed then disturbance can be mitigated for.	Low: If best practice is followed then disturbance can be mitigated and will have a relatively low impact.

Table A 4.3: Operational impacts relating to the airport hub (generic for all options)

Ref no.	Source (activity)	Feature or activity creating impact	Impact	Receptors	Direct / Indirect	Location of impact	Duration	Magnitude of impact: upper range	Magnitude of impact: lower range
1	Aquatic ecology								
1.1	Flight operations	Air pollution Increase in air pollution from combustion of aviation fuel (NO_x, CO, CO_2, SOx, hydrocarbons, particulates, VOCs)	Changes to air quality and deposition on habitats could cause dieback of designated aquatic flora	Designated and non-designated flora	Indirect	Immediate surrounding area and beyond.	Permanent	Uncertain. Modelling required.	Uncertain. Modelling required.
		Air pollution Fuel dumping	Kerosene may be dumped from aircraft which could lead to contamination of estuarine waters with associated effects on species and habitats.	All aquatic habitats and species	Indirect	Immediate surrounding area and beyond.	Temporary	Uncertain	Very low / negligible if this practice can be avoided.
		Noise and vibration from approaching aeroplanes and general operations	Disturbance to species / change in behaviour of species	Marine mammals (seals) Fish	Indirect	Immediate surrounding area and beyond (modelling needed)	Permanent	Medium. Depends on level of noise.	Low. Depends on level of noise.
		Artificial lighting for runways etc. Increased shading in other areas.	Disturbance to species which could have their behaviour modified as a result of artificial	Marine mammals Fish Flora (e.g. saltmarsh)	Indirect	Immediate surrounding area	Permanent	Medium. Depends on level of lighting / shading.	Low. Depends on level of lighting / shading.

Ref no.	Source (activity)	Feature or activity creating impact	Impact	Receptors	Direct / Indirect	Location of impact	Duration	Magnitude of impact: upper range	Magnitude of impact: lower range
			lighting. Death/failure to thrive of plant species in shaded areas.						
1.2	Ground operations	Air pollution Increase in air pollution from vehicles accessing airport (passenger and delivery) and from ground operations	Changes to air quality and deposition on habitats could cause dieback of designated aquatic flora	Aquatic flora	Indirect	Immediate surrounding area and beyond.	Permanent	Medium. Modelling required.	Low. Modelling required.
		Changes to water environment	Reduction in water quality from discharge of low quality water (low dissolved oxygen, pollutants) into estuary. Risk of surface water contamination, including from drainage, de-icing operations and accidental fuel spillage.	Marine mammals Fish Benthic invertebrates	Direct/ Indirect	Immediate surrounding area and beyond (modelling needed)	Temporary	Low. If best practice is used.	Low. If best practice is used.
		Changes to water environment Wastewater	Additional waste water loading on existing sewage treatment works could increase the risk for overflow	Fish Benthic estuarine species Macrophytes and macroalgae	Indirect	Immediate surrounding area and beyond.	Temporary (intermittent)	Very low if design incorporates requirement.	Very low if design incorporates requirement.

Ref no.	Source (activity)	Feature or activity creating impact	Impact	Receptors	Direct / Indirect	Location of impact	Duration	Magnitude of impact: upper range	Magnitude of impact: lower range
			into estuarine waters without appropriate planning, leading to reduction in water quality (decrease in dissolved oxygen levels and increase in nutrient loading).	Phytoplankton					
2	**Terrestrial ecology**								
2.1	Flight operations	Air pollution Increase in air pollution from combustion of aviation fuel (NO_x, CO, CO_2, SOx, hydrocarbons, particulates, VOCs)	Changes to air quality and deposition on habitats could cause displacement and or dieback of designated terrestrial flora and fungi	Designated and non-designated flora and fungi	Indirect	Immediate surrounding area and beyond.	Permanent	Uncertain. Modelling required.	Uncertain. Modelling required.
		Air pollution Fuel dumping	Kerosene may be dumped from aircraft which could lead to contamination of terrestrial habitats with associated effects on species.	All terrestrial habitats and species	Indirect	Immediate surrounding area and beyond.	Temporary	Uncertain	Very low / negligible if this practice can be avoided.
		Noise and vibration from approaching	Disturbance to species / change in behaviour of	Annex II designated birds (particularly	Indirect	Immediate surrounding area and	Permanent	Medium. Depends on level of noise.	Low. Depends on level of noise.

Ref no.	Source (activity)	Feature or activity creating impact	Impact	Receptors	Direct / Indirect	Location of impact	Duration	Magnitude of impact: upper range	Magnitude of impact: lower range
		aeroplanes and general operations	species	important for breeding birds) Protected species, especially for species which forage at night, e.g. bats.		beyond (modelling needed)			
		Artificial lighting for runways etc. Increased shading in other areas.	Disturbance to species which could have their behaviour modified as a result of artificial lighting. Death/failure to thrive of plant species in shaded areas.	Annex II designated birds (particularly important for breeding birds) Protected species, especially for species which forage at night, e.g. bats.	Indirect	Immediate surrounding area	Permanent	Medium. Depends on level of lighting / shading.	Low. Depends on level of lighting / shading.
1.2	Ground operations	Air pollution Increase in air pollution from vehicles accessing airport (passenger and delivery) and from ground operations	Changes to air quality and deposition on habitats could cause dieback of designated flora or fungi	Designated and non-designated flora and fungi	Indirect	Immediate surrounding area and beyond.	Permanent	Medium. Modelling required.	Low. Modelling required.
1.3	Bird strike management	Active bird deterrent	Loss of functional habitat for feeding, roosting and breeding.	Annex II designated birds	Indirect		Permanent	High: Exclusion of birds from internationally designated SPA habitat.	High

Ref no.	Source (activity)	Feature or activity creating impact	Impact	Receptors	Direct / Indirect	Location of impact	Duration	Magnitude of impact: upper range	Magnitude of impact: lower range
		Reducing potential for birds to use surrounding habitat	Loss of functional habitat leading to fragmentation of network.	Annex II designated birds	Indirect		Permanent	High: Exclusion of birds from internationally designated SPA habitat and surrounding habitat	High

A 5 Example Bird Species Population Distribution Maps (from WeBS): Dark Bellied Brent Goose and Black-tailed Godwit distribution maps

The Thames Estuary, for the purposes of WeBS, is usually taken to include the coast between the Rivers Medway and Crouch. Most of the intertidal habitat is muddy in character, with extensive areas of saltmarsh around Canvey Island. The narrow strip of saltmarsh along the north Kent coast was once more extensive, but was embanked to create coastal wet grassland. Much of the area is surrounded by sea walls, due to the relatively low-lying adjoining land coupled with rising sea levels. Land claim has removed about 12% of the Thames Estuary, mostly before the 19th century. Much of the site is heavily industrialised with major ports, chemical works and extensive areas of housing, apart from the north Kent coastline, which is more rural. Particular issues of conservation concern have included port developments and proposals for a new airport at Cliffe Marshes (Davidson 1998).

Low Tide Count year: 08/09

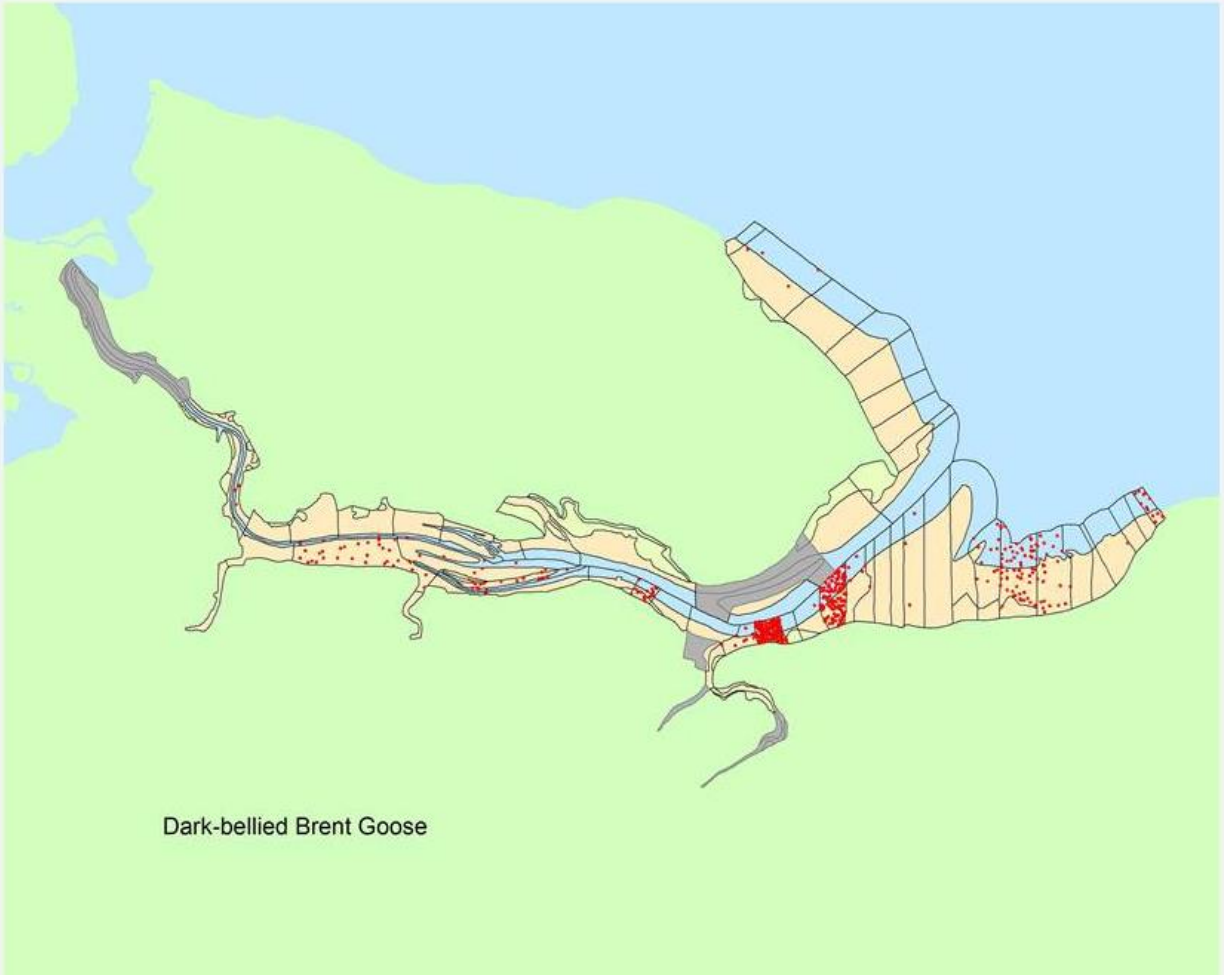
Display Map	English Name	Month Peak	Monthly average	Average density
◉	Brent Goose (Dark-bellied)	704	452	0.19
○	Shelduck	285	200	0.08
○	Wigeon	1883	871	0.30
○	Teal	76	36	0.01
○	Mallard	63	36	0.02
○	Pintail	4	1	<0.01
○	Oystercatcher	3208	2907	2.53
○	Ringed Plover	107	70	0.04
○	Golden Plover	756	333	0.17
○	Grey Plover	1181	513	0.28
○	Lapwing	1623	837	0.42
○	Knot	17941	6561	3.39
○	Dunlin	32123	17818	9.35
○	Black-tailed Godwit	531	323	0.17
○	Bar-tailed Godwit	3	1	<0.01
○	Curlew	768	603	0.42
○	Redshank	699	414	0.25
○	Turnstone	152	106	0.06
	Gadwall	4	1	<0.01
	Shoveler	8	3	<0.01
	Common Scoter	20	7	0.02
	Red-breasted Merganser	2	<1	<0.01
	Red-throated Diver	1	<1	<0.01
	Great Crested Grebe	3	1	<0.01
	Cormorant	34	16	<0.01
	Little Egret	14	9	<0.01
	Grey Heron	2	1	<0.01
	Moorhen	30	10	<0.01
	Coot	20	7	<0.01
	Avocet	11	4	<0.01

The Medway Estuary, on the North Kent coast, is formed by the river outflow upon which stand Rochester, Chatham and Gillingham, opening into a series of mudflats, brackish saltmarsh and sub-tidal islands. It is central to a local network of estuarine sites, also encompassing the Thames and Swale. The area is heavily urbanised and industrialised, not only along the south bank but also at the mouth: the Isle of Grain and Sheerness face each other on opposite sides of the river channel. The extent of intertidal and saltmarsh habitat is protected under SPA designation, though is considered in unfavourable declining condition, largely because of coastal erosion of saltmarsh. *Spartina* growth may also be an issue, whilst land claim for development is a persistent threat. Watersports, wildfowling and shipping activity are potentially disturbing factors.

Low Tide Count year: 05/06

Display Map	English Name	Month Peak	Monthly average	Average density
◉	Brent Goose (Dark-bellied)	215	123	0.23
○	Shelduck	791	479	1.07
○	Wigeon	1966	942	1.34
○	Teal	667	307	0.45
○	Mallard	61	26	0.04
○	Pintail	135	60	0.10
○	Oystercatcher	515	263	0.77
○	Ringed Plover	30	17	0.05
○	Golden Plover	0	0	0.00
○	Grey Plover	269	139	0.43
○	Lapwing	834	421	1.15
○	Knot	50	16	0.04
○	Dunlin	4936	2775	8.44
○	Black-tailed Godwit	65	32	0.10
○	Bar-tailed Godwit	23	7	0.01
○	Curlew	1367	385	0.82
○	Redshank	494	270	0.70
○	Turnstone	145	54	0.14
	Greylag Goose	520	218	0.31
	Canada Goose	935	339	0.48
	Gadwall	4	1	<0.01
	Shoveler	10	4	<0.01
	Red-breasted Merganser	8	2	0.01
	Great Northern Diver	1	<1	<0.01
	Little Grebe	3	<1	<0.01
	Great Crested Grebe	35	10	0.05
	Cormorant	18	5	<0.01
	Little Egret	11	5	0.01
	Grey Heron	3	<1	<0.01

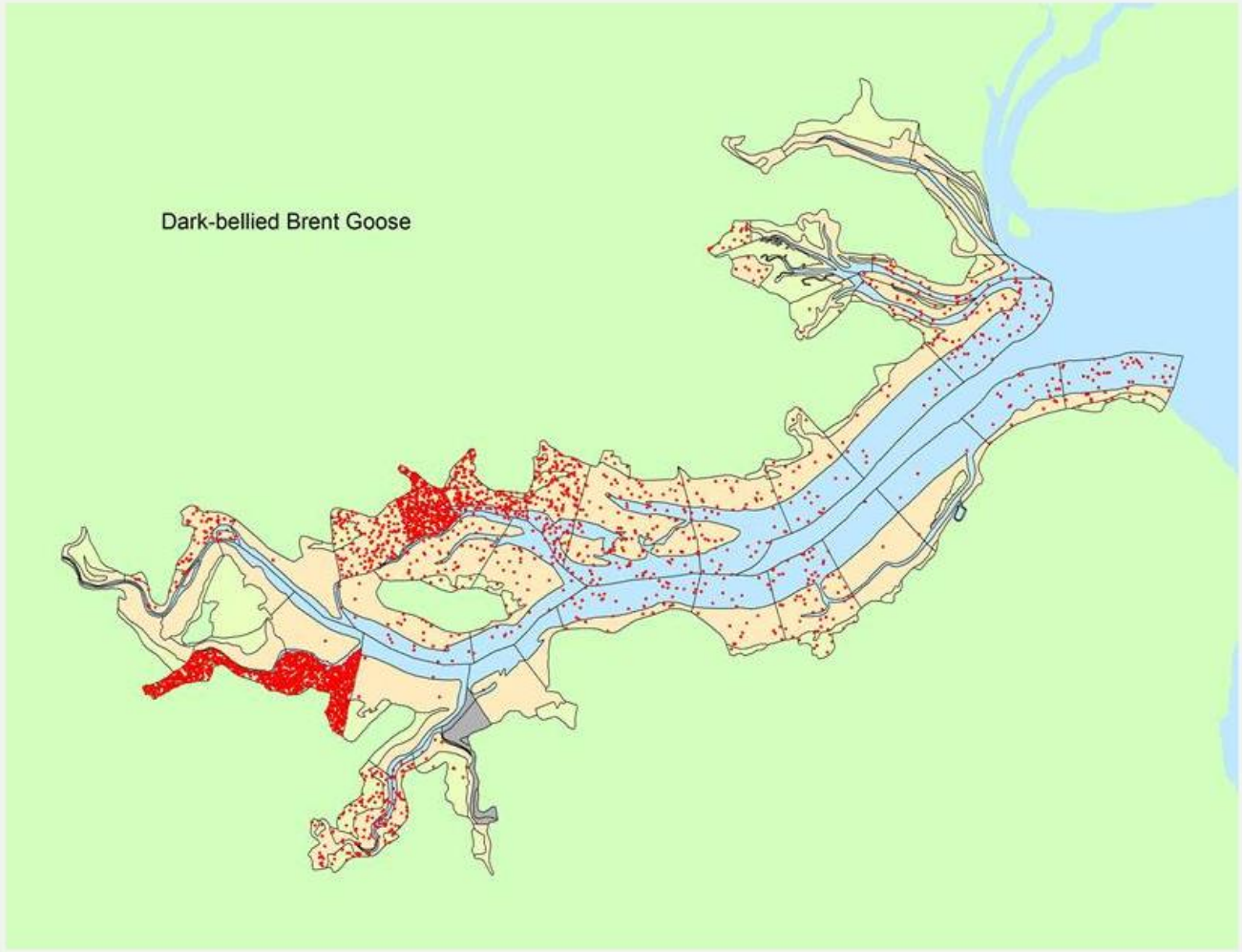
The Swale Estuary separates the Isle of Sheppey from the Kent mainland and adjoins the Medway Estuary to the west. At low tide there are extensive inter-tidal flats, with a relatively narrow water channel. The inner zones are muddy and the sediments become increasingly sandy towards the south. Most of the site is surrounded by saltmarsh, with the most substantial expanses along the northern shore. There is a sand and shingle spit at Shell Ness, behind which is a mixture of saltmarsh grading into grassland. Industrial activity is limited and includes port and harbour facilities, a paper mill at Kemsley and boat building facilities at Conyer Creek. Most leisure activities are centred on sailing and other water sports and there are three marinas within the estuary. Much of the area is subject to active wildfowling (Buck 1997, Musgrove et al 2003).



Low Tide Count year: 11/12

Display Map	English Name	Month Peak	Monthly average	Average density
◉	Brent Goose (Dark-bellied)	1446	501	0.22
○	Brent Goose (Light-bellied)	4	1	<0.01
○	Shelduck	1546	1102	0.40
○	Wigeon	6036	3215	1.13
○	Teal	1701	1090	0.39
○	Mallard	613	170	0.05
○	Pintail	219	94	0.03
○	Oystercatcher	4014	2390	1.41
○	Ringed Plover	172	94	0.05
○	Golden Plover	2145	1280	0.76
○	Grey Plover	770	592	0.36
○	Lapwing	3159	1404	0.77
○	Knot	2370	1689	1.00
○	Dunlin	9621	6221	3.75
○	Black-tailed Godwit	1329	849	0.45
○	Bar-tailed Godwit	1159	776	0.50
○	Curlew	1079	852	0.48
○	Redshank	1078	925	0.52
○	Turnstone	182	147	0.09
	Mute Swan	40	10	<0.01
	Canada Goose	12	3	<0.01
	Brent Goose	42	21	<0.01
	Gadwall	16	4	<0.01
	Shoveler	2	<1	<0.01
	Goldeneye	2	<1	<0.01
	Red-breasted Merganser	7	5	<0.01
	Little Grebe	25	15	0.02
	Great Crested Grebe	29	21	0.02
	Slavonian Grebe	1	<1	<0.01
	Cormorant	39	28	0.01

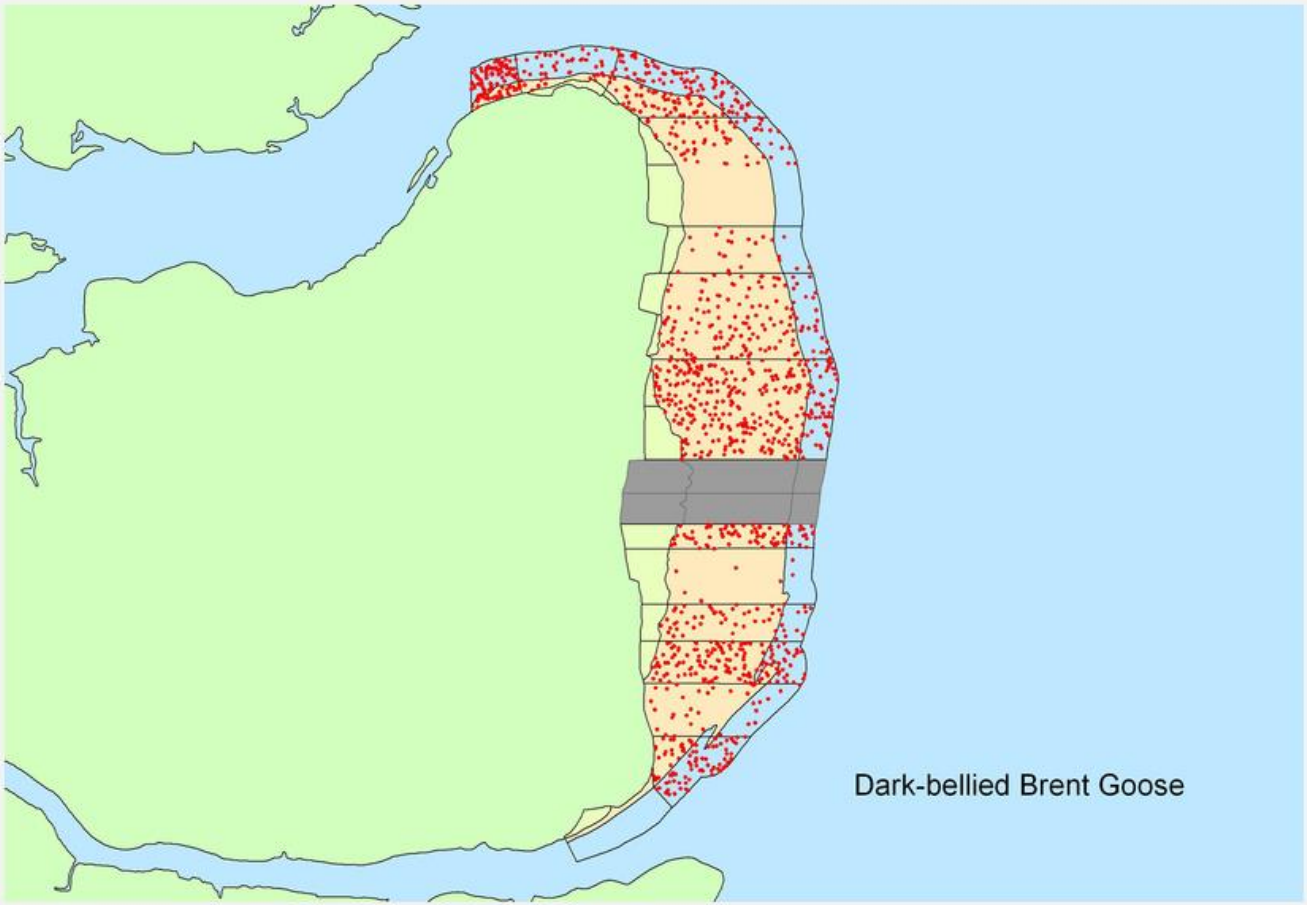
The Blackwater Estuary is located on the coast of Essex in eastern England. It is the largest estuary in Essex and is one of the largest estuarine complexes in East Anglia. Its mud flats are fringed by saltmarsh on the upper shores, with shingle, shell banks and offshore islands a feature of the tidal flats. The diversity of estuarine habitats results in the site being of importance for a wide range of over-wintering waterbirds, including geese, ducks and waders. The importance of the Blackwater Estuary as both a wintering and staging post for large numbers of wildfowl and wading birds is underlined by its protective legislation, being designated as a Ramsar site, a SPA and SSSI. The site also contains both national and local nature reserves. Erosion of saltmarsh is a major issue on this site whilst disturbance from bait diggers, watersports and shell fishing also occurs.



Low Tide Count year: 11/12

Display Map	English Name	Month Peak	Monthly average	Average density
◉	Brent Goose (Dark-bellied)	3430	2391	0.69
○	Brent Goose (Light-bellied)	0	0	0.00
○	Shelduck	2234	1876	0.54
○	Wigeon	2292	1920	0.59
○	Teal	3458	2902	0.89
○	Mallard	385	241	0.07
○	Pintail	661	426	0.12
○	Oystercatcher	889	624	0.35
○	Ringed Plover	136	71	0.04
○	Golden Plover	2855	1838	0.87
○	Grey Plover	1198	1068	0.64
○	Lapwing	2069	1422	0.67
○	Knot	5545	3557	1.86
○	Dunlin	23543	19209	11.10
○	Black-tailed Godwit	811	549	0.26
○	Bar-tailed Godwit	163	89	0.05
○	Curlew	1025	801	0.34
○	Redshank	2022	1702	0.73
○	Turnstone	173	149	0.09
	Mute Swan	3	3	<0.01
	Greylag Goose	4	1	<0.01
	Canada Goose	17	8	<0.01
	Barnacle Goose	3	<1	<0.01
	Gadwall	30	10	<0.01
	Shoveler	31	15	<0.01
	Eider	26	13	0.01
	Long-tailed Duck	1	<1	<0.01
	Common Scoter	46	28	0.03
	Goldeneye	406	208	0.18
	Smew	2	<1	<0.01
	Red-breasted Merganser	123	80	0.06

Dengie Flats lie between the Blackwater and Crouch-Roach Estuaries. The Flats are comprised of an extensive area of tidal mudflat with saltmarsh towards the eastern end of the Dengie Peninsula. Evidence suggests that there is considerable interchange of waterbirds between these adjacent estuaries. The mudflats support extensive growth of *Entermorpha* alga along with populations of molluscs, marine worms and crustaceans. Unusually, for an open-coast situation, the mudflats grade into saltmarsh and the transition zone is characterised by mud-mounds with shell-lined gullies between them. The saltmarsh vegetation is relatively intact, despite being exposed to wave action, and a series of drainage channels bisect this habitat. Opposite Bradwell, at the northern end of the site, there is a small sand and shingle spit, the front of which has been severely eroded. Agricultural operations have claimed most of the historic grazing marshes, which are now located behind the sea wall. Although a relatively remote site, there is some recreational activity; for example, water sports, beach recreation, bait digging and wildfowling. Bradwell Nuclear Power Station, at the extreme northwest corner, represents the only major industrial development adjacent to the site (Musgrove *et al*. 2003).

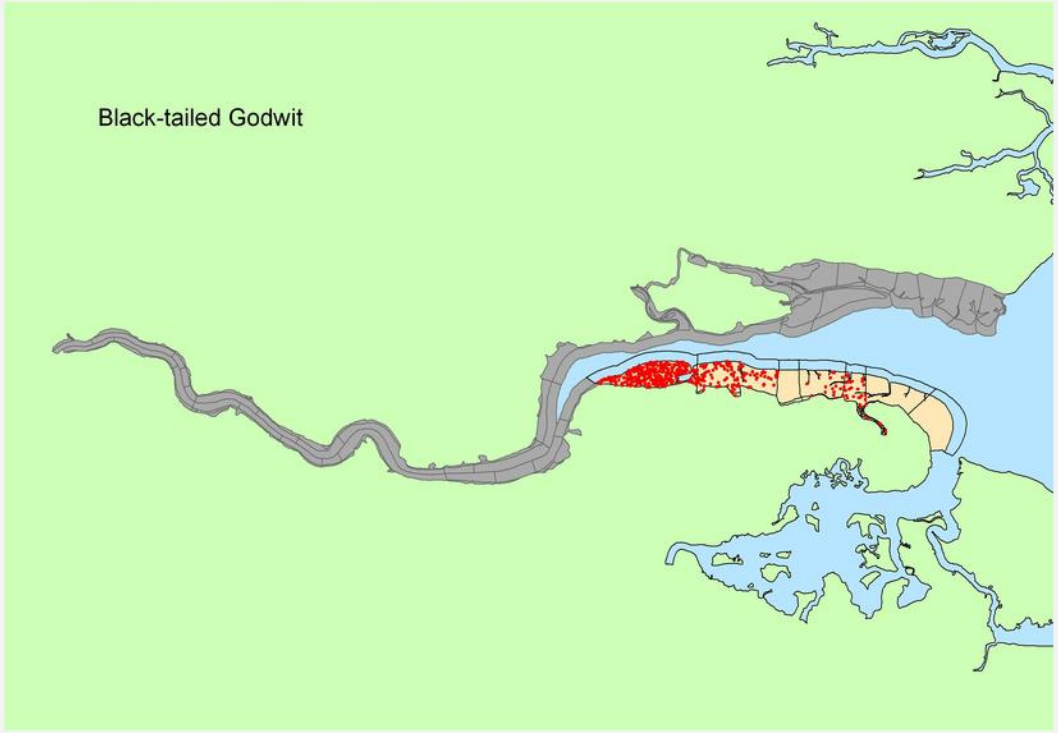


Low Tide Count year: 08/09

Display Map	English Name	Month Peak	Monthly average	Average density
◉	Brent Goose (Dark-bellied)	881	595	0.41
○	Brent Goose (Light-bellied)	0	0	0.00
○	Shelduck	205	86	0.04
○	Wigeon	281	86	0.03
○	Teal	32	12	<0.01
○	Mallard	58	19	<0.01
○	Pintail	2	<1	<0.01
○	Oystercatcher	4489	1959	1.43
○	Ringed Plover	13	11	0.01
○	Golden Plover	8820	2252	1.09
○	Grey Plover	1480	986	0.86
○	Lapwing	589	192	0.10
○	Knot	9075	4062	3.02
○	Dunlin	5991	3618	3.39
○	Black-tailed Godwit	0	0	0.00
○	Bar-tailed Godwit	1930	935	0.69
○	Curlew	349	250	0.18
○	Redshank	395	252	0.17
○	Turnstone	160	87	0.11
	Shoveler	11	4	<0.01
	Little Egret	3	2	<0.01
	Grey Heron	1	<1	<0.01
	Sanderling	41	21	0.04
	Spotted Redshank	1	<1	<0.01

Black-tailed Godwit

The Thames Estuary, for the purposes of WeBS, is usually taken to include the coast between the Rivers Medway and Crouch. Most of the intertidal habitat is muddy in character, with extensive areas of saltmarsh around Canvey Island. The narrow strip of saltmarsh along the north Kent coast was once more extensive, but was embanked to create coastal wet grassland. Much of the area is surrounded by sea walls, due to the relatively low-lying adjoining land coupled with rising sea levels. Land claim has removed about 12% of the Thames Estuary, mostly before the 19th century. Much of the site is heavily industrialised with major ports, chemical works and extensive areas of housing, apart from the north Kent coastline, which is more rural. Particular issues of conservation concern have included port developments and proposals for a new airport at Cliffe Marshes (Davidson 1998).



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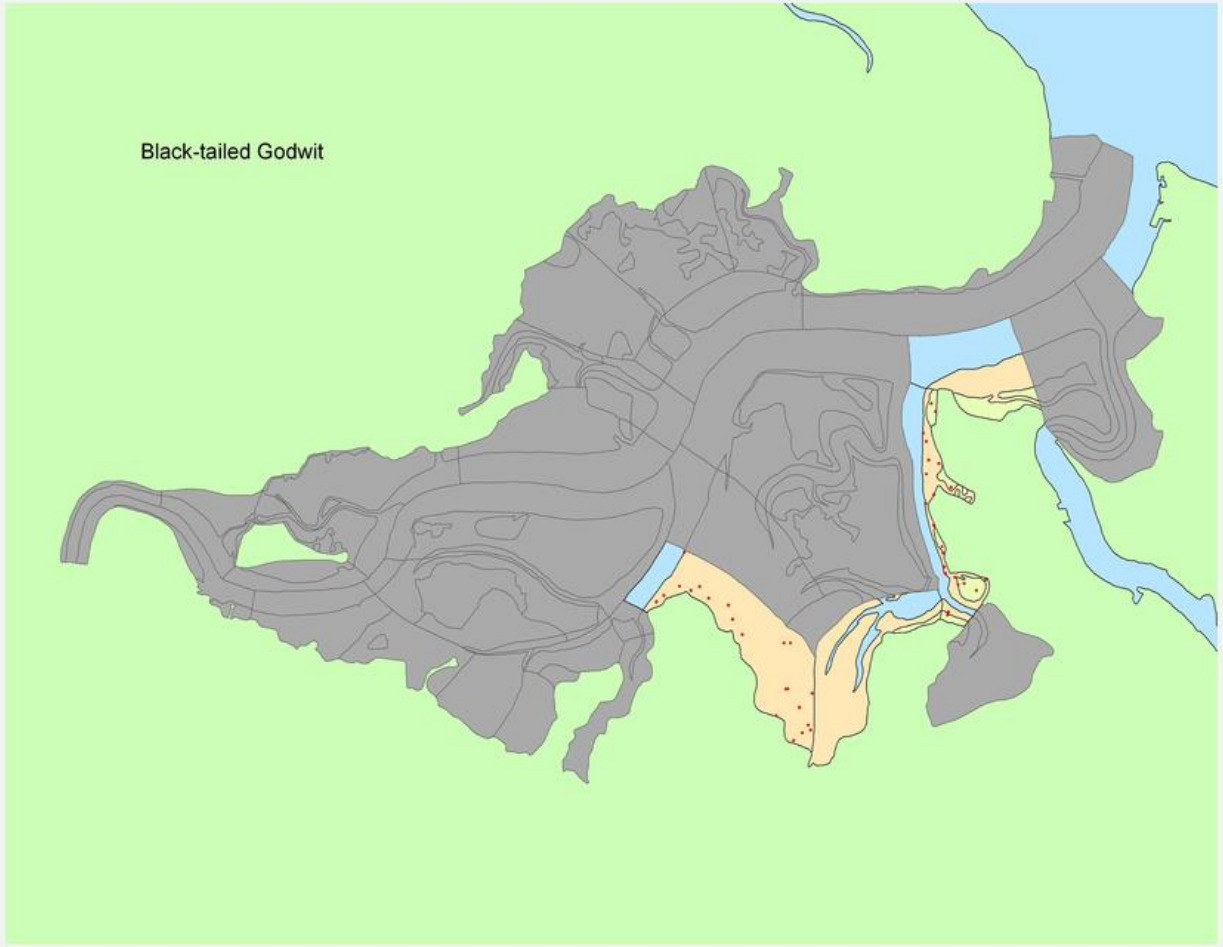
○	Curlew	768	603	0.42
○	Redshank	699	414	0.25
○	Turnstone	152	106	0.06
	Gadwall	4	1	<0.01
	Shoveler	8	3	<0.01
	Common Scoter	20	7	0.02
	Red-breasted Merganser	2	<1	<0.01
	Red-throated Diver	1	<1	<0.01
	Great Crested Grebe	3	1	<0.01
	Cormorant	34	16	<0.01
	Little Egret	14	9	<0.01
	Grey Heron	2	1	<0.01
	Moorhen	30	10	<0.01
	Coot	20	7	<0.01
	Avocet	11	4	<0.01
	Sanderling	90	31	0.04
	Little Stint	5	2	<0.01

The Medway Estuary, on the North Kent coast, is formed by the river outflow upon which stand Rochester, Chatham and Gillingham, opening into a series of mudflats, brackish saltmarsh and sub-tidal islands. It is central to a local network of estuarine sites, also encompassing the Thames and Swale. The area is heavily urbanised and industrialised, not only along the south bank but also at the mouth: the Isle of Grain and Sheerness face each other on opposite sides of the river channel. The extent of intertidal and saltmarsh habitat is protected under SPA designation, though is considered in unfavourable declining condition, largely because of coastal erosion of saltmarsh. *Spartina* growth may also be an issue, whilst land claim for development is a persistent threat. Watersports, wildfowling and shipping activity are potentially disturbing factors.



Low Tide Count year: 05/06

Display Map	English Name	Month Peak	Monthly average	Average density
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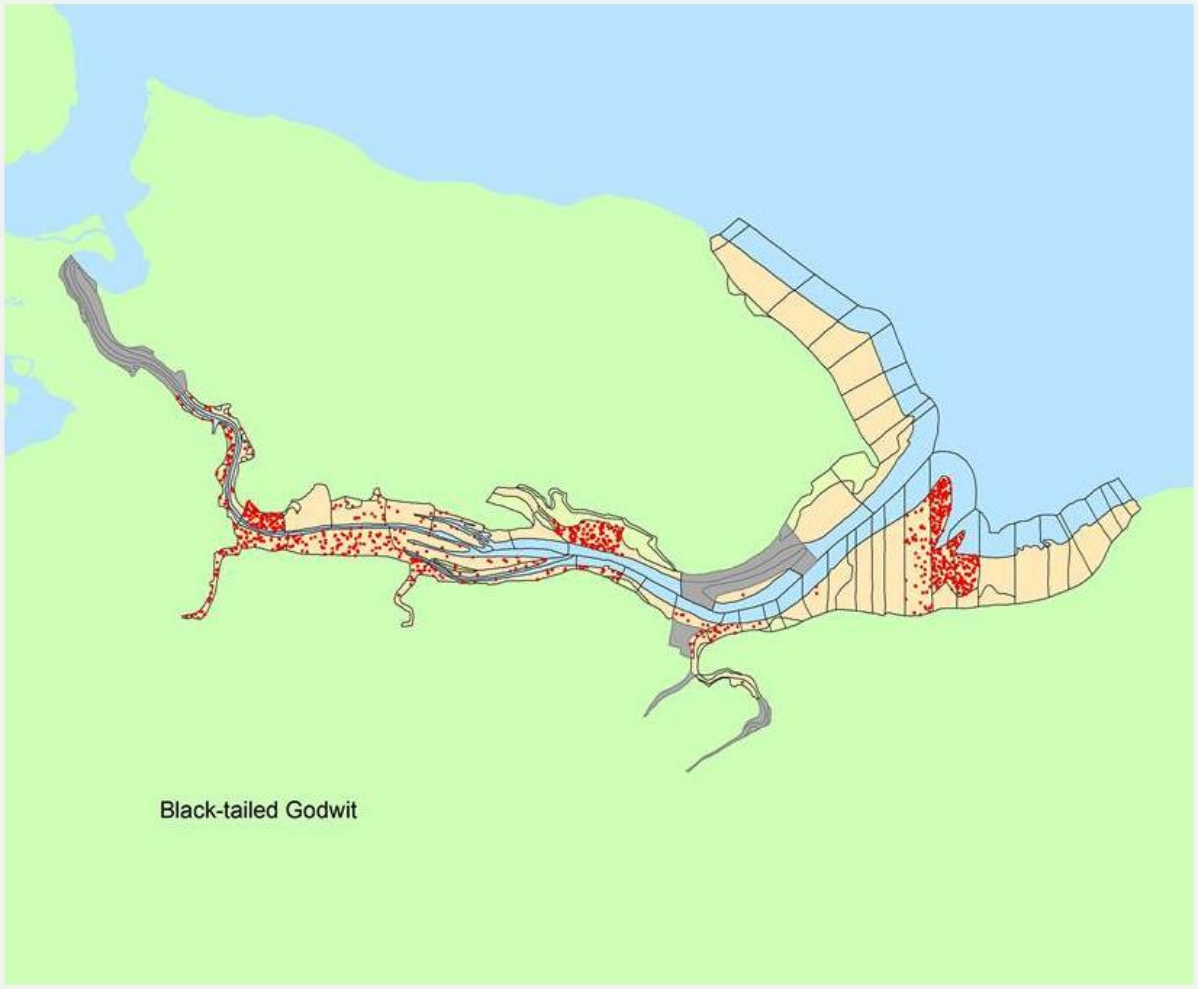
○	Teal	667	307	0.45
○	Mallard	61	26	0.04
○	Pintail	135	60	0.10
○	Oystercatcher	515	263	0.77
○	Ringed Plover	30	17	0.05
○	Golden Plover	0	0	0.00
○	Grey Plover	269	139	0.43
○	Lapwing	834	421	1.15
○	Knot	50	16	0.04
○	Dunlin	4936	2775	8.44
◉	Black-tailed Godwit	65	32	0.10
○	Bar-tailed Godwit	23	7	0.01
○	Curlew	1367	385	0.82
○	Redshank	494	270	0.70
○	Turnstone	145	54	0.14
	Greylag Goose	520	218	0.31
	Canada Goose	935	339	0.48
	Gadwall	4	1	<0.01
	Shoveler	10	4	<0.01
	Red-breasted Merganser	8	2	0.01
	Great Northern Diver	1	<1	<0.01
	Little Grebe	3	<1	<0.01
	Great Crested Grebe	35	10	0.05
	Cormorant	18	5	<0.01
	Little Egret	11	5	0.01
	Grey Heron	3	<1	<0.01
	Avocet	91	43	0.20
	Sanderling	0	0	0.00

The Swale Estuary separates the Isle of Sheppey from the Kent mainland and adjoins the Medway Estuary to the west. At low tide there are extensive inter-tidal flats, with a relatively narrow water channel. The inner zones are muddy and the sediments become increasingly sandy towards the south. Most of the site is surrounded by saltmarsh, with the most substantial expanses along the northern shore. There is a sand and shingle spit at Shell Ness, behind which is a mixture of saltmarsh grading into grassland. Industrial activity is limited and includes port and harbour facilities, a paper mill at Kemsley and boat building facilities at Conyer Creek. Most leisure activities are centred on sailing and other water sports and there are three marinas within the estuary. Much of the area is subject to active wildfowling (Buck 1997, Musgrove et al 2003).



Low Tide Count year: 11/12

Display Map	English Name	Month Peak	Monthly average	Average density
○	Brent Goose (Dark-bellied)	1446	501	0.22
○	Brent Goose (Light-bellied)	4	1	<0.01
○	Shelduck	1546	1102	0.40
○	Wigeon	6036	3215	1.13
○	Teal	1701	1090	0.39
○	Mallard	613	170	0.05
○	Pintail	219	94	0.03
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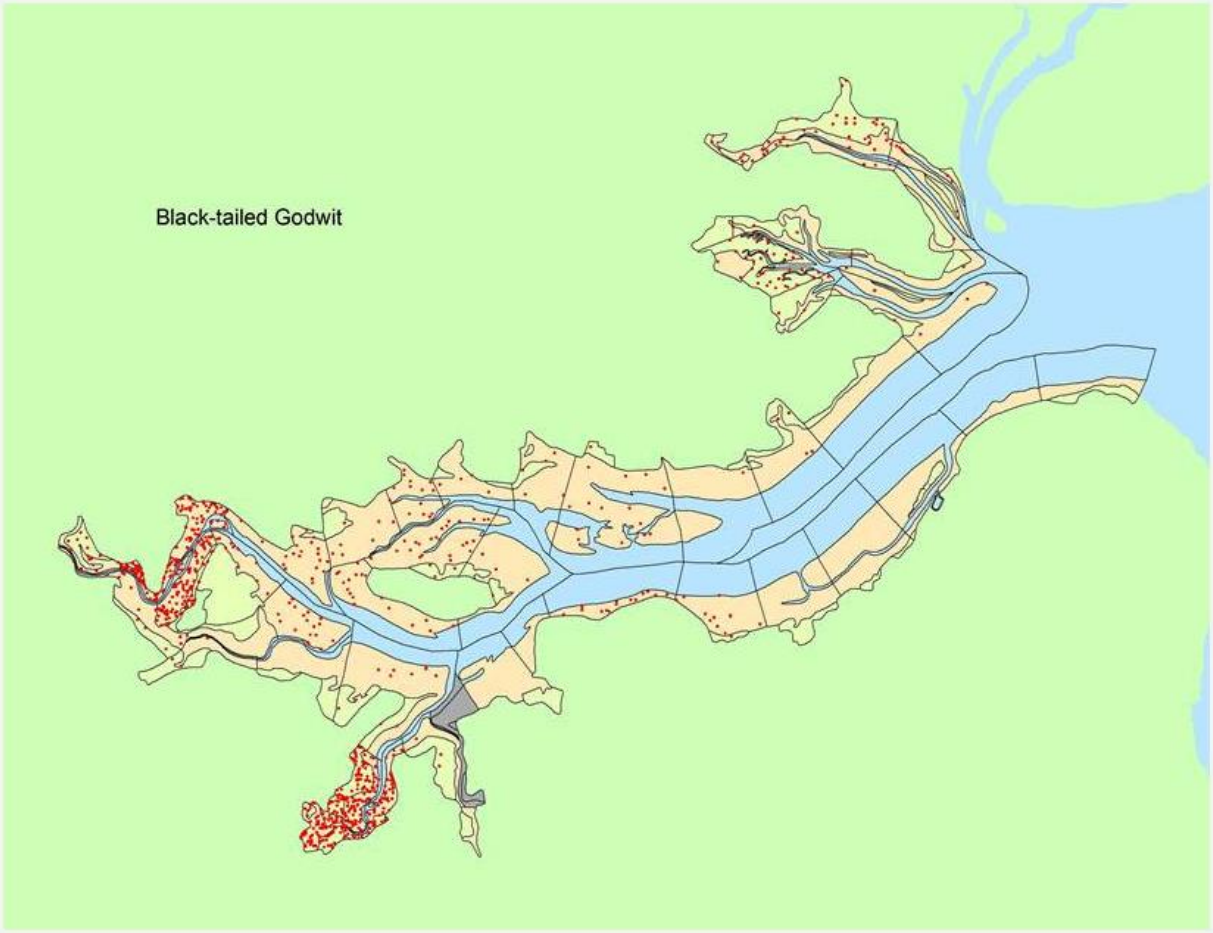
○	Lapwing	3159	1404	0.77
○	Knot	2370	1689	1.00
○	Dunlin	9621	6221	3.75
◉	Black-tailed Godwit	1329	849	0.45
○	Bar-tailed Godwit	1159	776	0.50
○	Curlew	1079	852	0.48
○	Redshank	1078	925	0.52
○	Turnstone	182	147	0.09
	Mute Swan	40	10	<0.01
	Canada Goose	12	3	<0.01
	Brent Goose	42	21	<0.01
	Gadwall	16	4	<0.01
	Shoveler	2	<1	<0.01
	Goldeneye	2	<1	<0.01
	Red-breasted Merganser	7	5	<0.01
	Little Grebe	25	15	0.02
	Great Crested Grebe	29	21	0.02
	Slavonian Grebe	1	<1	<0.01
	Cormorant	39	28	0.01
	Little Egret	30	18	<0.01
	Grey Heron	5	3	<0.01
	Moorhen	1	<1	<0.01

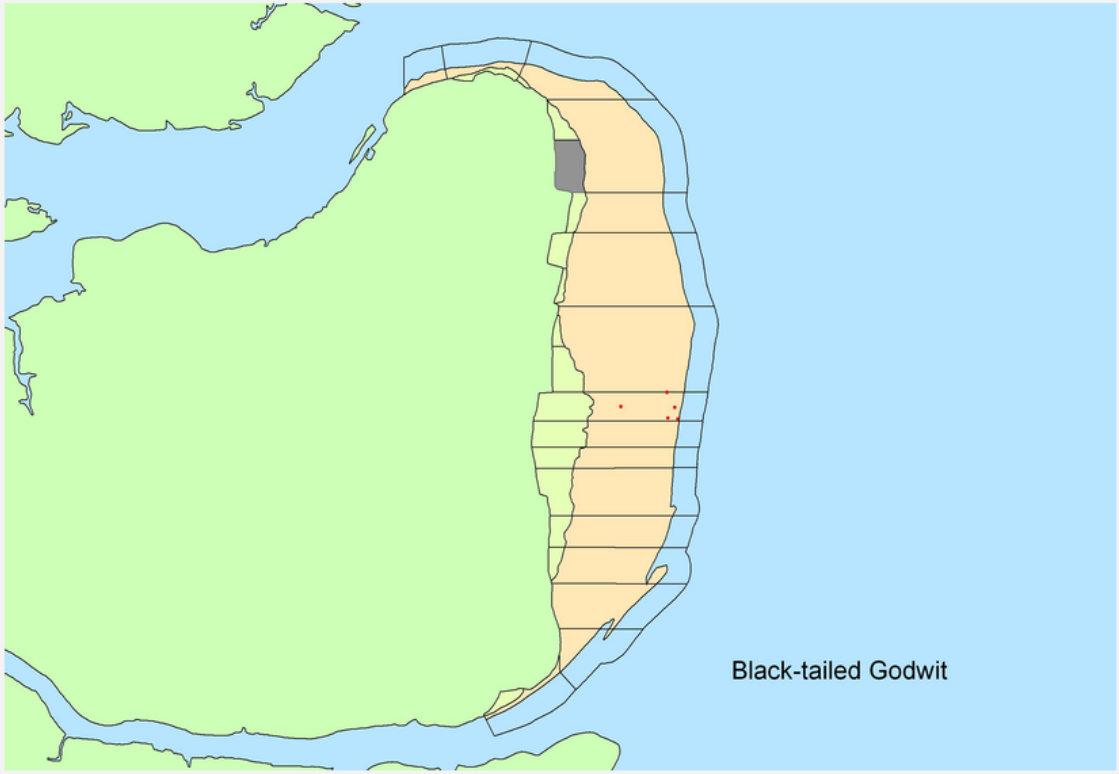
The Blackwater Estuary is located on the coast of Essex in eastern England. It is the largest estuary in Essex and is one of the largest estuarine complexes in East Anglia. Its mud flats are fringed by saltmarsh on the upper shores, with shingle, shell banks and offshore islands a feature of the tidal flats. The diversity of estuarine habitats results in the site being of importance for a wide range of over-wintering waterbirds, including geese, ducks and waders. The importance of the Blackwater Estuary as both a wintering and staging post for large numbers of wildfowl and wading birds is underlined by its protective legislation, being designated as a Ramsar site, a SPA and SSSI. The site also contains both national and local nature reserves. Erosion of saltmarsh is a major issue on this site whilst disturbance from bait diggers, watersports and shell fishing also occurs.



Low Tide Count year: 11/12

Display Map	English Name	Month Peak	Monthly average	Average density
○	Brent Goose (Dark-bellied)	3430	2391	0.69
○	Brent Goose (Light-bellied)	0	0	0.00
○	Shelduck	2234	1876	0.54
○	Wigeon	2292	1920	0.59
○	Teal	3458	2902	0.89
○	Mallard	385	241	0.07
○	Pintail	661	426	0.12
○	Oystercatcher	889	624	0.35
○	Ringed Plover	136	71	0.04
○	Golden Plover	2855	1838	0.87
○	Grey Plover	1198	1068	0.64
○	Lapwing	2069	1422	0.67
○	Knot	5545	3557	1.86
○	Dunlin	23543	19209	11.10
◉	Black-tailed Godwit	811	549	0.26
○	Bar-tailed Godwit	163	89	0.05
○	Curlew	1025	801	0.34
○	Redshank	2022	1702	0.73
○	Turnstone	173	149	0.09
	Mute Swan	3	3	<0.01
	Greylag Goose	4	1	<0.01
	Canada Goose	17	8	<0.01
	Barnacle Goose	3	<1	<0.01
	Gadwall	30	10	<0.01
	Shoveler	31	15	<0.01
	Eider	26	13	0.01
	Long-tailed Duck	1	<1	<0.01
	Common Scoter	46	28	0.03
	Goldeneye	406	208	0.18
	Smew	2	<1	<0.01
	Red-breasted Merganser	123	80	0.06
	Goosander	12	3	<0.01
	Red-throated Diver	1	<1	<0.01

Dengie Flats lie between the Blackwater and Crouch-Roach Estuaries. The Flats are comprised of an extensive area of tidal mudflat with saltmarsh towards the eastern end of the Dengie Peninsula. Evidence suggests that there is considerable interchange of waterbirds between these adjacent estuaries. The mudflats support extensive growth of *Entermorpha* alga along with populations of molluscs, marine worms and crustaceans. Unusually, for an open-coast situation, the mudflats grade into saltmarsh and the transition zone is characterised by mud-mounds with shell-lined gullies between them. The saltmarsh vegetation is relatively intact, despite being exposed to wave action, and a series of drainage channels bisect this habitat. Opposite Bradwell, at the northern end of the site, there is a small sand and shingle spit, the front of which has been severely eroded. Agricultural operations have claimed most of the historic grazing marshes, which are now located behind the sea wall. Although a relatively remote site, there is some recreational activity; for example, water sports, beach recreation, bait digging and wildfowling. Bradwell Nuclear Power Station, at the extreme northwest corner, represents the only major industrial development adjacent to the site (Musgrove *et al*. 2003).



Low Tide Count year: 01/02

Display Map	English Name	Month Peak	Monthly average	Average density
○	Brent Goose (Dark-bellied)	627	356	0.11
○	Brent Goose (Light-bellied)	1	<1	<0.01
○	Shelduck	362	147	0.05
○	Wigeon	79	31	0.01
○	Teal	878	544	0.18
○	Mallard	398	261	0.09
○	Pintail	0	0	0.00
○	Oystercatcher	7061	4136	2.11
○	Ringed Plover	98	47	0.03
○	Golden Plover	910	431	0.17
○	Grey Plover	1170	795	0.47
○	Lapwing	622	228	0.10
○	Knot	3980	3315	2.17
○	Dunlin	4992	2943	1.56
◉	Black-tailed Godwit	20	5	<0.01
○	Bar-tailed Godwit	758	427	0.21
○	Curlew	408	292	0.14
○	Redshank	1002	527	0.22
○	Turnstone	103	51	0.03
	Whooper Swan	1	<1	<0.01
	Barnacle Goose	7	2	<0.01
	Shoveler	40	10	<0.01
	Red-breasted Merganser	2	<1	<0.01
	Cormorant	15	5	<0.01
	Little Egret	18	9	<0.01
	Grey Heron	7	3	<0.01
	Sanderling	14	6	<0.01
	Snipe	2	1	<0.01
	Black-headed Gull	340	108	(0.03)
	Common Gull	111	40	(<0.01)
	Lesser Black-backed Gull	13	3	(<0.01)

Appendix B: Estuarine Process & Geomorphology

B 1: Water Framework Directive Water body Status Information

Table B1.1: Water Framework Directive information for water bodies within the study area

Water Body Name	Water Body ID	Hydromorph-ological Status	Current Ecological Status	Biological Quality	Physcio-Chemical Quality	Hydromorph-ology
Rivers						
Dry Valley south of Gravesend	GB106040024230	Not designated A/HMWB	Moderate Status	-	-	Not High
Tributary of Medway Estuary at High Halstow	GB106040024120	Not designated A/HMWB	Moderate Status	-	-	Not High
Tributary of Medway Estuary at Kingsnorth	GB106040024030	Not designated A/HMWB	Moderate Status	-	-	Not High
Damhead Creek	GB106040024160	Not designated A/HMWB	Moderate Status	-	-	Not High
Estuarine						
Thames Estuary	GB530603911401	Heavily Modified	Moderate Potential	Moderate	Moderate	-
Lakes						
Unnamed (Buckland lake)	GB30642407	Artificial	Good Potential	-	-	Not High

Table B1.2: Water Framework Directive information for ground water water bodies within the study area

Water Body Name	Water Body ID	Quantitative Quality	Groundwater dependant terrestrial ecosystems	Impact on surface waters	Saline or other intrusions	Resource balance
Groundwater						
North Kent Medway Chalk	GB40601G500300	Poor	Good	Poor	Good	Poor

Appendix C: Cultural Heritage

C 1: List of designated features within option footprints

Table C1.1: IAAG2 (London-Medway) Option - Summary of heritage assets potentially physically impacted during construction

Asset No.	Asset Name	Designation	Significance
DKE19081	Cooling castle and its associated landscaped setting	Scheduled Monument	National
DKE1390	Inner Ward To Cooling Castle	Listed Building Grade: I	National
DKE1389	Cooling Castle Gatehouse	Listed Building Grade: I	National
DKE1590	Church Of St Helen	Listed Building Grade: I	National
DKE1594	Church Of St James	Listed Building Grade: I	National
DKE1383	Charnel House At North West Corner Of Churchyard	Listed Building Grade: II	National
DKE1381	Manor Farmhouse	Listed Building Grade: II	National
DKE1384	Harvey Monument 20 Yards South West Of South Porch Of Church Of St Helen	Listed Building Grade: II	National
DKE1385	No 170 - 174 Church Street	Listed Building Grade: II	National
DKE1386	The Red House	Listed Building Grade: II	National
DKE1387	Walnut Tree Cottage	Listed Building Grade: II	National
DKE1388	Comport And Baker Tombs 5 Yards To South Of Church Of St James	Listed Building Grade: II	National
DKE1392	Marshgate And Cartshed To East	Listed Building Grade: II	National
DKE1500	No 185 Church Street	Listed Building Grade: II	National
DKE1591	Steel And Hatch Monument 1 Yard South Of South Aisle Of Church Of St Helen	Listed Building Grade: II	National
DKE1595	Chest Tomb 10 Yards South Of Church Of St James	Listed Building Grade: II	National
DKE1602	Buck Hole Farmhouse	Listed Building Grade: II	National
DKE1795	Barn At Rye Farm	Listed Building Grade: II	National
DKE1784	Chantry Cottage	Listed Building Grade: II	National
DKE1792	Barn 30 Yards North East Of Cooling Castle Gatehouse	Listed Building Grade: II	National
DKE1796	Smith Monument 30 Yards West Of Church Of St Helen	Listed Building Grade: II	National
DKE1797	No 176 Church Street	Listed Building Grade: II	National
DKE1894	Allens Hill Farmhouse	Listed Building Grade: II	National
DKE1896	Quickrills	Listed Building Grade: II	National
DKE1897	Longford House	Listed Building Grade: II	National
DKE1898	Court Sole	Listed Building Grade: II	National
DKE21727	Crash site of Hawker Hurricane I	Protected Military Remains	National
MWX17540	Site of a gunpowder and chemical explosives factory, Lower Hope Point, Cliffe	Potential designated site	National
MKE2569	Decoy pond near Decoy Fleet, Buckland Marsh, High Halstow	Potential designated site	National
MWX0370	Thames watermen and lightermen boundary marker (London stone)	Potential designated site	National
NA	Cliffe Conservation Area	Conservation Area	Regional
41	AAP surrounding SAM 269, Cliffe Fort	Area of Archaeological Potential	Regional
42	AAP surrounding Roman pottery kiln, workshop & occupation site	Area of Archaeological Potential	Regional
43	AAP surrounding Pm beacon & battery	Area of Archaeological Potential	Regional
44	AAP surrounding Roman pottery	Area of Archaeological Potential	Regional
45	AAP surrounding Roman & Medieval pottery & pits	Area of Archaeological Potential	Regional

Asset No.	Asset Name	Designation	Significance
46	AAP surrounding Roman settlement & kiln	Area of Archaeological Potential	Regional
47	AAP surrounding undated mound	Area of Archaeological Potential	Regional
48	AAP surrounding undated mound	Area of Archaeological Potential	Regional
49	AAP surrounding undated mound	Area of Archaeological Potential	Regional
50	AAP surrounding undated mounds	Area of Archaeological Potential	Regional
51	AAP surrounding Roman pottery kiln & cremation	Area of Archaeological Potential	Regional
52	AAP surrounding Roman cremation, settlement & undated mound	Area of Archaeological Potential	Regional
53	AAP surrounding Pm lime kiln	Area of Archaeological Potential	Regional
54	AAP surrounding Medieval & Postmed church	Area of Archaeological Potential	Regional
55	AAP surrounding Pa axe & BA hoard	Area of Archaeological Potential	Regional
56	AAP surrounding undated gravel pit	Area of Archaeological Potential	Regional
76	AAP surrounding Roman pottery and mounds	Area of Archaeological Potential	Regional
77	AAP surrounding Medieval halberd & pottery	Area of Archaeological Potential	Regional
78	AAP surrounding Roman burial & two undated mounds	Area of Archaeological Potential	Regional
79	AAP surrounding undated mound	Area of Archaeological Potential	Regional
80	AAP surrounding undated mound	Area of Archaeological Potential	Regional
81	AAP surrounding Roman urn, Coastguard station and stakes	Area of Archaeological Potential	Regional
82	AAP surrounding Roman briquetage, pottery & saltworks	Area of Archaeological Potential	Regional
83	AAP surrounding Roman saltworks & Pm decoy	Area of Archaeological Potential	Regional
84	AAP surrounding Roman saltworks	Area of Archaeological Potential	Regional
86	AAP surrounding Pm industrial site	Area of Archaeological Potential	Regional
87	AAP surrounding undated saltpan	Area of Archaeological Potential	Regional
88	AAP surrounding Roman settlement & industrial site	Area of Archaeological Potential	Regional
89	AAP surrounding IA & Roman pottery kiln	Area of Archaeological Potential	Regional
90	AAP surrounding Roman saltworkings & undated midden	Area of Archaeological Potential	Regional
91	AAP surrounding Em gun battery	Area of Archaeological Potential	Regional
92	AAP surrounding SAM 25457, Medieval castle	Area of Archaeological Potential	Regional
93	AAP surrounding Medieval & Pm church	Area of Archaeological Potential	Regional
95	AAP surrounding undated ring ditch	Area of Archaeological Potential	Regional
102	AAP around prehistoric site, High Halstow	Area of Archaeological Potential	Regional

Asset No.	Asset Name	Designation	Significance
129	AAP around Alpha Cement Works and early medieval settlement	Area of Archaeological Potential	Regional
130	AAP around World War II anti-vehicle obstacles	Area of Archaeological Potential	Regional
138	AAP around Johnson's cement works and kiln chamber	Area of Archaeological Potential	Regional
139	AAP around Cliff Creek cement works	Area of Archaeological Potential	Regional
140	AAP around Nine Elms cement works and World War II infantry trench	Area of Archaeological Potential	Regional
141	AAP around tramways relating to Nine Elms and Creek Works	Area of Archaeological Potential	Regional
142	AAP around jetties and fences	Area of Archaeological Potential	Regional
143	AAP around Lower Hope Point explosives works	Area of Archaeological Potential	Regional
144	AAP around Parkers Wick	Area of Archaeological Potential	Regional
145	AAP around sheep wick	Area of Archaeological Potential	Regional
146	AAP around circular enclosure	Area of Archaeological Potential	Regional
147	AAP around ring-ditches	Area of Archaeological Potential	Regional
148	AAP around possible worked wood	Area of Archaeological Potential	Regional
149	AAP around World War II anti-aircraft site	Area of Archaeological Potential	Regional
150	AAP around pillbox	Area of Archaeological Potential	Regional
151	AAP around engine house for defence electric lights	Area of Archaeological Potential	Regional
152	AAP around World War II landscape including anti-aircraft site, barracks and grid pattern in field	Area of Archaeological Potential	Regional
173	AAP around Cliffe village	Area of Archaeological Potential	Regional
190	AAP around Pleistocene deposits	Area of Archaeological Potential	Regional
194	AAP around area of multiperiod potential	Area of Archaeological Potential	Regional
196	AAP around geology of archaeological potential	Area of Archaeological Potential	Regional
197	AAP around geology of archaeological potential	Area of Archaeological Potential	Regional
198	AAP around geology of archaeological potential	Area of Archaeological Potential	Regional
200	AAP around geology of archaeological potential	Area of Archaeological Potential	Regional
220	AAP around geology of archaeological potential	Area of Archaeological Potential	Regional

Table C1.2: Isle of Grain Option - Summary of heritage assets potentially physically impacted during construction

Asset No.	Asset Name	Designation	Significance
DKE19172	Slough fort and wing batteries	Scheduled Monument	National
DKE19160	Coastal artillery defences on the isle of grain, immediately east and south east of grain village	Scheduled Monument	National
DKE1374	Church Of St James	Listed Building: Grade I	National
DKE1377	Church Of All Saints	Listed Building: Grade I	National
DKE18942	Slough Fort, All Hallows, Medway, Kent	Listed Building: Grade II*	National
DKE1499	Rose And Crown Public House	Listed Building: Grade II	National
DKE1609	White House Farmhouse	Listed Building: Grade II	National
DKE1907	The Hogarth Inn	Listed Building: Grade II	National
DKE20000	World War Anti-Tank Obstacles On The Foreshore	Listed Building: Grade II	National
DKE20053	World War II aircraft, in mud flats north of Allhallows - Aircraft	Protected Military Remains	National
DKE21729	Crash site of Messerschmitt Bf109E-4 - Aircraft	Protected Military Remains	National
MKE16291	Site of Yantlet firing range, Isle of Grain	Potential designated site	National
MKE42325	QF Decoy Site, Allhallows	Potential designated site	National
No HER reference	Stone obelisk at mouth of Yantlet Creek	Potential designated site	National
MWX18725	The London Stone, north Saltings, Isle of Grain	Potential designated site	National
15	AAP surrounding MD & PM saltworkings	Area of Archaeological Potential	Regional
16	AAP surrounding PM fort & battery	Area of Archaeological Potential	Regional
17	AAP surrounding MD & PM church	Area of Archaeological Potential	Regional
18	AAP surrounding Roman cemetery	Area of Archaeological Potential	Regional
19	AAP surrounding undated stone foundations	Area of Archaeological Potential	Regional
28	AAP surrounding Roman pottery & briquetage	Area of Archaeological Potential	Regional
32	AAP surrounding beacon	Area of Archaeological Potential	Regional
33	AAP surrounding MD & PM church	Area of Archaeological Potential	Regional
34	AAP surrounding Roman cremation & post MD fort	Area of Archaeological Potential	Regional
35	AAP surrounding Roman occupation site, World War II defences, river frontage	Area of Archaeological Potential	Regional
113	AAP around Grain Fortifications	Area of Archaeological Potential	Regional
122	AAP around Yantlet Creek	Area of Archaeological Potential	Regional
157	AAP around World War II pillbox	Area of Archaeological Potential	Regional
159	AAP around pillbox	Area of Archaeological Potential	Regional
160	AAP around pillbox	Area of Archaeological Potential	Regional
161	AAP around pillboxes, stakes, moorings and river frontage	Area of Archaeological Potential	Regional
162	AAP around pillbox	Area of Archaeological Potential	Regional
163	AAP around ROC post	Area of Archaeological Potential	Regional
164	AAP around grid pattern in cropmarks	Area of Archaeological Potential	Regional

Asset No.	Asset Name	Designation	Significance
165	AAP around possible anti-aircraft battery	Area of Archaeological Potential	Regional
166	AAP around Pleistocene deposits and prehistoric occupation site	Area of Archaeological Potential	Regional
167	AAP around grid pattern of cropmarks	Area of Archaeological Potential	Regional
168	AAP around pillbox	Area of Archaeological Potential	Regional
169	AAP around World War II observation tower	Area of Archaeological Potential	Regional
170	AAP around barrow	Area of Archaeological Potential	Regional
171	AAP around possible prehistoric settlement site	Area of Archaeological Potential	Regional
172	AAP around Grain military defences, prehistoric and Roman sites and industrial area. Quarried areas not included.	Area of Archaeological Potential	Regional
201	AAP around geology of archaeological potential	Area of Archaeological Potential	Regional
207	AAP around geology of archaeological potential	Area of Archaeological Potential	Regional
209	AAP around geology of archaeological potential	Area of Archaeological Potential	Regional
212	AAP around geology of archaeological potential	Area of Archaeological Potential	Regional
215	AAP around geology of archaeological potential	Area of Archaeological Potential	Regional
222	AAP around geology of archaeological potential	Area of Archaeological Potential	Regional
223	AAP around geology of archaeological potential	Area of Archaeological Potential	Regional

Table C1.3: Metrotidal Option - Summary of heritage assets potentially physically impacted during construction

Asset No.	Asset Name	Designation	Significance
DKE19172	Slough fort and wing batteries	Scheduled Monument	National
DKE18942	Slough Fort, All Hallows, Medway, Kent	Listed Building: Grade II*	National
DKE20053	World War II aircraft, in mud flats north of Allhallows	Protected Military Remains	National
MKE16419	Explosive stores, St Mary's Marshes, St Mary Hoo	Potential designated site	National
No HER reference	Stone obelisk at mouth of Yantlet Creek	Potential designated site	National
MWX18725	The London Stone, north Saltings, Isle of Grain	Potential designated site	National
34	AAP surrounding Roman cremation & post medieval fort	Area of Archaeological Potential	Regional
35	AAP surrounding Roman occupation site, World War II defences, river frontage	Area of Archaeological Potential	Regional
81	AAP surrounding Roman urn, Coastguard station and stakes	Area of Archaeological Potential	Regional
82	AAP surrounding Roman briquetage, pottery & saltworks	Area of Archaeological Potential	Regional
122	AAP around Yantlet Creek	Area of Archaeological Potential	Regional
150	AAP around pillbox	Area of Archaeological Potential	Regional
151	AAP around engine house for defence electric lights	Area of Archaeological Potential	Regional
153	AAP around explosive stores	Area of Archaeological Potential	Regional
160	AAP around pillbox	Area of Archaeological Potential	Regional
161	AAP around pillboxes, stakes, moorings and river frontage	Area of Archaeological Potential	Regional
162	AAP around pillbox	Area of Archaeological Potential	Regional
164	AAP around grid pattern in cropmarks	Area of Archaeological Potential	Regional
165	AAP around possible anti-airctaft battery	Area of Archaeological Potential	Regional
166	AAP around Pleistocene deposits and prehistoric occupation site	Area of Archaeological Potential	Regional
167	AAP around grid pattern of cropmarks	Area of Archaeological Potential	Regional
207	AAP around geology of archaeological potential	Area of Archaeological Potential	Regional
212	AAP around geology of archaeological potential	Area of Archaeological Potential	Regional
215	AAP around geology of archaeological potential	Area of Archaeological Potential	Regional

Table C1.4: Foster and Partners Option - Summary of heritage assets potentially physically impacted during construction

Asset No.	Asset Name	Designation	Significance
DKE19172	Slough fort and wing batteries	Scheduled Monument	National
DKE19160	Coastal artillery defences on the isle of grain, immediately east and south east of grain village	Scheduled Monument	National
DKE1374	Church Of St James	Listed Building: Grade I	National
DKE1377	Church Of All Saints	Listed Building: Grade I	National
DKE18942	Slough Fort, All Hallows, Medway, Kent	Listed Building: Grade II*	National
DKE1378	Barn 25 Yards South Of Brickhouse Farmhouse	Listed Building: Grade II	National
DKE1499	Rose And Crown Public House	Listed Building: Grade II	National
DKE1907	The Hogarth Inn	Listed Building: Grade II	National
DKE1909	Brickhouse Farmhouse	Listed Building: Grade II	National
DKE20000	World War Ii Anti-Tank Obstacles On The Foreshore	Listed Building: Grade II	National
DKE20199	HEINKEL HE111P-4 (3078) 5J+JP	Protected Military Remains	National
MKE16291	Site of Yantlet firing range, Isle of Grain	Potential designated site	National
MKE16419	Explosive stores, St Mary's Marshes, St Mary Hoo	Potential designated site	National
MKE42325	QF Decoy Site, Allhallows	Potential designated site	National
No HER reference	Stone obelisk at mouth of Yantlet Creek	Potential designated site	National
MWX18725	The London Stone, north Saltings, Isle of Grain	Potential designated site	National
9	AAP surrounding PM battery	Area of Archaeological Potential	Regional
10	AAP surrounding PM fort & battery	Area of Archaeological Potential	Regional
11	AAP surrounding SAM 297, PM tower/ beacon	Area of Archaeological Potential	Regional
15	AAP surrounding MD & PM saltworkings	Area of Archaeological Potential	Regional
16	AAP surrounding PM fort & battery	Area of Archaeological Potential	Regional
17	AAP surrounding MD & PM church	Area of Archaeological Potential	Regional
18	AAP surrounding Roman cemetery	Area of Archaeological Potential	Regional
19	AAP surrounding undated stone foundations	Area of Archaeological Potential	Regional
29	AAP surrounding flint implement & Roman pottery	Area of Archaeological Potential	Regional
30	AAP surrounding BA founders hoard	Area of Archaeological Potential	Regional
31	AAP surrounding undated enclosures	Area of Archaeological Potential	Regional
32	AAP surrounding beacon	Area of Archaeological Potential	Regional
33	AAP surrounding MD & PM church	Area of Archaeological Potential	Regional
34	AAP surrounding Roman cremation & post MD fort	Area of Archaeological Potential	Regional
35	AAP surrounding Roman occupation site, World War II defences, river frontage	Area of Archaeological Potential	Regional
113	AAP around Grain Fortifications	Area of Archaeological Potential	Regional
122	AAP around Yantlet Creek	Area of Archaeological Potential	Regional
153	AAP around explosive stores	Area of Archaeological Potential	Regional
157	AAP around World War II pillbox	Area of Archaeological Potential	Regional

Asset No.	Asset Name	Designation	Significance
158	AAP around pillbox	Area of Archaeological Potential	Regional
159	AAP around pillbox	Area of Archaeological Potential	Regional
160	AAP around pillbox	Area of Archaeological Potential	Regional
161	AAP around pillboxes, stakes, moorings and river frontage	Area of Archaeological Potential	Regional
162	AAP around pillbox	Area of Archaeological Potential	Regional
163	AAP around ROC post	Area of Archaeological Potential	Regional
164	AAP around grid pattern in cropmarks	Area of Archaeological Potential	Regional
165	AAP around possible anti-aircraft battery	Area of Archaeological Potential	Regional
166	AAP around Pleistocene deposits and prehistoric occupation site	Area of Archaeological Potential	Regional
167	AAP around grid pattern of cropmarks	Area of Archaeological Potential	Regional
168	AAP around pillbox	Area of Archaeological Potential	Regional
169	AAP around World War II observation tower	Area of Archaeological Potential	Regional
170	AAP around barrow	Area of Archaeological Potential	Regional
171	AAP around possible prehistoric settlement site	Area of Archaeological Potential	Regional
172	AAP around Grain military defences, prehistoric and Roman sites and industrial area. Quarried areas not included.	Area of Archaeological Potential	Regional
201	AAP around geology of archaeological potential	Area of Archaeological Potential	Regional
207	AAP around geology of archaeological potential	Area of Archaeological Potential	Regional
209	AAP around geology of archaeological potential	Area of Archaeological Potential	Regional
212	AAP around geology of archaeological potential	Area of Archaeological Potential	Regional
215	AAP around geology of archaeological potential	Area of Archaeological Potential	Regional
217	AAP around geology of archaeological potential	Area of Archaeological Potential	Regional
222	AAP around geology of archaeological potential	Area of Archaeological Potential	Regional
223	AAP around geology of archaeological potential	Area of Archaeological Potential	Regional

Table C1.5: Transport for London Option - Summary of heritage assets potentially physically impacted during construction

Asset No.	Asset Name	Designation	Significance
DKE19172	Slough fort and wing batteries	Scheduled Monument	National
DKE19160	Coastal artillery defences on the isle of grain, immediately east and south east of Grain village	Scheduled Monument	National
DKE1374	Church Of St James	Listed Building: Grade I	National
DKE1377	Church Of All Saints	Listed Building: Grade I	National
DKE1612	Church Of St Peter and St Paul Saints	Listed Building: Grade I	National
DKE1375	Church Of St Mary	Listed Building: Grade II*	National
DKE18942	Slough Fort, All Hallows, Medway, Kent	Listed Building: Grade II*	National
DKE19911	Former Airship Shed at Moat Farm	Listed Building: Grade II	National
DKE1376	The Old Rectory	Listed Building: Grade II	National
DKE1378	Barn 25 Yards South Of Brickhouse Farmhouse	Listed Building: Grade II	National
DKE1498	Court Lodge Farm House	Listed Building: Grade II	National
DKE1499	Rose And Crown Public House	Listed Building: Grade II	National
DKE1609	White House Farmhouse	Listed Building: Grade II	National
DKE1611	Newland's Farm House	Listed Building: Grade II	National
DKE1613	Granary 20 Yards To North Of Court Lodge Farm House	Listed Building: Grade II	National
DKE1786	South View	Listed Building: Grade II	National
DKE1787	St Mary's Hall	Listed Building: Grade II	National
DKE1833	Mackay's Court	Listed Building: Grade II	National
DKE1907	The Hogarth Inn	Listed Building: Grade II	National
DKE1908	Fenn Street Farm House	Listed Building: Grade II	National
DKE1909	Brickhouse Farmhouse	Listed Building: Grade II	National
DKE20000	World War II Anti-Tank Obstacles On The Foreshore	Listed Building: Grade II	National
DKE22407	Grain Crossing Signal Box	Listed Building: Grade II	National
DKE21725	Crash site of Hawker Hurricane I	Protected Military Remains	National
DKE21728	Crash site of Dornier Do17Z-3	Protected Military Remains	National
DKE21729	Crash site of Messerschmitt Bf109E-4	Protected Military Remains	National
DKE21730	Crash site of Heinkel He 111H-2	Protected Military Remains	National
DKE20053	World War II aircraft	Protected Military Remains	National
DKE21732	Hawker Hurricane 1	Protected Military Remains	National
MKE16291	Site of Yantlet firing range, Isle of Grain	Potential designated site	National
MKE16419	Explosive stores, St Mary's Marshes, St Mary Hoo	Potential designated site	National
MKE42325	QF Decoy Site, Allhallows	Potential designated site	National
No HER reference	Stone obelisk at mouth of Yantlet Creek	Potential designated site	National
MWX18725	The London Stone, north Saltings, Isle of Grain	Potential designated site	National
NA	St Mary Hoo Conservation Area	Conservation Area	Regional
7	AAP surrounding Post medieval battery	Area of Archaeological Potential	Regional
8	AAP surrounding early medieval pottery kiln	Area of Archaeological Potential	Regional
9	AAP surrounding Post medieval battery	Area of Archaeological Potential	Regional
10	AAP surrounding Post medieval fort & battery	Area of Archaeological Potential	Regional
12	AAP surrounding Roman occupation	Area of Archaeological Potential	Regional
13	AAP surrounding Roman flask	Area of Archaeological Potential	Regional
14	AAP surrounding Post medieval tower/beacon	Area of Archaeological Potential	Regional
15	AAP surrounding medieval & Post medieval saltworkings	Area of Archaeological Potential	Regional

Asset No.	Asset Name	Designation	Significance
16	AAP surrounding Post medieval fort & battery	Area of Archaeological Potential	Regional
17	AAP surrounding medieval & Post medieval church	Area of Archaeological Potential	Regional
18	AAP surrounding Roman cemetery	Area of Archaeological Potential	Regional
19	AAP surrounding undated stone foundations	Area of Archaeological Potential	Regional
20	AAP surrounding Roman pottery	Area of Archaeological Potential	Regional
21	AAP surrounding Roman cremation	Area of Archaeological Potential	Regional
22	AAP surrounding medieval church	Area of Archaeological Potential	Regional
23	AAP surrounding undated rectilinear enclosure	Area of Archaeological Potential	Regional
24	AAP surrounding medieval & Post medieval chapel	Area of Archaeological Potential	Regional
25	AAP surrounding Roman pit & medieval pottery	Area of Archaeological Potential	Regional
26	AAP surrounding Roman pit	Area of Archaeological Potential	Regional
27	AAP surrounding undated ring ditch	Area of Archaeological Potential	Regional
28	AAP surrounding Roman pottery & briquetage	Area of Archaeological Potential	Regional
29	AAP surrounding flint implement & Roman pottery	Area of Archaeological Potential	Regional
30	AAP surrounding Bronze Age founders hoard	Area of Archaeological Potential	Regional
31	AAP surrounding undated enclosures	Area of Archaeological Potential	Regional
32	AAP surrounding beacon	Area of Archaeological Potential	Regional
33	AAP surrounding medieval & Post medieval church	Area of Archaeological Potential	Regional
34	AAP surrounding Roman cremation & post medieval fort	Area of Archaeological Potential	Regional
35	AAP surrounding Roman occupation site, World War II defences, river frontage	Area of Archaeological Potential	Regional
97	AAP around area of wharves	Area of Archaeological Potential	Regional
100	AAP around World War II command post	Area of Archaeological Potential	Regional
101	AAP around World War II anti-aircraft site	Area of Archaeological Potential	Regional
113	AAP around Grain Fortifications	Area of Archaeological Potential	Regional
114	AAP around military and river front remains	Area of Archaeological Potential	Regional
121	AAP around former military installation	Area of Archaeological Potential	Regional
122	AAP around Yantlet Creek	Area of Archaeological Potential	Regional
123	AAP around Wharf	Area of Archaeological Potential	Regional
124	AAP around Wharves	Area of Archaeological Potential	Regional
125	AAP around Roman ditch	Area of Archaeological Potential	Regional

Asset No.	Asset Name	Designation	Significance
126	AAP around prehistoric site, Lower Stoke	Area of Archaeological Potential	Regional
153	AAP around explosive stores	Area of Archaeological Potential	Regional
154	AAP around historic village	Area of Archaeological Potential	Regional
155	AAP around World War II obstacles	Area of Archaeological Potential	Regional
156	AAP around cropmarks	Area of Archaeological Potential	Regional
157	AAP around World War II pillbox	Area of Archaeological Potential	Regional
158	AAP around pillbox	Area of Archaeological Potential	Regional
159	AAP around pillbox	Area of Archaeological Potential	Regional
160	AAP around pillbox	Area of Archaeological Potential	Regional
161	AAP around pillboxes, stakes, moorings and river frontage	Area of Archaeological Potential	Regional
162	AAP around pillbox	Area of Archaeological Potential	Regional
163	AAP around ROC post	Area of Archaeological Potential	Regional
164	AAP around grid pattern in cropmarks	Area of Archaeological Potential	Regional
165	AAP around possible anti-airctaft battery	Area of Archaeological Potential	Regional
166	AAP around Pleistocene deposits and prehistoric occupation site	Area of Archaeological Potential	Regional
167	AAP around grid pattern of cropmarks	Area of Archaeological Potential	Regional
168	AAP around pillbox	Area of Archaeological Potential	Regional
169	AAP around World War II observation tower	Area of Archaeological Potential	Regional
170	AAP around barrow	Area of Archaeological Potential	Regional
171	AAP around possible prehistoric settlement site	Area of Archaeological Potential	Regional
172	AAP around Grain military defences, prehistoric and Roman sites and industrial area. Quarried areas not included.	Area of Archaeological Potential	Regional
201	AAP around geology of archaeological potential	Area of Archaeological Potential	Regional
203	AAP around geology of archaeological potential	Area of Archaeological Potential	Regional
205	AAP around geology of archaeological potential	Area of Archaeological Potential	Regional
207	AAP around geology of archaeological potential	Area of Archaeological Potential	Regional
208	AAP around geology of archaeological potential	Area of Archaeological Potential	Regional
209	AAP around geology of archaeological potential	Area of Archaeological Potential	Regional
211	AAP around geology of archaeological potential	Area of Archaeological Potential	Regional
212	AAP around geology of archaeological potential	Area of Archaeological Potential	Regional

Asset No.	Asset Name	Designation	Significance
215	AAP around geology of archaeological potential	Area of Archaeological Potential	Regional
216	AAP around geology of archaeological potential	Area of Archaeological Potential	Regional
217	AAP around geology of archaeological potential	Area of Archaeological Potential	Regional
219	AAP around geology of archaeological potential	Area of Archaeological Potential	Regional
220	AAP around geology of archaeological potential	Area of Archaeological Potential	Regional
221	AAP around geology of archaeological potential	Area of Archaeological Potential	Regional
222	AAP around geology of archaeological potential	Area of Archaeological Potential	Regional
223	AAP around geology of archaeological potential	Area of Archaeological Potential	Regional